The Theory and Empirics of Exchange Rates

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To Our Families

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Preface

Determining the levels of (and changes in) exchange rates, as well as assessing the impact of these changes are topics that have been receiving increasing attention since 1973. This interest came as a result of the global shift to flexible exchange rates following the collapse of the Bretton Woods system of fixed exchange rates in 1971 when the United States suspended the convertibility of the dollar into gold. Academic and professional economists are interested in these topics because they constitute a challenging area of inquiry and because variations in exchange rates affect the risk and return on investment, as well as market shares, whenever a foreign exchange factor is involved, which is inevitable in this era of globalization. Indicative of the importance of the exchange rate factor is that foreign exchange risk management has become a thriving field since the regime shift in the 1970s, and as a result instruments and techniques have been developed to deal with this risk. Policymakers are also interested in the determination of, and changes in, exchange rates because these changes have significant macroeconomic ramifications, affecting almost every macroeconomic variable, including the major four (growth, inflation, unemployment, and the balance of payments). It is for all of these reasons that research on exchange rates has been mushrooming.

Given the importance of the topic and because it is constantly evolving with momentum, we decided to write this book as a comprehensive reference for those interested in the field. The book provides detailed exposition (using both diagrammatic and mathematical representation) of the models of exchange rates and the balance of payments. Moreover, we highlight the observed failure of the macroeconomic approach to exchange rates, providing explanations for this failure and discussing alternative approaches such as the microstructure approach and behavioral finance. It is hoped that this book will be a helpful reference for economists and policymakers who are interested in exchange rates.

Writing this book was a rather hectic job that would not have been possible without the help and support we received from several individuals. First and foremost, we must thank our families who had to bear the opportunity cost of writing this book. The list of individuals whom we would like to thank is rather long, but there are people who were specifically helpful. We utilized the computer skills and data retrieving ability of John Vaz who was (and is) always ready to give a hand. Liam Lenten was just as helpful in providing data and other information. Lee Smith and Hassan Shahzad read previous tedious versions of the manuscript and came up with sets of constructive suggestions that have helped improve the presentation. Shobita Koohli, the librarian at GUST, was helpful in obtaining many of the references cited in this book, which she did rather efficiently. Sulaiman Al-Jassar provided much-needed help, technical and otherwise, for the first author when he first arrived at Kuwait University in October 2008, when this book was finalized. Informal discussions with Weshah Razzak on exchange rate economics proved to be useful for refining some of the ideas presented in this book.

Other people we would like to thank include Kevin Dowd, Bob Sedgwick, Nabeel Al-Loughani, Ali Ansari, Robert Cook, Bob Ankli, Nayef Al-Hajraf, and Sulaiman Al-Abduljader. Last, but not the least, we would like to thank the crew at World Scientific, particularly Pui Yee and Juliet Lee. Thanks to them, for dealing with World Scientific, a publisher that we have not dealt with before, has been a rather pleasant experience.

Needless to say, we are responsible entirely for any errors and omissions in this book. It is dedicated to our beloved children who are concerned about changes in exchange rates as they experience the rise and fall of the value of domestic currencies in foreign currency terms when they travel abroad.

Imad Moosa
Razzaque Bhatti
November 2008

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List of Acronyms

2SLS	Two stage least squares
AGS	Ashley–Granger–Schmalensee (test)
ARCH	Autoregressive conditional heteroskedasticity
ARIMA	Autoregressive integrated moving average
BCCR	Banco Central de Costa Rica
BIS	Bank for international settlements
BP	Balance of payments
CAPM	Capital asset pricing model
CC	Commercial client transactions
CC	Currency demand
CD	Canadian-domiciled investment transactions
CES	Constant elasticity of substitution
CIP	Covered interest parity
CK	Common knowledge
DW	Durbin–Watson (statistic)
EB	External balance
EBS	Electronic brokerage service
EGARCH	Exponential generalized autoregressive conditional heteroskedasticity
EMS	European monetary system
EMU	European monetary union
FD	Foreign institution transactions
FX	Foreign exchange
GARCH	Generalized autoregressive conditional heteroskedasticity
GDP	Gross domestic product
GLS	Generalized least squares
GMM	Generalized method of moments
GNP	Gross national product
HP	Hodrick–Prescott (filter)

IB	Internal balance
IMF	International Monetary Fund
IMMS	International Money Market Services
IS	Investment and saving equilibrium
LD	Loan demand
LM	Liquidity preference and money supply equilibrium
M1	Narrow money
M2	Broad money
M3	Broad money
MAE	Mean absolute error
MMS	Money market survey
MSE	Mean square error
NCK	Non-common knowledge
OLS	Ordinary least squares
OPEC	Organization of petroleum exporting countries
OTC	Over-the-counter
PPP	Purchasing power parity
RCC	Reserve currency country
REEM	Rational expectations efficient market
RMSE	Root mean square error
S&P	Standard and Poor's
SDR	Special drawing rights
TVP	Time-varying parametric
UIP	Uncovered interest parity
VAR	Vector autoregressive
VECM	Vector error correction model
VMA	Vector moving average
WLS	Weighted least-squares

Currency Abbreviations

AUD	Australian dollar
CAD	Canadian dollar
CHF	Swiss franc
DEM	German mark
DKK	Danish krone
EUR	Euro
FFR	French franc
GBP	British pound
JPY	Japanese yen
KOW	Korean won
NOK	Norwegian krone
SEK	Swedish krone
USD	US dollar

Note: The convention used in this book is that, unless otherwise stated, exchange rates are expressed in direct quotation, as the domestic currency price of one unit of the foreign currency. Thus, a rise in the exchange rate implies foreign currency appreciation and vice versa. AUD/USD is the direct quotation from an Australian perspective, meaning the price of one US dollar in Australian dollar terms.

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CHAPTER 1
Why Do We Study Exchange Rates?

1.1. Introduction

This book is about the theory of, and empirical evidence on, exchange rates. We are living in the era of globalization in which governments, firms, and individuals deal with each other across borders, which makes them exposed to the foreign exchange risk resulting from fluctuations in exchange rates. Even if a firm does not deal with the rest of the world, it is exposed to foreign exchange risk because these changes affect its share in the domestic market. For example, domestic currency appreciation induces foreign firms to enter the domestic market, thereby threatening the market shares of purely domestic firms. This is an example of the microeconomic effects of changes in exchange rates. From a macroeconomic perspective, exchange rate fluctuations affect output, employment, inflation, the external balance, interest rates, and monetary and fiscal policies (macroeconomic policy in general).

Some cynics make the observation that the shift from fixed to flexible exchange rates following the collapse of the Bretton Woods system in the early 1970s resulted in the promotion of telex operators to foreign exchange dealers. Beyond the humor in this statement, the effects of this shift have been profound in terms of the (increased) uncertainty surrounding the outcome of financial and commercial cross-border transactions. The shift has led to the emergence of two thriving and interrelated industries: exchange rate forecasting and foreign exchange risk management.

An important aspect of globalization that has brought exchange rates to the forefront (in terms of importance as a macroeconomic variable) is the internationalization (or globalization) of finance. This process has been driven by advances in information and computer technologies, globalization of national economies, liberalization and deregulation of national financial and capital markets, and competition among the providers of financial intermediary services. Several factors indicate an ever-increasing degree of the internationalization of finance, including (i) the volume of international bank lending (including cross-border lending and domestic lending denominated in foreign currencies); (ii) the value of securities transactions with foreigners; (iii) the flows of portfolio investment and foreign direct investment; (iv) the value of daily turnover (trading volume) in the global foreign exchange market and (v) the percentage of foreign exchange trading conducted with crossborder counterparties.

Given that this book is about the exchange rate, the price of foreign exchange that is determined in the foreign exchange market, it is perhaps of most interest for us here to talk about the volume of trading in the foreign exchange market. Measuring the volume of trading in this market is not straightforward because, unlike the stock market (which is an organized exchange), it is a global over-the-counter (OTC) market, a huge network of telecommunication linking market participants, the buyers, and sellers of currencies. Arriving at an exact figure for the volume of trading in the global foreign exchange market is almost impossible. Instead, the size of the market is measured through surveys conducted by the central banks of individual countries and coordinated by the Basel-based Bank for International Settlements.

This exercise, called the triennial central bank survey, is conducted once every 3 years, the last of which was in April 2007. The survey's results (reported in Bank for International Settlements, 2007) revealed that the average daily turnover in the global foreign exchange market was \$3.2 trillion, up by 63% on the previous survey of April 2004.[1] In the 1992 survey, this figure was \$880 billion (Figure 1.1). The reason why growth of the volume of trading in the foreign exchange market is considered as an indicator for the internationalization of finance is that most of this amount is used to finance capital account transactions (involving the buying and selling of securities denominated in various currencies) or the trading of currencies (as financial assets) in their own right. Some 62% of total trading is carried out with cross-border counterparties. This rapid growth of the foreign exchange market is a reflection of the growth of other indicators of the internationalization of finance, including the volume of international bank lending, the value of securities transactions with foreigners, and the flows of portfolio investment and foreign direct investment. Foreign exchange transactions are associated with cross-border current account and

[1] Out of the \$3210 billion dollars of daily trading, spot transactions accounted for \$1005 billion, whereas outright forward and swaps accounted for the rest.

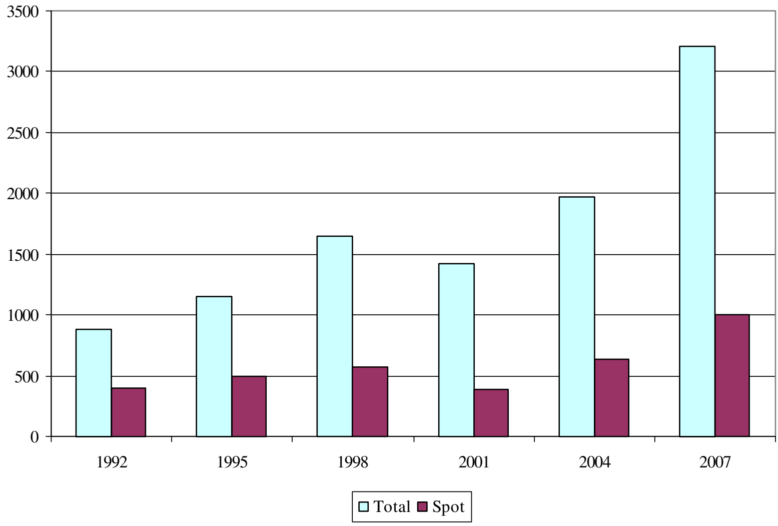

Figure 1.1. Daily turnover in the foreign exchange market ($ million).

capital account transactions, as well as transactions with local counterparties involving foreign currencies (for example, foreign currency deposits held by locals with domestic banks).

1.2. The Importance of Exchange Rates

It is not an exaggeration to say that the exchange rate is the single most important macroeconomic variable in an open economy. This is so much the case in the present environment of financial deregulation and globalization of financial markets. In this section, we elaborate on some of the points that were raised briefly in the previous section.

1.2.1. *The Exchange Rate and Business Operations*

The exchange rate is very important for businesses, particularly under the present international environment. Business firms indulge in international operations to reap the benefits arising from the globalization of trade and finance. One obvious benefit of international trade is the extension of the market for the firm's products beyond the national frontiers. The advantage of the globalization of finance is to enhance the ability of business firms to diversify their financing and investment portfolios. However, there is no "free lunch": these opportunities bring with them exposure to foreign exchange risk, which results from (unanticipated) fluctuations in exchange rates.

Foreign exchange risk is typically classified into transaction risk, economic risk, and translation risk. Transaction risk results from the effect of fluctuations in exchange rates on the contractual cash flows associated with existing trade contracts, as well as foreign assets and liabilities. Economic risk, on the other hand, results from the effect of changes in the (real) exchange rate on cash flows that are not contractual as well as market share. Translation risk (also called accounting risk) results from the effect of exchange rate fluctuations on the domestic currency values of foreign currency assets and liabilities. It arises mainly in the process of constructing consolidated financial statements for a firm with foreign subsidiaries. History is full of examples of companies that have disappeared because of adverse movements in exchange rates, and there are even more examples of companies that were affected profoundly in terms of shrinking profit and market shares.[2]

The outcome of business operations involving exposure to foreign exchange risk is contingent upon the movement of the underlying exchange rate between the time at which a decision to enter an operation (or take a position) is taken and the materialization of the outcome. The generation of exchange rate forecasts is therefore necessary for taking decisions pertaining to these operations. The following are some examples:[3]

- In uncovered interest arbitrage (also known as carry trade), a short position is taken on a low-interest currency while a long position is taken on a high-interest currency if it is expected that the high-interest currency will not depreciate against the low-interest currency by more than the interest rate differential.
- In spot-forward speculation, a currency is bought forward and sold spot if the spot exchange rate on the maturity of the forward contract is higher than the forward rate (and vice versa).
- In speculation by using options, a long call or a short put is taken if the underlying currency is expected to appreciate (and vice versa).

[2]For an illustration of how foreign exchange risk arises and its classification, see Moosa (2003). For details on how exchange rate affects the prices, costs, revenues, and profits of an exporting firm, see Moosa (2005).

[3]A detailed description of financial decisions involving exchange rate forecasting can be found in Moosa (2000b).

These are but a few examples of business decisions that require exchange rate forecasting. Unless business firms decide to go technical and use "black boxes" to forecast exchange rates, some understanding of the exchange rate determination process may prove to be useful.

1.2.2. *The Exchange Rate and Macroeconomic Policy*

Under a system of flexible exchange rates, central banks intervene in the market on a regular basis to "smooth" and "iron out" fluctuations in exchange rates. Sometimes, they even intervene to accomplish the nearly-impossible objective of reversing an established market trend, only to fail spectacularly in this endeavor (recall the bitter experiences of the Bank of England in September 1992 and the Thai monetary authorities in July 1997).

The argument for central bank intervention is based on the propositions that (i) exchange rate fluctuations can be excessive and (ii) exchange rate fluctuations have adverse effects on economic activity. The first proposition actually implies the importance of understanding the behavior of exchange rates. The second proposition is that exchange rates create uncertainty that adversely affects the value of international trade and investment. Fluctuations in exchange rates can affect international trade in a number of ways. The first is that agents respond to uncertainty by reducing the volume of international transactions. The response may also involve a change in the composition of output and investment to reduce risk. Moreover, fluctuations in exchange rates may affect macroeconomic policy formation by changing policy trade-offs (see, for example, International Monetary Fund, 1984). There is also some evidence that exchange rate uncertainty has a negative effect on exports and the allocation of resources (see, for example, Arize, 1995).

1.2.3. *Macroeconomic Linkages Through Exchange Rates*

The exchange rate provides a key macroeconomic linkage between the domestic economy and the rest of the world that takes place through goods and asset markets. In the goods market, the exchange rate establishes linkages between domestic and foreign prices, as domestic prices are some sort of exchange rate-adjusted foreign prices (not exactly but close enough). Some of the effect of foreign prices on domestic prices is transmitted through the labor market, as workers may demand wage increases when higher import prices raise the cost of living (and higher import prices may result purely from foreign currency appreciation). In general, changes in exchange rates may produce imported inflation and loss of competitiveness. Asset markets also have exchange rate linkages. The choice among assets depends on the trade-off between risk and return, a linkage that can be expressed in terms of uncovered interest parity (UIP).

Microeconomic linkages through the exchange rate involve resource allocation. When the real exchange rate makes the economy highly competitive, resources are drawn into the traded goods sector, which is mirrored in the factor market by a new allocation of resources. The economy becomes trade-oriented, with rising employment of capital and labor in the export- and import-competing sectors. The distribution of income is also affected. If the country has a traditional export sector (for example, agriculture or mining), then a very competitive exchange rate (undervalued domestic currency) will make traditional exports profitable. There are also implications for asset markets. When domestic returns are below foreign returns, capital flight will occur, leaving a smaller amount of resources available for domestic investment. When capital controls are imposed, those who indulge in (illegal) capital flight (for example, those who fake trade invoices) often do so at the expense of those who do not (perhaps because they cannot).

Exchange rate policies/regimes affect the external balance and the internal balance through their effects on total spending (via the demand for money) and on the competitiveness of traded goods. According to Collier and Joshi (1989), the external balance should be interpreted as the achievement of a sustainable current account deficit (a deficit that is consistent with a realistic medium-run projection of foreign capital inflow). The internal balance is a more complex target as it has employment (or output) and inflation as its components. Policymakers would like to have high employment and output and low inflation, but complications are introduced by the fact that there may be a trade-off between these subtargets (as implied by the Phillips curve). Exchange rate regimes/policies affect the internal balance because the price of a currency has an important direct effect on the general price level (through goods market linkages), and an important indirect influence on the level of aggregate economic activity. Microeconomic efficiency, or the efficiency of resource allocation, is important for the objective of maximizing real income. Exchange rate regimes/policies affect efficiency in two ways: (i) by affecting the uncertainty surrounding the outcome of economic transactions (particularly foreign-trade transactions) and (ii) by making the imposition of trade restrictions more or less likely.

1.3. Stylized Facts and Figures

Some stylized facts have been observed about the actual behavior of exchange rates and their relation with other macroeconomic variables. We start with the stylized facts on the behavior of exchange rates without reference to possible determining variables. Then, we examine the stylized facts pertaining to the behavior of exchange rates relative to that of macroeconomic factors that are supposed to be the determining factors.

1.3.1. *Stylized Facts: Exchange Rates Only*

Four stylized facts can be observed about the behavior of exchange rates. These stylized facts, which are derived from a visual inspection of historical data, are the following: (i) exchange rates appear to follow a random walk with little or no drift; (ii) they move predominantly in cycles, but it is not obvious whether they are procyclical or countercyclical with respect to economic activity; (iii) the behavior of exchange rate can be described as a combination of bubbles and crashes and (iv) they exhibit volatility clustering.

Stylized facts (i) and (ii) are related. Little or no drift actually means the dominance of cycles (and of course random variation). This can be seen in Figure 1.2, which depicts the time paths of the U.S. dollar exchange rates against the Japanese yen (JPY), British pound (GBP), Australian dollar (AUD), and special drawing rights (SDR). Apart from the period of fixed exchange rates, when the exchange rates were stable, subsequent behavior is characterized by significant cyclical and random variation with little trend (no strong sustained trends). The cyclical behavior is clearer in Figure 1.3, which exhibits the smoothed time paths of the four exchange rates.[4] The dominance of cycles over trends is a characteristic that distinguishes exchange rates from stock prices. However, it is not clear whether exchange rates are procyclical or countercyclical (Lenten, 2006). In Chapter 14, we will show that the various exchange rate models described in this book, and other macroeconomic models, have different predictions of the cyclical behavior of exchange rates.

The second stylized fact is that exchange rates typically exhibit movements that can be described as “bubbles followed by crashes.” This simply

[4]The smoothed time paths are derived by applying the HP filter to the exchange rate data.

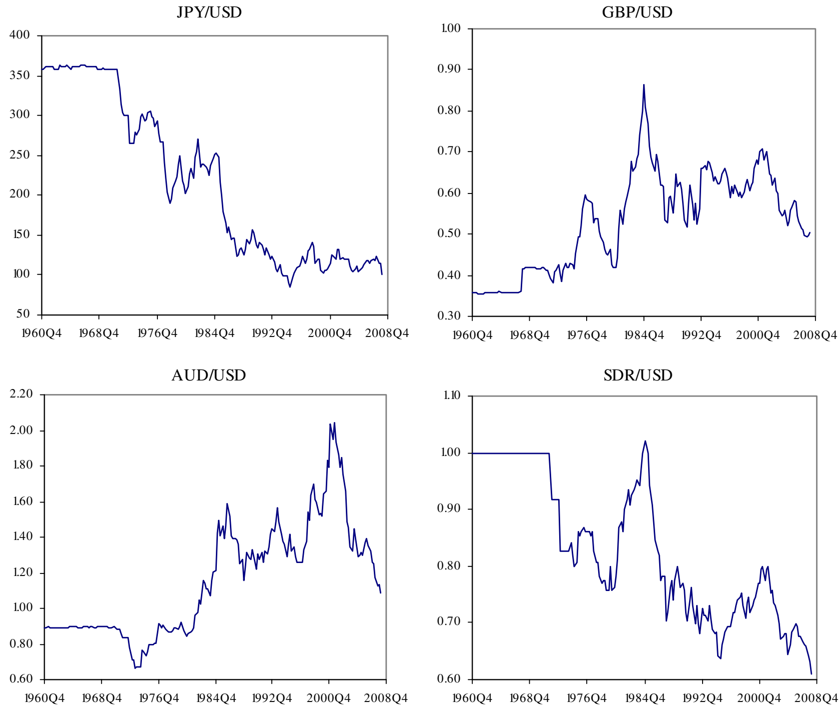

Figure 1.2. Time paths of exchange rates versus the U.S. dollar.

means that exchange rates exhibit sustained upward movements for a long period in a bubble-like movement, then they crash by losing all of the previous gains over a short (or shorter) period. Take, for example, the exchange rate of the SDR versus the U.S. dollar. We can observe two episodes of bubbles and crashes, which are magnified in Figure 1.4. Table 1.1 reports the magnitude of the rise and fall of the dollar in the two episodes. In the first episode (1979:Q4–1987:Q4), it took the dollar 21 quarters to rise by 34.7% and 12 quarters to fall by 31%. In the second episode (1995:Q2–2004:Q4), it took the dollar 30 quarters to rise by 25.6% and 11 quarters to fall by 19.4%.

But there is no bubble and crash like that of the Australian dollar versus the U.S. dollar, which materialized very recently. Figure 1.5 illustrates the episode with a plot of daily data over the period 4 January 2005–10 October 2008. It took the Australian dollar the time between 4 January 2005 and 15 July 2008 to rise from 0.7668 to its peak of 0.9802. By 10 October 2008,

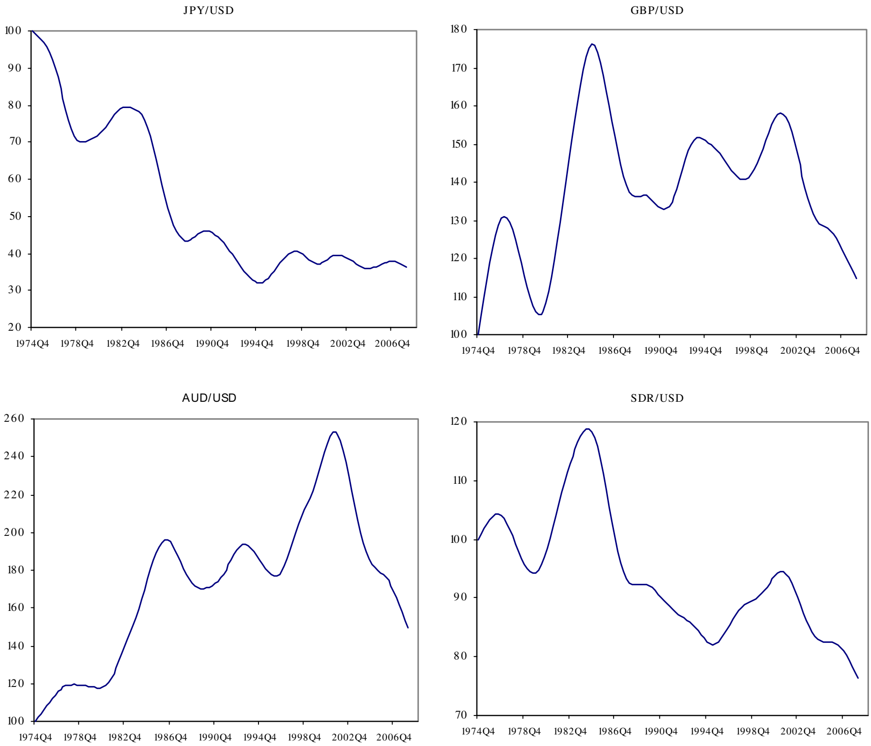

Figure 1.3. Smoothed time paths of exchange rates versus the U.S. dollar.

the Australian dollar had fallen to 0.6529. This is a spectacular crash that no model and no forecaster could have predicted.[5]

The last stylized fact when we examine the behavior of exchange rates on their own is volatility clustering. This means that periods of calm are followed by periods of calm (clustering of small changes in the exchange rate); then periods of turbulence are followed by periods of turbulence (clustering of big changes in the exchange rate). This behavior can be seen clearly in Figure 1.6, which also provides some indication that the percentage changes in exchange rates are not normally distributed. Table 1.2 reports some

[5]Following a short-lived recovery from this level, the Australian currency plunged to just over 0.60 by the end of October 2008. Some explanations for this depreciation are presented in Chapter 14.

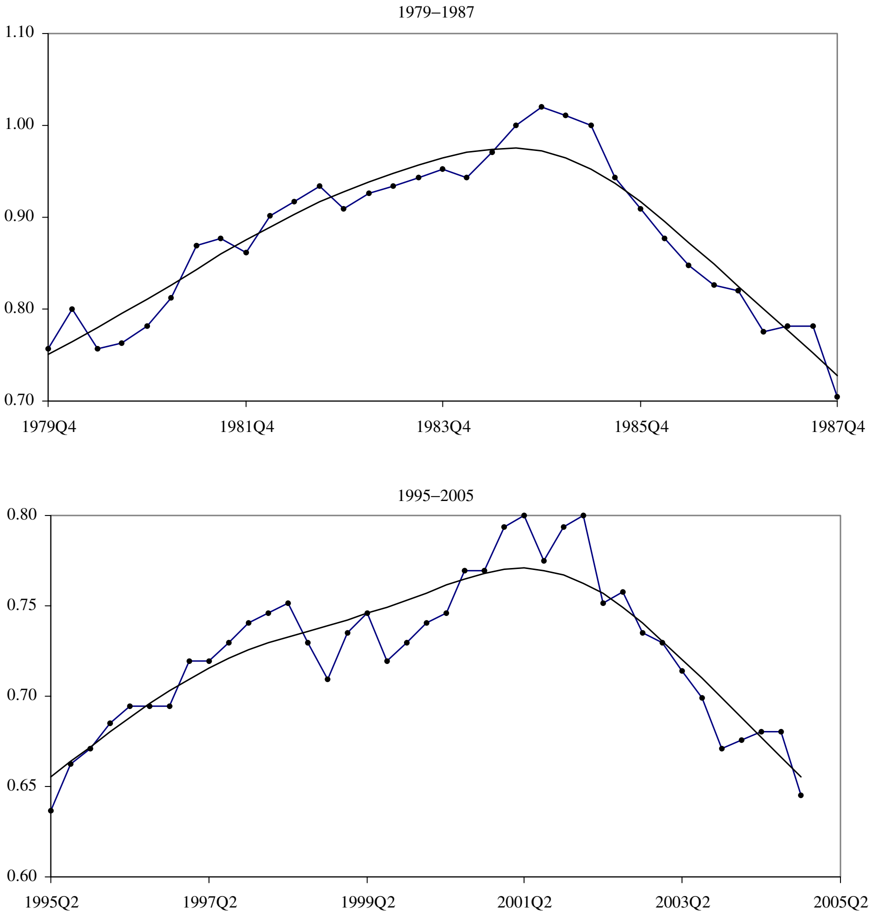

Figure 1.4. Bubbles and crashes of the dollar (SDR/USD).

indicators based on the data used to plot Figure 1.6. We can see, for example, that 32 observations on the JPY/USD rate fall above the 99th percentile and 10 observations fall above the threshold of three standard deviations above the mean (a 3-sigma event). It can also be seen from the table that the largest percentage change in the EUR/USD is 4.29 standard deviations above the mean. The probability of a 4-sigma (or, to be precise, a 4.29-sigma) event is extremely low, and it is certainly not compatible with a normal probability distribution. But this is nothing compared to what happened to the USD/AUD rate during the first 10 days of October 2008, as it registered

Table 1.1. Bubbles and crashes (SDR/USD).

Quarter	Exchange rate	% Change	Time in quarters
1979:Q4	0.7567		
1984:Q4	1.0204	+34.7	21
1987:Q4	0.7040	−31.0	12
1995:Q2	0.6369		
2002:Q1	0.8000	+25.6	30
2004:Q4	0.6452	−19.4	11

Figure 1.5. The great bubble and crash of the Australian dollar (USD/AUD, 4 January 2005–10 October 2008).

8- and 9-sigma events, as can be seen in Figure 1.7. The distribution of the percentage change in exchange rates contains too many extreme values to be normally distributed.[6]

[6]The probability of a 4-sigma event on any 1 day is 0.00317%, which means that a 4-sigma event is expected to occur once every 31,560 days. A 10-sigma event occurs with a probability of 7.62×10^{-22}%, or that it is expected to occur once every 5.2×10^{20} years. Dowd *et al.* (2008) calculate the probabilities of up to 25-sigma events, showing that this event should be expected to occur once every 1.309×10^{135} years.

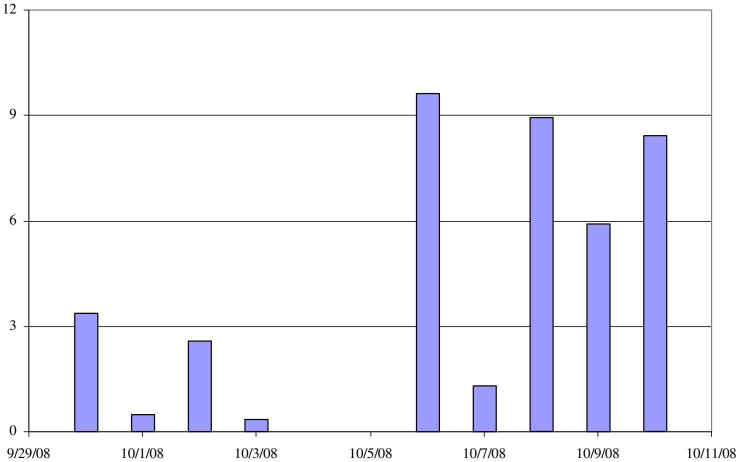

Figure 1.6. Standard deviations above or below the mean daily percentage change (USD/AUD, 30 September–10 October 2008).

Table 1.2. Some statistics of daily percentage changes in exchange rates (4 January 2005–10 October 2008).

Statistic	EUR/USD	GBP/USD	JPY/USD
1	1.41	1.37	1.32
2	1.59	1.58	1.88
3	16	14	32
4	9	10	10
5	4.29	4.00	3.63

1. 99th percentile.
2. The value falling three standard deviations above or below the mean.
3. Number of observations above or below the 99th percentile.
4. Number of observations above or below the mean plus (minus) three standard deviations.
5. Number of standard deviations above or below the mean where the highest or lowest values fall.

1.3.2. *Stylized Facts: Spot Rates, Forward Rates, and Macroeconomic Variables*

The first stylized fact is that the spot and forward rates tend to move in the same direction and by approximately the same amount, particularly if the

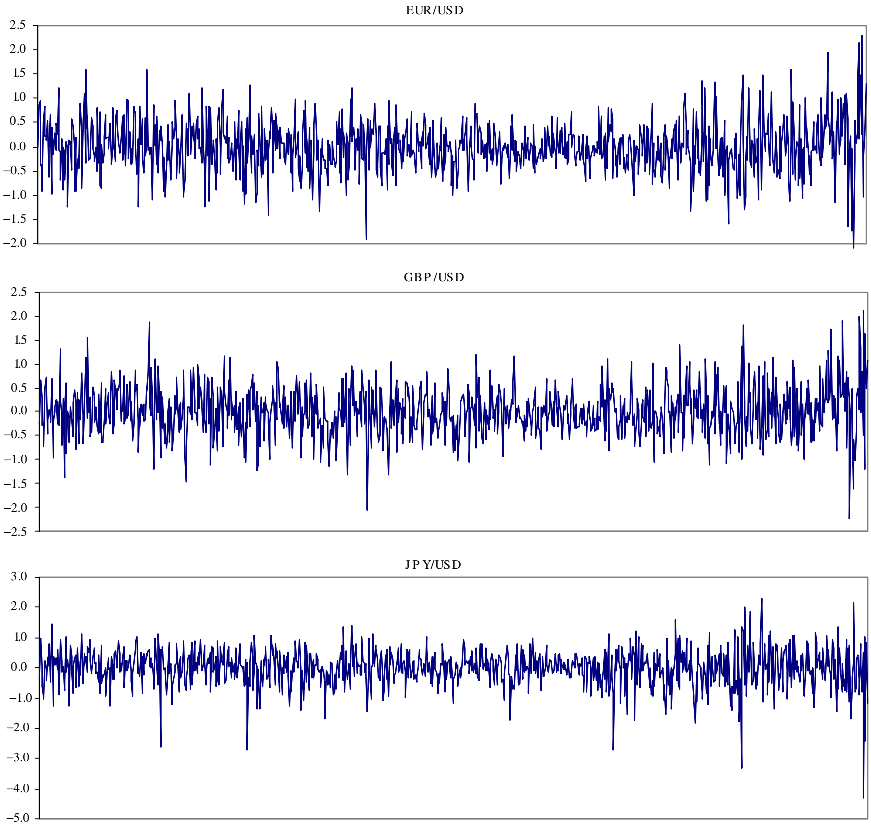

Figure 1.7. Volatility clustering in exchange rates (percentage changes: 4 January 2005–10 October 2008).

movements are large. The implication of this observation is that it is not advisable to use the forward rate to predict the spot rate expected to prevail in the future. The spot and forward rates are related contemporaneously, as implied by covered interest parity, and not what is implied by the unbiased efficiency hypothesis. This issue will be discussed in Chapter 9.

Exchange rates are more volatile than macroeconomic variables. Table 1.3 reports the standard deviations of quarterly percentage changes in four exchange rates and three macroeconomic variables covering the U.S. and three other countries: industrial production, the general price level (measured by the consumer price index, CPI) and the money supply. It is obvious that exchange rates are more volatile than the macroeconomic variables

Table 1.3. Standard deviations of quarterly percentage rates of change.

	1985–89	1990–94	1995–99	2000–2007	1985–2007
Exchange rates					
SDR/USD	3.78	3.36	2.54	2.34	3.01
JPY/USD	6.65	5.43	7.44	4.40	5.99
GBP/USD	6.36	6.72	3.00	3.47	4.98
AUD/USD	6.32	4.06	4.88	5.49	5.29
Industrial production					
U.S.	1.04	1.19	0.83	1.15	1.09
Japan	1.26	1.74	1.89	2.09	1.85
U.K.	1.67	1.26	0.86	1.25	1.31
Australia	1.85	1.07	1.18	1.25	1.34
Prices					
U.S.	0.52	0.50	0.36	0.36	0.63
Japan	0.66	0.47	0.63	0.63	0.54
U.K.	0.68	1.13	0.34	0.34	0.76
Australia	0.44	0.72	0.51	0.51	0.81
Money supply					
U.S.	1.71	1.23	0.90	1.60	1.62
Japan	1.94	1.65	1.11	2.40	1.93
U.K.	0.77	1.07	0.50	0.41	0.84
Australia	2.15	2.74	1.41	3.24	2.63

that are supposed to determine them. This observation raises the following question: how can a highly volatile variable be determined by variables that move relatively smoothly over time? Among the exchange rates, the least volatile is, as expected, the SDR/USD rate because the SDR is a basket of currencies (hence, the SDR/USD rate is a multilateral rather than a bilateral rate). Out of the three bilateral rates, the AUD/USD rate seems to be the most volatile.

The other stylized facts describe the possible relations between the exchange rate and individual macroeconomic variables. The following can be stated:

- There is no close correspondence between movements in exchange rates and movements in domestic and foreign price levels. This proposition, which casts doubt on the theory of purchasing power parity (PPP), is more valid over a short rather than a long period. The problem (for exchange rate modeling) is that PPP is a cornerstone of the monetary model of exchange rates.

- There is a weak general tendency for countries experiencing sharp deterioration in the current account to experience subsequent and consequent depreciation of their currencies. For example, the U.S. dollar appreciated considerably during the period 1981–85 while the current account was dipping further into the red. The current account plays a key role in the Hooper–Morton model and all versions of the portfolio balance model.
- Countries that experience rapid expansion of their money supplies also experience rapid depreciation of their currencies. The word "rapid" must be emphasized here because this proposition seems to be valid for hyperinflation countries only (for example, Germany in the 1920s). This proposition is a prediction of the monetary model of exchange rates.[7]

Figure 1.8 shows the behavior of the actual exchange rates of the yen and pound against the U.S. dollar and the corresponding PPP rates. The latter are calculated by adjusting the actual exchange rates at the base period (1988:Q4) for prices (by multiplying the base period rates by the price ratios prevailing in subsequent periods). We can see the contrast between the actual behavior of the exchange rates and the behavior predicted by PPP. The PPP rates are calculated under the assumption that prices are the only determining factor of exchange rates. Notice that if the exchange rate is determined by prices only (which is what PPP tells us), the time path of the exchange rate would be rather smooth and it would be significantly less volatile than the actual rate. This provides support for the stylized fact that there is no close correspondence between movements in exchange rates and movements in domestic and foreign price levels. But one could argue that we cannot expect the exchange rate to be determined by one or two price indices, and that other variables should be brought into play. However, we will find out throughout this book that no matter what combination of variables we bring in, the behavior of exchange rates is difficult to explain and predict. This observation, however, does not mean that macroeconomic fundamentals do not matter. The importance, or otherwise, of fundamentals is an issue that will be revisited in Chapter 14.

[7] For a detailed account of five major hyperinflation episodes and the performance of the monetary model and purchasing power parity under hyperinflation, see Gazos (2008).

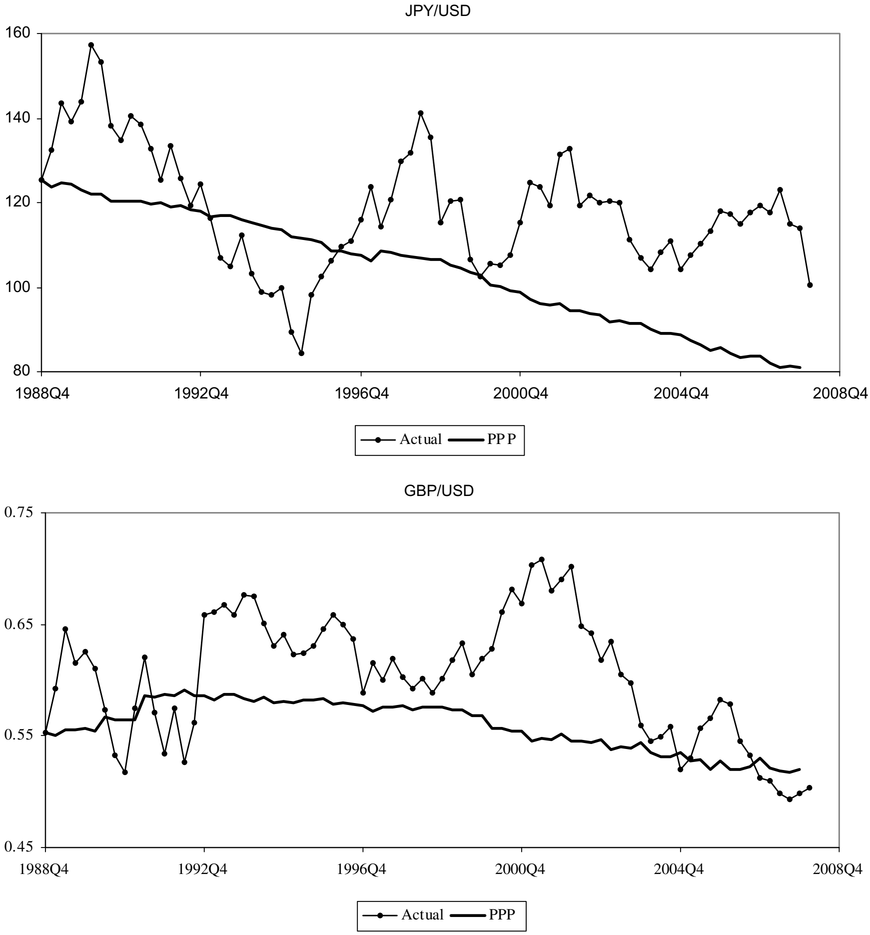

Figure 1.8. Exchange rates and prices: deviations from PPP.

1.4. Exchange Rates and Other Financial Prices: The Subprime Crisis as an Example

The relation between exchange rates and other financial prices is not clear. Take, for example, the relation between exchange rates and stock prices. On a firm level, we should expect domestic currency depreciation to be beneficial for the stocks of exporting firms and harmful for the stocks of importing firms. But in aggregate, the relation is not clear. On the capital account side, stock prices should be boosted by expectation of domestic currency appreciation, but the econometric extraction of expected values may not reflect the actual expectation formation mechanism, thus producing misleading results.

Perhaps it is insightful in this respect to observe what happened in the foreign exchange market during the subprime crisis that surfaced in mid-2007 and affected all financial markets (see, for example, Moosa, 2008a,b). During the crisis, the foreign exchange market witnessed increasing volatility and (initially) further depreciation of the U.S. dollar. Higher volatility resulted from rapid unwinding of carry trade positions as a result of lower appetite for financial risk. Carry trade involves taking a short position on a low-interest currency and a corresponding long position on a high-interest currency.[8] The risk involved in this operation is the potential loss resulting from the possibility of the appreciation of the low-interest currency against the high-interest currency by more than the interest rate differential, which means that exchange rate volatility discourages the conduct of carry trade. Furthermore, the hedge funds affected by the subprime crisis started to unwind carry trade positions to meet margin calls following losses in their credit portfolios. Thus, the unwinding of carry trade positions led to exchange rate volatility, which in turn led to more unwinding of these positions.

Moreover, viewing the U.S. economy as being more vulnerable to the subprime crisis than the economies of Europe and Australasia brought with it further depreciation of the U.S. currency. By the end of October 2007, the U.S. dollar was at a record low against the euro, the lowest level against the Australian dollar since 1984, and the lowest level against the pound in 26 years. But then, the Australian currency lost 20 cents of its value against the U.S. dollar in less than 2 months, and as the ramifications of the subprime crisis became clearer and as it was "upgraded" to a full-blown credit and financial crisis. In the first half of October 2008, the Australian dollar crashed against the U.S. dollar, as we have seen.[9]

Figure 1.9 shows the behavior of the Dow Jones Industrial Average and three dollar exchange rates (EUR/USD, JPY/USD, and GBP/USD) using daily data over the period 10 February 2006–10 September 2008 (note that the subprime crisis surfaced in June 2007). There is simply no obvious

[8]On carry trade, see Moosa (2008c).

[9]One plausible explanation is that U.S. dollar-based investors were liquidating their Australian assets and converting them into U.S. dollars because they were in need for U.S. dollar funds.

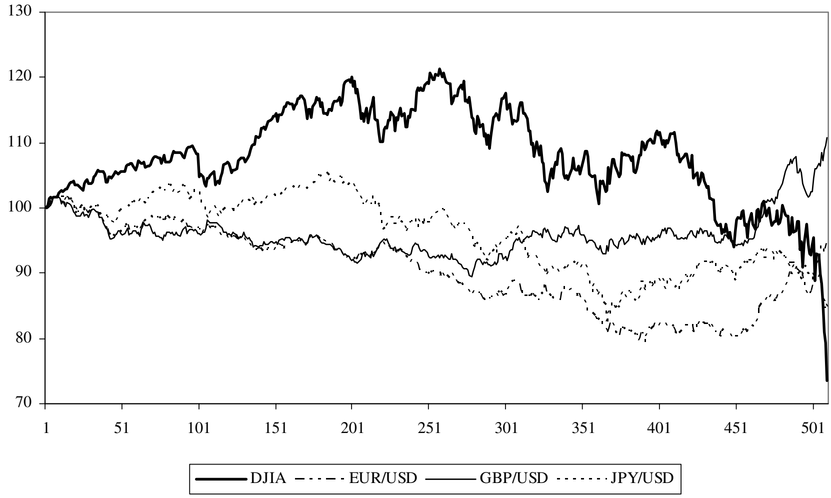

Figure 1.9. Exchange rates and stock prices (10 February 2006–10 September 2008).

relation between stock prices and exchange rates. The relation between the two variables seems to depend on time and the particular exchange rate. For the whole period shown in the graph, the correlation coefficient between the DJIA and the three exchange rates was as follows: 0.14 for the EUR/USD rate, −0.75 for the GBP/USD rate, and 0.48 for the JPY/USD rate. At one time, correlation was generally positive, but toward the end of the period covered by the graph, the dollar strengthened significantly against the pound as the U.S. stock market collapsed. It is true that the British stock market was also collapsing at the same time and that the U.K. was affected by the credit crisis. But the crisis was American by birth, and it seems implausible to think that the U.K. was affected by an American crisis more than America itself. What then explains the rapid appreciation of the dollar against the pound as the ramifications of the crisis were becoming more and more conspicuous? The problem is that even if one or more plausible explanations can be found, these explanations (individually or collectively) cannot be captured by an exchange rate determination model.[10]

[10]Apart from the reason pointed out in the previous footnote, one could think of other plausible reasons for the strength of the U.S. currency in the midst of the credit crisis. The sheer size and diversity of U.S. financial markets may still be appealing to investors, particularly that the U.S. government has the power to issue the dollar, which is the world's

1.5. Exchange Rate Regimes

This book presents a description of models designed for various exchange rate regimes. Most of these models deal with the determination of flexible exchange rates. The balance of payments models presented in Chapter 4 deals with the effect of macroeconomic changes on the balance of paymets under fixed exchange rates. In between, the Girton–Roper model presented in Chapter 7 is designed to deal with the joint determination of the exchange rate and international reserves under a system of managed floating. For this reason, it may be worthwhile to go through a brief classification of exchange rate regimes in theory and practice. For a detailed discussion of exchange rate regimes and their implications, see Moosa (2005).

1.5.1. *Exchange Rate Regime Classification*

From a theoretical perspective, exchange rate regimes can be classified (according to the flexibility of exchange rates) into perfectly fixed exchange rates, fixed but adjustable exchange rates, and perfectly flexible exchange rates. The movements in flexible exchange rates are small and continuous, resulting from changes in market forces (shifts in the supply and demand curves). Changes in fixed (but adjustable) exchange rates are large and discrete, resulting from deliberate policy actions (changing the par value of the domestic currency). While a change in a fixed exchange rate is called "devaluation" (downward) and "revaluation" (upward), the corresponding changes in a flexible exchange rate are called "depreciation" and "appreciation," respectively. It is often the case (particularly in the media, but also in academic work) that the words "depreciation" and "devaluation" are (mistakenly) used interchangeably as if they meant the same thing.

Other regimes include fixed but flexible within a band, fixed but adjustable and flexible within a band, and flexible exchange rates with

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main reserve currency. Foreign direct investment flows would be another reason, given that the crisis has left numerous undervalued companies and assets in the U.S. Furthermore, other countries started cutting their interest rates vigorously when the dollar interest rates were low, thus reducing the interest rate differential against the dollar. Finally, a reason for the renewed strength of the dollar that has nothing to do with the crisis is the cyclical behavior of exchange rates. The dollar, it seems, had reached its trough in July 2008, and it was about time it would appreciate. On the other hand, the depreciation of the dollar against the yen was caused by the reversal of carry trade operations.

market intervention. Managed floating (also called dirty floating), independent floating, and target zones are regimes that fall under the heading "flexible rates with market intervention." The main difference lies in the degree and frequency of market intervention, and hence the flexibility of the exchange rate. Exchange rate flexibility is lower under managed floating than under independent floating. But under both of these systems, intervention is mainly directed at combating speculative pressure and reducing exchange rate volatility (this is at least what is normally claimed, although there is the view that managed floating has the objective of influencing the market trend of the exchange rate). Indeed, the difference between managed floating and independent floating is typically blurred.

A system of target zone differs from managed floating and independent floating in at least two respects: (i) establishing a range for the exchange rate for a future period and (ii) observing closely the exchange rate in the conduct of monetary policy to keep it within the target range. But unlike the adjustable peg system, a target zone system does not imply a formal commitment to intervene in the foreign exchange market to keep the exchange rate within the target range. The target range is reviewed and changed if necessary.

In practice, and following the classification system of the International Monetary Fund, exchange rate regimes are classified according to the degree of exchange rate flexibility into (i) fixed exchange rates, (ii) flexible exchange rates, and (iii) intermediate regimes. The so-called clean floating or perfectly flexible exchange rates hardly exist these days, and not even the free-market champions of the IMF advocate a system like this. Under these three broad categories, there are specific regimes, including the following:

Dollarization

The term "dollarization" is generic, implying the use of the currency of one country as the legal tender of another country. As the U.S. dollar is the most commonly used currency for this purpose, we use the term "dollarization" and not "euroization" or "poundization." Further discussion of dollarization can be found in Chapter 9.

Currency Unions

A currency union is another hard-peg system where a group of countries use a common currency, which means that these countries have fixed exchange rates among them. The obvious example is the European Monetary Union.

Currency Boards

A currency board is a system of fixed exchange rates that was common in colonial territories during the first half of the twentieth century. Under this system, the currency board is obliged to supply, on demand and without limit, the foreign currency to which the domestic currency is pegged.

Single-Currency Pegs

Pegging to a single currency amounts to fixing the bilateral exchange rate against another currency (the anchor currency). The anchor currency is, or should be, that of the major trading partner.

Multicurrency Pegs

Unlike single-currency pegs, multicurrency pegs (or basket pegs) do not give rise to a form of currency area. Rather than reflecting acceptance of optimum currency area arguments in favor of a link to a single currency, the choice of a basket peg may be interpreted as a rejection of these arguments. Again, it is possible that the pegged exchange rate is allowed to move within a band, giving rise to what Frankel *et al.* (2001) call a "band around a basket peg."

Adjustable Pegs

Under adjustable pegs (fixed but adjustable exchange rates), the country undertakes an obligation to defend the peg, but reserves the right to alter the exchange rate to correct a fundamental disequilibrium. The Bretton Woods system (1944–71) was a system of adjustable pegs.

Crawling Pegs

One variation on fixed exchange rates that is common among high-inflation developing countries is the crawling peg, whereby the government announces a schedule of small, discrete devaluations. A country adopting a crawling peg undertakes an obligation to defend the peg but either commits itself to moving the peg in small steps in accordance with a preannounced rule or reserves the right to change the peg in small steps that are discretionary in size and timing. This is called a discretionary crawling peg. Like the adjustable peg, a crawling peg involves a choice between pegging to a single currency and pegging to a basket of currencies. Again, the presumption is that pegging to a basket is superior.

1.5.2. *Exchange Rate Regime Verification*

It has become an undisputed fact of life that, with respect to exchange rate regime choice, countries do not necessarily practise what they declare. This phenomenon has led to the emergence of a new strand of research in international finance, appearing under the headings "exchange rate regime verification," "*de facto* versus *de jure* regimes," and "fear of floating" (also fear of fixing or fear of pegging).[11] Countries do not adhere to the declared regime for a number of reasons.

China provides the most recent example of adopting a regime (crawling peg) and declaring another one (basket peg). Moosa *et al.* (2008) attempt to verify the exchange rate regime that China has been following since 21 July 2005 when a policy shift was implemented, presumably taking China from a dollar peg to a basket peg. The results show that while the previous regime of simple and strict dollar peg has indeed been abandoned, the evidence does not support the proposition that the current exchange rate regime is a basket peg. It is suggested, based on the empirical results, that the current Chinese regime is some sort of a discretionary crawling peg against the U.S. dollar. It is argued that this regime is consistent with the Chinese objectives of maintaining a competitive advantage while avoiding a trade war with the U.S. Moosa (2008d) reaches the same conclusion by demonstrating that a crawling peg model is more powerful in forecasting the yuan/dollar exchange rate than a basket peg model.

1.6. What Is to Come

As stated earlier, this book deals mainly with flexible exchange rates, but we also consider fixed exchange rates and managed floating. In Chapter 2, we study the Mundell–Fleming model under both fixed and flexible exchange rates. We will see how the model can be viewed as an exchange rate determination model and how it can be used to assess the effectiveness of monetary and fiscal policies under fixed and flexible exchange rates. Chapter 3 covers

[11] For a detailed discussion of these issues, see Moosa (2005).

the determination of (flexible) exchange rates under monetarist conditions, including perfect price flexibility. The flexible-price monetary model, which came as a challenge to the Mundell–Fleming model, is simply an extension of the quantity theory of money to the case of open economy. One problem with this model is the very assumption of perfect price flexibility, which leads to the proposition that purchasing power parity is valid not only in the long run but also in the short run.

Just like the flexible price monetary model has been suggested as a replacement for the Mundell–Fleming flow model, the monetary approach to the balance of payment has been suggested as a replacement for the elasticities, Keynesian and income absorption approaches. This topic is covered in Chapter 4, which is concerned with the balance of payment adjustment mechanism under fixed exchange rates. It will be shown, however, that it is possible to come up with a synthesis of the monetary and Keynesian approaches.

In Chapter 5, we study the Dornbusch sticky-price model, which is a representation of long-run equilibrium toward which the economy tends to adjust, while in the short run it is possible that the exchange rate may overshoot its long-run value (hence, the model is also called the "overshooting model"). This model explains the paradox that countries with high interest rates tend to have currencies that are expected to appreciate. The initial rise in domestic interest rates leads to steep appreciation of the domestic currency, which is expected to be followed by slow depreciation to satisfy uncovered interest parity. Thus, this model plugs loopholes in the Mundell–Fleming model and the flexible-price monetary model. Other sticky-price models were developed subsequently, including the real interest differential model, Driskell's generalized stock-flow sticky-price model, the equilibrium real exchange rate model of Hooper and Morton, the Buiter–Miller model with a core inflation rate, and Frankel's sticky-price model with a wealth effect. These models are described in Chapter 6.

While Chapters 2–6 deal with either fixed or flexible exchange rates, Chapter 7 provides an exposition of a model that is designed for an intermediate arrangement, whereby both the exchange rate and the level of international reserves change. This is the monetary model of exchange market pressure developed by Girton and Roper, who suggest that the monetary model is valid for either a pure float or a pure peg (the monetary approach to the balance of payment). This makes a lot of sense because in practice there is no pure float and hardly a pure peg, unless we are talking about currency unions or currency boards.

All monetary models are asset market models that are restrictive in the sense that they only allow for one asset: money. The portfolio balance model described in Chapter 8 allows for the holding of bonds. This model postulates that a deficit or surplus in the current account gives rise to a portfolio balance effect on the exchange rate. The role of the current account is prominent in this model because the accumulation or otherwise of assets (wealth) is supposed to take place via the current account. A synthesis of the monetary and portfolio balance models is also presented in Chapter 8. Furthermore, it is shown that the portfolio balance model can be modified by introducing a role for the banking sector and the effect of bank lending.

The exchange rate models described in Chapters 2, 3, and 5–8 do not allow individuals and firms to hold foreign currencies. This is a restriction that is not consistent with reality where diversified currency portfolios are held for transaction, precautionary, and speculative motives. The tendency to hold foreign currencies in addition to, or instead of, the domestic currency is called "currency substitution." In the currency substitution model, which is described in Chapter 9, the demand for money functions is modified by introducing the expected change in the exchange rate as an additional explanatory variable. The model shows that allowing for currency substitution makes exchange rates volatile and even indeterminate in extreme cases.

In Chapter 10, we move from macroeconomic models to the microstructure model of exchange rates. The unsatisfactory performance of macroeconomic models has led some economists to rethink the exchange rate determination process by introducing an explicit role for the process of trading in the foreign exchange market. One of the major contributors to the field, Richard Lyons, tells an interesting story to explain why he developed interest in the microstructure approach to exchange rates after he spent a day in a dealing room where he watched dealers in action. When he visited the dealing room, he writes "At that time, I considered myself an expert, having written my thesis on exchange rates. I thought I had a handle on how it worked. I thought wrong" (Lyons, 2001a, p. xiii). No wonder that Lyons's name will be mentioned quite frequently in Chapter 10 (and in Chapter 13).

While the microstructure approach has been suggested to explain the empirical failure of macroeconomic models, an earlier attempt was made without departing from the macroeconomic framework. Instead of relating changes in exchange rates to total changes in economic fundamentals, the news approach relates changes in exchange rates to unanticipated changes in the fundamentals or news about fundamentals. This approach is considered in Chapter 11. The main problem with this approach is the task of extracting of the news components of total changes in macroeconomic fundamentals, which makes the econometric testing of the news model rather difficult. In particular, the representation of the news components by the residual of a univariate model of the underlying macroeconomic variable may introduce errors in variables and generated regressors problems.

Chapters 12 and 13 present the empirical evidence on the macroeconomic and microstructure models of exchange rates, respectively. Evidence on the macroeconomic models described in earlier chapters is based on conventional econometric methods, out-of-sample forecasting, cointegration-based dynamic models, and simultaneous equation models. In general, the evidence on macroeconomic models is dismal. The evidence on the microstructure models shows that order flow, which is the most important microstructure variable, has some explanatory power that far exceeds that of macroeconomic variables such as interest rates. However, one has to bear in mind that order flow is a "proximate cause," and that it is not "the underlying cause of exchange rate movements" because "the underlying cause is information" (Lyons, 2001a, p. 17). While the microstructure approach provides an explanation for the failure of macroeconomic models, hence providing an alternative approach, other alternative approaches are discussed in Chapter 14, where we also conclude.

CHAPTER 2

Exchange Rate Determination in the Mundell–Fleming Model

2.1. Introduction

The foundations of the Mundell–Fleming open economy macroeconomic model were laid in the early 1960s in the classical writings of Mundell (1960, 1961b,c, 1962, 1963a, 1964) and Fleming (1962).[1] The contribution made by this model was a systematic analysis of (i) the role played by trade and capital flows equilibria in determining the equilibrium exchange rate and (ii) the impact of international capital mobility on the effectiveness of monetary and fiscal policies under fixed and flexible exchange rates. The model influenced the thinking of a generation of economists who extended the work of Mundell and Fleming in the late 1960s and throughout the 1970s.[2] Frenkel and Razin (1987) rightly described the Mundell–Fleming model as the "workhorse of traditional open-economy macroeconomics."

The backdrop to the Mundell–Fleming model was provided by the economic conditions prevailing in the 1950s and the early 1960s: fixed exchange rates, capital controls, segmented capital markets, high unemployment, and low inflation. During these two decades, Keynesian macroeconomic thinking was highly dominant in policy-making circles. Key contributions in this area were made, among others, by Metzler (1942), Machlup (1943), Harberger (1950), Laursen and Metzler (1950), and Alexander (1952) who developed models (based on the simple version of the Keynesian income-expenditure framework) to deal with a static world characterized by rigid

[1]For a detailed discussion on the Mundell–Fleming model, see Frenkel and Razin (1987), Mundell (2001), and Boughton (2003).

[2]See, for example, Krueger (1965), Sohmen (1967), Prachowny, (1977), and Dornbusch (1976a,c) who based their work on the Mundell–Fleming model or extended it to investigate the impact of fiscal and monetary policies under fixed and flexible exchange rates.

wages and prices, unemployment, and limited linkages among countries. Based on Keynesian general equilibrium analysis, these models elucidated the effects of trading on Keynesian multipliers, the effects of devaluation, the determination of floating exchange rates, and the role of the terms of trade in the Keynesian consumption function. In these models, the role of monetary factors in the open economy (which is central to the classical paradigm) was downplayed, if not ignored altogether. In his *Survey of Contemporary Economics*, Metzler (1948, p. 212) was quite explicit in repudiating "the central role which [the classical mechanism] attributes to the monetary system." However, these new models gave no guide to the alternative mechanisms that would eliminate external imbalances over time, assuming instead that sterilization policies could be pursued indefinitely.

Meade (1951) employed a standard Keynesian fixed-price income-expenditure approach within a much broader framework, which also emphasized the role of monetary factors, to demonstrate how an economy could achieve, simultaneously, balance of payments equilibrium (external balance) and full employment (internal balance). In a nutshell, this was to be achieved by a combination of demand management (expenditure increasing/reducing policies) and foreign exchange policies (expenditure switching policies). There was, however, one major gap in Meade's theoretical treatment of international macroeconomics. This treatment was based on comparative static analysis, which omitted the dynamic process of change from one equilibrium position to another.[3]

An external imbalance implies that stocks of domestic wealth (money and perhaps other assets) are not stationary. This means that the economy must move from one equilibrium position to another over time, even in the absence of exogenous shocks. A question then arises concerning the adjustment mechanism. The earliest mechanism of dynamic adjustment in the open economy was Hume's "price-specie-flow mechanism," whereby inflation-inducing international flow of reserves forces the economy to attain a steady-state external payments equilibrium. The persisting post-war balance of payments imbalances seemed to be at odds with this mechanism, leading to the following questions: would this process be a stable one, and how would its nature depend on the activist economic policies that might be prevailing? Notwithstanding the enormous amount of work on how an open

[3]Meade (1951, p. viii) pointed to this major gap in his analysis when he said: "But I must confess frankly that there is one piece of modern technique in economic analysis which is very relevant to the problems discussed in this volume, but of which I have made no use. I refer to the analysis of the dynamic process of change from one position of equilibrium to another."

economy works, surprisingly little progress was made toward answering these questions until the advent Mundell's work in the early 1960s.

In a series of articles, Mundell took up the challenge, not only to fill the gap that Meade's omission of dynamics had left, but also to elaborate on numerous other related issues, such as the desirability of adopting fixed rather than flexible exchange rates, the relative efficacy of stabilization policies under alternative exchange rate regimes, and the appropriate use of stabilization policies under different economic conditions.[4] Following Meade, Mundell (1961b) emphasized the monetary sector, using a liquidity preference theory of money demand to tie down short-run equilibrium. Mundell (1961b) reintroduced the idea of a self-regulating adjustment mechanism that had been central to the classical framework. In particular, he demonstrated the applicability of Hume's price-specie-flow mechanism of automatic adjustment to an economy with saving and unemployment, or in which the quantity theory of money did not hold. Mundell (1961b) showed how the widespread sterilization of reserve flows could be expected to disrupt international adjustment. He suggested that Keynes's income-specie-flow mechanism (analogous to Hume's price-specie-flow mechanism) would ensure long-run equilibrium in international payments even in a world of rigid prices.

While (in his "disequilibrium system" argument) Mundell (1961b) demonstrated how the income-specie-flow mechanism would restore balance of payments equilibrium under Keynesian conditions, he did not delineate automatic forces tending to restore full employment. In his subsequent paper in 1962, he addressed this issue by pursuing the idea of a "policy mix" in which fiscal policy would play a central role. He applied a dynamic approach to the joint use of monetary and fiscal policies to attain internal and external stability under fixed exchange rates. He also showed a dilemma that authorities might face under fixed exchange rates was maintaining balance of payments equilibrium with internal stability and capital mobility, arguing that it could be resolved by gearing monetary policy to the

[4]Rose (2000) argued that Robert Mundell richly deserved the Nobel Prize for economics (which he got) because his contributions to the field of international monetary economics were path-breaking and have stood the test of time. Included in this path-breaking work, according to Rose, are the work on optimum currency areas (Mundell, 1961a), monetary dynamics with classical steady-state properties (Mundell, 1960), efficacy of fixed and flexible exchange rates (Mundell, 1961c), the appropriate use of monetary and fiscal policies (Mundell, 1962), the Mundell–Fleming model (Mundell, 1963a), and the Mundell–Tobin effect (Mundell, 1963b).

external balance and fiscal policy to the internal balance. A subtle insight that underlies this work is that dynamic stability conditions might be different for alternative policy assignments, which could therefore be used to assess the appropriateness of the policy mix. In another related piece of work, Mundell (1960) explored the appropriateness of fixed and flexible exchange rates in the process of adjusting to shocks. He showed that success of the adjustment process depends on government policy rules, the speed of adjustment in domestic prices under conditions of excess or deficit demand, and the degree of capital mobility.

In his paper, Mundell (1961c) developed an open-economy macroeconomic model based on the work of Laursen and Metzler (1950) to compare the effects of monetary policy, fiscal policy, and commercial policy on output and employment under fixed and flexible exchange rates. Mundell (1961c) concluded that monetary policy is more effective under flexible exchange rates, while fiscal and commercial policies are more effective under fixed exchange rates, accordingly proposing that countries with flexible exchange rates should rely more on monetary policy and less on fiscal policy to correct large-scale unemployment. In a subsequent paper, Mundell (1963a) demonstrated that (with perfect capital mobility) monetary policy is effective under flexible exchange rates, whereas fiscal policy is effective under fixed exchange rates. Another contribution of this work was to demonstrate that the international demand for trade and capital flows (and not the international demand for supply of money) plays a key role in determining the exchange rates. Fleming (1962) developed a model similar to Mundell's basic short-run equilibrium framework (based on the Keynesian fixed-price expenditure approach) to demonstrate the relative effectiveness of monetary and fiscal policies under fixed and flexible exchange rates. Mundell and Fleming justly share credit for this contribution.[5]

2.2. Disequilibrium Systems and Alternative Adjustment Mechanisms

Mundell (1961b) argues that the fundamental proposition of the classical paradigm of international economics is the presence of an automatic

[5]Fleming (1962) did not address formally the long-term adjustment process implicit in the Keynesian model, confining himself to some prescient remarks. In particular, he noted that the sensitivity of capital movements to interest rate changes was greater in the short run than in the long run, meaning that the difference between monetary and fiscal policies (with respect to effectiveness and sustainability) was likely to be lower in the long run than in the short run (Fleming, 1962, pp. 375, 376).

mechanism that leads to a steady-state equilibrium in the balance of payments. This proposition enabled the classical economists to isolate the short-run dynamic process of international adjustment from the long-run position, and to assume implicitly that disequilibrium is a transitory state. Yet, experience seems to indicate that external disequilibria may remain for extended periods and that the modern system is a disequilibrium system. He argues that this nature of the international disequilibrium system has sometimes been attributed (erroneously) to the Keynesian foreign trade multiplier, whereby an increase in exports induces an increase in imports that is smaller than the initial increase in exports. This argument gave rise to the belief that Hume's price-specie-flow mechanism of international adjustment is invalid for an economy in which there is saving and unemployment, or in which the quantity theory of money does not hold.

Mundell (1961b) shows that Hume's price-specie-flow mechanism is valid even if gold flows are allowed to have their natural effects on the domestic money supply (and hence on interest rates, investment, and incomes). Thus, the mechanism is valid in the case of a Keynesian world of unemployment with rigid prices and wages, although the price-specie-flow mechanism will be replaced by the income-specie-flow mechanism. For example, in the Keynesian world of unemployment with price and wage rigidity, an increase in the money supply would result in lower interest rates, capital outflow, and a rise in investment spending and output because of the multiplier effect. This process will be reversed eventually as gold outflow (due to capital outflow and the increase in imports) produces monetary contraction.

Mundell (1961b) begins with the observation that balance of payments imbalances are, by definition, associated with changing stocks of wealth. Then, he proceeds to compare the classical and Keynesian conditions under which the dynamics leads the economy toward steady-state equilibrium. Mundell shows that sterilization can disrupt the automatic adjustment process despite the income-specie-flow mechanism. He further argues that sterilization (which offsets losses of international reserves with an equivalent expansion of domestic credit) can only have a temporary effect, given finite stocks of central bank credit and reserves.

Mundell (1961b) demonstrates that general equilibrium in an open economy requires that the markets for goods, money, and foreign exchange to be in balance in terms of both current and inventory excess demand for money. Thus, general equilibrium is achieved when (i) the current supply of goods is equal to the current demand for goods, (ii) the existing stock of money is equal to the demand, and (iii) the balance of payments equilibrium.

Equilibrium in each of these markets/sectors depends on money income, interest rate, and the quantity of money. These results, however, are not dependent on the quantity theory of money. In fact, a change in the money supply can impinge upon effective demand and the balance of payments only if it first affects the interest rate. Thus for a static equilibrium in an open economy to be established, excess demand must be zero in each market. Symbolically:

$$X(Y, i) = 0; \quad X_Y > 0, \quad X_i < 0 \tag{2.1}$$

$$L(Y, i, M) = 0; \quad L_Y > 0, \quad L_i < 0, \quad L_M < 0 \tag{2.2}$$

$$F(Y, i) = 0; \quad F_Y < 0, F_i \geq 0 \tag{2.3}$$

where X, L, and F respectively represent the excess demand for goods (which is equal to investment minus saving plus net exports) the excess demand for money, and the balance of payments surplus (trade balance plus net capital imports). Y, i, and M respectively denote the real income, the interest rate and the quantity of money, whereas the terms X_Y, X_i, L_Y, L_i, L_M, F_Y, and F_i are the partial derivatives, which determine the slopes of the *XX* (*IS*) Investment and Saving Equilibrium, *LL* Liquidity Preference and money supply equilibrium (*LM*), and *FF* (*BP*) schedules, as plotted in Figure 2.1.

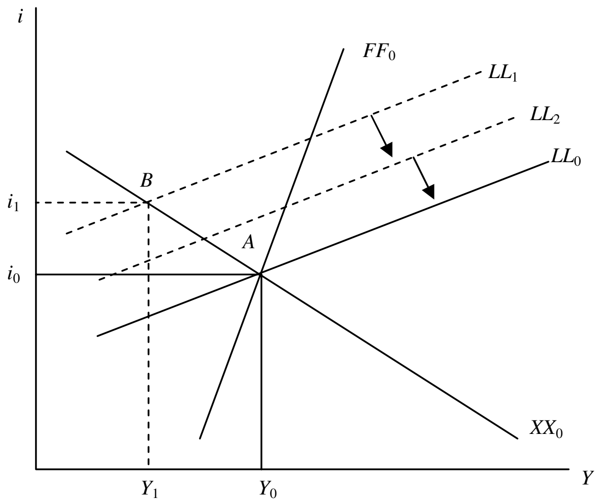


Figure 2.1. Price-specie-flow and income-specie-flow adjustment mechanisms.

The *XX* (internal balance) schedule traces combinations of interest rate and real income that are consistent with equilibrium in the goods market. This schedule is negatively sloped because a rise in the interest rate causes deflationary pressure, whereas a decline in real income causes inflationary pressure. The *LL* schedule represents the combinations of interest rate and real income, along which there is equilibrium in the money market for a given quantity of money. It slopes upward, shifting to the right as the money supply increases, and vice versa. The *FF* external balance schedule traces the locus of interest rate and real income along which there is equilibrium in the balance of payments. This schedule has a positive slope because an increase in the interest rate improves the balance of payments (by attracting capital), whereas an increase in real income worsens the balance of payments (causing deterioration in the trade balance as a result of higher prices).

In Figure 2.1, the three schedules (XX_0, FF_0, and LL_0) trace the conditions of equilibrium in the goods, foreign exchange, and money markets. Initially, the open economy is in equilibrium at point A where the markets are in (a static) equilibrium with the interest rate at i_0 and real income at Y_0. It must be noted that the quantity of money in circulation is constant at A. Consequently, the LL_0 schedule shifts to the right or to the left, depending on whether there is a surplus or a deficit in the balance of payments, as the money supply depends on foreign exchange reserves. To analyze the adjustment process in the open economy, we invoke the following postulates of the gold standard: (i) real income rises or falls as there is excess demand or excess supply in the goods market, (ii) the interest rate rises or falls as there is excess demand or supply in the money market, (iii) bank reserves rise or fall as there is a surplus or a deficit in the balance of payments, and (iv) the money supply rises or falls as reserves exceed or fall short of their desired level.

Mundell (1961b) shows that the dynamic adjustment toward general equilibrium at point A occurs automatically under both the classical world with price flexibility (through the price-specie-flow mechanism) and the Keynesian world with price and wage rigidity (through the income-specie-flow mechanism). Consider first the adjustment process in the classical world with flexible prices via the price-specie-flow mechanism. Suppose that there is a reduction in the money supply that shifts the *LL* schedule from LL_0 to LL_1. As a result, the markets for goods and money move to a new equilibrium position at point B, with a rise in the interest rate from i_0 to i_1 and a fall in income from Y_0 to Y_1. The economy cannot sustain an overall equilibrium at point B, because it lies to the left of the

FF schedule, indicating that there is a surplus in the balance of payments. The resulting capital inflow and increasing foreign exchange reserves will in turn induce an increase in the money supply, a decrease in interest rate, and an increase in both nominal income and prices. Consequently, the LL_1 schedule begins to shift gradually back to its original position (via LL_2).

Consider now how adjustment to general equilibrium takes place in the Keynesian world with price and wage rigidity. A decrease in the money supply results in an increase in the interest rate from i_0 to i_1, which causes capital inflow and a reduction in investment spending. This, in turn, leads to a fall in income from Y_0 to Y_1 through the multiplier effect. As a consequence of the rise in the interest rate and the fall in income, there is an improvement in both the capital and trade accounts. Eventually, there is a surplus in the balance of payments and hence an increase in foreign exchange reserves, which in turn results in an expansion in the money supply and a shift in the *LL* schedule from LL_1 to its original level (LL_0). Thus, equilibrium is restored with the original level of prices and income in both the classical and Keynesian cases. However, this adjustment occurs through variations in the price level in the former, but through changes in income in the latter.

Mundell (1961b) argues that while balance of payments disequilibrium has an automatic effect on the money supply under fixed exchange rates, this effect can be offset if the change in the liquidity situation does not coincide with the situation necessary for internal balance. Apart from changes in government expenditure or taxes, the monetary authorities can offset the liquidity effects of external disequilibrium by applying different instruments. But irrespective of the technique employed by the monetary authorities to shield the balance of payments from the money supply, the operation of the adjustment process will be impeded. This is illustrated in Figure 2.2.

Assume that the initial equilibrium at point *A* is disturbed by an increase in foreign interest rates. This causes greater outflow or smaller inflow of capital at the same domestic interest rate, shifting the foreign balance schedule from FF_0 to FF_1. Only at i_1 and Y_1 (as indicated by a new equilibrium point, *B*) can equilibrium be restored in both the goods market and the balance of payments. This point would be obtained automatically if the authorities allowed the adjustment process to go on unimpeded, in which case the *LL* schedule would shift upward and to the left until point *B* is reached. With a policy of neutralization (sterilization), however, the *LL* schedule stays approximately in its original position. The partial equilibrium at *B* is maintained with equilibrium in the goods and money markets but

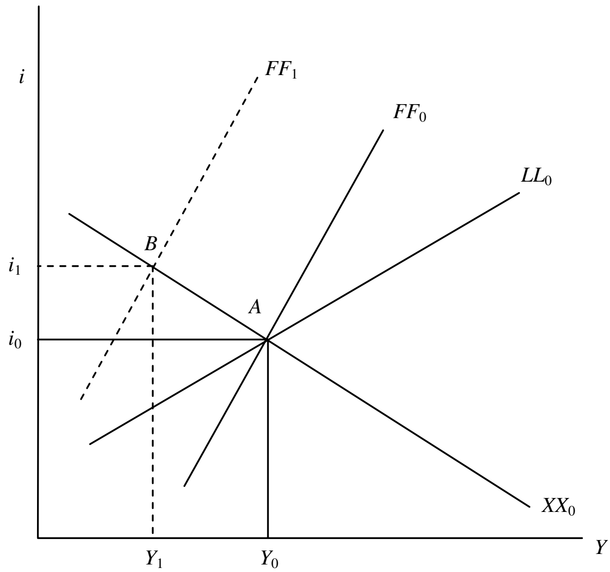


Figure 2.2. Sterilization and balance of payments disequilibrium.

disequilibrium in the balance of payments. This situation persists as long as the central bank can maintain the money supply and continues to run down its foreign exchange reserves. The sterilization policy coincides with the policy of stabilizing income. Failure to neutralize gold inflows (capital inflows) would result in lower levels of employment and output, as represented by point *B* in Figure 2.2.

If the central bank reinforces its neutralization policy by open market operations (to maintain the original level of output and employment), the balance of payments deficit is likely to be much greater than before. Suppose, for instance, that the demand for exports of the home country declines following a recession in the rest of the world. As a result, the trade balance deteriorates (through the multiplier effect on income) by shifting both the *FF* and *XX* schedules from FF_0 to FF_1 and XX_0 to XX_1 respectively, as shown in Figure 2.3. In the absence of neutralization, the automatic adjustment mechanism would cause a shift of the initial equilibrium from point *A* to point *B*, at a lower level of output and employment. But with a policy of neutralizing the external deficit (thus maintaining a constant money supply along the original LL_0 schedule), the fall in exports would lead to a lower level of output and employment at A'. In this instance,

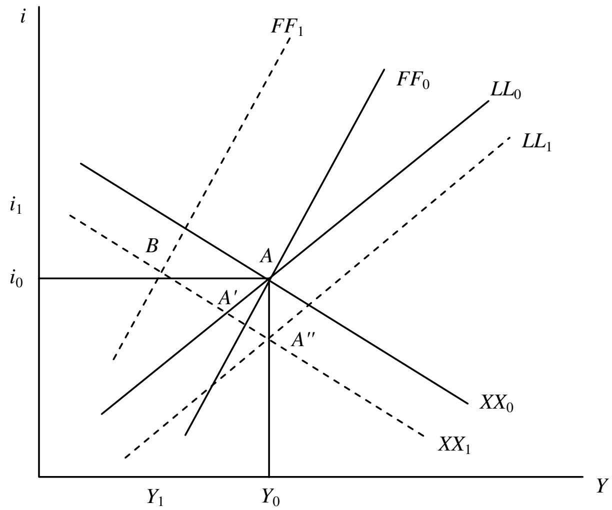


Figure 2.3. Balance of payments disequilibrium.

the central bank reinforces its neutralization policy by further open market operations to maintain output at Y_0. To this end, the money supply must be increased to the point where the LL schedule shifts from LL_0 to LL_1 to intersect the internal balance schedule XX_1 at A''. At this point, there is a balance of payments deficit that is greater than the deficit at A'.

Mundell (1961b) argues that the above examples suffice to illustrate the nature of the disequilibrium system and why it has arisen. Thus, many countries may continue to experience external disequilibrium for a considerable period, taking no explicit steps to correct the situation and preventing the adjustment process from having its natural corrective effect. Clearly, the policy of maintaining full employment with price stability is incompatible with the external balance. It is therefore seldom possible to determine the appropriate policy for correcting the external balance without first examining the nature of equilibrium in other markets. In Figure 2.4, the four quadrants, A, B, C, and D, represent the four types of disequilibrium: (i) depression and deficit, (ii) depression and surplus, (iii) inflation and surplus, and (iv) inflation and deficit.

It is argued that relying on one instrument (monetary policy) alone would not be sufficient to deal simultaneously with internal and external disequilibria. As it is evident in Figure 2.4, only the disequilibrium indicated by point D' can be improved by monetary policy alone, while all other points

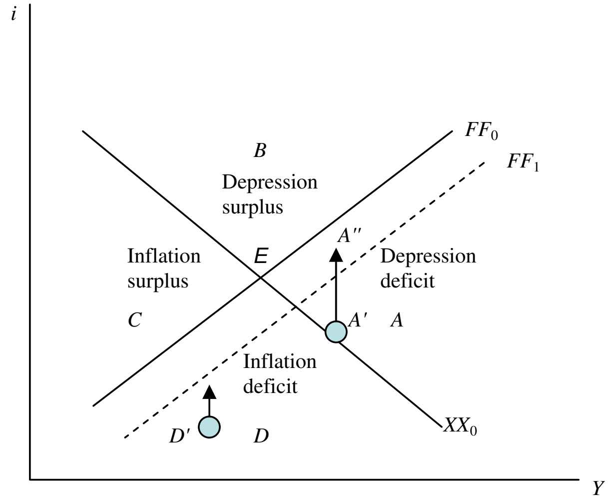


Figure 2.4. Different situations of disequilibrium.

of disequilibria require at least a dual policy.[6] For inflationary pressure and deficit at point D', the appropriate policy is a simple increase in interest rate because it relieves inflationary pressure (by reducing aggregate demand) and corrects the external balance (by attracting capital). Now suppose that there is at point A' an approximate internal balance at full employment and an external deficit (due to speculation against the domestic currency in favor of the foreign currency). If the central bank raises the interest rate to correct speculative capital outflow (by shifting the FF schedule to FF_1), the external deficit would be converted into surplus, as represented by point A''. This policy would not restore the overall balance, but it would rather result in some deflationary tension and unemployment. To prevent unemployment, therefore, an additional policy should be pursued because a simple policy

[6]Mundell (1961b, p. 167) argues that point D' represents roughly the position of France before the devaluation of 1958, and also the kind of disequilibrium prevailing in Europe after the war, while point A' represents the United Kingdom in the summer of 1957 when there was an approximate internal balance at reasonably full employment, but also an external deficit that had been aggravated by speculation against the British pound in favor of the German mark. In late September, the authorities raised the bank rate to 7%, an action that corrected speculative capital outflow (shifting the FF schedule to the right) and converted the external deficit into surplus at the expense of some deflationary tension and unemployment, as indicated at point A''.

involving a change in only one instrument (such as the monetary policy instrument) would not be sufficient.

2.3. Efficacy of Fixed and Flexible Exchange Rates

Mundell (1960) investigated the relative efficacy of fixed and flexible exchange rates as a conduit to adjustment to economic shocks. He showed that the result depended on government policy rules, the speed of domestic price level adjustment in the face of excess or deficient demand, and the degree of capital mobility. It is shown that the fixed exchange rate system operates most effectively if capital is highly mobile, whereas the flexible exchange rate system works best if capital is immobile. The fixed exchange rate works effectively if capital is highly mobile because the adjusting variable (interest rate) has a direct effect on the market to which it responds (the balance of payments), but the system is ineffective if capital is less mobile because the interest rate can affect the balance of payments only through interaction with the goods market and the price level. On the other hand, the flexible exchange rate system does not work effectively if capital is highly mobile because the interest rate has a more direct effect on the balance of payments than the market to which it responds (the goods market), but it works effectively if capital is immobile because this indirect repercussion is small or zero. In both cases, however, the system works best if variables respond to the markets on which they exert the most direct influence.

The relative effectiveness of fixed and flexible exchange rates can be illustrated by examining equilibrium conditions in the market for goods and foreign exchange. Equilibrium in the former is reached when the current world demand for domestic goods is equal to the current supply (or equivalently the excess of domestic saving over domestic investment is equal to the trade surplus).[7] Deflationary pressure arises in the economy when the excess of domestic saving over domestic investment exceeds the trade surplus, whereas inflationary pressure arises when excess saving falls short

[7]This can be illustrated by using the national income equilibrium condition in which the sum of injections into the circular flow of income (investment, government expenditure, and exports) is equal to the sum of withdrawals from it (saving, taxes, and imports). Hence, $I + G + X = S + T + M$, where I is the investment, G is the government expenditure, X is the exports, S is the saving, T is the tax revenue, and M is the imports. By rearranging the equation and assuming that $T = G$, we can derive an equation setting the condition that for equilibrium in the markets for goods and foreign exchange, the excess of domestic saving must be equal to the trade balance. This is written as $S - I = X - M$.

of the trade surplus. Similarly, equilibrium in the foreign exchange market is reached when foreign exchange payments are equal to foreign exchange receipts, or equivalently when net capital exports (lending) are equal to the trade surplus. In the absence of equality between foreign exchange payments and receipts, a balance of payments surplus or deficit would arise, depending on whether lending is greater or less than the trade surplus.

Equilibrium in both markets is determined by the domestic interest rate and the ratio of domestic to foreign prices (the terms of trade), given the exchange rate. The interest rate is determined by monetary policy, meaning that the central bank must always supply funds to the public (for example, via open market operations) to make any given interest rate compatible with capital market equilibrium. For the entire system to be in equilibrium, the following conditions must hold: (i) the excess of domestic saving over domestic investment must be equal to the trade surplus, (ii) the excess of securities supplied by the central bank must be equal to net capital indebtedness, and (iii) the trade surplus must be equal to net capital exports. Assuming that foreign prices, incomes, and interest rates are constant, changes in the terms of trade arise only from changes in the exchange rate or the domestic price level.

Given these assumptions, the interest rate and the terms of trade appear to be the main forces determining equilibrium in the markets for goods and foreign exchange, as represented by the *XX* and *FF* schedules in Figure 2.5. The *FF* schedule represents combinations of interest rate and domestic prices (or the exchange rate) along which the foreign exchange market is in equilibrium. Equilibrium in the foreign exchange market requires the equality of net capital exports and the trade balance (or equivalently foreign exchange payments and receipts). At any point on the *FF* schedule, the balance of payments is in equilibrium, although its composition changes in favor of higher rates of net capital exports and larger trade surpluses as the economy moves upward and to the right. At any point below (or to the right of) the *FF* schedule, the interest rate is too low or the relative price of domestic goods is too high, causing capital outflow and a trade deficit, respectively (and hence an overall deficit in the balance of payments). And at any point above or to the left of the *FF* schedule, the interest rate is too high or the relative price of domestic goods is too low, leading to capital inflow and a surplus in the trade balance, respectively (and hence an overall surplus in the balance of payments).

However, all points on the *FF* schedule (tracing combinations of interest rates and terms of trade) represent balance of payments equilibrium. But for the entire system to be in equilibrium, there must also be balance in the

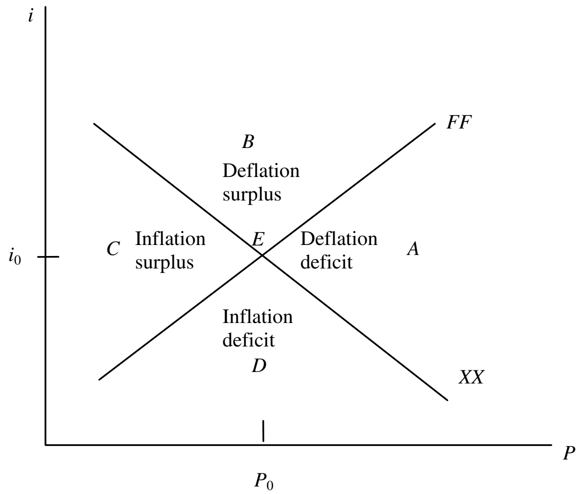


Figure 2.5. Equilibrium in goods and foreign exchange markets and disequilibrium situations.

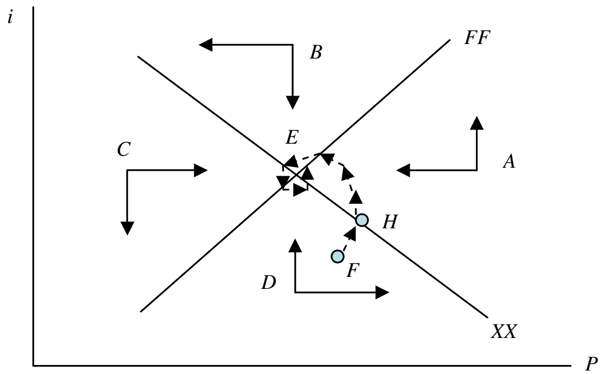
market for goods, which requires equality between the trade balance and the excess of saving over investment. The trade balance is affected primarily by the terms of trade: a rise in the domestic price level or currency appreciation worsens the trade balance, and vice versa. So, higher levels of the terms of trade result in excess supply of goods, and hence deflationary pressure in the economy. As income is higher at high levels of the terms of trade, the level of saving also tends to be higher. Therefore, an increase in the terms of trade is deflationary for two reasons: (i) it reduces the trade balance and (ii) it boosts saving. On the other hand, changes in the interest rate influence primarily the rate of investment spending. At high interest rates, the rate of investment is lower than at low rates, which means that an increase in the interest rate is deflationary. Thus, both an increase in the price level (or currency appreciation) and an increase in interest rate are deflationary. At any point above and to the right of the *XX* schedule, there is deflationary pressure. Conversely, at any point below and to the left of this schedule, there is inflationary pressure in the economy. Only along the *XX* schedule is the goods market in equilibrium.

The entire economic system is in equilibrium only at point E, with an equilibrium interest rate i_0 and equilibrium terms of trade P_0. At point A, which is above the *XX* schedule and below the *FF* schedule, there is deflationary pressure and a deficit in the balance of payments. At point B, which is above both the *XX* and *FF* schedules, there is deflationary pressure and a surplus in the balance of payments. At point C, which is above the FF schedule and below the XX schedule, there is a surplus in the balance of payments and inflationary pressure. At point D, which is below both the FF and XX schedules, there is a deficit in the balance of payments and inflationary pressure.

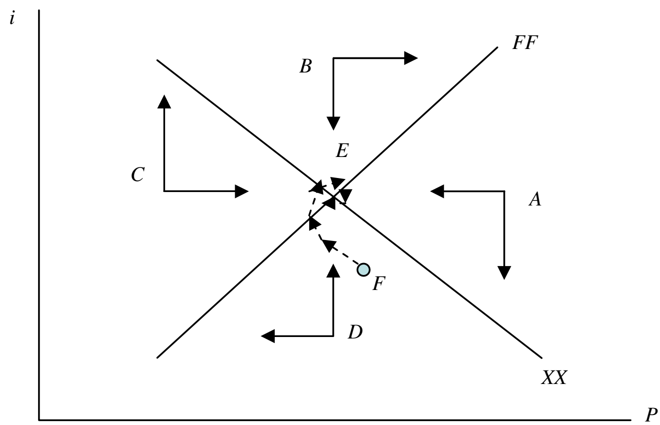
2.4. Dynamic Adjustment Under Fixed and Flexible Exchange Rates

The static equilibrium described by the external and internal balance schedules provides a convenient framework for determining the dynamic responses under fixed and flexible exchange rates. These responses are partly determined by free market reactions and partly by the stabilization policy of the central bank. In the absence of stabilization, there is a tendency for the price level to rise or fall, depending on whether there is excess demand (inflationary pressure) or excess supply (deflationary pressure) in the goods market. There is also a tendency for the exchange rate to rise or fall, depending on whether there is a deficit or surplus in the balance of payments. If the monetary authorities choose to stabilize the exchange rate, they must be willing to buy and sell foreign exchange at a fixed exchange rate. If they stabilize the price level, they must buy and sell goods at a fixed price. To this end, the authorities rely on monetary policy.

Let us first consider the case where the central bank pegs the exchange rate. Interest rate is raised when the balance of payments is in deficit and reduced when it is in surplus. In this case, the price level is free to respond to disequilibrium in the market for goods. Thus the interest rate rises at any point below and to the right of the FF schedule, and falls at any point above and to the left of the FF schedule. Likewise, the price level rises at any point below and to the left of the internal balance schedule and falls at any point above and to the right of this schedule. These dynamic responses are described by the arrows in Figure 2.6(a). Four quadrants (labelled A, B, C, and D) respectively represent four different disequilibrium positions: deflation and deficit, deflation and surplus, inflation and surplus, and inflation and deficit. At these positions, automatic changes in interest rates and prices materialize to ensure equilibrium in the economic system. In quadrant A, for example, the interest rate tends to rise because of the balance of payments deficit, whereas the price level tends to fall because of deflationary pressure. In quadrant B, on the other hand, both the interest rate and price level tend to fall because of the balance of payments surplus and



(a)



(b)

Figure 2.6. Dynamics of adjustment under fixed and flexible exchange rates.

deflationary pressure, respectively. In quadrant C, the price level tends to rise because of inflationary pressure, whereas the interest rate tends to fall because of the balance of payments surplus. And in quadrant D, both the price level and interest rate tend to rise because of inflationary pressure and the deficit in the balance of payments, respectively.

It must be noted that one of the two arrows in each quadrant points to the direction of equilibrium, while the other points to a direction that suggests cyclical movement around equilibrium. This means that there is a stable equilibrium at point E and that it may be approached cyclically. At point F in quadrant D, the price level and interest rate tend to rise because of inflationary pressure and payments deficits, respectively. These changes work in opposite directions on the balance of payments (the capital account improves while the trade balance deteriorates) but in the same direction on the goods market, which reaches equilibrium before the balance of payments. As the interest rate rises, the economy moves from point F to point H on the XX schedule to bring the goods market into equilibrium. Because of the deficit in the balance of payments, the interest rate continues to rise, creating deflationary pressure in the goods market. In quadrant A, the interest rate rises and the price level falls. These changes operate in the same direction on the balance of payments (both the capital and trade accounts improve), but in opposite directions in the goods market. Thus, the foreign exchange market clears before the goods market. The interest rate and price level move into quadrant B, in which they fall. So, the cycle continues in a counter-clockwise direction.

Let us now consider the flexible exchange rate system in which the central bank stabilizes the domestic price level. The central bank tightens credit conditions (by raising interest) when there is inflationary pressure in the goods market and relaxes credit conditions (by reducing the interest rate) when there is deflationary pressure. The exchange rate is free to move to ensure equilibrium in the balance of payments. As shown in Figure 2.6(b), the four quadrants (labeled A, B, C, and D) represent four disequilibrium conditions, whereas the directions of the arrows describe the paths of interest and exchange rates. There is stable equilibrium at point E, which is reached in a cyclical fashion. Consider, for example, point F that represents disequilibrium in the markets for goods and foreign exchange. At this point, the domestic currency tends to depreciate because of the balance of payments deficit, whereas the interest rate tends to rise because of inflationary pressure. Both of these changes work in the same direction on the foreign exchange market (leading to a correction in the balance of payments), but they work in opposite directions on the goods market (leading to inflationary pressure). The balance of payments improves before inflationary pressure is relieved. The cycle may continue, as under fixed exchange rates, but it moves in an opposite direction. Unlike what happens under fixed exchange rates, the movement toward equilibrium is clockwise under flexible exchange rates.

2.5. Dynamic Adjustment and the Role of Capital Mobility

Mundell (1960) shows that a fixed exchange rate system works well if capital is internationally mobile, and vice versa. The slope of the FF schedule (which depends upon the degree of responsiveness of capital flows to the interest rate and the trade balance to the terms of trade) is also affected by the extent of capital mobility. The higher the degree of capital mobility relative to the responsiveness of the trade balance, the lower is the slope of the *FF* schedule. Thus, the *FF* schedule turns flat if capital is perfectly mobile and vertical if capital is completely immobile. The effectiveness of fixed and flexible exchange rates under these two extreme scenarios is illustrated in Figure 2.7.

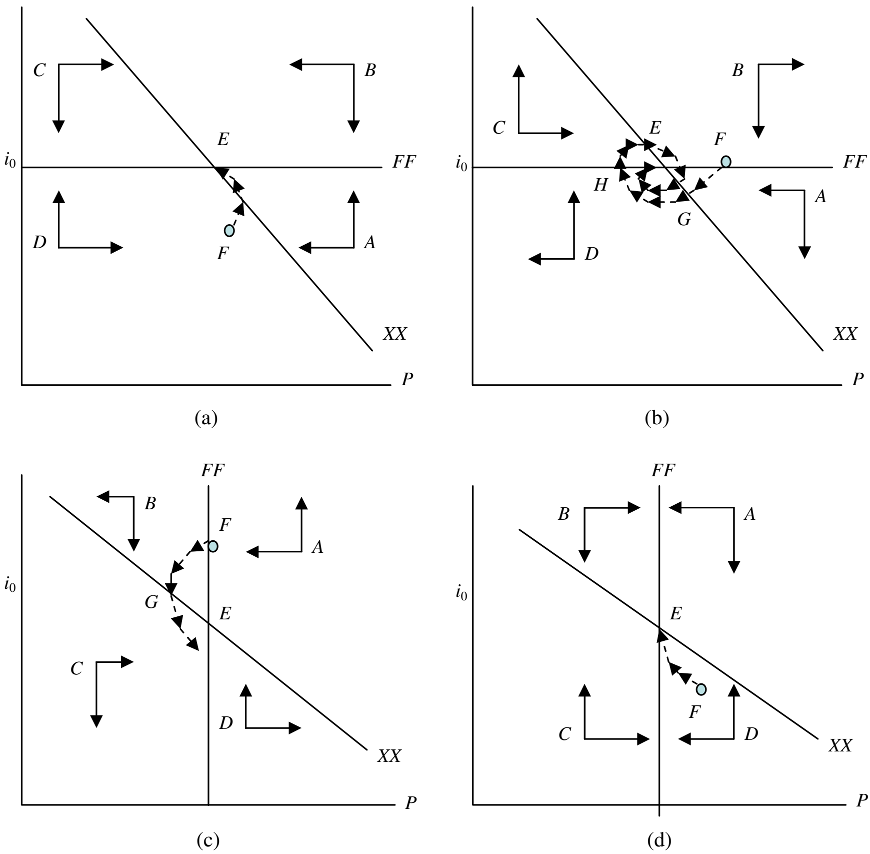


Figure 2.7. Dynamic adjustment and the role of capital mobility. (a) Fixed rates and perfect capital mobility; (b) flexible rates and perfect capital mobility; (c) fixed rates and capital immobility; and (d) flexible rates and capital immobility.

In Figure 2.7(a), it is shown that the path to equilibrium under fixed exchange rates is no longer cyclical. This can be illustrated by considering the path of the interest rate and the price level in either quadrant A or quadrant C. In these quadrants, the two variables move in directions that equilibrate the markets for goods and foreign exchange. Once the economy moves into either of these quadrants, it becomes trapped and moves directly toward equilibrium. But (as shown in Figure 2.6(a)), the economy may move from quadrant D either directly to equilibrium or into quadrant A. Likewise, the economy may move from quadrant B into quadrant C. But if capital is perfectly mobile (as it is in Figure 2.7(a)), the path to equilibrium in quadrants D and A cannot cross the FF line, which means that it is not cyclical under fixed exchange rates when capital is perfectly mobile. This implies that the central bank has little power to affect the domestic interest rate and that any attempt to do so will only result in changes in the rate of capital imports. The actual interest rate remains near its equilibrium level, implying little interaction with the goods market. Disequilibrium in the goods market can therefore be eliminated directly by changes in the price level. While changes in the price level do affect the balance of payments, very small changes in interest rate are sufficient to restore equilibrium. Thus, fixed exchange rates are effective when capital is perfectly mobile because the adjusting variable (interest rate) has a direct effect on the market to which it responds (balance of payments).

Consider now how perfect capital mobility affects the efficacy of the flexible exchange rate system. In Figure 2.7(b), one arrow in each quadrant points to equilibrium whereas the other arrow suggests circular motion around equilibrium. For example, consider quadrants A and C. If the interest rate and exchange rate combination passes into one of these quadrants, it is immediately clear that equilibrium cannot be approached directly. This is in direct contrast with the case of a flexible exchange rate system observed in Figure 2.6(b), where equilibrium is reached directly from these quadrants. Consider, for example, point F where there is equilibrium in the balance of payments and a deflationary gap. To prevent deflationary pressure, the central bank eases credit conditions by reducing the interest rate, which causes capital outflow and hence a deficit in the balance of payments. As a result, the domestic currency depreciates, stimulating effective demand and eventually eliminating the deflationary gap. But the interest rate is slightly below equilibrium at point G, in which case currency depreciation continues, resulting in inflationary pressure in the goods market and the reversal of the interest rate policy by the central bank. The central bank now tightens credit conditions to correct the balance of payments deficit and produce a surplus at point H. Eventually the cycle draws closer to equilibrium. It must be noted, however, that internal stability is not achieved by the direct effect of changes in credit conditions on effective demand. Instead, it is achieved by the indirect effect of changes in the exchange rate.

Let us now consider how alternative exchange rate regimes work under the other extreme of perfectly immobile capital. In Figures 2.7(c) and 2.7(d), the FF schedule is vertical, indicating that a change in the interest rate has no direct effect on the balance of payments. Figure 2.7(c) shows that, under fixed exchange rates, capital immobility may lead to cyclical adjustment to equilibrium. For example, the foreign exchange market is in equilibrium at point F, but there is deflationary pressure in the market for goods. As the price level falls, the trade balance improves, inducing the central bank to reduce the interest rate. The fall in the price level and interest rate helps relieve deflationary pressure. But a balance of payments surplus emerges at point G, so that the interest rate continues to fall, resulting in inflationary pressure. The increase in the price level corrects the balance of payments surplus and leads to the emergence of an inflationary gap. The fall in the interest rate, however, has no effect on the balance of payments and it works to aggravate inflationary pressure in the goods market. The balance of payments is equilibrated first and then (because of the continued rise in the price level) a balance of payments deficit arises. The cycle may, therefore, continue in a spiral motion around equilibrium.

However, a cycle is not inevitable. As it is evident from Figure 2.7(c), the existence of a cycle depends on the speed at which the central bank alters the interest rate relative to the speed at which the price level moves. The more slowly the central bank adjusts the interest rate in response to a surplus or deficit, the less likely it is that equilibrium will be reached cyclically. Thus, fixed exchange rates cannot work well when capital is perfectly immobile because, in the presence of cycles, the interest rate affects the balance of payments only through interaction with the goods market and the price level.

Figure 2.7(d) shows how flexible exchange rates work when capital is perfectly immobile. In quadrants B and D, both arrows point directly to equilibrium, which means that the approach to equilibrium is direct (asymptotic). At point F, inflationary pressure in the market for goods induces the central bank to tighten credit conditions, while a deficit in the balance of payments causes currency depreciation. As a balance of payments equilibrium is achieved, the movement in the exchange rate slows so that the inflationary gap is eliminated by a direct upward movement of the interest rate. No cycles develop because the rise in the interest rate is unlikely to affect the balance of payments. Thus flexible exchange rates work effectively when capital is immobile because it does not lead to cycles in the system, which means that the interest rate affects the balance of payments directly without any interaction with the goods market and the price level.

2.6. The Appropriate Use of Monetary and Fiscal Policies

Mundell (1962) presents an extension of his work on what he calls the "principle of effective market classification," postulating that a system works best if policies are assigned to the markets on which they exert the most direct influence (or if monetary and fiscal policies are paired with the objectives on which they have the most influence). Specifically, he argues that monetary policy and fiscal policy ought to be aimed at the external balance and internal balance, respectively. Failure to follow this prescription, he argues, could worsen internal and external imbalances.

Mundell (1962) applies a dynamic approach to the joint use of monetary and fiscal policies to attain internal and external stability under fixed exchange rates. He points out that the policy dilemma arising under fixed exchange rates (with respect to attaining internal and external stability together) can be resolved if capital flows are responsive to the interest rate differential. He demonstrates that by gearing monetary policy to the external balance and fiscal policy to the internal balance, governments can avoid having to trade off internal against external goals in the short run.[8] The key to his argument lies in the claim that either monetary or fiscal expansion can raise output, but that they have opposite effects on interest rates. Thus a country that is simultaneously experiencing a deflationary gap and a balance of payments deficit could couple a fiscal expansion with a monetary contraction in such a way as to boost aggregate demand while attracting sufficiently large capital inflow to close the foreign payments gap. Without capital mobility, however, such a policy prescription is unlikely to succeed. Mundell (1962) goes on to argue that, when capital is mobile and the exchange rate is pegged, a stable policy mix requires assigning fiscal policy to the internal balance and monetary policy to the external balance.

This assignment problem is demonstrated with the aid of internal balance (*IB*) and external balance (*EB*) schedules, as shown in Figure 2.8. The *IB* schedule represents combinations of interest rates (monetary policy) and net government spending (*G*-*T*) along which there is continuing

[8]The external balance is defined as zero official settlement balance, whereas the internal balance is defined as full employment with price stability.

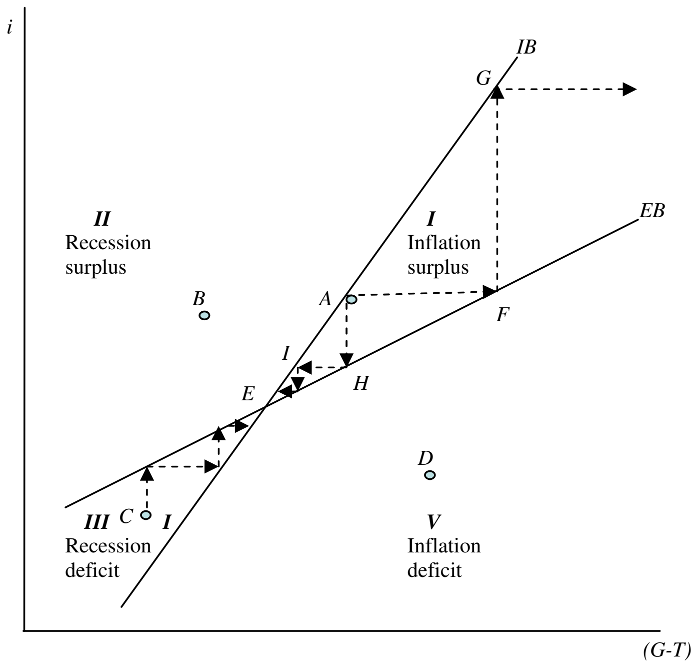


Figure 2.8. Appropriate use of monetary and fiscal policies under fixed and flexible exchange rates.

full-employment equilibrium in the market for goods. Along this schedule, full employment output is equal to the aggregate demand for output or (what amounts to the same condition) domestic demand for domestic goods is equal to full-employment output less exports. The *IB* schedule has positive slope because higher interest rates are associated with larger budget deficits to maintain the level of domestic expenditure. At any point on the *IB* schedule, therefore, an increase in the interest rate causes a decline in real investment and output, which has to be compensated for by an increase in government expenditure to restore equilibrium in the goods market at full-employment output. The *EB* schedule represents all combinations of interest rate and net government spending that are compatible with equilibrium in the balance of payments for a given exchange rate. The *EB* schedule has a positive slope because an increase in the interest rate (by attracting capital inflows and lowering domestic expenditure and hence imports) leads to balance of payments improvement, whereas an increase in the budget deficit (by raising domestic expenditure and hence imports) leads to deterioration in the balance of payments. Starting from any point on the *EB* schedule, an increase in the interest rate produces an external surplus, which has to be compensated for by an increase in government expenditure to restore equilibrium in the balance of payments.

Monetary policy is captured by variation in interest rate (measured on the vertical axis), whereas fiscal policy is represented by variation in net government spending (measured on the horizontal axis). There is an inverse relation between the two policy instruments, as it is shown by the upward-sloping *IB* and *EB* schedules. This is because a higher level of interest rates reflects, *ceteris paribus*, a lower level of the money supply (tight monetary policy) but a higher level of government expenditure (expansionary fiscal policy). Although both schedules slope upward, the *EB* schedule is flatter than the *IB* schedule because changes in the money supply (and hence the interest rate) are assumed to have a greater relative effect on the external balance than on the internal balance. Changes in the interest rate are generally considered to affect the balance of payments through both the capital and current accounts. A rise in the interest rate causes not only an increase in net short-term capital inflows, but also lower domestic real investment and income, which acts to reduce imports. Changes in the interest rate thus exert direct and indirect effects on the balance of payments, whereas they affect the internal balance only through the direct effect on real investment.

As it is evident from Figure 2.8, only one combination of monetary and fiscal policies allows the simultaneous attainment of both internal and external stability. Any other combination leads to one or both of the targets not being met. Points above or to the left of the *IB* schedule represent combinations of the two instruments that produce such high interest rates (given the level of government expenditure or fiscal policy stance) that they would lead to low investment, low income, and unemployment. Similarly, all points below or to the right of the *IB* schedule represent real investment levels that are so high that they contribute to inflation. On the other hand, points above or to the left of the *EB* schedule reflect interest rates that are higher than what is required for balance of payments equilibrium at the given exchange rate, hence a balance of payments surplus would be generated due to capital inflow. Points below or to the right of the *EB* schedule represent a balance of payments deficit because interest rates rate are too low, resulting in capital outflow. Thus Figure 2.8 can be divided into four quadrants: I, II, III, and IV, representing four different situations of disequilibrium: (i) inflation and surplus, (ii) recession and surplus, (iii) recession and deficit, and (iv) inflation and deficit.

It can be demonstrated that the simultaneous attainment of internal and external stability (as represented by point E in Figure 2.8) can take place only by a careful choice of the two policy instruments. Consider, for example, a situation of full employment combined with a balance of payments surplus as represented by point A. To correct the surplus in the balance of payments by fiscal policy, the budget deficit must rise from the level at point A to that at point F. At point F, there is equilibrium in the balance of payments, but the wider budget deficit causes inflationary pressure. If the threatening inflationary pressure is to be prevented via monetary policy, the interest rate must be raised from the level indicated by point F to that indicated by point G. But at point G, there is again a balance of payments surplus, which in turn requires further widening of the budget deficit. This process continues with the interest rate and the budget deficit moving even further from equilibrium. Thus, the system becomes unstable if fiscal policy is directed toward the *EB* target while monetary policy is directed toward the *IB* target. On the other hand, assigning monetary policy to the *EB* target and fiscal policy to the *IB* target leads to a sequence of policy steps (as indicated in Figure 2.8 by solid arrows from point A to H to I) driving the economy closer to point E that represents stable equilibrium with full employment and balanced payments. A similar conclusion can be reached for points B, C, and D.

2.7. Stabilization Policies Under Fixed and Flexible Exchange Rates

Mundell (1961c) challenges Keynes's orthodox mercantilist policy lessons (that policies promoting investment and exports and inhibiting saving and imports boost employment and output) by arguing that these policies are inapplicable to countries whose central banks do not peg their currencies.[9] He presents a model based on the work of Laursen and Metzler (1950) to examine the relative effects of fiscal, monetary, and commercial policies on employment under flexible exchange rates and compares these effects with those observed under fixed exchange rates. Three important conclusions

[9]Mundell (1961c) demonstrates that mercantilist policies involving tariffs, trade controls, and export subsidies are less effective under flexible exchange rates and are likely even to worsen unemployment and output as the multiplier effect of a change in the trade balance is dissipated by changes in the exchange rate, leaving a terms-of-trade effect with deflationary consequences.

emerge from Mundell's study. First, fiscal policy is more effective under flexible than under fixed exchange rates because leakages through foreign trade are closed by changes in exchange rates (an increase in spending leads to an expansion in income, whereas a deficit in the balance of payments produces further income expansion through currency depreciation). Second, monetary policy is more effective under flexible than under fixed exchange rates because the multiplier effect of increased investment is greater, and also because the reduction in capital imports induces further currency depreciation and income expansion. Third, commercial policy is less effective under flexible than under fixed exchange rates (it could even worsen employment and output under fixed rates). The policy implication that follows from these conclusions is that countries with flexible exchange rates should rely on monetary policy and fiscal policy to correct large-scale unemployment.

To demonstrate these results, Mundell (1961c) begins with an open economy that reaches equilibrium when two conditions are met: (i) the demand for goods and services must be equal to the supply of goods and services and (ii) the balance of payments must be in equilibrium. The first condition is satisfied when output is equal to the sum of domestic expenditure and the trade balance, whereas the second condition is satisfied when the trade deficit is equal to net capital imports. It is assumed that capital imports and exports are determined by domestic and foreign interest rates, whereas the interest rate is determined by monetary policy. On the other hand, imports depend on domestic income whereas exports depend on the exchange rate. It is further assumed that foreign incomes are given during the period under consideration and that domestic output is perfectly elastic up to the point of full employment. The system is then reduced to two equilibrium conditions in two variables: the level of output (correlated with the level of employment) and the exchange rate.

To compare the effectiveness of alternative policies in an open economy with dynamic stability under fixed and flexible exchange rates, Mundell (1961c) uses the internal balance (XX) and the external balance (FF) schedules, both of which are positively sloped. The XX and FF schedules respectively trace (for a given level of interest rate) the loci of exchange rates and real incomes along which the demand for goods is equal to the supply of goods and the balance of payments is in equilibrium. The positive slope of the XX schedule indicates that an increase in output creates an excess supply of goods, while an increase in the exchange rate creates excess demand for goods. Consequently, an increase in output must be associated with an increase in the exchange rate for excess demand to remain zero.

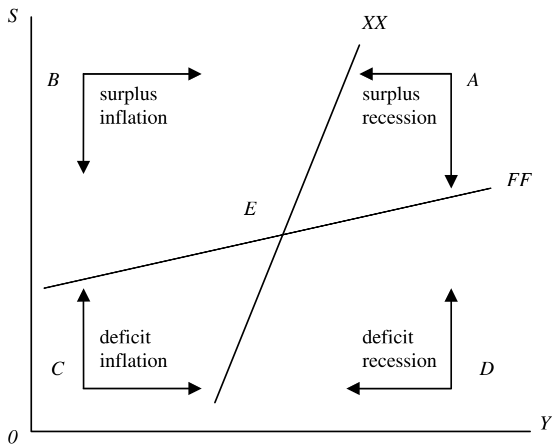


Figure 2.9. The stable case.

Likewise, the positive slope of the *FF* schedule indicates that an increase in the exchange rate (domestic currency depreciation) leads to improvement in the balance of payments, whereas an increase in income leads to its deterioration. An increase in the exchange rate must be accompanied by an increase in output if the balance of payments is to remain constant.

However, this information is not sufficient to determine the effect on income and the exchange rate of fiscal and monetary policies under different exchange rate regimes, as it is necessary to know which of the two schedules is steeper. For the dynamic stability of fixed and flexible exchange rate regimes, the slope of the *XX* schedule must exceed that of the *FF* schedule, as shown in Figure 2.9. On the other hand, the stability condition is not met in Figure 2.10 because the slope of the *XX* schedule is less than that of the *FF* schedule. In both diagrams, internal and external balance are reached at point E. In Figure 2.9, the four quadrants A, B, C, and D represent four sets of different economic conditions: (i) surplus and recession, (ii) surplus and inflation, (iii) deficit and inflation, and (iv) deficit and recession. Figure 2.10 shows that a rise in government expenditure or the money supply (causing an increase in aggregate demand by shifting the *XX* schedule to the right) is unlikely to lead to stable equilibrium with a higher level of income under fixed or flexible exchange rates when the slope of the *XX* curve is less than the slope of the *FF* curve.

Consider the effect of fiscal policy on output and employment under fixed and flexible exchange rates. Suppose that the economy is initially

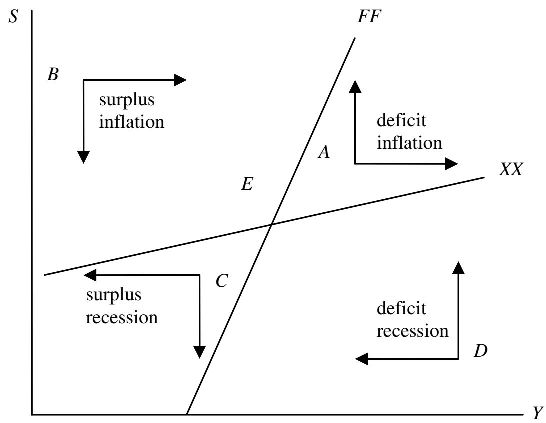


Figure 2.10. The unstable case.

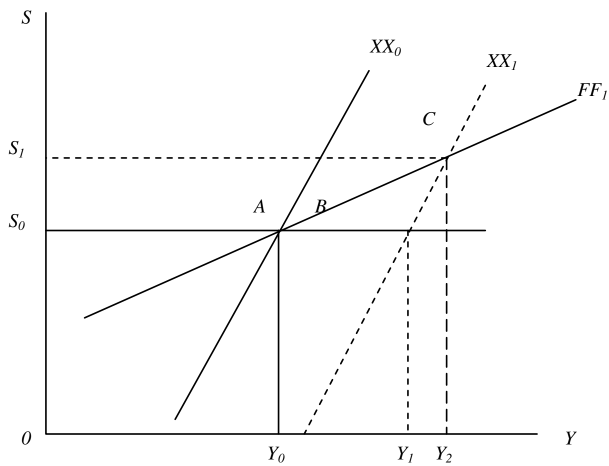


Figure 2.11. The effect of fiscal policy under flexible exchange rates.

in equilibrium at point A in Figure 2.11, with real income at Y_0 and the exchange rate at S_0.[10] An increase in government spending or a reduction in taxes creates excess demand for goods and services. To restore equilibrium, this excess demand has to be eliminated by a rise in output or domestic

[10]The economy is in equilibrium internally because the excess demand for domestic goods and services is zero at point A, and the balance of payments is in equilibrium too. Thus excess demand for goods and foreign exchange is zero at point A.

currency appreciation. Consequently, the XX schedule shifts from XX_0 to XX_1, eventually moving the economy from A to C. If the exchange rate remains fixed at S_0, the economy will settle at B with equilibrium in the goods market and a balance of payments deficit. Under flexible exchange rates, the deficit at B will be eliminated by depreciation of the domestic currency, which in turn creates excess demand in the goods market, inducing successive rounds of income increases and exchange rate changes until the economy settles down at C. At this point, equilibrium is re-established in the markets for goods and foreign exchange at higher levels of income (Y_2) and exchange rate (S_1). The increase in income from Y_0 to Y_2 under flexible exchange rates must be greater than what is caused by the foreign trade multiplier (AB or Y_0Y_1) to eliminate excess demand in the market for goods at the fixed exchange rate (S_0). Therefore, fiscal policy is more effective in changing output and employment under a system of flexible exchange rates than under a system of fixed exchange rates.

The effect of monetary policy on output and employment is illustrated in Figure 2.12. Suppose that the economy is initially in equilibrium at point A, with no excess demand or supply in the markets for goods and foreign exchange. Consider what happens to equilibrium in the goods market and the balance of payments when there is a rise in the money supply. At the outset, an increase in the money supply leads to a fall in the interest rate via the liquidity effect, which in turn stimulates investment and creates excess

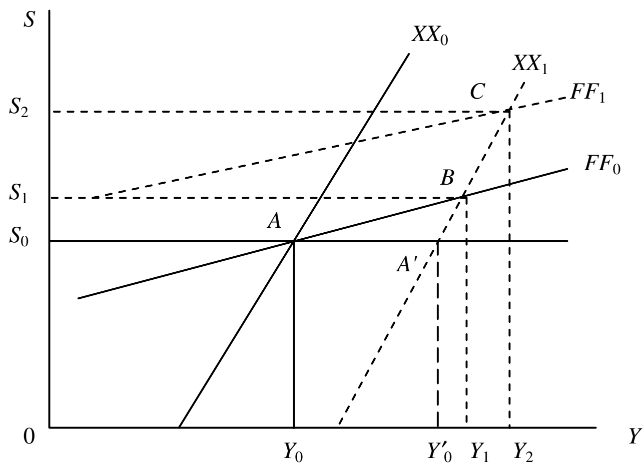


Figure 2.12. The effect of monetary policy under flexible exchange rates.

demand for domestic goods. As a result, the XX schedule shifts from XX_0 to XX_1, moving the equilibrium position from A to B with a higher level of income (Y_1) and a higher exchange rate (S_1). A fall in the interest rate also leads to capital outflow (increases in capital exports) or a reduction in capital imports and hence deterioration in the capital account, whereas a rise in income leads to deterioration in the current account via a rise in imports. Therefore, an overall deficit in the balance of payments would arise at point B, which in turn causes a shift in the FF schedule from FF_0 to FF_1, eventually moving the economy from B to C. Consequently, there is a further rise in the exchange rate from S_1 to S_2 and in real income from Y_1 to Y_2. If the exchange rate is kept constant at S_0 by the monetary authorities, the FF schedule will become horizontal at S_0, and the economy will reach equilibrium at A' at a lower level of income (Y_0').

Monetary policy is more effective under flexible exchange rates than under fixed exchange rates because it raises output from Y_0 to Y_2 in the first case and from Y_0 to Y_0' in the second case. Moreover, monetary policy is more effective than fiscal policy under flexible exchange rates for two reasons. First, a rise in investment (stimulated by a fall in the interest rate) has a greater multiplier effect on employment than in the case of fiscal policy, because leakage through the foreign trade multiplier is eliminated. Second, higher capital exports (or lower capital imports) lead to currency depreciation, producing a larger trade surplus (or smaller deficit). However, the size of the final gain in employment depends on the responsiveness of investment to the interest rate, the import content of investment spending, and the responsiveness of capital movement to the interest rate.

2.8. The Standard Mundell–Fleming Model

Mundell (1963a) and Fleming (1962) are the two main celebrated contributions that have led to the standard Mundell–Fleming model of exchange rate determination. The model is also used to analyze the efficacy of monetary and fiscal policies under fixed and flexible exchange rates in a world with perfect capital mobility. Mundell (1961c) was the first economist to extend the simple Keynesian macroeconomic model by adjusting it for foreign trade, capital mobility, and the possibility of exchange rate changes. However, Mundell (1961c) did not take the speed of capital market adjustment to the extreme to explore the impact of perfect capital mobility on policy effectiveness under fixed and flexible rates. In one of his most seminal contributions, Mundell (1963a) demonstrated that, in the extreme case of perfect capital mobility, only fiscal policy affects output under fixed exchange rates, whereas monetary policy only serves to alter the level of international reserves. In contrast, monetary policy is most effective under flexible exchange rates, whereas the power of fiscal policy is weakened dramatically in this case.[11]

The Mundell–Fleming model (or what is also known as the flow model) is designed particularly for a small open economy that cannot affect real incomes, interest rates and prices in the rest of the world, and in which resources are unemployed and money wage rates are fixed.[12] The latter two assumptions of the flow model imply that while aggregate supply plays a passive role in fixing the domestic price level, aggregate demand plays an active role in determining the level of income and employment.

2.8.1. *Fundamental Propositions of the Mundell–Fleming Model*

Like Keynes's macroeconomic model, the Mundell–Fleming model is based on the macroeconomic foundations of all markets for goods, labor, capital, and foreign exchange. While all these markets are regarded as perfectly competitive, it is assumed that the labor market does not clear quickly. In particular, the Mundell–Fleming model assumes that money wages and prices are rigid. This model is based on several propositions, which are outlined in what follows.

Proposition 1

In a small open economy with fixed money wages, prices and unemployed resources, output, and employment are determined in the goods market by

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[11]One implication of this work, as Obstfeld (2001, p. 6) argues, is that the balance of payments might be a misleading indicator of external balance in a world where central banks could in principle borrow reserves from world capital markets.

[12]Boughton (2003) argues that Dornbusch (1976a,c) was the first to codify these contributions into what he called the Mundell–Fleming model. Ever since, this version of the model has been so dominant in the literature that it has blurred the separate contributions of the two scholars, and the reverse sequencing of their names has seldom been questioned. Although the Dornbuschian reversal into the "Mundell–Fleming model" is now firmly entrenched, the more natural alphabetical ordering (the Fleming–Mundell model) has been used, among others, by Kenen (1985, 1994), Turnovsky and Kingston (1977), and Rodriguez (1979). Boughton also argues that what has become known as the Mundell–Fleming model is essentially Fleming's equations combined with Mundell's policy analysis (Boughton, 2003, p. 3).

aggregate demand. The aggregate supply curve is therefore perfectly elastic and turns horizontal at a fixed price level, implying that the whole burden of adjustment falls on aggregate demand rather than on prices or money wages. Unlike the monetary model, this model emphasizes the demand side, rather than the supply side, of the economy.

Proposition 2

Both fixed and flexible exchange rate regimes are assumed to be stable systems, having an automatic tendency to move toward equilibrium with full employment and balance of payments equilibrium. The underlying stability in these regimes can be obtained via both Hume's price-specie-flow mechanism and Keynes's income-specie-flow mechanism.

Proposition 3

Saving, private expenditure on consumption, and taxes vary directly with real income, whereas private expenditure on investment varies inversely with interest rate. This implies that a fall in investment reduces aggregate demand and, as a consequence, output and employment. This effect is magnified by the multiplier.

Proposition 4

The demand for money varies directly with real income and inversely with interest rate. The money market clears when the demand for real money balances is in line with the supply of real money balances.

Proposition 5

Monetary policy has no impact on output and employment under fixed exchange rates, whereas fiscal policy has no impact on output and employment under flexible exchange rates. This also implies that, under fixed exchange rates, monetary policy is a device for altering the level of reserves, whereas fiscal policy is a device for altering the trade balance under flexible exchange rates (policies do not affect the level of output and employment). On the contrary, fiscal policy has a strong effect on output and employment under fixed exchange rates, whereas monetary policy has a strong effect on output and employment under flexible exchange rates.

Proposition 6

PPP does not hold at all, even in the long run, which implies that the trade balance does not depend on the real exchange rate alone. Instead, it depends positively on the real or nominal exchange rate and negatively on real income. Moreover, the trade balance is determined independently of the capital account. However, a deficit (surplus) in the former is financed by a surplus (deficit) in the latter.

Proposition 7

The capital account represents the net capital flows originating from the export and import of capital induced mainly by the difference between domestic and foreign interest rates, which in turn are determined by monetary policy. This implies that if capital is perfectly mobile, then even the smallest deviation of the domestic interest rate from the foreign rate may provoke infinite capital flows into and out of the home country. In the Mundell–Fleming model, however, perfect mobility is considered as a special case.

Proposition 8

There is no role for expectations in the determination of prices and exchange rates. Exchange rate expectations are assumed to be static.

Proposition 9

The equilibrium exchange rate is determined by trade and capital flows equilibria in the foreign exchange market, rather than stock equilibria in the capital market. As in the monetary model, monetary policy plays an important role in affecting the path of the equilibrium exchange rate. In particular, it is assumed that a monetary expansion leads to domestic currency depreciation, but the model does not assign any explicit role in exchange rate determination to stock equilibria in capital markets.

2.8.2. *The Structure of the Mundell–Fleming Model*

Based on the above propositions, the standard Mundell–Fleming model for a small open economy, with fixed import prices and foreign interest rates, can be represented by following equations:

$$Y = C(Y) + I(i) + G + T(Y, S) \tag{2.4}$$

$$L(Y, i) = D + R \tag{2.5}$$

$$\dot{R} = T(Y, S) + K(i - i^{*} - \dot{S}^{e}/S) \tag{2.6}$$

where Y is the real income, C is the real consumption spending by households (which depends on real income), I is the real investment spending by firms (which depends on the interest rate), G is the real government spending, T is the trade balance (which depends on real income and the exchange rate) $R(\dot{R})$ is the official stock of foreign exchange reserves (changes in the official stock of foreign exchange reserves), D is the stock of government bonds, and K is the capital account.

Equation (2.4) represents the *IS* schedule, which traces all combinations of interest rate and real income along which the goods market is in equilibrium. Equation (2.5) is the *LM* schedule, which represents the condition for equilibrium in the money market, equating the demand for money (depending on real income and interest rate) with the quantity of government bonds and the official stock of foreign exchange reserves held by the central bank. Equation (2.6) is the balance of payments (*BP*) schedule, stipulating that changes in the official holdings of foreign exchange reserves must be equal to the excess of trade and capital flows moving into and out of the economy in each market period. It is assumed that export inflows are determined by the exchange rate, that import outflows are determined by real income, and that net capital inflows are determined by the interest differential.

The Mundell–Fleming model, as represented by equations (2.4)–(2.6), can be used to derive the reduced form equation of the equilibrium exchange rate and to investigate the impact of monetary and fiscal policies on the endogenous variables (Y, i, and S under flexible exchange rates and Y, i, and R under fixed exchange rates). To investigate the relative impact of monetary and fiscal policies under alternative exchange rate regimes, a comparative static analysis will be conducted to determine the sign of monetary and fiscal policy multipliers ($\mathrm{d}Y/\mathrm{d}D$ and $\mathrm{d}Y/\mathrm{d}G$). It is customary to limit such analysis to "small" changes in the exogenous variables and consequent "small" changes in the endogenous variables (all the underlying functions in the model are assumed to be approximately linear). To obtain a linear system, we take the total differential of the structural equations (2.4)–(2.6), arranging the resulting full linear equation system in a matrix form such that the endogenous variables appear on the left-hand side while the exogenous variables appear on the right-hand side. Thus we end up with

$$\begin{bmatrix} A & -I_i & 0 \\ L_Y & L_i & 0 \\ T_Y & K_i & -1 \end{bmatrix} \begin{bmatrix} \mathrm{d}Y \\ \mathrm{d}i \\ \mathrm{d}\dot{R} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & T_S & 0 \\ 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & -T_S & K_i \end{bmatrix} \begin{bmatrix} \mathrm{d}G \\ \mathrm{d}D \\ \mathrm{d}R \\ \mathrm{d}S \\ \mathrm{d}i^* \end{bmatrix} \tag{2.7}$$

where $A = 1 - C_Y - T_Y > 0$.

2.9. The Reduced Form Equation of the Equilibrium Exchange Rate

Since Cassel made purchasing power parity an operational theory of foreign exchange in 1916, surprisingly few systematic attempts have been made to model the behavior of exchange rates in a general macroeconomic equilibrium framework. This theoretical vacuum persisted until the early 1960s when Mundell (1961c, 1963a) and Fleming (1962) filled it by developing (independently) the flow model of exchange rates. The model, which presumes a total absence of purchasing power parity, postulates that the exchange rate moves to equilibrate the international demand for flows of foreign exchange originating from current account and capital account transactions. Although the markets for goods, labor, capital, and foreign exchange must clear before an open economy reaches equilibrium, the Mundell–Fleming model postulates that it is the international demand for trade and capital flows alone (and not the international demand for and supply of money) that plays a key role in exchange rate determination.

As in the monetary model, a monetary expansion in the flow model results in currency depreciation, but there is no explicit role for stock equilibria in the money market to affect the exchange rate. Perhaps the flow model posits that a monetary expansion affects the exchange rate only indirectly by the extent to which it affects the demand for and supply of foreign exchange flows originating from trade and capital account transactions (via its effect on interest rates and real income).

The reduced form equation of the equilibrium exchange rate that follows from the flow model postulates that the exchange rate is determined by macroeconomic factors such as relative prices, incomes, and interest rates.

The equilibrium exchange rate is positively related to relative prices and relative incomes, but inversely related to relative interest rates. Typically, the Mundell–Fleming model can be derived from equation (2.6).[13] To this end, the balance of payments equation (2.6) can be re-specified by using a two- country, -commodity, and -asset assumption. Consequently, the current account balance in equation (2.6) (exports less imports of goods and services) varies directly with the real exchange rate (defined as the nominal exchange rate adjusted by relative prices, (SP^*/P) and inversely with relative real incomes (Y/Y^*). On the other hand, the balance of payments on the capital account varies directly with the interest rate differential $(i - i^*)$, with exchange rate expectations assumed to be static (that is, $\dot{S}^e = 0$).

2.9.1. *The Current Account*

The current account is determined independently of the capital account. Therefore, adjustment in the domestic economy is required to maintain equilibrium in the balance of payments. The model postulates that purchasing power parity does not hold at all (even in the long run) and therefore the current account is determined not only by relative prices, but also by relative incomes across countries. An increase in domestic prices relative to foreign prices is predicted to have a negative effect on the current account, leading (all else being constant) to domestic currency depreciation. Goods prices are assumed to move sluggishly, allowing exchange rate changes originating from other sources to alter the relative prices of domestic and foreign goods. An increase in domestic real income is thought (all else being equal) to cause domestic currency depreciation. This is because an increase in income leads to an increase in imports and current account deterioration, with no offsetting effect on capital flows.

Consequently, the current account (CA), which is represented by the first component of equation (2.6), can be rewritten in a logarithmic form as

$$ca = a_1(s - p + p^*) - a_2(y - y^*) \tag{2.8}$$

which tells us that the current account is determined by the logarithmic values of the real exchange rate and relative incomes (logs are represented by lower case letters) and a_1 and a_2 are the price and income elasticities of trade inflows.

[13] See Bhatti (2001).

2.9.2. *The Capital Account*

The Mundell–Fleming flow model also assumes that foreign and domestic assets are not perfect substitutes, which means that interest differentials may induce finite capital flows into or out of a country. More precisely, it is argued that (given risk aversion) investors require a risk premium to move their capital funds from one financial center to another. In the special case of perfect capital mobility, even the smallest deviation of the domestic interest rate from the foreign interest rate is predicted to induce infinite flows into or out of the domestic economy. Thus, the capital account balance or net capital inflow (*KA*), which is represented by the second component in equation (2.6), can be rewritten in logarithmic form as

$$ka = b(i - i^*). \tag{2.9}$$

Balance of payments equilibrium requires that the flow of capital across exchanges is just sufficient to finance the current account deficit or absorb the surplus. This means that the sum of the capital and current accounts must be zero, implying that a surplus on one account must be balanced by a deficit on the other. If we add equations (2.8) and (2.9), a pure float requires the following condition to hold at all times:

$$a_1(s - p + p^*) - a_2(y - y^*) + b(i - i^*) = 0. \tag{2.10}$$

Rearranging equation (2.10) and solving for s, we obtain

$$s = (p - p^*) + \frac{a_2}{a_1}(y - y^*) - \frac{b}{a_1}(i - i^*). \tag{2.11}$$

Note that equation (2.11) reduces to PPP if the price elasticity of domestic exports is infinite (that is, as $a_1 \to \infty$) in which case the exchange rate will be determined exclusively by PPP. The Mundell–Fleming model of exchange rates will be empirically valid if the coefficients on relative prices and relative income are significantly positive, while that on the interest rate differential is significantly negative. In contrast, acceptance of the hypotheses that the coefficient on relative prices is unity and that the coefficients on relative income and interest rates are zero amounts to accepting the property of exclusiveness in PPP. As it is evident from equation (2.11), the exchange rate is directly and positively related to relative prices and real incomes, while it is inversely related to the interest rate differential.

The Mundell–Fleming flow model of exchange rate determination can be illustrated using the *IS-LM-BP*, *TT*, *FF*, and *AD-AS* schedules as shown in

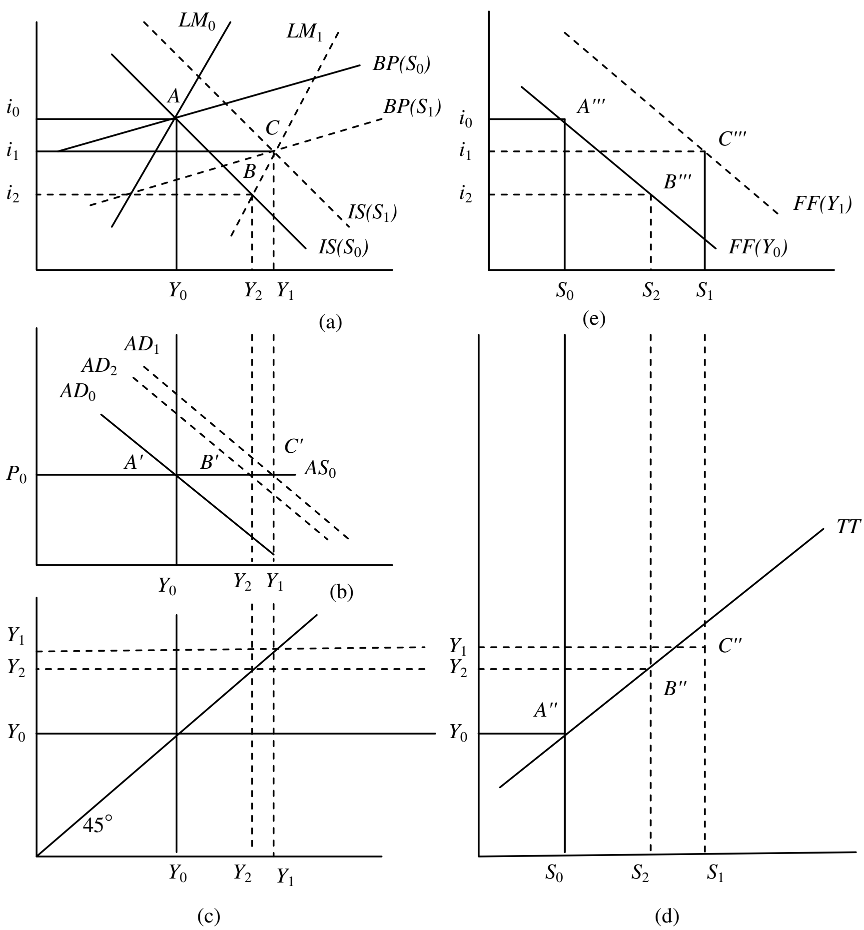

Figure 2.13. Equilibrium in the open economy and exchange rate determination.

Figure 2.13. In Figure 2.13(a), the *IS* curve represents the relation underlying equation (2.4) in the (Y, i) space. For a given exchange rate, this curve traces combinations of real income and interest rate that are consistent with equilibrium in the market for goods. The *IS* curve shifts to the right via a rise in exports (as the exchange rate rises) and vice versa. The *LM* curve represents all combinations of real income and interest rate that are compatible with equilibrium in the money market. The *BP* curve represents all combinations of real income and interest rate that are compatible with

balance of payments equilibrium. It must be noted that the *BP* curve is derived for a given exchange rate, which means that it shifts to the right as a result of a rise in the exchange rate induced by a deficit in the balance of payments. The *BP* curve is upward sloping because as income rises at any given exchange rate, the current account deteriorates as import demand rises. To maintain equilibrium in the balance of payments, the capital account must improve, which in turn requires net capital inflows via a rise in the interest rate. It follows that higher income must be associated with higher interest rates for equilibrium in the balance of payments. The extent of an increase in the interest rate that is required to offset a small rise in income depends on the interest elasticity of net capital flows. The greater this elasticity, the flatter the *BP* curve. In the extreme case of perfect capital mobility (when even the slightest increase in the interest rate is sufficient to stimulate infinite capital inflow), the *BP* curve becomes flat.

Figures 2.13(d) and 2.13(e) keep track of the current and the capital account components of the balance of payments, respectively. The *TT* schedule represents the current account component of the balance of payments as represented by equation (2.6). It traces combinations of real income and exchange rate that are compatible with a balanced current account. It must be noted that, even under a pure float, the economy does not have to settle on the *TT* schedule because the current account is not required to balance, neither in the short run nor in the long run. The model only requires that any current account deficit (surplus) be offset by a capital account surplus (deficit) of the same size. The *FF* schedule represents the capital account component of the balance of payments. It slopes downward for a given level of income, implying that it shifts to the right as income rises, as equilibrium requires a rise in the exchange rate to compensate for additional import demand. The *FF* schedule is flat if capital is perfectly mobile, and hence there is no horizontal shift when income rises.

In Figure 2.13(b), the *AD* and *AS* schedules are derived from the *IS*, *LM*, and *BP* schedules. The *AD* curve has a negative slope, and it is plotted for a given level of the nominal money supply. This implies that if the nominal money supply increases, the *AD* curve shifts to the right. The *AS* curve is flat in the Mundell–Fleming model, implying that the burden of adjustment falls on the level of economic activity (or real income), rather than on prices. Figure 2.13(c) simply tracks the level of income (via the 45-degree line), from the horizontal axis to the vertical axis and then over the *TT* schedule in Figure 2.13(d).

Initially, an open economy is in equilibrium at points A, A', A'', and A''' with interest rate i_0, real income Y_0, price level P_0, and exchange rate S_0.

Let us consider the effect of expansionary monetary policy on the underlying variables in the open economy, including the exchange rate. As the price level is fixed by the flat aggregate supply curve (AS_0), an increase in the nominal money supply is equivalent to a pro rata rise in the real money supply. As a result, the *LM* schedule in Figure 2.13(a) shifts permanently to the right from LM_0 to LM_1. The economy moves from *A* to *B* in Figure 2.13(a) with a fall in the interest rate from i_0 to i_1. In Figure 2.13(b), the aggregate demand curve shifts to the right from AD_0 to AD_2 as a result of the increase in the nominal money supply as reflected by the shifting of the *LM* curve from LM_0 to LM_1. As prices are assumed to be fixed in the short run (as represented by the flat *AS* curve, AS_0), the price level (P_0) remains unchanged when equilibrium moves from A' to B'. Thus, the burden of adjustment falls on real income, which rises from Y_0 to Y_2 as a result of an increase in investment spending by firms due to the fall in the interest rate from i_0 to i_2.

Moreover, the fall in the interest rate leads to capital outflow and hence deterioration in the capital account, while a rise in income causes deterioration in the current account via a rise in imports. At point *B*, which lies below and to the right of the *BP* curve, there is an overall deficit in the balance of payments, which in turn causes a rise in the exchange rate. Thus (as predicted by the Mundell–Fleming model), the exchange rate must rise from S_0 to S_2 when real income rises from Y_0 to Y_2 and the interest rate falls from i_0 to i_2. Thus the economy moves from A'' to B'' and from A''' to B''' in Figures 2.13(d) and 2.13(e), respectively. It must be noted that the economy cannot settle at points B, B', B'', and B''' in Figures 2.13(a), 2.13(b), 2.13(d), and 2.13(e), respectively. This is because (as a result of the rise in the exchange rate from S_0 to S_2) the competitiveness of the domestic economy improves, leading to a rise in the demand for domestic output and hence a shift in the *IS* curve from *IS* (S_0) to *IS* (S_1) and the *AD* curve from AD_2 to AD_1. The boost to demand has the effect of pushing the interest rate up to i_1, part of the way back to its original level of i_0. The rise in the exchange rate also causes a shift in the *BP* curve from *BP* (S_0) to *BP* (S_1).

Eventually, the economy reaches equilibrium at points C, C', C'', and C''', with a higher level of income (Y_1), lower interest rate (i_1), and higher exchange rate (S_1), given the price level P_0. The balance of payments returns to equilibrium because a partial rise in the interest rate reduces the capital account deficit to a level where the current account surplus created by currency depreciation (at point C'' in Figure 2.13(d)) is sufficient to cover it. It must be noted that the current account surplus (at C'') is the net outcome of a positive influence (the rise in the exchange rate) and a negative influence (the increase in Y). The former effect is stronger than the latter.

Thus, the Mundell–Fleming model predicts that an expansion in the money supply leads to (i) currency depreciation; (ii) an increase in real income; (iii) a fall in the interest rate, provided that capital is not perfectly mobile; and (iv) improvement in the current account of the balance of payments. It must be noted that the first conclusion is qualitatively similar to that of the monetary model, though there is no reason to suppose that the exchange rate will rise proportionately to monetary expansion. The effect on real income is in sharp contrast with that of the monetary model.

2.10. Stabilization Policies Under Alternative Exchange Rate Regimes

Both Mundell (1963a) and Fleming (1962) investigated the impact of perfect capital mobility on the short-run effects of monetary and fiscal policies under alternative exchange rate regimes. Mundell (1963a) utilized the *XX*, *LL*, and *FF* schedules (or what can be described as the standard *IS-LM-BP* model) to present a comparative static analysis of the effectiveness of fiscal and monetary policies under fixed and flexible exchange rates. Fleming (1962) used a mathematical model consisting of nine equations built on the simple Keynesian fixed-price expenditure approach. Mundell (1964) developed a two-country macroeconomic model based on seven equations.

Some key results emerged from the work of Mundell (1963a) and Fleming (1962) on the effectiveness of monetary and fiscal policies under fixed and flexible exchange rates. First, the nature of the exchange rate regime has an important bearing, not only on the relative effectiveness of monetary and fiscal policies, but also on their relative practicability or sustainability. Under fixed exchange rates (except to the extent that there is a surplus in the balance of payments), a monetary expansion can be sustained only as long as reserves hold out, while a fiscal expansion may be sustained indefinitely if capital movements are sufficiently sensitive to interest rates. Under floating exchange rates, on the other hand, expansionary monetary and fiscal policies can be sustained indefinitely as far as the balance of payments situation is concerned. Second, monetary policy has a strong effect on output and employment under flexible exchange rates, but it has no effect under fixed exchange rates. Third, fiscal policy has a strong effect on output and employment under fixed exchange rates, while it has no effect under flexible exchange rates.

The effects of monetary and fiscal policies under fixed and flexible exchange rates can be explained by using equation (2.7) to derive comparative static policy multipliers, which represent conditional predictions of the underlying policies in the Mundell–Fleming model. The *IS-LM-BP*, *IB-EB*, and *D-S* frameworks are used to compare policy effectiveness under alternative exchange rate regimes.

2.10.1. *Fixed Exchange Rates, Capital Mobility and Stabilization Policies*

As the central bank intervenes in the foreign exchange market with fixed exchange rates, it must purchase the otherwise unwanted foreign exchange reserves and pay for them by issuing domestic currency to avert any downward pressure on the exchange rate. Similarly, it must supply the otherwise unavailable foreign exchange reserves and receive previously circulating domestic money to avert any upward pressure on the exchange rate. Consequently, the exchange rate remains unchanged under fixed exchange rates ($\mathrm{d}S = 0$), where equilibrium in the foreign exchange market is achieved when the balance of payments is zero ($\dot{R} = 0$). The condition $\dot{R} = 0$ also implies that the *LM* curve does not shift. Under fixed exchange rates, real income (Y), domestic interest rate (i), and the stock of foreign exchange reserves (R) are determined endogenously, whereas government expenditures (G), domestic credit (D), changes in the stock of foreign exchange reserves ($\dot{R}$), the exchange rate (S), and the foreign interest rate (i^*) are determined exogenously. Given these assumptions, we rearrange the matrices of equation (2.7) so that the left-hand side has a column in $\mathrm{d}Y$, $\mathrm{d}i$, and $\mathrm{d}R$ (three endogenous variables), while the right-hand side has a column in $\mathrm{d}G$, $\mathrm{d}D$, $\mathrm{d}\dot{R}$, $\mathrm{d}S$, and $\mathrm{d}i^*$ (five exogenous variables). Thus we have

$$\begin{bmatrix} A & -I_i & 0 \\ L_Y & L_i & -1 \\ T_Y & K_i & 0 \end{bmatrix} \begin{bmatrix} \mathrm{d}Y \\ \mathrm{d}i \\ \mathrm{d}R \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & T_S & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & -T_S & K_i \end{bmatrix} \begin{bmatrix} \mathrm{d}G \\ \mathrm{d}D \\ \mathrm{d}\dot{R} \\ \mathrm{d}S \\ \mathrm{d}i^* \end{bmatrix}. \quad (2.12)$$

Equation (2.12) can be used to work out the fiscal and monetary policy multipliers to demonstrate that while fiscal policy is effective under fixed exchange rates, monetary policy is not. This is because, under fixed exchange rates, a rise in the money supply is completely offset by the sale of foreign exchange reserves in defense of the fixed exchange rate. As it is evident from equation (2.5), when the money supply rises via open market operations under fixed exchange rates, the interest rate falls while income rises. This incipient fall in the interest rate results in capital outflow and deterioration of the capital account, while the incipient rise in real income (resulting from increased investment spending induced by a fall in the interest rate) leads to a rise in imports and deteriorating current account. Consequently, there is an overall deficit in the balance of payments, and hence pressure on the domestic currency to depreciate. To defend the fixed exchange rate, the authorities must sell foreign exchange reserves. The fall in the level of foreign exchange reserves causes the *LM* curve to shift backward to its original position. These results can be represented by the following equations:

$$\frac{\mathrm{d}Y}{\mathrm{d}G} = \frac{K_i}{AK_i + T_Y I_i} > 0 \tag{2.13}$$

$$\frac{\mathrm{d}Y}{\mathrm{d}D} = 0 \tag{2.14}$$

$$\frac{\mathrm{d}R}{\mathrm{d}D} = -1. \tag{2.15}$$

By dividing the top and bottom of equation (2.13) by K_i and letting $K_i \to \infty$, the fiscal policy multiplier is reduced to $1/A$, which means that $\mathrm{d}y/\mathrm{d}G = 1/A$ or $\mathrm{d}y/\mathrm{d}G = 1/(1 - C_Y - T_Y) > 0$. This implies that the magnitude of $\mathrm{d}Y/\mathrm{d}G$ depends on the marginal propensities to consume and import. In other words, the open economy results are the same as those that apply to a closed economy with a liquidity trap. Fiscal policy is highly potent in a small open economy under fixed exchange rates because there is no crowding out effect from changes in interest rates. In contrast, monetary policy is totally impotent under fixed exchange rates. It can also be demonstrated that devaluation of the domestic currency has a positive impact on income as it stimulates aggregate demand (that is, $\mathrm{d}Y/\mathrm{d}S > 0$), and that an increase in the foreign interest rate causes a recession (that is, $\mathrm{d}Y/\mathrm{d}i^* < 0$).

The relative efficacy of fiscal and monetary policies under fixed exchange rates with perfect capital mobility can be illustrated by using the *IS-LM-BP*, *IB-EB*, and *D-S* frameworks, as shown in Figures 2.14(a)–2.14(c), respectively. Because capital is perfectly mobile, the *BP* curve is horizontal at i_0, as shown in Figure 2.14(a). The economy is initially in equilibrium at A with Y_0 real income and i_0 interest rate, as shown in Figure 2.14(a) where

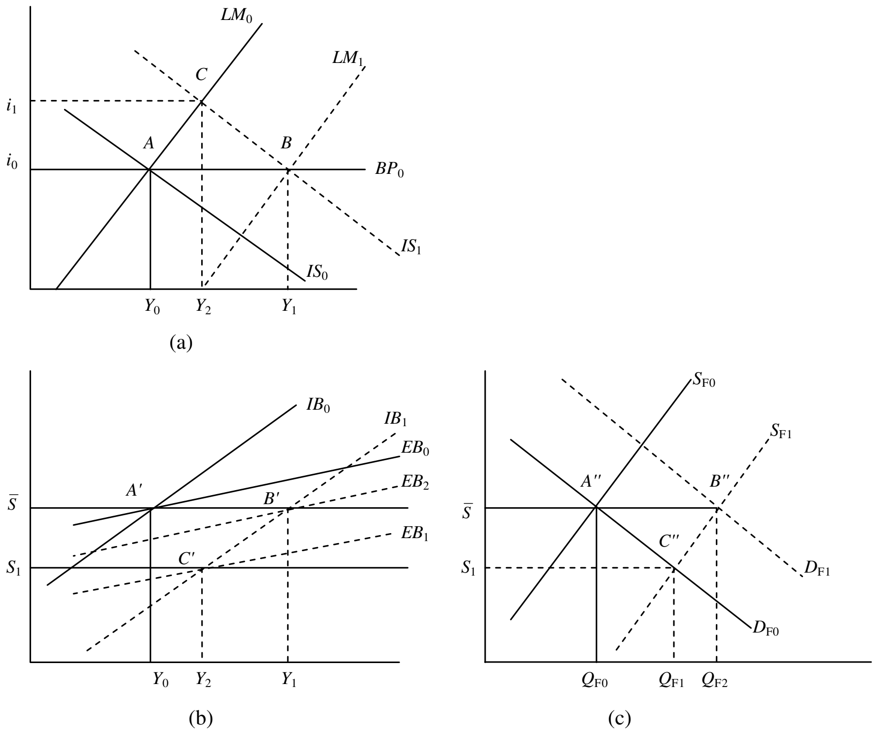

Figure 2.14. Fiscal expansion under fixed exchange rates.

the *IS*, *LM*, and *BP* curves intersect, implying that the markets for goods, money, and foreign exchange clear simultaneously. In Figure 2.14(b), point A' represents equilibrium in the internal as well as the external sectors, as indicated by the intersection of the *IB* and the *EB* curves. In Figure 2.14(c), the foreign exchange market is in equilibrium as there is no excess demand for foreign exchange at the fixed exchange rate ($\bar{S}$).

Let us now assume that there is an increase in government expenditure, causing an outward shift in the *IS* curve from IS_0 to IS_1 in Figure 2.14(a) and in the *IB* curve from IB_0 to IB_1 in Figure 2.14(b). Under fixed exchange rates, an increase in government expenditure gives rise to an increase in real income, which is associated with an increase in employment, provided that the economy is previously unemployed. As a result of the multiplier effect of government expenditure and employment, the economy reaches equilibrium at a higher level of real income, which means that the economy moves initially from A to C, A' to C', and from A'' to C'' in Figures 2.14(a)–2.14(c), respectively. At point C in Figure 2.14(a), the higher level of income (Y_2) leads to deteriorating current account because of higher spending on imports, whereas the higher interest rate (i_1) leads to improvement in the capital account via capital inflow. Because the improvement in the capital account is greater than the deterioration in the current account, a surplus in the balance of payments arises at point C in Figure 2.14(a).

The surplus in the balance of payments, which gives rise to a rightward shift in the supply curve for foreign exchange reserves (from S_{F0} to S_{F1}, as shown in Figure 2.14(c)) puts pressure on the domestic currency to appreciate. Moreover, the *EB* curve shifts downward from EB_0 to EB_1 at the higher level of real income Y_2 and the lower level of exchange rate S_1 at point C' in Figure 2.14(b). To avert currency appreciation (or a fall in the exchange rate from $\bar{S}$ to S_1), the central bank intervenes in the foreign exchange market to keep the exchange rate fixed at $\bar{S}$ by buying excess foreign exchange reserves. In Figure 2.14(c), the demand curve for foreign exchange shifts to the right from D_{F0} to D_{F1}, which makes the foreign exchange market clear at the fixed exchange rate ($\bar{S}$). Consequently, the level of foreign exchange reserves rises, leading to an increase in the money supply and hence a shift in the *LM* curve from LM_0 to LM_1 (Figure 2.14(a)) and a shift in the *EB* curve from EB_1 to EB_2 (Figure 2.14(b)). Eventually, the economy settles at points B, B', and B'', where equilibrium in all of the markets is re-established at the same interest and exchange rates (i_0 and $\bar{S}$), with a higher level of income (Y_1), and hence a higher level of employment.

With the exchange rate fixed at $\bar{S}$, an increase in the money supply (which shifts the *LM* curve to the right from LM_0 to LM_1) creates excess liquidity, leading to a fall in the interest rate from i_0 to i_1 and a rise in real income from Y_0 to Y_1, as shown in Figure 2.15(a). A fall in the interest rate causes capital outflow, leading to deterioration in the capital account, whereas an increase in real income boosts spending on imports, leading to deterioration in the current account. Consequently, a balance of payments deficit arises, which causes an upward shift in the *EB* curve from EB_0 to EB_1 in Figure 2.15(b) and an outward shift in the demand curve for foreign exchange from D_{F0} to D_{F1}, putting pressure on the domestic currency to depreciate. Under fixed exchange rates, the central bank intervenes in the foreign exchange market to keep the exchange rate fixed at $\bar{S}$ by selling foreign exchange reserves, shifting the supply of foreign exchange curve to S_{F1}. A fall in the foreign component of the money supply leads to an equivalent fall in the real money supply, and as a result the *LM* and *EB* curves shift backward to their original positions at point A in Figures 2.15(a) and

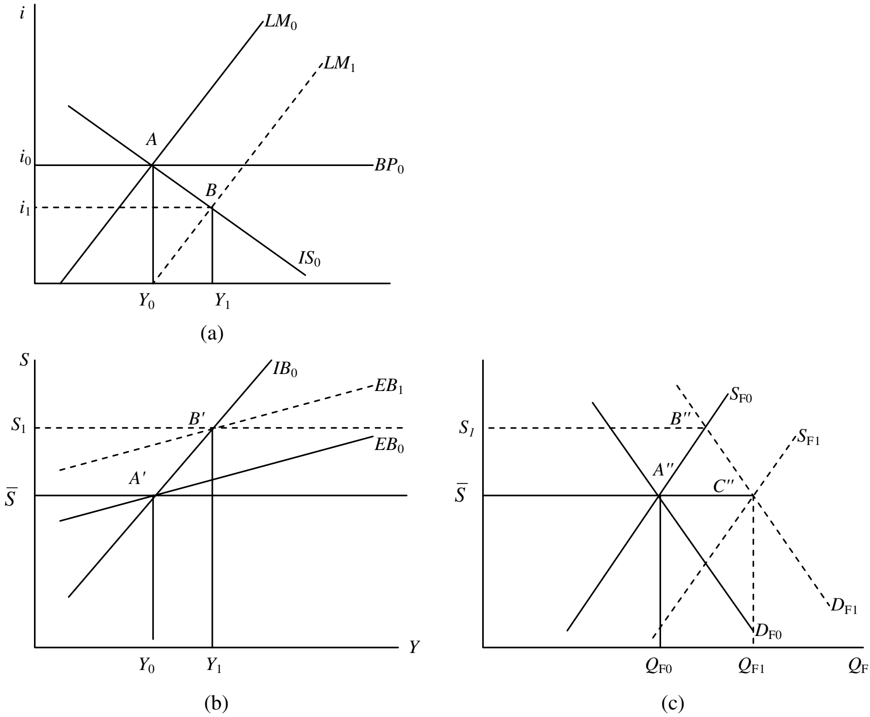

Figure 2.15. Monetary expansion under fixed exchange rates.

2.15(b), respectively. Thus, monetary policy has no impact on employment and income under fixed exchange rates. Mundell (1963a) concludes that the monetary authorities would have to abandon attempts to expand the money supply because their open-market purchases would exactly offset the sale of foreign exchange reserves in defense of the fixed exchange rate.

2.10.2. *Flexible Exchange Rates, Capital Mobility, and Stabilization Policies*

Under flexible exchange rates, the central bank does not intervene in the foreign exchange market: it neither purchases foreign exchange reserves to absorb excess supply, nor does it sell reserves to meet excess demand. Consequently, the exchange rate fluctuates freely to clear the foreign exchange market. The central bank does not hold foreign exchange reserves, implying that $\mathrm{d}R = 0$. Real income (Y), the domestic interest rate (i), and the exchange rate (S) are determined endogenously, whereas government spending (G), the domestic component of the money supply (D), the stock of foreign exchange reserves (R), changes in the stock of foreign exchange reserves ($\dot{R}$), and the foreign interest rate (i^*) are determined exogenously. By transposition, we rearrange the matrices of equation (2.7) so that the left-hand matrix has columns in $\mathrm{d}Y$, $\mathrm{d}i$, and $\mathrm{d}S$ (three endogenous variables), whereas the right-hand matrix has columns in $\mathrm{d}G$, $\mathrm{d}D$, $\mathrm{d}R$, $\mathrm{d}\dot{R}$, and $\mathrm{d}i^*$ (five exogenous variables).

$$\begin{bmatrix} A & -I_i & -T_S \\ L_Y & L_i & 0 \\ T_Y & K_i & T_S \end{bmatrix} \begin{bmatrix} \mathrm{d}Y \\ \mathrm{d}i \\ \mathrm{d}S \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & K_i \end{bmatrix} \begin{bmatrix} \mathrm{d}G \\ \mathrm{d}D \\ \mathrm{d}R \\ \mathrm{d}\dot{R} \\ \mathrm{d}i^* \end{bmatrix}. \tag{2.16}$$

Equation (2.16) can be used to work out fiscal and monetary policy multipliers under flexible exchange rates. These are given as follows:

$$\mathrm{d}Y/\mathrm{d}G = \frac{L_i}{L_i(1 - C_Y) + I_i L_Y - K_i L_Y} \geq 0 \tag{2.17}$$

$$\mathrm{d}Y/\mathrm{d}D = \frac{I_i - K_i}{L_i(1 - C_Y) + I_i L_Y - K_i L_Y} > 0. \tag{2.18}$$

In the case of perfect capital mobility (that is, $K_i \to \infty$), the policy multipliers represented by equations (2.17) and (2.18) boil down to the following:

$$\mathrm{d}Y/\mathrm{d}G = 0 \tag{2.19}$$

$$\mathrm{d}Y/\mathrm{d}D = 1/L_Y. \tag{2.20}$$

Clearly, if capital is perfectly mobile, fiscal policy is totally ineffective under flexible exchange rates because $\mathrm{d}Y/\mathrm{d}G = 0$, whereas monetary policy is effective to an extent that depends upon the income sensitivity of the demand for money (that is, $\mathrm{d}Y/\mathrm{d}D = 1/L_Y$).

The relative impact of fiscal and monetary policies on income under flexible exchange rates with perfect capital mobility can be illustrated with the aid of the *IS-LM-BP*, *IB-EB*, and *D-S* frameworks as shown in Figures 2.16 and 2.17. Suppose that the economy is initially in equilibrium at A, where the *IS-LM-BP*, *IB-EB*, and *D-S* curves intersect, showing that there is no excess demand in any of the markets under consideration. Let us now

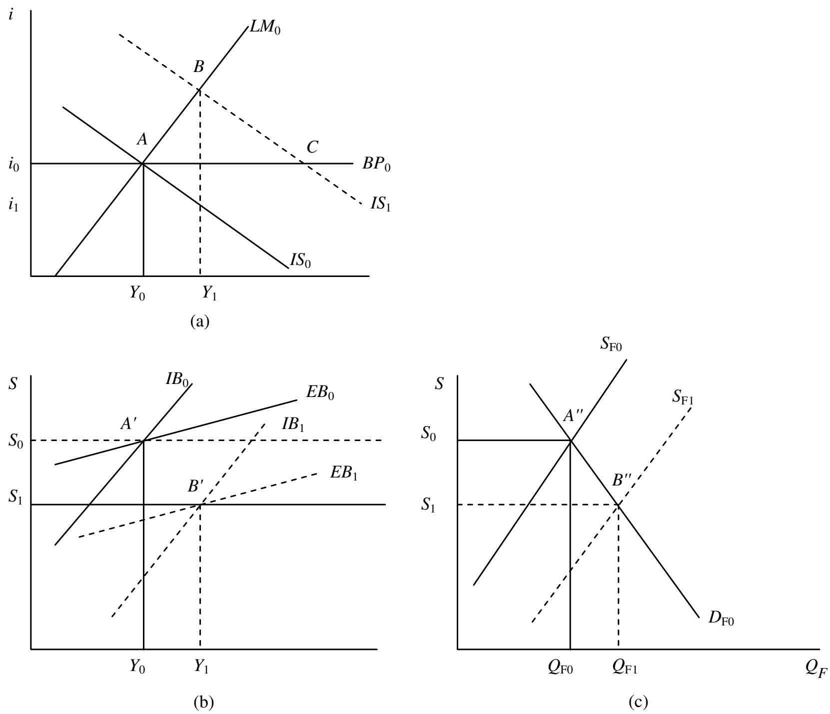

Figure 2.16. Fiscal expansion under flexible exchange rates.

assume that the government raises its spending, which causes an outward shift in the *IS* curve from IS_0 to IS_1 (Figure 2.16(a)) and in the *IB* curve from IB_0 to IB_1 (Figure 2.16(b)), moving the economy from *A* and *B* to A' and B', respectively. Increased government spending puts upward pressure on the interest rate, which induces capital inflows that lead to improvement in the capital account. On the other hand, increased government spending raises income but not to the extent of the initial increase as measured by the distance *AC*. Although the higher income (Y_1) leads to deterioration of the current account (a higher level of imports), improvement in the capital account balance resulting from higher domestic interest rates is much more than the deterioration in the current account. As a result, a surplus in the balance of payments arises at point *B*, which causes a downward shift in the *EB* curve from EB_0 to EB_1 (Figure 2.16(b)), leading to domestic currency appreciation. This is represented in Figure 2.16(c) by a shift of the supply curve of foreign exchange from S_{F0} to S_{F1}, lowering the exchange rate to S_1.

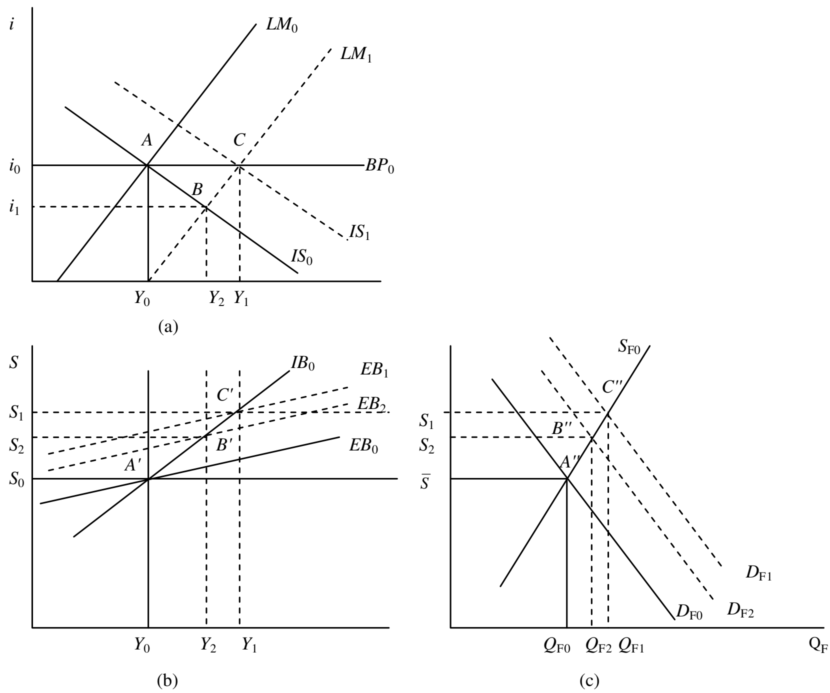

Figure 2.17. Monetary expansion under flexible exchange rates.

Appreciation of the domestic currency in turn makes domestic exports less competitive, leading to deterioration in the current account and consequently a backward shift in the *EB* curve from EB_1 to EB_0 and the *SF* curve from SF_1 to SF_0. Thus the economy returns to its original equilibrium position with output and employment unchanged. Fiscal policy fails totally under flexible exchange rates due to a 100% crowding out effect.

On the other hand, monetary policy has a strong effect on real income and employment under flexible exchange rates (the classical theory conclusion holds). This is illustrated in Figure 2.17. Let us consider an increase in the money supply via an open-market purchase of government securities, which causes the *LM* curve to shift to the right from LM_0 to LM_1, leading to a fall in the interest rate to i_1 and a rise in income to Y_2. A fall in the interest rate causes capital outflow, leading to capital account deterioration and a rise in income that leads to current account deterioration. Consequently, the economy moves from *A* to *B*, where there is an overall deficit in the balance of payments (Figure 2.17(a)). This causes an upward shift in the *EB* curve from EB_0 to EB_2 in Figure 2.17(b) and an outward shift in the demand for foreign exchange curve from D_{F0} to D_{F2} in Figure 2.17(c), eventually leading to a rise in the exchange rate from $\bar{S}$ to S_2. Depreciation of the domestic currency makes domestic exports competitive, leading to an improvement in the current account and consequently to the shifting of the IS curve from IS_0 to IS_1 (Figure 2.17(a)). As a result, the economy moves from point B to point C. Improvement in the current account also leads to higher levels of income and employment, which again causes deterioration in the current account, whereas a rise in the interest rate leads to capital account improvement. However, the deterioration in the current account is much larger than the improvement in the capital account. Consequently, a balance of payments deficit arises, shifting the EB curve from EB_2 to EB_1 and the demand for foreign exchange curve to D_{F1}. The exchange rate rises to S_1. Eventually, the economy settles at points C, C', and C'', with a higher level of income (Y_1) and a higher exchange rate (S_1) whereas the interest rate returns to its original level. Thus, a rise in the money supply has a strong effect on employment under flexible exchange rates (the quantity theory of money conclusion holds).

2.11. A Critique of Mundell's Results About Stabilization Policies

Some doubts were raised by McLeod (1964) and Niehans (1975) about Mundell's (1961c, 1963a) results regarding the efficacy of monetary and fiscal policies under fixed and flexible exchange rates. McLeod (1964) was skeptical of the results that Mundell (1963a) had derived in his paper, whereas Niehans (1975) questioned the results of Mundell (1961c, 1963a) about the efficacy of monetary policy under flexible exchange rates.

2.11.1. *McLeod's Critique of Mundell's Results*

McLeod (1964) begins his critique of Mundell (1963a) by arguing that "there is nothing new in the realization that the international capital mobility greatly complicates the operation of domestic stabilization policies, but a thorough study of just what the implications are is badly needed." He argues that Mundell (1963a) claims to have demonstrated that, with perfect capital mobility, monetary policy has no effect on employment under fixed exchange rates but has a high impact under flexible exchange rates, whereas fiscal policy has a high impact under fixed exchange rates but no impact under flexible exchange rates. McLeod's criticism of Mundell's work (1963a) can be divided into two strands: (i) Mundell's assumptions and (ii) the results about stabilization policies under fixed and flexible exchange rates.

The Assumptions

In his criticism of the assumptions, McLeod classifies them into two groups: incongruous assumptions and rigid functional relations. As for incongruous assumptions, McLeod argues that it is inappropriate to assume that existing (spot and forward) exchange rates are expected to persist indefinitely and that complications associated with speculation, the forward market, and exchange rate margins do not exist. Moreover, the assumptions of unemployed resources, constant returns to scale, and fixed money wages are not equivalent to the assumption that the supply of domestic output is elastic and that its price level is constant.

McLeod comments on "undue rigidities in functional relations." First, the assumption that investment depends on the interest rate only precludes any stimulus to income-creating expenditure from such factors as increased availability of funds, prospective improvement in profits, and the acceleration principle. It also prejudices the ability of the model to achieve new equilibrium as income rises. When coupled with the assumption that the interest rate is determined by the conditions prevailing in world capital markets, the investment-interest relation implies that investment is constant. Second, the postulation that the demand for money depends on income and the interest rate does not fairly represent modern monetary thinking. Even at given levels of income and interest rate, the public's liquidity preference may be altered gradually (for example, by the accumulation of wealth in the form of physical assets and liquid financial claims) or abruptly (for example, by improved expectations about future business conditions brought about by the announcement of policies designed to stimulate the economy). These two assumptions seriously limit the effectiveness of monetary policy as normally conceived. McLeod (1964) argues that even within the constraints set by simplifying assumptions, the logic of Mundell's analysis is far from rigorous and his results in regard to monetary and fiscal policies are by no means definitive.

Monetary Policy

McLeod argues that if a country's central bank cannot maintain an interest rate that is different from the general level prevailing abroad under perfect capital mobility, how can open market purchases and sales of securities be carried out? At a given level of income and interest rate, no one would wish to part with their existing holdings of securities in exchange for money. To escape this *cul-de-sac*, Mundell permits some difference between domestic and world interest rates, which sets off capital outflow, thereby putting upward pressure on the exchange rate or foreign exchange reserves. Only on the basis of this assumption does Mundell conclude that, under fixed exchange rates, the monetary authorities would have to abandon their attempt to expand the money supply (because open market purchases would be offset exactly by the sale of foreign exchange reserves in defense of the fixed rate). Under flexible exchange rates, however, they could effectively raise income and employment because capital outflows induce currency depreciation instead of depleting the stock of foreign exchange reserves and would thus produce export surplus. Putting it more bluntly, this implies that under flexible exchange rates, monetary policy can be used to bring about the export of unemployment. It is argued that if this is desirable under flexible exchange rates, why not alter the rate directly by intervention in the foreign exchange market instead of indirectly via a monetary expansion?

Is it true that under fixed exchange rates the authorities must abandon their efforts to expand income and employment by using monetary policy? The answer to this question is "no," as long as the authorities can borrow from abroad, because foreign borrowing is an effective alternative to the depletion of foreign exchange reserves. The same line of reasoning would apply to the case of flexible exchange rates, *mutatis mutandis*, if the authorities wished to avoid currency depreciation and to use the domestic interest rate to stimulate investment rather than to bring about an export surplus. In fact, by regulating their own foreign borrowing accordingly, the authorities could even bring about currency appreciation (instead of depreciation) if they thought that seemed desirable.

McLeod's critique goes further. Even if the above arguments are disregarded, and Mundell's conclusion about the effectiveness of monetary policy is accepted at face value, it is clearly the rigidity of the assumptions rather than the inherent characteristics of monetary policy that lead to his particular conclusions. In fact, Mundell seems to have postulated conditions that are similar to those of the liquidity trap. McLeod suggests that it should be called "Mundell's case of illiquidity," as it is based on conditions that prevent the public from getting the liquidity it needs.

Fiscal Policy

McLeod points out that Mundell's conclusion that fiscal policy is not effective under flexible exchange rates is in fact nothing but a tautological creation of his assumptions. To derive this result, Mundell has assumed that income and the money supply must vary proportionately, and hence no expansion can be brought about by fiscal policy as long as the money supply is held constant.

Coordinated Monetary and Fiscal Policies

McLeod suggests that a well coordinated combination of fiscal and monetary policies should work effectively despite Mundell's rigid assumptions. But this requires a suitable increase in government expenditure to boost income and employment (even though investment remains fixed) and a suitable amount of monetary expansion to accommodate a rise in income without any untoward effects on the interest rate. Mundell does consider a special case of combined operations of monetary, fiscal, and exchange rate policies (central bank financing of budget deficits with fixed exchange rates, but involving continuing central bank financing of the whole deficit). Two comments can be made on this special case. First, central bank open-market purchases to monetize the deficit do not deplete foreign exchange reserves as long as these operations are not carried out beyond the point necessary to satisfy the demand for money that is appropriate to the new level of income brought about by government spending. Second, when fiscal policy has done its best and the appropriate once-and-for-all increase in the money supply has been achieved, there would be no point in continuing to monetize the deficit, which thereafter could be financed by capital outflow.

The Foreign Drain

It is essentially the foreign drain (Mundell uses the term capital outflow instead) that negates monetary policy with stable exchange rates and that prevents the continued financing of the budget deficit by the central bank. The version of monetary policy in Mundell's world of flexible exchange rates only escapes the same limitation because it is used to achieve currency depreciation that in turn sets in motion the export multiplier. Mundell does recognize that there is an import surplus (foreign drain) as a result of a fiscal policy stimulus under fixed exchange rates, observing that it is automatically covered by capital inflow. This implies that the foreign drain should be considered as a limit on domestic stabilization policies in a model in which capital is perfectly mobile, as foreign borrowing is always readily available in such a model. Indeed, McLeod wonders how an economy could (in a world with infinitely elastic domestic supply, perfect capital mobility, and perfect substitutability of securities) possibly fall into the postulated condition of under-full employment.

2.11.2. *Niehans's Doubts About the Efficacy of Monetary Policy*

Niehans (1975) challenges the results of Mundell (1961c, 1963a), Krueger (1965) and Sohmen (1967) that the transition to flexible exchange rates would boost the efficacy of monetary policy in stabilizing the domestic output. He argues that this result is based on two assumptions. First, the price elasticities of the demand for exports and imports are not affected by the transition to flexible exchange rates. Second, capital flows are assumed to be independent of the exchange rate. If these two assumptions do not hold, the anticipated increase in the efficacy of monetary policy may not materialize.

Niehans begins by specifying the Keynesian open economy macroeconomic model as suggested by Sohmen (1967):

$$Y = E(Y, i) + X(S) - M(Y, S) \tag{2.21}$$

$$L(Y, i) = \bar{L} \tag{2.22}$$

$$M(Y, S) - X(S) + K(i, S - S^e) = 0. \tag{2.23}$$

Taking differentials and rearranging, we obtain

$$(1 - E_Y + M_Y)\mathrm{d}Y - E_i\mathrm{d}i + (M_S - X_S)\mathrm{d}S = 0 \tag{2.24}$$

$$L_Y\mathrm{d}Y + L_i\mathrm{d}i = \mathrm{d}\bar{L} \tag{2.25}$$

$$M_Y\mathrm{d}Y + K_i\mathrm{d}i + (M_S - X_S + K_S)\mathrm{d}S = 0. \tag{2.26}$$

The partial derivatives of equations (2.24)–(2.26) are assumed to take the following expected signs:

$$\begin{aligned} &E_i < 0, \quad M_S \leq M/S, \quad 1 - E_Y + M_Y > 0, \quad X_S \geq 0, \\ &M_Y > 0, \quad K_i < 0, \quad K_S \geq 0, \quad L_i < 0, \quad L_Y > 0. \end{aligned} \tag{2.27}$$

Exchange Rate Expectations and Capital Flows

In equation (2.23), net capital exports (K) are negatively related to the interest rate and the difference between the actual and expected exchange rates. Thus

$$\frac{\partial K}{\partial i} < 0 \tag{2.28}$$

$$\frac{\partial K}{\partial (S - S^e)} < 0. \tag{2.29}$$

If $S < S^e$, the domestic currency will appreciate in the future, thus creating an incentive for speculative capital inflows. If $S > S^e$, the domestic currency will depreciate in the future, giving rise to capital outflows. With stable expectations, a change in S will produce a change in $S - S^e$ in the same direction, which gives

$$\frac{\mathrm{d}(S - S^e)}{\mathrm{d}S} > 0. \tag{2.30}$$

The result represented by equation (2.30) holds because S^e moves less than S, which gives

$$\frac{\mathrm{d}S^e}{\mathrm{d}S} < 1. \tag{2.31}$$

In reality, it is conceivable that a given change in S produces an even larger change in the expected exchange rate, so that $\mathrm{d}S^e/\mathrm{d}S > 1$. While such unstable expectations may be important occasionally, they must be the exception rather than the rule.

Price Elasticities of the Demand for Exports and Imports

Real imports, M (measured in units of domestic goods) can be written as $M = S \times Q^M$, where $Q^M = M/S$ is the quantity of real imports measured in units of foreign goods.

Thus,

$$M_S = S \times Q^M_S + Q^M = \frac{M}{S}\left(Q^M_S \times \frac{S}{M} + 1\right) = \frac{M}{S}(\varepsilon_M + 1) \tag{2.32}$$

where ε_M is the price elasticity of the demand for imports, such that $M_S \leq M/S$ is equivalent to $\varepsilon_M \leq 0$. For the reaction of the import surplus, we have

$$M_S - X_S = \frac{M}{S}\left(Q^M_S \times \frac{S}{M} + 1\right) - \frac{X}{S}\left(X_S \frac{S}{X}\right) \tag{2.33}$$

which for $M = X$ reduces to the Marshall–Lerner condition:

$$M_S - X_S = \frac{M}{S}(\varepsilon_M + \varepsilon_X + 1). \tag{2.34}$$

By combining equations (2.24) and (2.25) to determine the value of $\mathrm{d}Y/\mathrm{d}\bar{L}$, we obtain

$$\frac{\mathrm{d}Y}{\mathrm{d}\bar{L}}(Flex) = \frac{\left(E_i + K_i \frac{M_S - X_S}{M_S - X_S + K_S}\right)}{(1 - E_Y + M_Y)L_i + L_Y E_i - (M_Y L_i - K_i L_Y)\frac{M - X_S}{M_S - X_S + K_S}}. \tag{2.35}$$

Since $(1-E_Y+M_Y)L_i < 0$, then for a positive effect of monetary expansion on output, the conditions $M_S - X_S + K_i < 0$ and $M_S - X_S < 0$ must be satisfied. This implies that if $M_S - X_S$ is positive and sufficiently high, then Y will fall as the money supply increases, giving rise to a paradox of a possible contractionary effect of monetary policy. The effect of monetary policy under flexible exchange rates, as implied by equation (2.35), can be compared with the effect of monetary policy under fixed exchange rates:

$$\frac{\mathrm{d}Y}{\mathrm{d}\bar{L}}(Fix) = \frac{E_i}{(1 - E_Y + M_Y)L_i + L_Y E_i}. \tag{2.36}$$

Clearly, the effect of monetary policy on output is the same under the two exchange rate regimes if $M_S - X_S = 0$. It can also be shown that $\mathrm{d}Y/\mathrm{d}\bar{L}(Flex)$ declines as $M_S - X_S$ increases. Thus, monetary policy is more effective under flexible exchange rates if $M_S - X_S < 0$. When $M_S - X_S = 0$, the difference between the two policies disappears. And when $M_S - X_S > 0$, monetary policy is less effective under flexible exchange rates than under fixed exchange rates.

2.12. Recapitulation

The usefulness of the Mundell–Fleming model is that it allows us to analyze the role played by trade and capital flows in the exchange rate determination process and to study the impact of international capital mobility on the effectiveness of monetary and fiscal policies under fixed and flexible exchange rates. Mundell's analysis filled the gap left in Mead's analysis who ignored the dynamic process whereby the economy moves from one equilibrium position to another. It was shown that the effectiveness of monetary and fiscal policies can be examined in several frameworks and that a fixed exchange rate system works well if capital is internationally mobile.

One of the important contributions of Mundell is the so-called "principle of effective market classification," which postulates that a system works in the best possible way if policy instruments are assigned to markets or sectors on which they have the most direct effect. He shows that the policy dilemma arising under fixed exchange rates (with respect to attaining internal and external stability simultaneously) can be resolved if capital flows are responsive to the interest rate differential. More specifically, Mundell shows that a country that is faced with deflation and a balance of payments deficit can boost aggregate demand while attracting capital flows by using a combination of fiscal expansion and monetary contraction.

The independent work of Fleming combined with the work of Mundell led to the emergence of the Mundell–Fleming model or the flow model of exchange rates. This model was more or less the first serious attempt to explain the behavior of exchange rates as Cassel made PPP an operational theory of exchange rates in 1916. In this sense, the works of Mundell and Fleming filled a vacuum in the literature that persisted until the early 1960s.

Despite these celebrated contributions and others, Mundell's work has been criticized on several grounds. It has been suggested, for example, that there is nothing new about the proposition that capital mobility complicates domestic stabilization policy. This work has been criticized on the basis of "incongruous assumptions" and "rigid functional relations." Even the proposition that the transition to flexible exchange rates would boost the efficacy of monetary policy has been challenged on the grounds that it is based on the assumptions that the elasticities of demand for exports and imports are not affected by the transition to flexible exchange rates and that capital flows are independent of exchange rates.

But that is not all. The Mundell–Fleming model, as a model of exchange rate determination, is criticized on the grounds that it ignores stock equilibria. It is this criticism that has led to the emergence of the asset models of exchange rates, starting with the flexible price monetary model. This is what we study next.

CHAPTER 3
The Flexible-Price Monetary Model of Exchange Rates

3.1. Introduction

In the mid-1970s, the Mundell–Fleming flow model, which is embedded in the open economy version of the Keynesian macroeconomic model, gave way to what is known as the Chicago flexible-price monetary model. The flow model was highly influential in the 1960s, particularly in policy-making circles, for at least three reasons. First, the model emphasized the use of an optimal combination of monetary and fiscal policy measures for demand management in the open economy, a prescription that remained unchallenged until the late 1960s.[1] Second, the Mundell–Fleming model was developed at a time when the Bretton Woods system was still in place, and much of the research on the model focused on its predictions under a system of fixed exchange rates. Third, the economic environment that provided the context for the Mundell–Fleming model was one of fixed exchange rates, capital controls, segmented capital markets, high unemployment, and low inflation.

With the breakdown of the Bretton Woods system in August 1971, the global economic environment underwent a dramatic change.[2] After a period

[1]The Keynesian consensus was first challenged by Milton Friedman, who launched the orthodox monetarist attack against policy-activism during the 1950s and 1960s. In the 1970s, a small group of economists (Robert Lucas of Chicago, Thomas Sargent of Minnesota, and Robert Barro of Chicago) launched a strong attack on the then mainstream macroeconomics. They demonstrated that the predictions of Keynesian economics were widely incorrect and that the doctrine on which they were based was fundamentally flawed.

[2]In August 1971, the U.S. suspended (rather abolished) the convertibility of the dollar into gold, which was one of the pillars of the Bretton Woods system. This followed mounting pressure on U.S. gold reserves as European central banks (particularly the French central bank) started to dump their dollar holdings, having felt that there are more dollars than gold.

of chaos and uncertainty, major industrial countries shifted toward a system of floating exchange rates in 1973, and started dismantling capital controls in the late 1970s. During the 1970s, inflation emerged as a core policy problem, whereas the 1980s were characterized by highly volatile and misaligned exchange and interest rates. The Mundell–Fleming model, which was developed in the Keynesian framework, failed to explain adequately exchange rate movements in the inflationary environment of the 1970s. This theoretical vacuum was filled by the development of a range of monetary or asset market models of exchange rates. Many of the monetary models that appeared in the late 1970s were extensions of the flexible-price monetary model pioneered by Frenkel (1976), Mussa (1976), and Bilson (1978a,b).[3]

The history of the monetary model, however, can be traced back two or even more than two centuries.[4] Frenkel (1976, p. 210) argues that the renewed emphasis on the role of the demand for and supply of money and assets such as stocks (in contrast with the Keynesian circular flow of income and the foreign trade multiplier approach to exchange rate determination) gave rise to the revival of the Bullionist controversy that culminated in the early 1800s, leading to the development of the "balance of trade theory" and the "inflation theory" of exchange rate determination rate by Ricardo (1811), Haberler (1936), and Viner (1937). In fact, remnants of the Bullionist controversy can be traced to present times in the various discussions and interpretations of the purchasing power parity doctrine. Humphrey (1978) argues that the monetary model has a long history (dating back at least 175 years) and that a rudimentary version of it was first used by Ricardo, Wheatley, and other classical economists to explain the fall of the paper pound following Britian's suspension of the convertibility of notes into

In a sense, therefore, the "gold rush" forced the U.S. to abolish convertibility into gold. The Europeans felt that America was fighting wars with borrowed money. In return, the U.S. told European countries, in the words of Nixon's Treasury Secretary John Connolly, that the dollar was "our currency but your problem."

[3]The other monetary models include the sticky-price model of Dornbusch (1976), the real interest differential model of Frankel (1979b), the equilibrium real exchange rate model of Hooper and Morton (1982), and the exchange market pressure model of Girton and Roper (1977). These models share the common premise that while asset markets (capital and foreign exchange) adjust instantaneously, goods markets do not. Moreover, these models are based on the same premise of the absence of substantial transaction costs and other impediments to the flow of goods and capital.

[4]On the history of the monetary model of exchange rates, see Humphrey (1978) and Moosa and Tawadros (1999).

bullion at a fixed price during the Napoleonic wars. Gustav Cassel used a version of the model to explain the fall of the German mark during World War I, while others focused on the hyperinflation episodes of the early 1920s. Copeland (1994, p. 155) believes that the monetary model is rooted in an approach to the balance of payments that dates back to the work of David Hume in 1741.

Frenkel (1976) and Mussa (1976) argue that the monetary approach can be looked at from two perspectives. First, it offers a monetary explanation for balance of payments disequilibria under fixed exchange rates, emphasizing the role of money and other assets in determining the balance of payments when the exchange rate is fixed. Second, it views exchange rate changes as a monetary phenomenon under a system of flexible exchange rates, emphasizing the role of money and other assets in exchange rate determination. As Mussa (1976) argues, the monetary approach emphasizes that both the balance of payments (meaning the official settlements balance) and the exchange rate are essentially monetary phenomena. Thus, the determinants of both the exchange rate and the balance of payments are the demand for and supply of various national monies. When the demand for particular money rises relative to the supply of that money, one or a combination of the following will happen: (i) the domestic component of the money supply expands, (ii) the domestic currency appreciates, and (iii) the official settlements balance goes into surplus.

Unlike the traditional flow model, the (flexible-price) monetary model postulates that the exchange rate moves to equilibrate the international demand for the stocks of national monies, rather than trade and capital flows. In essence, the monetary model views national monetary policies as the primary factor affecting the nominal exchange rate directly or indirectly. Unlike the flow model, however, both monetary and fiscal policies become irrelevant because they do not affect real but only nominal magnitudes (such as the nominal exchange rate, interest rate, and prices), eventually resulting in the neutrality rather than the super neutrality of money and a 100% crowding out effect. For example, due to rapid and instantaneous adjustments across the markets for goods, labor, money, and foreign exchange, an incipient fall in the interest rate (which is caused by the liquidity effect following a monetary expansion) induces a rise in aggregate demand. This in turn stimulates inflationary expectations, leading to a rise in the interest rate through the Fisher effect. The nominal interest and exchange rates rise proportionately to the inflation rate, and eventually the real interest rate, real exchange rate, and real income return to their original levels.

3.2. Key Propositions of the Flexible-Price Monetary Model

The flexible-price monetary model of exchange rates is based on the microeconomic foundations of perfectly competitive markets for labor, goods, bonds, and foreign exchange. These markets are assumed to clear instantaneously through the rational optimizing behavior of individual economic agents. In essence, the flexible-price monetary model rests on the key propositions that constitute the main theoretical basis of the new classical macroeconomic thinking that emerged in the 1970s to generate conclusions that are typical of global monetarism. The key propositions underlying the flexible-price monetary model include the following:

Proposition 1

Economic agents are rational optimizers who base their decisions on real factors. This implies that economic agents engaged across the markets for goods, bonds, foreign exchange, and even labor to optimize utility by making decisions based on real, rather than nominal, factors. For example, the demand for and supply of labor depend on real wages, which means that workers are not exposed to money illusion. Likewise, while deciding whether or not to invest in domestic or foreign goods and capital assets, investors take into consideration real (not nominal) returns on (domestic and foreign) goods and assets.

Proposition 2

Markets are perfectly competitive and clear instantaneously. The failure of markets to clear quickly indicates that some transactions are not carried out. For example, the unemployed could raise their utility by cutting the current wage rate.

Proposition 3

The aggregate supply curve is vertical. This implies that supply conditions in the labor market uniquely fix the level of output at the natural rate of unemployment and that fiscal and monetary policies have no real effects on the economy.

Proposition 4

The quantity theory of money holds continuously. This implies that the price level adjusts to the money supply to clear the money market by equating the supply of and demand for real money balances. An important policy implication that follows from the quantity theory is that an increase in the money supply leads to higher prices only, and eventually to the neutrality of money and a 100% crowding out of private expenditure by government spending.

Proposition 5

The purchasing power parity condition holds continuously, implying that the exchange rate between two currencies adjusts fully to offset the domestic–foreign inflation differential, forcing the real exchange rate to remain constant over time. Continuous purchasing power parity clears goods markets by bringing domestic prices into equality with exchange rate-adjusted foreign prices. This means that the purchasing power of two currencies is the same when converted into the same currency at the equilibrium exchange rate, thereby eliminating the presence of unexploited opportunities of profitable commodity arbitrage. It also ensures that the existing stocks of national currencies are held willingly and that the markets for real cash balances clear simultaneously.

Proposition 6

The Fisher condition holds at all times. This condition postulates that if domestic capital markets are perfectly competitive and efficient, the domestic nominal interest rate tends to adjust fully to the expected inflation rate, producing a constant real interest rate.

Proposition 7

The uncovered interest parity condition also holds continuously. This hypothesis states that, in frictionless markets for financial assets with similar risk–return characteristics and perfect capital mobility, risk–neutral investors are indifferent toward holding their portfolios either in domestic or foreign assets because they obtain the same nominal return on the portfolios when the nominal return is converted into a common currency.

Proposition 8

From Propositions 6 and 7 follows the proposition of real interest parity, which stipulates that the nominal interest differential adjusts fully to offset the excess of the domestic expected inflation rate over the foreign expected inflation rate, thereby equalizing domestic and foreign *ex ante* real interest rates.

Proposition 9

The rational expectations hypothesis implies that market participants make no systematic errors in forecasting prices and other variables. Under rational expectations, agents are assumed to make full use of all publicly relevant information (for example, a rise in the money supply) to forecast prices. Accordingly, any increase in the nominal money supply is reflected immediately in a corresponding increase in prices to keep the real money supply constant. The rational expectations hypothesis can, therefore, be alternatively called the "monetarist expectations formation hypothesis," postulating that agents form expectations of the future inflation rate on the basis of their perception of the likely future course of monetary policy.

Proposition 10

The markets for assets are assumed to be efficient, in the sense that the current market price of an asset reflects all available information and adjusts instantaneously to incorporate new information.

3.3. The Specification of the Flexible-Price Monetary Model

Based on Propositions 1–10, we can derive a reduced-form exchange rate equation representing the flexible-price monetary model. This is done by assuming that prices, nominal interest rates, and nominal exchange rates adjust instantaneously to clear goods, money, and foreign exchange markets. It is also assumed that monetary conditions are stable at home and abroad (implying that the quantity theory of money holds at all times), that the money demand function is stable, and that purchasing power parity holds continuously. These relations are represented by the following equations, where all variables (except interest rates) are expressed in natural logarithms:

$$p = m^{\mathrm{s}} - m^{\mathrm{d}} \tag{3.1}$$

$$p^* = m^{\mathrm{s}^*} - m^{\mathrm{d}^*} \tag{3.2}$$

$$m^{\mathrm{d}} = \alpha y - \beta i \tag{3.3}$$

$$m^{\mathrm{d}*} = \alpha y^* - \beta i^* \tag{3.4}$$

$$p = s + p^* \tag{3.5}$$

where p is the price level, m is the money supply, y is the real income and i is the nominal interest rate, and s is the exchange rate expressed as the domestic currency price of one unit of the foreign currency. The superscripts d, s, and * respectively imply demand, supply, and the corresponding foreign variable. Equations (3.1) and (3.2) represent the proposition that if domestic and foreign monetary conditions are stable, then the price levels adjust instantaneously to bring the demand for money into equality with the supply of money. These equations also imply that given the real demand for money, the price level is determined by (and varies proportionately with) the nominal money supply, a result that represents the essence of the quantity theory of money. Equations (3.3) and (3.4) show that the demand for nominal money balances in each country is a stable function of real income and the nominal interest rate, where the parameters α and β measure the income elasticity and the interest rate semi-elasticity of the demand for money, respectively. Equation (3.5) is the purchasing power parity condition, showing that the exchange rate adjusts to offset the inflation differential or that the domestic price level moves in one-to-one correspondence to the exchange rate-adjusted foreign price level.

In countries operating under flexible exchange rates, the money supply is exogenous, not only determining prices through equations (3.1) and (3.2), but also the nominal interest and exchange rates through equations (3.3)–(3.5). However, in countries operating under fixed exchange rates, the money supply is endogenous, in which case equation (3.5) determines the domestic price level, whereas equations (3.1)–(3.4) determine domestic and foreign real money balances. Consequently, the underlying exchange rate regime determines the set of dependent variables, without altering the underlying structure of the model.

By combining equations (3.1)–(3.4) and assuming that the domestic and foreign authorities can determine the money supply exogenously (that is, $m^{\mathrm{s}} = m$ and $m^{\mathrm{s}*} = m^*$), we obtain

$$p - p^* = (m - m^*) - \alpha(y - y^*) + \beta(i - i^*) \tag{3.6}$$

which implies that given the real domestic and foreign demand for money, the domestic price level will be higher (lower) than the foreign price level by the extent to which the domestic money supply is higher (lower) than the foreign money supply.

Substituting equation (3.5) into equation (3.6) yields the equation of exchange rate determination of the flexible-price monetary model, which is given by

$$s = (m - m^*) - \alpha(y - y^*) + \beta(i - i^*). \tag{3.7}$$

Equation (3.7) shows that the exchange rate, which is the relative price of two national monies, is determined by the relative money supply, $(m - m^*)$, relative income, $(y - y^*)$, and the interest rate differential, $(i - i^*)$.

3.4. A Digrammatic Representation of the Flexible-Price Monetary Model

It has been established that changes in the relative money supply and money demand (triggered by changes in interest rate and income) affect the exchange rate. Three important predictions about the exchange rate follow from the flexible-price monetary model, as represented by equation (3.7). First, an increase in the money supply results in a proportional depreciation of the domestic currency. Second, an increase in real income leads to appreciation of the domestic currency. Third, an increase in the nominal interest rate leads to depreciation of the domestic currency. These predictions are illustrated in Figures 3.1–3.4.

As equation (3.7) states, the exchange rate is determined jointly by the money supply, real income, and interest rate. While changes in the money supply affect the equilibrium exchange rate directly, changes in real income

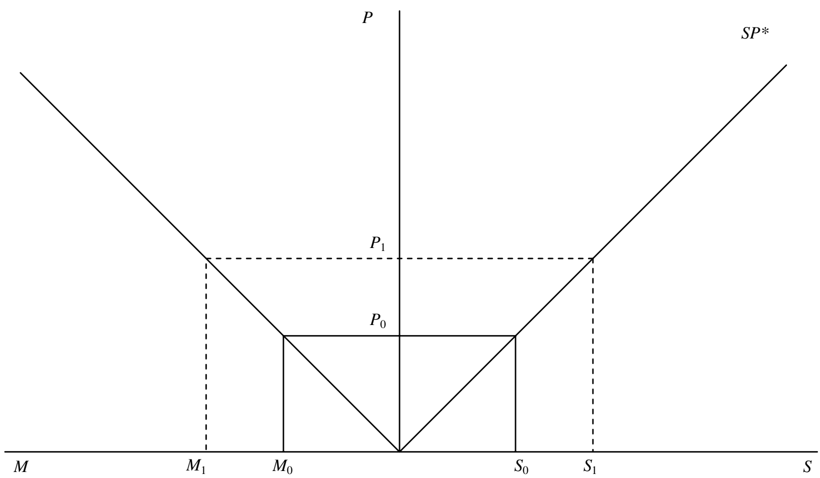

Figure 3.1. The effect of monetary expansion on the exchange rate (1).

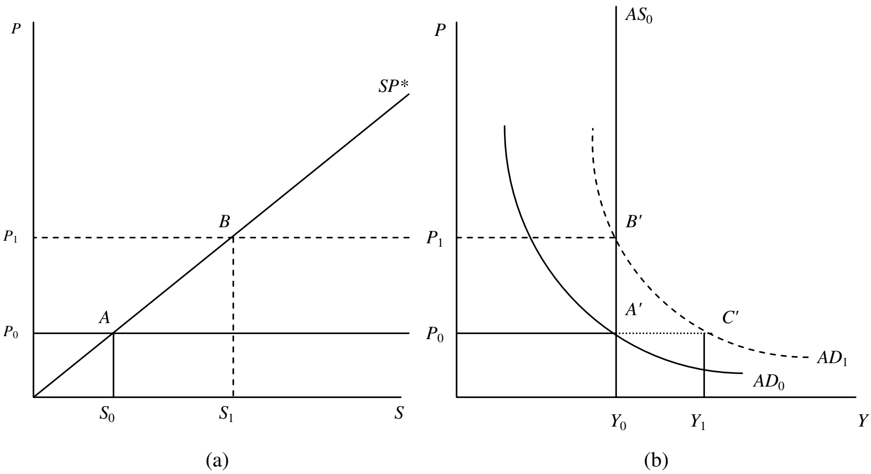

Figure 3.2. The effect of monetary expansion on the exchange rate (2).

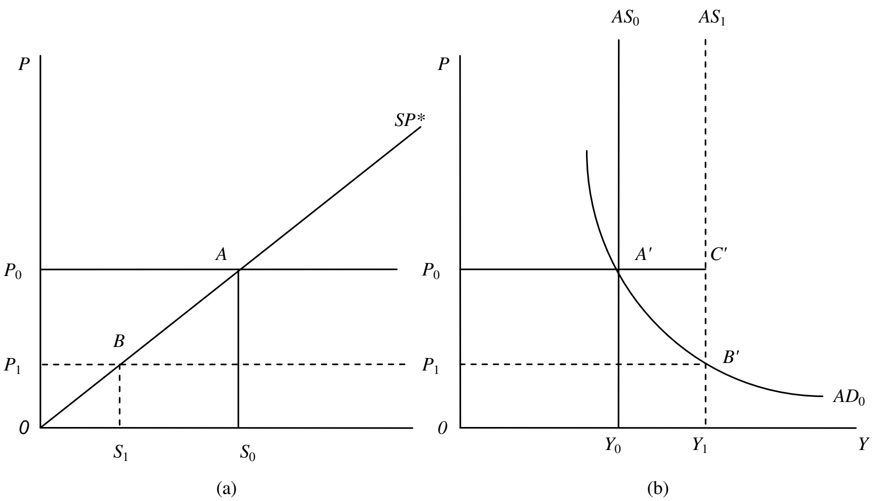

Figure 3.3. The effect of a rise in real income on the exchange rate.

and interest rate affect the exchange rate indirectly via changes in monetary conditions. For example, other factors being the same, a 10% rise in the domestic money supply leads, via the quantity theory of money, to a 10% rise in domestic prices, which (via purchasing power parity) leads to a 10%

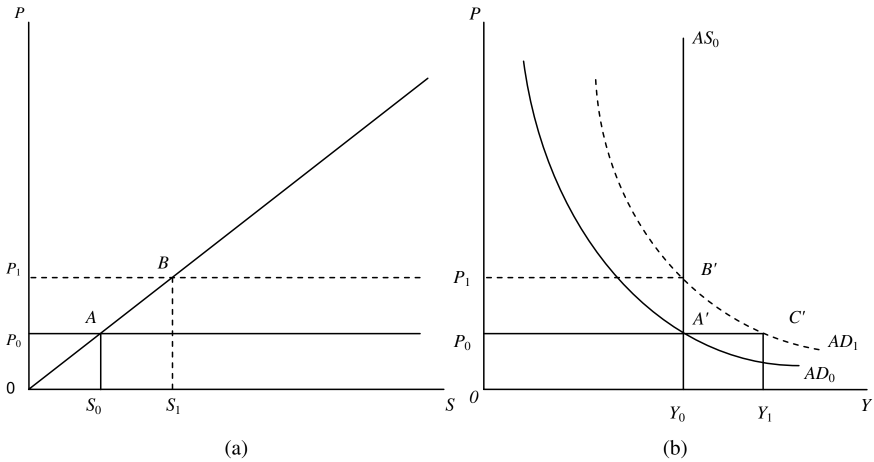

Figure 3.4. The effect of a rise in interest rate on the exchange rate.

rise in the exchange rate (depreciation of the domestic currency). This can be explained with the aid of Figure 3.1, which shows that the flexible price monetary model is in fact an extension of the quantity theory of money to an open economy. It also shows how the flexible-price monetary model works. According to the quantity theory of money, prices rise in proportion to the monetary expansion. Given foreign money supply and prices, as the domestic money supply increases from M_0 to M_1, the price level rises from P_0 to P_1 as predicted by the quantity theory of money. As a consequence of the rise in the price level from P_0 to P_1, the exchange rate rises from S_0 to S_1, as predicted by purchasing power parity.

Figure 3.2 shows that the effect on the exchange rate of a rise in the domestic money supply can also be explained with the aid of the aggregate demand curve (AD_0) and the vertical aggregate supply curve (AS_0), derived respectively for a given value of the money supply and output capacity (Y_0) by utilizing the quantity theory of money.[5] The economy is initially in equilibrium at the general price level P_0 (determined by the money supply, given the output level and the velocity of circulation, via the quantity theory of money) and at the exchange rate S_0 (determined by the ratio of domestic

[5]Given the full employment level of real output and the transaction velocity of money, the quantity theory of money $MV = PY$, links the general price level to the money supply (that is, $P = M\bar{V}/\bar{Y}$). The price level varies to ensure that real aggregate demand (which is a function of the real money supply) is brought into line with the supply of output.

to foreign prices via purchasing power parity). If the (domestic) price level is at P_0 (as shown in Figure 3.2(b)), a rise in the domestic money supply causes a shift in the aggregate demand curve to the right from AD_0 to AD_1, and as a consequence the economy moves from A' to C', showing a rise in nominal income that is proportional to the change in the money supply. The economy cannot settle at point C' because there is excess demand for goods, which will eventually lead to a rise in the domestic price level from P_0 to P_1. For a given foreign price level, a rise in the domestic price level leads (via purchasing power parity) to a proportional rise in the exchange rate from S_0 to S_1, as shown in Figure 3.2(a).

Consider now the effect on the exchange rate of an increase in real income from Y_0 to Y_1, with no change in the money supply. As shown in Figure 3.3(b), the economy is initially in equilibrium at A' where the aggregate supply of output (as represented by the vertical aggregate supply curve AS_0) is equal to the aggregate demand for output (as represented by the aggregate demand curve AD_0), putting the domestic price level at P_0. In Figure 3.3(a), the open sector of the economy is in equilibrium at point A, where the equilibrium exchange rate S_0 is consistent with the domestic price level (P_0) and real income (Y_0). At a given price level, higher real income implies increased demand for money. Put differently, with a given money supply we must have a constant nominal income (PY).[6] So, the higher is real income, the lower must be the price level. Given the price level at P_0, when nominal income rises from PY_0 to PY_1, the impact effect must be to create excess demand for money and excess supply of goods that is equal to the gap $Y_1 - Y_0$. Consequently, the economy moves from A' to C', reflecting both excess demand for money and excess supply of goods. It also follows that the domestic price level is pushed down from P_0 to P_1. In the new equilibrium position at point B', money and goods markets clear, with the same demand and supply as before the increase in real income and the same nominal income. The fall in the domestic price level from P_0 to P_1 in Figure 3.3(a) causes a proportional fall in the exchange rate from S_0 to S_1 to restore equilibrium in the open sector of the economy (and hence purchasing power parity).

What happens to the equilibrium exchange rate as a result of an increase in the domestic interest rate relative to the foreign rate is illustrated in Figure 3.4, which exhibits the relation between interest rate, prices, and

[6] If the quantity theory of money ($MV = PY$) holds, then money balances are demanded in proportion to nominal income, which gives $M = (1/v)Y = kY$.

exchange rate. The model predicts that, given the nominal money supply and real income, a rise in the domestic interest rate relative to the foreign rate implies that the domestic inflation rate is expected to rise. A rise in the domestic inflation rate in turn reflects excess demand, leading to an outward shift in the aggregate demand curve, (from AD_0 to AD_1), in which case the domestic price level increases from P_0 to P_1 and the exchange rate rises from S_0 to S_1.

It should be borne in mind that, unlike the traditional flow model, the flexible-price monetary model posits that it is stock equilibria (not flow equilibria) that determine the equilibrium exchange rate. As argued above, this does not imply that real factors (such as output) play no role at all in determining the equilibrium exchange rate. Real factors do affect exchange rates in the monetary model, but only indirectly to the extent that they first affect the demand for money. Expectations also play an important role in determining the current and future paths of the exchange rate. However, expectations in the monetary model are largely induced by monetary forces under the rational expectations hypothesis. It is therefore argued that expected changes in money stocks mainly determine expected differences in inflation rates via the quantity theory of money, whereas expected inflation differentials determine expected changes in exchange rates and differences in nominal interest rates through the Fisher effect. In essence, the flexible-price monetary model postulates that expected changes in relative money supplies lead to expectations of proportional changes in prices (or inflation differentials), which in turn lead to proportional changes in expected exchange and interest rates. Thus the current path of the exchange rate is determined not only by the current levels of national money supplies, but also by their expected levels and growth rates. If monetary forces determine both the price level and interest rate, the exchange rate reflects not only the excess of domestic over foreign price levels, but also the excess of domestic over foreign interest rates.

To understand the full workings of the flexible-price monetary model, we employ the standard *IS-LM-BP* and *AD-AS* frameworks, as shown in Figure 3.5. Initially, the open economy is in equilibrium in the markets for goods, money, and foreign exchange (as represented by the interaction of the *IS*, *LM*, and *BP* curves in Figure 3.5(a)), with interest rate at i_0 and real income at Y_0. At the real income level Y_0, the goods market clears at the equilibrium price level P_0, where aggregate demand is equal to aggregate supply (Figure 3.5(b)). On the other hand, the foreign exchange market clears at the exchange rate S_0, which brings the domestic price level (P_0) into line with the foreign price level (P_0^*).

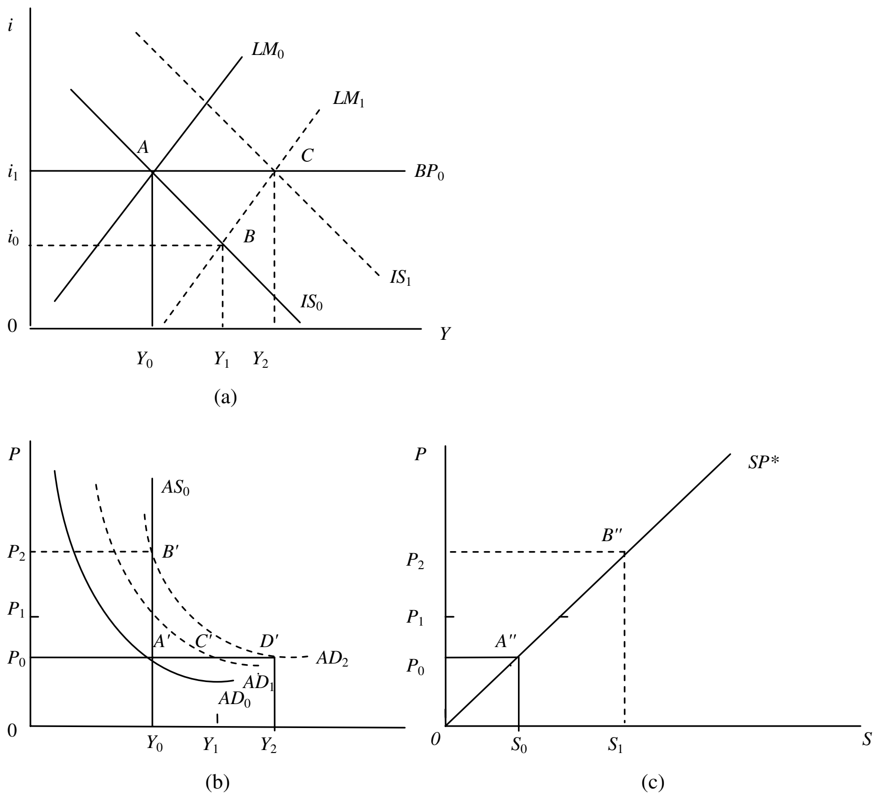

Figure 3.5. Equilibrium in the open economy and the equilibrium exchange rate.

Let us now assume that there is an increase in the money supply, which shifts the *LM* curve from LM_0 to LM_1, as shown in Figure 3.5(a). Given the price level P_0, a rise in the money supply and a consequent shift in the *LM* curve from LM_0 to LM_1 causes an outward shift in the aggregate demand curve from AD_0 to AD_1, as shown in Figure 3.5(b). As a result, the economy moves from *A* to *B* along IS_0 and from A' to C' along the *AD* curves AD_0 and AD_1, respectively. The movement from *A* to *B* reflects an incipient fall in the interest rate, which arises because of the liquidity effect. The incipient fall in the interest rate leads to an outflow of capital by making domestic assets unattractive, eventually leading to capital account deterioration. The fall in the interest rate results in an increase in income from Y_0 to Y_1 by stimulating investment, which in turn leads to deterioration in the current account via a rise in imports. Therefore, there is an overall deficit in the balance of payments at point B in Figure 3.5(a), which causes depreciation of the domestic currency under a system of flexible exchange rates. As a result, there is an improvement in the current account resulting from a rise in exports, and consequently the IS curve shifts to the right from IS_0 to IS_1, moving the economy from B to C. This in turn causes an outward shift in the aggregate demand curve from AD_1 to AD_2, moving the economy from C' to D', as shown in Figure 3.5(b). Unlike the Mundell–Fleming model, the economy in the monetary model cannot sustain equilibrium at C and D', even in the short run.

As the economy always settles at an output level that is consistent with the natural rate of unemployment, a rise in nominal income (following an expansion in the money supply) results in excess demand for output in the economy, which in turn generates expectations of a rise in prices. Thus, the excess of demand over available output (that is consistent with the natural rate of unemployment) causes inflation that is proportional to the rise in the money supply, which in turn leads to a proportional fall in the real money supply, shifting the LM curve from LM_1 to its original position of LM_0. Eventually, the economy returns to the equilibrium position that it started from, with real income and interest rate remaining at Y_0 and i_0. The economy settles at points A, B', and B'' in Figures 3.5(a), 3.5(b), and 3.5(c), respectively. The nominal interest rate rises from i_0 to i_1, the price level from P_0 to P_1 and the nominal exchange rate from S_0 to S_1.

3.5. Some Variants of the Flexible-Price Monetary Model

In this section, we consider three variants of the flexible-price monetary model of exchange rate determination. These variants of the model, which are described in turn in the following subsections are (i) the rational expectations monetary model, (ii) Frenkel's flexible-price monetary model with a wealth effect, and (iii) a general monetary model.

3.5.1. *The Rational Expectations Monetary Model*

Expectations play a special role in determining the exchange rate in the monetary model. Because the demand for domestic and foreign money depends (like the demand for any other asset) on the expected rate of return, the current value of the exchange rate must incorporate the expectations of market participants concerning the future course of events. If the foreign exchange market is efficient, market participants make full use of all publicly available information that is expected to affect the current path of the exchange rate. Therefore, the current exchange rate must reflect fully the expectations held by market participants about the future rate of monetary growth. Under the monetarist rational expectations doctrine, the expected inflation rate does not reflect past inflation rates but it is a rational forecast of the future growth rate of the money supply.[7] Therefore, as Bilson (1978a) argues, a monetary expansion is likely to lead to further depreciation by creating expectations of future monetary growth. Therefore, we obtain the following relations:

$$\Delta p^{\mathrm{e}} = \Delta m^{\mathrm{e}} \tag{3.8}$$

$$\Delta p^{*\mathrm{e}} = \Delta m^{*\mathrm{e}} \tag{3.9}$$

$$\Delta m^{\mathrm{e}} = \Delta m^{\mathrm{e}}(\Delta m, I) \tag{3.10}$$

$$\Delta m^{*\mathrm{e}} = \Delta m^{*\mathrm{e}}(\Delta m^{*}, I^{*}). \tag{3.11}$$

Equations (3.8) and (3.9) represent the monetarist hypothesis that inflationary expectations are based on what the market believes the future rate of monetary growth will be. Under rational expectations, equations (3.8) and (3.9) imply that rational economic agents have full knowledge of the structure of the economy and the theory of inflation (the quantity theory of money), which makes them capable of forecasting the future rate of monetary growth and inflation. Equations (3.10) and (3.11) explain how the money growth forecasts are formulated. Under rational expectations, economic agents form expectations rationally, using all available information (I) in predicting future monetary growth. They also revise their predictions as new information arrives, producing zero-mean, serially uncorrelated forecasting errors.

The role played by the expected inflation rate in determining the exchange rate enters the exchange rate equation via the Fisher condition and real interest parity, where the nominal interest rate is defined as the sum of the real interest rate and the expected inflation rate. Moreover, the role of expectations also enters the monetary model via uncovered interest parity, whereby the expected change in the exchange rate is proportional (or equal)

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[7] Both Frenkel (1976) and Bilson (1978a,b) base this view of expectations on the work of Sargent and Wallace (1975).

to the interest differential. Hence, we have

$$i = r^{\mathrm{e}} + \Delta p^{\mathrm{e}} \tag{3.12}$$

$$i^* = r^{*\mathrm{e}} + \Delta p^{*\mathrm{e}} \tag{3.13}$$

$$i - i^* = \Delta p^{\mathrm{e}} - \Delta p^{*\mathrm{e}} \tag{3.14}$$

$$\Delta s^{\mathrm{e}} = i - i^*. \tag{3.15}$$

An alternative version of the flexible-price monetary model can be obtained by substituting equation (3.7) into equation (3.15), which gives

$$s = (m - m^*) - \alpha(y - y^*) + \beta(\Delta s^{\mathrm{e}}). \tag{3.16}$$

An implication of the assumption that purchasing power parity holds at all times is that the expected change in the exchange rate is equal to the expected inflation differential. *Ex ante* purchasing power parity can be obtained by substituting equation (3.14) into equation (3.15):

$$\Delta s^{\mathrm{e}} = \Delta p^{\mathrm{e}} - \Delta p^{*\mathrm{e}}. \tag{3.17}$$

Furthermore, as prices are determined by the supply of money relative to the demand for money, it must be true that relative inflation expectations should be determined by the difference in the expected monetary growth rates. The interest rate differential determines the expected change in the exchange rate, which is determined by the inflation differential, and this in turn is determined by expectations about monetary growth rates. Therefore, we have

$$\Delta s^{\mathrm{e}} = i - i^* = \Delta p^{\mathrm{e}} - \Delta p^{*\mathrm{e}} = \Delta m^{\mathrm{e}} - \Delta m^{\mathrm{e}*}. \tag{3.18}$$

If $(\Delta p^{\mathrm{e}} - \Delta p^{\mathrm{e}*})$ or $(\Delta m^{\mathrm{e}} - \Delta m^{\mathrm{e}*})$ is substituted into equation (3.7), the flexible-price monetary model can be specified as

$$s = (m - m^*) - \alpha(y - y^*) + \beta(\Delta p^{\mathrm{e}} - \Delta p^{\mathrm{e}*}) \tag{3.19}$$

or

$$s = (m - m^*) - \alpha(y - y^*) + \beta(\Delta m^{\mathrm{e}} - \Delta m^{*\mathrm{e}}). \tag{3.20}$$

Equations (3.19) and (3.20) show that the interest rate differential reflects differences in the expected inflation rates, which in turn reflect differences in the expected monetary growth rates. A country experiences higher interest rates because inflationary expectations are higher as a result of the expectation of more rapid monetary growth. Thus, according to equations (3.19) and (3.20), a rise in the expected inflation differential or the expected monetary growth rates leads to depreciation of the domestic currency.

Using the covered interest parity (CIP) condition, we can derive Bilson's (1978a) equation of exchange rate determination. The CIP condition states that

$$f = i - i^* \tag{3.21}$$

where f is the forward spread. By substituting equation (3.21) into equation (3.7), we obtain

$$s = (m - m^*) - \alpha(y - y^*) + \beta f. \tag{3.22}$$

equation (3.22) tells us that a currency that sells at a forward premium ($f > 0$) should be expected to appreciate, and vice versa.

Using the identity $\Delta s^e \equiv E_t(\Delta s_{t+1}) = E_t(s_{t+1}) - s_t$, where E is the expectation operator, equation (3.16) can be rewritten as

$$\begin{aligned} s_t = {} & (1+\beta)^{-1}(m - m^*) - \alpha(1+\beta)^{-1}(y - y^*) \\ & + \beta(1+\beta)^{-1}E_t(s_{t+1}). \end{aligned} \tag{3.23}$$

By iterating equation (3.23) forward, the rational expectations solution may be written as[8]

$$s_t = \frac{1}{(1+\beta)} \sum_{i=0}^{\infty} \left(\frac{\beta}{1+\beta}\right)^i E[(m - m^*)_{t+i} - \beta(y - y^*)_{t+i} \mid \Omega_t] \tag{3.24}$$

where t and $t + i$ represent the current and future values of the underlying variables, respectively. Equation (3.24) represents the rational expectations version of the flexible-price monetary model.

3.5.2. *Frankel's Flexible-Price Monetary Model with a Wealth Effect*

Frankel (1982a) argues that one reason for the collapse of the explanatory power of the monetary model during the period 1974–78 is that there had been a large downward shift in the demand for the dollar relative to the

[8]To obtain the rational expectations solution of equation (3.23) for $t + 1$, we take a one-period lead on both sides of the equation and take one-period expectations of the resulting expression, $E_t(s_{t+1})$, which is then substituted into equation (3.23). Equation (3.24) is obtained by repeating the process for the expectation terms $E_{t+2}(s_{t+3})$, $E_{t+3}(s_{t+4})$, ...

German mark throughout the floating-rate period. He tested money demand functions for both the U.S. and Germany for the period under consideration and found that the supply of the mark (demand for the U.S. dollar) has been increasing (decreasing) at a rate of 1% per quarter. He also found evidence indicating the significance of the wealth variable in explaining money demand in both countries. As there is a long history of theoretical and empirical support for the inclusion of a wealth variable in the money demand function, Frankel (1982a) developed an alternative version of the flexible-price monetary model that accounts for the wealth effect on the exchange rate. For the purpose of specifying this version of the model, the money demand functions are modified by incorporating wealth variables to obtain:

$$m^{\mathrm{d}} = \alpha y - \beta i + \phi w \tag{3.25}$$

$$m^{\mathrm{d}*} = \alpha y^* - \beta i^* + \phi w^*. \tag{3.26}$$

By combining equations (3.1), (3.2), and (3.5), we obtain

$$s = (m - m^*) - \alpha(y - y^*) + \beta(i - i^*) - \phi(w - w^*). \tag{3.27}$$

It is also assumed that there is perfect capital mobility and substitutability, so that uncovered interest parity holds. Moreover, by combining equations (3.15) and (3.17), we find that the interest differential is equal to the expected inflation differential:

$$i - i^* = \Delta p^{\mathrm{e}} - \Delta p^{*\mathrm{e}}. \tag{3.28}$$

Thus an equivalent form of the flexible-price monetary model is

$$s = (m - m^*) - \alpha(y - y^*) + \beta(\Delta p^{\mathrm{e}} - \Delta p^{\mathrm{e}*}) - \phi(w - w^*) \tag{3.29}$$

where the exchange rate is positively related to the relative money supply and the expected inflation differential, but negatively to relative real income and relative wealth.

3.5.3. *A General Monetary Model of Exchange Rates*

Dornbusch (1976b, pp. 153–156) developed a more general monetary model of exchange rates, which in no way precludes the role of real factors, as these may be expected to enter as determinants of the demand for real balances and thus exert an effect on the nominal exchange rate. As the exchange rate is determined as part of the general (real and monetary) equilibrium of the system, there is no relevant sense in which one would want to assert that the exchange rate is an exclusively monetary phenomenon. Such a view portrays monetary and real variables as jointly influencing the equilibrium level of the exchange rate.

A more general monetary model can be derived by assuming that purchasing power parity holds only for traded goods. For this purpose, the purchasing power parity equation (3.5) is rewritten as

$$p_{\mathrm{T}} = s + p_{\mathrm{T}}^* \tag{3.30}$$

where $p_{\mathrm{T}}(p_{\mathrm{T}}^*)$ is the domestic (foreign) currency price of traded goods. By assuming that the price level is a weighted average of the prices of traded and non-traded goods, we have

$$p = \theta p_{\mathrm{N}} + (1-\theta) p_{\mathrm{T}} \tag{3.31}$$

$$p^* = \theta^* p_{\mathrm{N}}^* + (1-\theta^*) p_{\mathrm{T}}^* \tag{3.32}$$

where $\theta(\theta^*)$ denotes the share of non-traded goods and traded goods in the domestic (foreign) price index. If equal weights for non-traded and traded goods are used to construct domestic and foreign price indexes ($\theta = \theta^*$), combining equations (3.31) and (3.32) yields

$$p_{\mathrm{T}} - p_{\mathrm{T}}^* = (p - p^*) + \theta[(p_{\mathrm{T}} - p_{\mathrm{T}}^*) - (p_{\mathrm{N}} - p_{\mathrm{N}}^*)]. \tag{3.33}$$

By substituting equation (3.33) into equations (3.30) and (3.6), we obtain an exchange rate equation of the general monetary model of exchange rates

$$\begin{aligned} s = (m - m^*) - \alpha(y - y^*) + \beta(i - i^*) \\ + \theta[(p_{\mathrm{T}} - p_{\mathrm{T}}^*) - (p_{\mathrm{N}} - p_{\mathrm{N}}^*)] \end{aligned} \tag{3.34}$$

where the nominal exchange rate is determined by the demand for and supply of money as well as the relative price structures.

Dornbusch (1976b) argues that equation (3.34) represents a view of the exchange rate that is appropriate for full equilibrium or the "long run," hence providing a benchmark for judging departures and alternatives. The general monetary model represented by equation (3.34) upholds the assumption of instantaneous clearance across all markets by explicitly imposing the condition of monetary stock equilibrium, goods market equilibrium, and purchasing power parity for traded goods. It also shows that either of these conditions may not hold in the short run, which means that the exchange rate may depart from the underlying prediction. Therefore, if monetary disturbances overshadow real disturbances, the exchange rate will be determined exclusively in the asset market, and not in the goods market. Moreover, if the prices of goods are sticky in the short run, the exchange rate determination process will be dominated by asset markets (more specifically by capital mobility and money market equilibrium).

3.6. Policy Implications of the Flexible-Price Monetary Model

The flexible-price monetary model implies that money stocks and inflationary expectations are key determinants of the exchange rate and stresses the role of monetary policy in influencing these determinants. Specifically, the model postulates that money stocks are exogenously controlled by national central banks and that the public's expectations about the future purchasing power of various currencies are strongly shaped by current policy actions and announcements. The model produces a number of policy implications.[9]

First, given the foreign monetary growth rate, a pre-announced permanent reduction in domestic monetary expansion is the most effective means to halt and reverse depreciation of the domestic currency. This is because the announcement (as new information) immediately affects the exchange rate through the price expectations channel. However, this policy implication is valid only when the public firmly believe that the pre-announced policy target is a reliable indicator of the future growth rate of the money supply.

Second, exchange rate movements occur when domestic monetary policies are divergent and inconsistent across countries. Consequently, dissimilar monetary policies (that is, international differences in the rates of

[9]Humphrey (1977a, p. 7) argues that these implications are subject to the particular assumptions underlying the monetary model and that some of them are disputable. This is particularly true of the assumptions of purchasing power parity, real interest parity, and the exogeneity of real income, as the empirical evidence suggests that while these conditions may hold in long-run equilibrium, they may not hold over any realistic short-run policy horizon, nor over the transitional adjustment period following economic shocks. Consequently, any policy prescription based on the monetary model would probably be modified.

monetary growth per unit of real output) cause the money/output ratios to diverge, which in turn gives rise to differences in relative inflationary expectations and hence in relative interest rates, eventually affecting exchange rates. For the stability of exchange rates, therefore, countries must abandon divergent policies for a uniform rule tying the money growth rate to the growth rate of real income. It is, however, worth noting that, within the context of the monetary model, it is impossible for a single country to stabilize its exchange rate by adhering to a monetary rule if other countries persist in monetary fine-tuning. In short, exchange rate stability is virtually impossible when countries pursue incompatible monetary policies.

Finally, a policy of monetary coordination is the key to exchange rate stability. If all countries agree to adopt the same monetary expansion rule (for example, a rule calling for a constant rate of domestic monetary growth fixed in relation to the trend growth rate of domestic output), they will all enjoy the same long-run stable domestic inflation rate. The floating exchange rates of these countries will be virtually as constant as an institutionally fixed rate. In this case, policy coordination would allow countries to enjoy the advantages of fixed exchange rates while retaining some degree of national monetary autonomy.

3.7. Recapitulation

The monetary model may be viewed as being restrictive in the sense that agents only hold money, in which case the exchange rate moves to equilibrate the international demand for stocks of money. For example, the flexible-price monetary model assumes not only that there are no barriers segmenting international goods markets (such as transportation costs and trade barriers), but also that domestic and foreign goods are perfect substitutes. Similarly, the model makes an analogous assumption for bond markets. Not only are there no barriers segmenting international bond markets (such as transaction costs and capital controls), it is also the case that domestic and foreign bonds are perfect substitutes. In essence, the flexible-price model postulates that there is only one good (perfect price flexibility, implying purchasing power parity) and only one bond (perfect asset substitutability, implying uncovered interest parity). In the flexible-price model, the exchange rate is determined by stock equilibrium in money markets, which is achieved very quickly (if not continuously) through continuous adjustment of goods prices and bond returns, thereby maintaining complete neutrality of monetary policy on a continuous basis. The model yields an equation in which the exchange rate is determined by relative prices, which are in turn determined by the relative money supply, relative income, and interest differential under stable domestic and foreign monetary conditions. We have already derived several versions of the flexible-price model as represented by equations (3.7) and (3.19).

CHAPTER 4
The Theory of the Balance of Payments

4.1. The Price-Specie Flow Mechanism

Prior to the 1930s, there were no comprehensive theories of the balance of payments, devaluation, and balance of payments policy (Johnson, 1977, p. 218). The price-specie flow mechanism of Hume (1752) was, however, viewed as one of the earliest approaches to the balance of payments. While this mechanism is recognized to be the historical origin of the monetary approach to the balance of payments, Johnson (1977) regarded it as no more than a well worked out theory of the mechanism of international adjustment under the gold standard.[1] Johnson (1972a, p. 1555) argues that Hume was concerned about refuting the mercantilists' policy of accumulating precious metals within a country and their consequent recommendation of policies designed to bring about a surplus in the balance of payments.

Hume (1752) used the price-specie flow mechanism to demonstrate the impossibility of the mercantilist goal of maintaining permanently balance of payments surplus and a corresponding persistent specie inflow. He noted that the additional specie would (by raising domestic prices relative to foreign prices and so discouraging exports and spurring imports) result in a balance of payments deficit and eventually a reversal of the specie flow. Based on the quantity theory of money, it was demonstrated that the mercantilist fear of the scarcity of money was unwarranted as any quantity of money, via a proportional adjustment in prices, could drive the trade of a country. Thus, the price-specie flow mechanism, which is *per se* a corollary of the quantity theory of money, demonstrates that a surplus in a country's balance of payments causes relative prices to rise via a consequent expansion in the money supply, which in turn establishes equilibrium in the balance of payments by reducing exports and raising imports.

[1] See Johnson (1972a) and Frenkel and Johnson (1976).

To understand how this mechanism works, let us first look at how the exchange rate is determined under the gold standard. Each country defines the gold content of its currency and then stands ready to convert its paper currency (or fiat money) into gold at a fixed price. As the gold content in a unit of each currency is fixed, exchange rates are also fixed. This is known as the mint parity, at which one country's currency could be exchanged for another country's currency. Suppose that x and y are the domestic and foreign currencies, respectively, and that the price of an ounce of gold is a units of x and b units of y. Therefore, the mint parity at which the domestic currency is exchanged for the foreign currency under the gold standard is given by

$$(x/y)^M = \frac{a}{b}. \tag{4.1}$$

The equilibrium exchange rate can move between the gold import and export points, setting lower and upper limit around the mint parity.[2] If the cost of shipping gold between the two countries is a fraction, e, of the value of the gold shipped, then the gold export and import points from the perspective of the home country are respectively given by[3]

$$(x/y)^U = \frac{a}{b} + e\left(\frac{a}{b}\right) = (1+e)\left(\frac{a}{b}\right) \tag{4.2}$$

$$(x/y)^L = \frac{a}{b} - e\left(\frac{a}{b}\right) = (1-e)\left(\frac{a}{b}\right). \tag{4.3}$$

The gold export and import points imply that no resident in the home country would be willing to pay more than $(1+e)(a/b)$ units of x for one unit of y and receive less than $(1-e)(a/b)$ units of x for one unit of y. This is because it is possible to buy a/b units of x worth of gold, ship it to the other country and sell it for one unit of y, and vice versa. The gold export and import points have implications for the shape of the supply and demand curves for foreign exchange (currency y) curves. The supply curve becomes infinitely elastic or horizontal at the gold export point, while the demand curve becomes horizontal at the gold import point. In between, they have the normal upward and downward sloping shapes. This is illustrated in

[2]During the period 1880–1914, the mint parity between the dollar and pound was approximately \$4.875, based on a U.S. official gold price of \$20.67 per ounce and a U.K. official gold price of £4.24 per ounce. The dollar/pound exchange rate would not fluctuate beyond the gold point (about 3 cents above and below the mint parity), which represented the cost of shipping. At any exchange rate outside the gold points, it would be possible to gain arbitrage profit by converting currency into gold and shipping the gold to another center.

[3]For a detailed discussion, see Moosa (1998, p. 155).

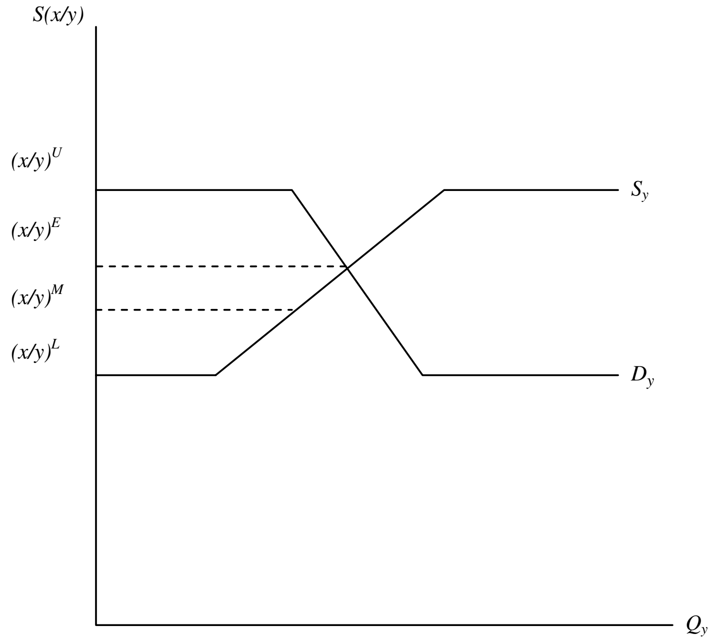

Figure 4.1. The equilibrium exchange rate under gold standard.

Figure 4.1, which shows that the equilibrium exchange rate $(x/y)^E$ is above the mint parity rate, $(x/y)^M$. The exchange rate can move between the gold import and export points but not outside this range.

Let us now describe how the balance of payments deficit or surplus is corrected automatically under the gold standard through the price-specie flow mechanism. Suppose that the home country buys more goods and services from the foreign country, which means that the home country has a trade deficit with the foreign country. When looked at in the light of the price-specie flow mechanism, it follows that the residents of the home country wish to import more goods and services from the foreign country than do the residents of the foreign country. This means that the residents of the home country have to supply more units of currency *x* than are demanded by the residents of the foreign country. The supply–demand imbalance reduces the value of *x* relative to *y* if the two countries are operating under flexible exchange rates, but this does not happen under the gold standard. Rather, as soon as the domestic currency (*x*) dips even slightly below the mint parity, people will sell it to the central bank for gold, ship the gold to the foreign country, and sell it in exchange for the foreign currency (y). As a result, gold begins to move out of the deficit country, leading to a monetary contraction. Thus, the deficit country loses gold, whereas the surplus country accumulates gold. Given the quantity theory of money, the deficit country experiences deflation while the surplus country experiences inflation, which leads to a correction of the balance of payments.

Figure 4.2 illustrates the channels through which the price-specie flow mechanism re-establishes equilibrium in the balance of payments after a country experiences a deficit or a surplus. The movement of gold into the surplus country results in a monetary expansion, whereas the movement of gold out of the deficit country results in a monetary contraction. Consequently, prices rise in the surplus country and fall in the deficit country, in which case exports fall in the former and rise in the latter while imports rise in the former and fall in the latter. This process would continue until equilibrium in the balance of payments is restored.

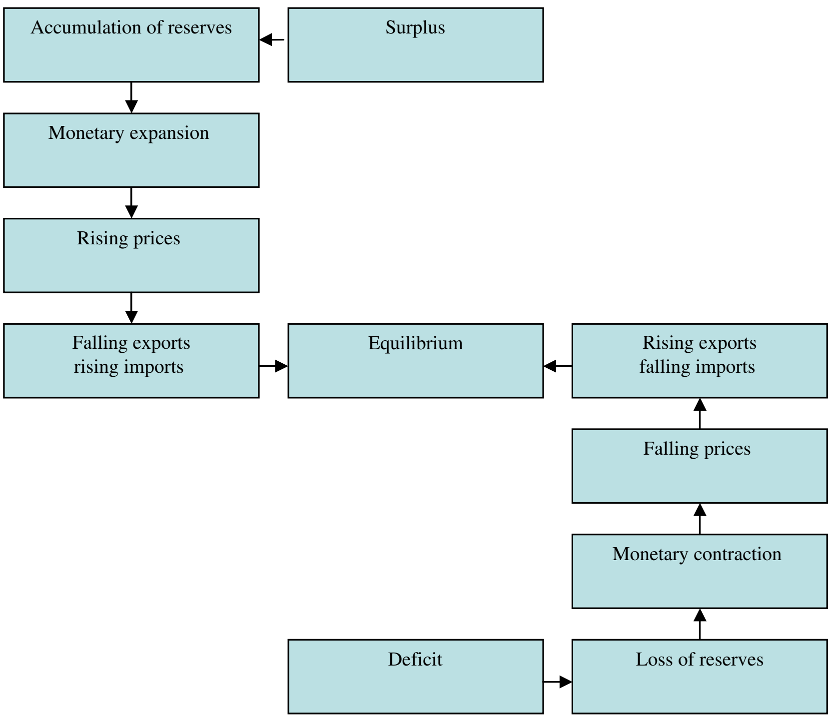

Figure 4.2. The price-specie–flow mechanism.

4.2. The Elasticities Approach and the J-Curve Effect

Bickerdike (1920), Robinson (1937), and Metzler (1948) are credited with developing a popular model of balance of payments that has come to be known as the elasticities approach to devaluation or the balance of payments.[4] The elasticities approach is based on the assumption of partial equilibrium in the markets for imports and exports. While there is extensive literature on the elasticities approach to devaluation, Marshall (1923) was the first economist to point out that devaluation might produce an unfavorable effect on the trade balance in equilibrium, provided that "the total elasticity of demand of each country be less than unity, and on the average be less than one half. . . ."[5] This proposition was restated later by Lerner (1944, p. 378), and has come to be known as the Marshall–Lerner condition. Work on this issue was extended considerably by Brown (1942) who started with the same premise of a trade balance in equilibrium analysis but introduced the elasticities of supply, the marginal propensities to import, and several other factors as determinants of the trade balance upon devaluation. Robinson (1937), however, discarded the assumption of trade balance equilibrium and derived a formula for the effect of devaluation on the trade balance (which is not in equilibrium), but only for the case of when the balance is expressed in domestic currency terms.

In a nutshell, the elasticities approach to the balance of payments is based on the Marshallian partial equilibrium analysis designed to address three questions. First, is devaluation effective in improving a devaluing country's trade balance? Second, what would be the implications of devaluation for economic activity and employment in a political environment that is hostile to the idea of securing "full employment" by more direct governmental policies? Third, is an improvement in the terms of trade equivalent to an increase in the welfare of the devaluing country?

The elasticities approach begins with the assumption that the prices of exports and imports adjust to equilibrate the demand for and supply of exports and imports. According to this approach, the trade balance equation is differentiated with respect to the exchange rate and then the results are translated to establish the "elasticities conditions" necessary for a positive effect of devaluation on the trade balance. While there are various variants of the elasticities conditions for successful devaluation, the simplest is the

[4] See, for example, Dornbusch (1975, p. 859).
[5] See Hirschman (1949).

Marshall–Lerner condition. Based on a standard two-country (home and foreign), two-commodity (exports and imports) model and the assumption that underemployment exists in each country, the Marshall–Lerner condition can be derived from the trade balance equation:

$$B_{\mathrm{f}} = \frac{P_{\mathrm{x}}}{S} Q_{\mathrm{x}} \left(\frac{P_{\mathrm{x}}}{S} \right) - P_{\mathrm{m}} Q_{\mathrm{m}} (S P_{\mathrm{m}}) \tag{4.4}$$

where B_{f} is the domestic trade surplus or deficit in foreign currency terms, S is the exchange rate (defined as the domestic currency price of a unit of the foreign currency), $P_{\mathrm{x}}(P_{\mathrm{m}})$ is the home currency price of exports (imports), and $Q_{\mathrm{x}}(Q_{\mathrm{m}})$ is the physical quantity of exports (imports). The foreign currency value of exports is the foreign price of exports (P_{x}/S) multiplied by the quantity of exports (Q_{x}), where the latter is a function of P_{x}/S. Likewise, the foreign currency value of imports is the foreign currency price of imports (P_{m}) multiplied by the quantity of imports (Q_{m}), which is a function of the domestic currency price of imports (SP_{m}). By differentiating equation (4.4) with respect to S, we obtain

$$\frac{\mathrm{d}B_{\mathrm{f}}}{\mathrm{d}S} = \frac{P_{\mathrm{x}}}{S} \frac{\mathrm{d}Q_{\mathrm{x}}}{\mathrm{d}S} + Q_{\mathrm{x}} \frac{\mathrm{d}(P_{\mathrm{x}}/S)}{\mathrm{d}S} - \frac{P_{\mathrm{m}} \mathrm{d}Q_{\mathrm{m}}}{\mathrm{d}S} \tag{4.5}$$

which, after simplification, can be written as

$$\frac{\mathrm{d}B_{\mathrm{f}}}{\mathrm{d}S} = \frac{P_{\mathrm{x}}}{S} \cdot \frac{\mathrm{d}Q_{\mathrm{x}}}{\mathrm{d}S} - P_{\mathrm{m}} \frac{\mathrm{d}Q_{\mathrm{m}}}{\mathrm{d}S} - \frac{P_{\mathrm{x}} Q_{\mathrm{x}}}{S^2}. \tag{4.6}$$

By multiplying and dividing the first and second terms on the right-hand side of equation (4.6) to form elasticities, we have

$$\begin{aligned} \frac{\mathrm{d}B_{\mathrm{f}}}{\mathrm{d}S} = {} & \frac{P_{\mathrm{x}}}{S} \left[\frac{Q_{\mathrm{x}}}{S} \left(\frac{S}{Q_{\mathrm{x}}} \cdot \frac{\mathrm{d}Q_{\mathrm{x}}}{\mathrm{d}S} \right) \right] \\ & - P_{\mathrm{m}} \left[\frac{Q_{\mathrm{m}}}{S} \left(\frac{S}{Q_{\mathrm{m}}} \cdot \frac{\mathrm{d}Q_{\mathrm{m}}}{\mathrm{d}S} \right) \right] - \frac{P_{\mathrm{x}} Q_{\mathrm{x}}}{S^2}. \end{aligned} \tag{4.7}$$

Let us now define the elasticities of the supply of and demand for foreign exchange of the home country (E_{sd} and E_{dd}) as

$$E_{\mathrm{sd}} = \left[\frac{S}{Q_{\mathrm{x}}} \cdot \frac{\mathrm{d}Q_{\mathrm{x}}}{\mathrm{d}S} \right] \tag{4.8}$$

$$E_{\mathrm{dd}} = - \left[\frac{S}{Q_{\mathrm{m}}} \cdot \frac{\mathrm{d}Q_{\mathrm{m}}}{\mathrm{d}S} \right]. \tag{4.9}$$

By substituting equations (4.8) and (4.9) into equation (4.7), we obtain

$$\frac{\mathrm{d}B_{\mathrm{f}}}{\mathrm{d}S} = \frac{P_{\mathrm{x}}Q_{\mathrm{x}}}{S^2}E_{\mathrm{sd}} + \frac{P_{\mathrm{m}}Q_{\mathrm{m}}}{S}E_{\mathrm{dd}} - \frac{P_{\mathrm{x}}Q_{\mathrm{x}}}{S^2}. \tag{4.10}$$

Simplifying, by setting $S = P_{\mathrm{m}} = P_{\mathrm{x}} = 1$ and assuming initial equilibrium in the trade balance, we obtain

$$\frac{1}{Q_{\mathrm{x}}}\frac{\mathrm{d}B_{\mathrm{f}}}{\mathrm{d}S} = E_{\mathrm{sd}} + E_{\mathrm{dd}} - 1. \tag{4.11}$$

Equation (4.11) implies that for devaluation to have a positive effect on the trade balance, the sum of the domestic elasticities of the supply of and demand for foreign exchange must be greater than unity.

It is, however, worth noting that a country's demand for and supply of foreign exchange are not homogenous schedules. In fact, each schedule can be looked at in terms of a single elasticity, like the demand and supply schedules for a commodity. On the contrary, each elasticity is highly composite, being made of many different goods and services. Moreover, as argued by Robinson (1937), the elasticities of the supply of and demand for foreign exchange depend on four elasticities. The elasticity of domestic supply of foreign exchange depends upon the elasticity of foreign demand for exports (η_{x}) and the elasticity of domestic supply of exports (ε_{x}). The elasticity of domestic demand for foreign exchange depends on the elasticity of domestic demand for imports (η_{m}) and the elasticity of foreign supply of imports (ε_{m}).

As the elasticities approach is a partial equilibrium version of a standard two-country, two-commodity model, the effects of exchange rate changes on the markets for imports and exports can be analyzed separately. Assuming partial equilibrium in both export and import markets, equation (4.4) can be written as

$$\begin{aligned} B_{\mathrm{f}} = {} & \frac{1}{S}P_{\mathrm{x}}Q_{\mathrm{x}}[Q_{\mathrm{x}}^{\mathrm{d}}(P_{\mathrm{x}}/S) = Q_{\mathrm{x}}^{\mathrm{s}}(P_{\mathrm{x}})] \\ & - P_{\mathrm{m}}Q_{\mathrm{m}}[Q_{\mathrm{m}}^{\mathrm{d}}(SP_{\mathrm{m}}) = Q_{\mathrm{m}}^{\mathrm{s}}(P_{\mathrm{m}})] \end{aligned} \tag{4.12}$$

where the equal to signs in the square brackets represent the equilibrium condition of equality between demand and supply. By differentiating equation (4.12) with respect to own prices and then substituting the result into the own-price elasticities of the supply of exports, demand for exports, supply of imports, and demand for imports, we obtain[6]

$$\frac{1}{Q_{\mathrm{x}}}\frac{\mathrm{d}B_{\mathrm{f}}}{\mathrm{d}S} = \frac{\varepsilon_{\mathrm{x}}\varepsilon_{\mathrm{m}}(\eta_{\mathrm{x}} + \eta_{\mathrm{m}} - 1) + \eta_{\mathrm{x}}\eta_{\mathrm{m}}(\varepsilon_{\mathrm{x}} + \varepsilon_{\mathrm{m}} + 1)}{(\varepsilon_{\mathrm{x}} + \eta_{\mathrm{x}})(\varepsilon_{\mathrm{m}} + \eta_{\mathrm{m}})} \tag{4.13}$$

where

$$\eta_{\mathrm{x}} = -\frac{\mathrm{d}Q_{\mathrm{x}}^{\mathrm{d}}}{\mathrm{d}(P_{\mathrm{x}}/S)} \cdot \frac{P_{\mathrm{x}}/S}{Q_{\mathrm{x}}^{\mathrm{d}}} \tag{4.14}$$

$$\eta_{\mathrm{m}} = -\frac{\mathrm{d}Q_{\mathrm{m}}^{\mathrm{d}}}{\mathrm{d}(SP_{\mathrm{m}})} \cdot \frac{SP_{\mathrm{m}}}{Q_{\mathrm{m}}^{\mathrm{d}}} \tag{4.15}$$

$$\varepsilon_{\mathrm{x}} = \frac{\mathrm{d}Q_{\mathrm{x}}^{\mathrm{s}}}{\mathrm{d}P_{\mathrm{x}}} \cdot \frac{P_{\mathrm{x}}}{Q_{\mathrm{x}}^{\mathrm{s}}} \tag{4.16}$$

$$\varepsilon_{\mathrm{m}} = \frac{\mathrm{d}Q_{\mathrm{m}}^{\mathrm{s}}}{\mathrm{d}(P_{\mathrm{m}})} \cdot \frac{P_{\mathrm{m}}}{Q_{\mathrm{m}}^{\mathrm{s}}}. \tag{4.17}$$

Equation (4.13) represents the effects of devaluation on the trade balance in terms of the four elasticities, showing that the conditions for improvement are $\eta_{\mathrm{x}}\eta_{\mathrm{m}} > \varepsilon_{\mathrm{x}}\varepsilon_{\mathrm{m}}$ and $\eta_{\mathrm{x}} + \eta_{\mathrm{m}} - 1 > 0$.

Figure 4.3 illustrates the effect of devaluation of the domestic currency (a higher exchange rate) on the current account (or trade balance). In Figures 4.3(a) and 4.3(b), devaluation is ineffective because the elasticities of demand for imports and exports are low. This is represented diagrammatically by steep demand curves for imports and exports. In this case, devaluation results in a small reduction in import expenditure, as shown in Figure 4.3(a), and a fall (rather than a rise) in exports revenue, as shown in Figure 4.3(b). The latter occurs because devaluation in this case reduces the foreign currency price of exports by more than the increase in the quantity of exports demanded. Hence, devaluation may lead to deterioration rather than improvement in the current account. In Figures 4.3(c) and 4.3(d), on the other hand, demand is elastic, as represented by shallow demand curves for exports. Devaluation in this case causes a significant reduction in import expenditure and a rise (not a fall) in export revenue, leading to improvement in the current account.

While there is abundant evidence to suggest that the Marshall–Lerner condition is indeed met (at least for industrial countries), there are circumstances under which devaluation is not successful. For example, one might

[6]For derivation, see Johnson (1977, pp. 219 and 220).

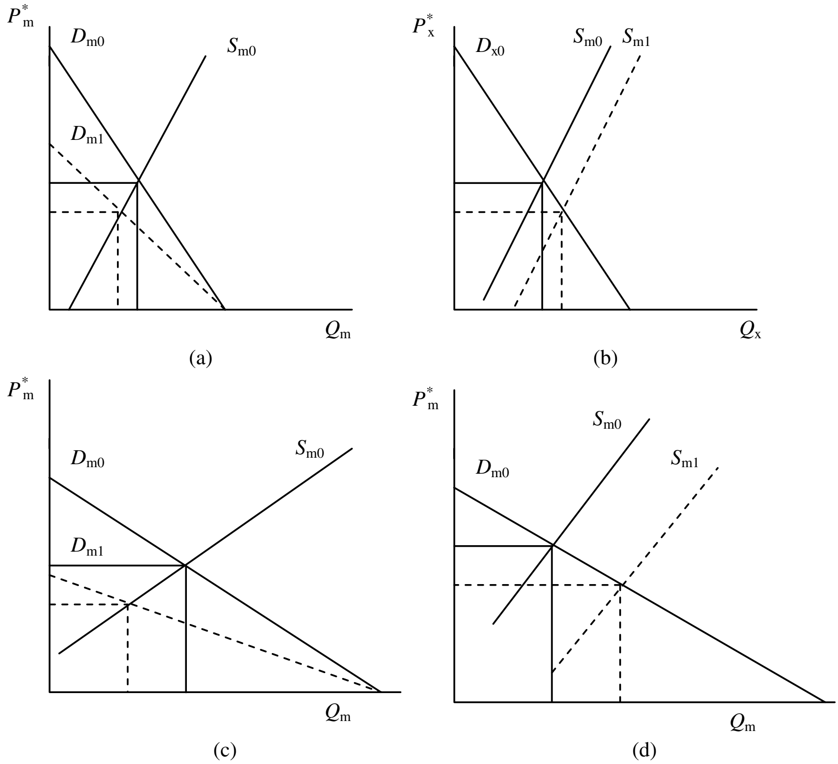

Figure 4.3. The effect of devaluation when elasticities are low and high.

wonder why the U.S. trade balance deteriorated so much in 1972 despite the 1971 devaluation of the dollar. This unfavorable effect of devaluation on the trade balance is known as the "J-curve effect," which stipulates that following devaluation the trade balance of the devaluing country worsens before it begins to improve. This is because the Marshall–Lerner condition is not satisfied in the short run but it is in the long run. If the elasticity of demand is lower in the short run than in the long run, there is a possibility that the current account may deteriorate even further in the short run before recovering in the long run. This phenomenon is illustrated in Figure 4.4. At time t_1, when the trade balance is in deficit, a decision is taken to correct it by devaluation. In the period immediately following devaluation, the trade balance deteriorates, registering a larger deficit. With the passage of time, elasticities increase and once the Marshall–Lerner condition is satisfied, the current account starts to improve. At time t_2, the deficit reaches its highest

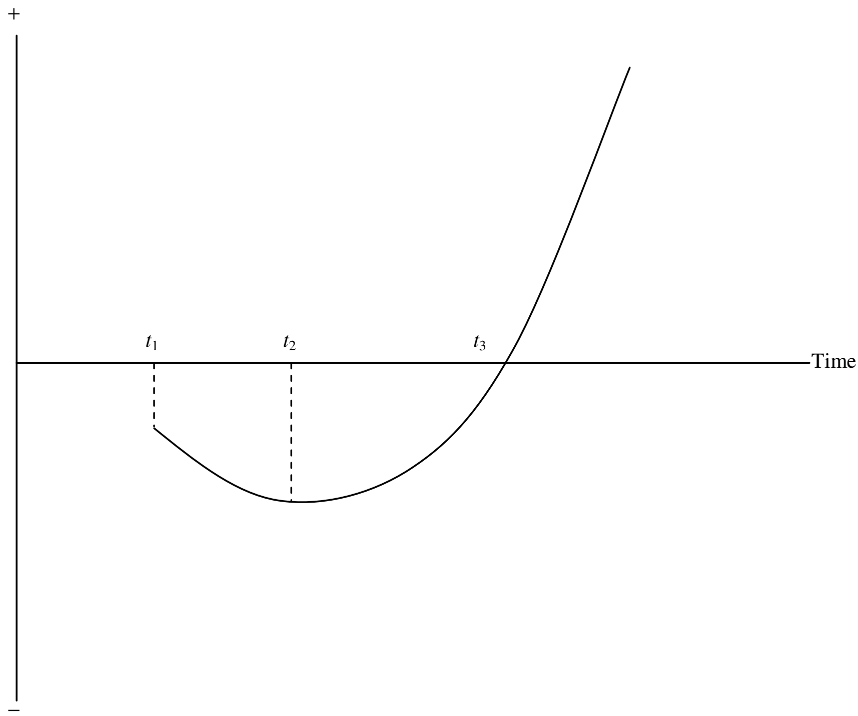

Figure 4.4. The J-curve effect.

value, and from there onward it begins to shrink. At time t_3, the deficit is eliminated, and this is followed by the achievement of a surplus. The time path of the trade balance position resembles the letter J, and this is why this process is called the J-curve effect.

Several reasons have been put forward to rationalize the existence of the J-curve effect. Krueger (1983) argues that this phenomenon emanates from the fact that at the time the exchange rate changes, goods already in transit and under contract have been purchased, and the completion of those transactions dominates short-term changes in the trade balance. Therefore, the trade balance deteriorates first, but after the passage of time (during which the elasticities have a chance to change) it begins to improve. Magee (1973) has attributed the J-curve effect to the fact that the rapid increase in activity (measured by real income) relative to economic activity abroad may swamp any favorable effects that might arise. He argues that the J-curve effect tends to emerge in the period during which contracts already in force in specified currencies dominate current account transactions. Over time, however, post-devaluation contracts begin to dominate, and the "pass-through" of devaluation begins to materialize. Finally, Junz and Rhomberg (1973) argue that expansion in exports and contraction in imports occur only after substantial lags. They identify at least five lags in the process between a change in the exchange rate and its ultimate effect on trade. The relevant lags pertain to (i) recognition of the changed situation, (ii) the decision to change real variables, (iii) delivery time, (iv) replacement of inventories and materials, and (v) production.

4.3. The Keynesian Multiplier Approach

Based on general equilibrium analysis of demand relations and the income multiplier, the Keynesian approach to the balance of payments was developed by Harberger (1950), Laursen and Metzler (1950), and Meade (1951). For a simplified analysis, it is assumed that the elasticities of supply are infinite, making changes in the exchange rate and the terms of trade identical and the exchange rate merely a control instrument over the terms of trade.

A simplified exposition of this approach, after the normalization of domestic currency prices and the exchange rate to unity, can be represented by the three-equation system:

$$Y_{\mathrm{h}} = E_{\mathrm{h}}(Y_{\mathrm{h}}) + M_{\mathrm{f}}(Y_{\mathrm{f}}, S) - M_{\mathrm{h}}(Y_{\mathrm{h}}, S) \tag{4.18}$$

$$Y_{\mathrm{f}} = E_{\mathrm{f}}(Y_{\mathrm{f}}) - \frac{M_{\mathrm{f}}}{S}(Y_{\mathrm{f}}, S) + M_{\mathrm{h}}(Y_{\mathrm{h}}, S) \tag{4.19}$$

$$\frac{B}{S} = \frac{M_{\mathrm{f}}}{S}(Y_{\mathrm{f}}, S) - M_{\mathrm{h}}(Y_{\mathrm{h}}, S) \tag{4.20}$$

where the variables with a subscript h are domestic variables, whereas the variables with a subscript f are foreign variables. By differentiating, with the assumption that the current account is in balance initially, a condition can be derived that must be fulfilled for devaluation to have a positive effect on the trade balance. The condition is

$$\frac{1}{M}\frac{\mathrm{d}\left(\frac{B}{S}\right)}{\mathrm{d}S} = \frac{(1-E_{\mathrm{h}})(1-E_{\mathrm{f}})(\eta_{\mathrm{h}}+\eta_{\mathrm{f}}-1)}{(1-E_{\mathrm{h}})m_{\mathrm{f}}+(1-E_{\mathrm{f}})m_{\mathrm{h}}+(1-E_{\mathrm{f}})(1-E_{\mathrm{h}})} \tag{4.21}$$

where $1-E$ is the marginal propensity to save, m is the marginal propensity to import, and η is the elasticity of demand for imports. For devaluation to improve the trade balance, two conditions must be met: (i) the marginal propensities to save and import must be less than unity but greater than zero and (ii) the sum of the elasticities of demand for imports and exports must be greater than unity.

As shown clearly by equation (4.21), the Keynesian general equilibrium multiplier approach is not quantitatively different from the elasticities approach. This is because, like the elasticities approach, the Keynesian approach emphasizes the Marshall–Lerner condition. However, there are some additional conditions that must be satisfied in the case of the Keynesian approach. First, the fulfillment of the Marshall–Lerner condition cannot produce improvement in the trade balance unless there are unemployed resources to absorb excess demand for domestic output. Thus if resources were fully employed, the excess demand for domestic output resulting from devaluation would drive the exchange rate back up to its initial level via a proportional rise in domestic prices. Second, as Metzler (1951) argues, one of the marginal propensities to save could be negative without making the equilibrium of the world system unstable. It is reasonable to assume that, in a closed economy, there is a positive period-by-period flow of saving and investment, without taking account of the effect of accumulation on productive capacity and unemployed resources. In an open economy, on the other hand, the excess of domestic saving over domestic investment is assumed to go into the accumulation of international reserves (or, more accurately, into domestic money balances or securities obtained by exchanging foreign money with the monetary authorities). So it may be reasonable to postulate a continuing flow of foreign assets in the Keynesian equilibrium model, but it is far less reasonable to make the arbitrary assumption that the accumulation necessarily takes the form of domestic cash by residents and international reserves by the monetary authorities. This leads to a third criticism of the "naïve" partial-equilibrium elasticities approach, which is equally applicable to the "sophisticated" elasticities-cum-multipliers Keynesian model. In principle, it is incorrect to treat a stock adjustment process (such as that involved in a balance of payment disequilibrium) as an income-related flow whose equilibrium magnitude is determined by the general equilibrium flow relation.

4.4. The Income Absorption Approach

The elasticities approach was particularly relevant to the economic conditions characterized by the depression and unemployment of the 1930s. Consequently, this approach became far less defensible and usable in the immediate period of suppressed and open inflation. However, the majority of economists continue to apply the elasticities approach to inflationary conditions by rationalizing its failure in the short run in terms of the J-curve effect. It is argued that devaluation leads to current account improvement in the long run and deterioration in the short run, thereby giving rise to a debate between the "elasticities pessimists" and the "elasticities optimists."

In contrast, Alexander (1952) bypassed the elasticities issue and went directly to the core issue of inflationary conditions to emphasize that it is not price changes alone (but also income changes) that determine the effect of devaluation on the trade balance. Alexander (1952) argued that while the Marshallian partial equilibrium analysis of supply and demand is a very useful tool for analyzing the factors determining the price and output for a single good, its extension to the analysis of the effects of devaluation on imports and exports as a whole can be questionable. This approach, however, is of restrictive use in the determination of total employment and output in the economy. The complexity of the relations that govern the demand and supply conditions in international trade requires the conventional elasticities formulae to be stated in terms of total (not partial) elasticities. This is because partial elasticities measure the effects of price changes on the quantities of exports and imports only, thereby ignoring the effect of changes in other variables (such as income) that may offset the effects of devaluation. Total elasticities, which are appropriate for the analysis of the effects of devaluation, depend on the behavior of the whole economic system.

Alexander (1952) developed an alternative approach, which is known as the income-absorption or the aggregate spending approach, to analyze the effect of devaluation on the trade balance. This approach takes into account the effects of changes in both price and income following devaluation. Let us begin with the national income identity, showing that total income is equal to consumption (C) plus investment (I) plus government expenditure (G) plus exports (X) minus imports (M), which gives

$$Y = C + I + G + X - M. \tag{4.22}$$

Equation (4.22) can be shortened by merging the first three terms ($C + I + G$) on the right-hand side and representing them by A, which is the fraction of Y "absorbed" as a result of spending by households, businesses, and the government. The term X-M is the difference between exports and imports, which constitutes the trade balance (B). Thus national income is the sum of absorption and the trade balance:

$$Y = A + B. \tag{4.23}$$

It follows that the trade balance must always be the difference between income and absorption, as given by

$$B = Y - A. \tag{4.24}$$

Thus if $Y > A$, the trade balance is in surplus, while if $Y < A$, it is in deficit. If devaluation is to affect the trade balance, it can do so in two ways: (i) it can change production as a result of an induced change in absorption and (ii) it can change the amount of real absorption associated with any given level of real income. Thus a change in the trade balance ($\mathrm{d}B$) is equal to the difference between the change in output ($\mathrm{d}Y$) and the change in absorption ($\mathrm{d}A$):

$$\mathrm{d}B = \mathrm{d}Y - \mathrm{d}A. \tag{4.25}$$

Devaluation leads to two effects on the absorption of goods and services in a devaluing country. First, devaluation leads to an increase in real income, which boosts real consumption (absorption) proportionately to the increase in income (that is, $c\mathrm{d}Y$). Second, devaluation has a direct effect on absorption (*DE*):

$$\mathrm{d}A = c\mathrm{d}Y - DE \tag{4.26}$$

where c is the propensity to absorb, which is equal to the propensity to consume plus the propensity to invest, and *DE* is the direct effect of devaluation on absorption. Substituting equation (4.26) into equation (4.25), we obtain

$$\mathrm{d}B = (1 - c)\mathrm{d}Y + DE. \tag{4.27}$$

Equation (4.27) is useful because it provides answers to three basic questions pertaining to the processes whereby (i) devaluation affects income, (ii) a change in income affects absorption, and (iii) devaluation affects absorption directly at any given level of income. These questions also pertain to the values of c and *DE*. To provide answers to these questions in precise terms, one has to take into consideration the entire economic structure of the devaluing country and of the rest of the world.

Devaluation leads to an increase in the real income of the devaluing country when its exports go up, consequently domestic demand is stimulated through the multiplier effect, provided that there are unemployed resources in the devaluing country. Besides the multiplier effect, the effect of devaluation on income depends on two other factors: (i) the degree to which a higher level of output is likely to materialize without an extensive rise in prices in the devaluing country and (ii) the degree to which the rest of the world can absorb the increase in exports associated with the decline in the foreign prices of exports resulting from devaluation.

The net effect of devaluation on the trade balance depends not only on the total amount of additional production induced in the devaluing country, but also on the difference between the total amount of production and the induced increase in consumption. Under conditions of unemployment, devaluation will have a positive effect on the trade balance only if the propensity to absorb goods and services is less than unity and the sum of the total elasticities of demand for exports and imports (entering into the determination of $\mathrm{d}Y/\mathrm{d}S$) is greater than unity. If c is greater than unity, the balance of trade will not improve as a result of a higher level of output. Under these circumstances, devaluation might be effective in stimulating recovery but not in improving the trade balance, except possibly through the direct effect (DE), as implied by equation (4.27). On the contrary, if resources are fully employed, devaluation will simply cause inflation (the variables are implicitly measured at world prices) with elasticities being irrelevant to the size of the effect on the trade balance.

If there is full employment initially, or if c is almost unity or greater than unity, the only way for devaluation to have a positive effect on the trade balance is through the direct effect on absorption (that is, a fall in absorption). Absorption in fact measures the extent to which C, I, and G contribute to national income. Notice that if $Y - A > 0$, then the foreign sector contributes to national income. If, on the other hand, $Y - A < 0$, the foreign sector is a drag on the domestic economy. If we start with full employment equilibrium, it is not possible to produce more goods and services (output remains unchanged). Under these circumstances, if the domestic currency is devalued, net exports will increase and the end result will be strictly inflation. When foreigners want to spend more on domestic goods, without a corresponding increase in domestic output, the high level of demand for domestic goods will only result in a rise in domestic prices. Under conditions of full employment, therefore, the success of devaluation depends entirely on a reduction in the level of real domestic spending. If real absorption cannot be reduced, excess spending caused by devaluation will generate inflation, eventually offsetting the effect of devaluation.

The Keynesian and the absorption approaches to the balance of payments can be illustrated with the aid of the S-I and X-M schedules, as shown in

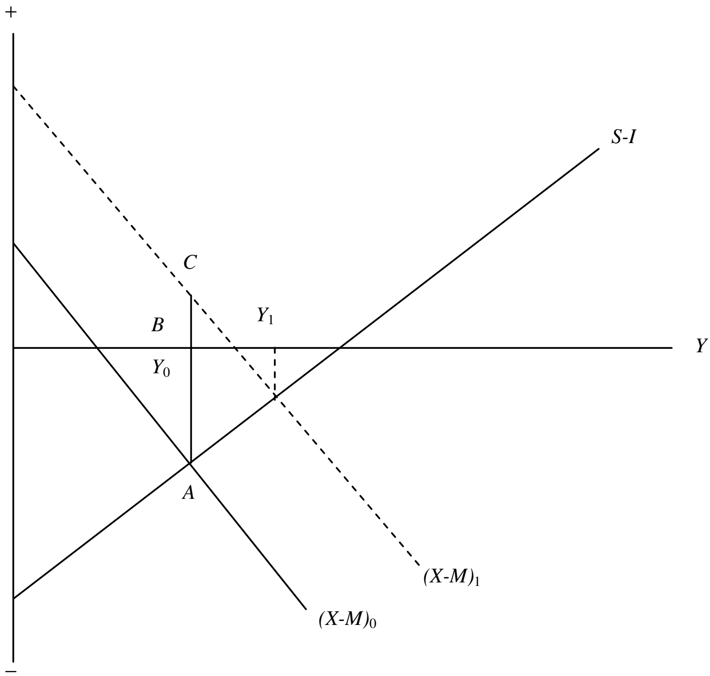

Figure 4.5. Keynesian and absorption approaches to the balance of payments.

Figure 4.5. The S-I schedule, which shows the excess of domestic saving over domestic investment at any level of income, is upward sloping because saving (S) is an increasing function of income (Y), while I can be assumed to be independent of Y. Thus, as Y rises, S-I rises. The X-M schedule, which shows the excess of exports over imports at any level of income, slopes downward because M is an increasing function of Y, while X is independent of Y. Suppose that the economy is initially in equilibrium at less than the full employment level of income (Y_0) where there is also a deficit in the trade balance as measured by the distance AB. At point A, which is consistent with the less than full employment equilibrium level of income (Y_0), the gap between domestic saving and domestic investment is equal to the gap between exports and imports. If the Marshall–Lerner condition is satisfied, devaluation leads to a shift in the X-M schedule from $(X$-$M)_0$ to $(X$-$M)_1$. If the level of income is unchanged, as is implicitly assumed by the elasticities approach, the current account registers a surplus measured by the distance

BC. However, an increase in net exports is bound to have an expansionary effect on the economy, leading to a rise in the level of income to Y_1, at which point the current account is still in deficit, albeit smaller than before.

The explanation of this result is simple: a rise in income leads to a rise in imports, reducing the extent of the rise in net exports resulting from devaluation. The satisfaction of the Marshall–Lerner condition is not a sufficient condition for devaluation to have a favorable effect on the current account. Thus, whether or not devaluation leads to an improvement in the trade balance depends on absorption, and not on the Marshall–Lerner condition. Moreover, whether or not devaluation has a favorable effect on the trade balance depends on whether or not the economy's resources are underemployed. If resources are fully employed, a rise in absorption following devaluation leads to a proportional rise in domestic prices, eventually offsetting the effects of devaluation on exports by making them expensive.

Merrett and Wabe (1964) argue that devaluation may lead to a shift in the domestic saving and investment schedules, which in turn affects the extent to which it affects the trade balance and the equilibrium level of real income. Yet, the likelihood of such a possibility has not been recognized in the standard literature. For instance, less may be saved at any given level of real income, if devaluation entails worsening in the terms of trade and therefore lower real income. At any given level of income, domestic investment may be greater, if exporters and industries competing with importers are encouraged by the thriving activity within their sectors. To allow for shifts in the net exports and net saving curves, it is assumed that the functions for exports, imports, saving, and investments are linear[7]:

$$X = a_0 + a_1 Y \tag{4.28}$$

$$M = \alpha_0 + \alpha_1 Y \tag{4.29}$$

$$S = b_0 + b_1 Y \tag{4.30}$$

$$I = \beta_0 + \beta_1 Y. \tag{4.31}$$

In equilibrium, net domestic saving flows must be equal to the net export flows. In other words

$$S - I = X - M. \tag{4.32}$$

[7]Here and elsewhere we distinguish between "saving" and "savings" on the grounds that saving is a flow variable (the portion of income that is not spent), whereas "savings" constitute a stock variable (accumulation of saving flows).

Substituting equations (4.28)–(4.31) into equation (4.32), we obtain

$$Y = \frac{A_2 - A_1}{(a_1 - \alpha_1) + (b_1 - \beta_1)} \tag{4.33}$$

where $A_1 = b_0 - \beta_0$ and $A_2 = a_0 - \alpha_0$. By differentiating equation (4.33), we obtain

$$\mathrm{d}Y = \frac{1}{(a_1 - \alpha_1) + (b_1 - \beta_1)} \mathrm{d}(A_2 - A_1). \tag{4.34}$$

Equation (4.34) represents the effects on the equilibrium level of income of shifts in the four functions. To see the effects of these shifts on both the trade balance and the equilibrium level of income, equations (4.28) and (4.29) are combined to express the trade balance $(X - M)$ as follows:

$$X - M = A_2 + (a_1 - \alpha_1)Y. \tag{4.35}$$

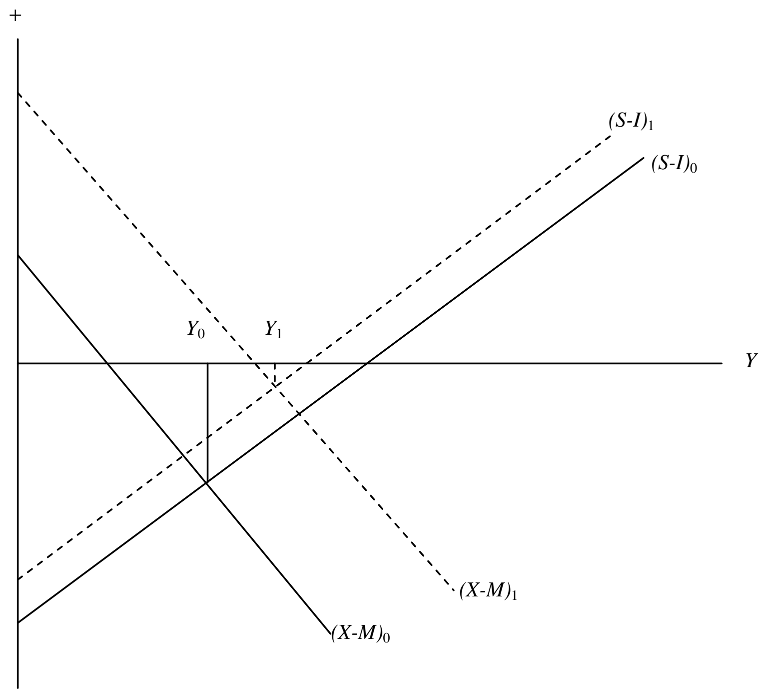

Figure 4.6. The effect of a fall in saving and a rise in exports.

By substituting equation (4.33) into equation (4.35), we obtain

$$X - M = A_2 + (a_1 - \alpha_1)\left[\frac{A_2 - A_1}{(a_1 - \alpha_1) + (b_1 - \beta_1)}\right]. \tag{4.36}$$

And by differentiating equation (4.36), we obtain

$$\begin{aligned} \mathrm{d}(X - M) &= \frac{(a_1 - \alpha_1)}{(a_1 - \alpha_1) + (b_1 - \beta_1)}\mathrm{d}(A_2 - A_1) + \mathrm{d}A_2 \\ &= \frac{1}{(a_1 - \alpha_1) + (b_1 - \beta_1)}[(a_1 - \alpha_1)\mathrm{d}A_1 + (b_1 - \beta_1)\mathrm{d}A_2]. \end{aligned} \tag{4.37}$$

Equation (4.37) shows the effects of shifts in the four functions on the trade balance. If $1/[(a_1 - \alpha_1) + (b_1 - \beta_1)] > 0$, then for devaluation to have a positive effect of on the equilibrium level of income, the shift in

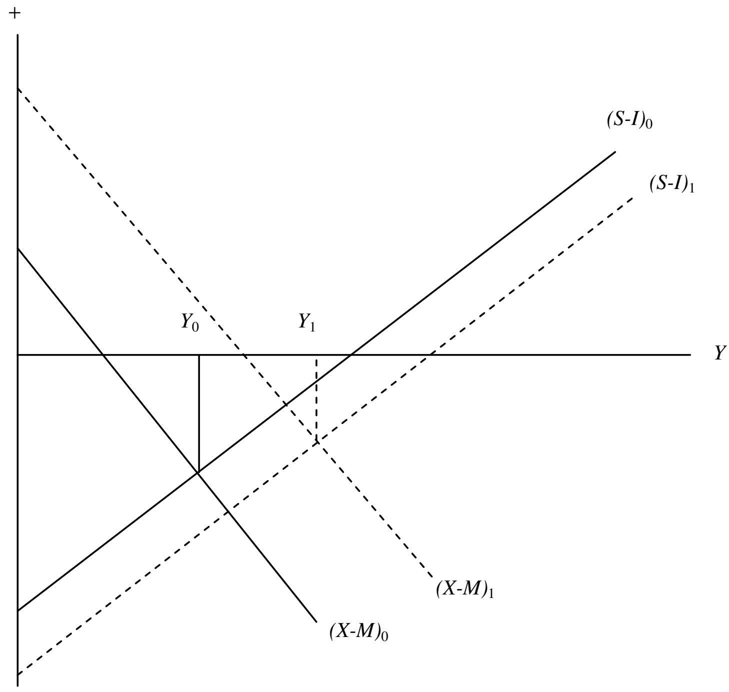

Figure 4.7. The effect of a rise in saving and exports.

the net exports curve must be greater than the shift in the net saving curve (that is, $\mathrm{d}A_2 > \mathrm{d}A_1$). From equation (4.37), this condition implies that $(b_1 - \beta_1)\mathrm{d}A_2 > -(a_1 - \alpha_1)\mathrm{d}A_1$. Merrett and Wabe (1964) have identified four different cases regarding the effects of the shifts in the four functions on the equilibrium income and the trade balance.

1. If $\mathrm{d}A_2 > 0$ and $\mathrm{d}A_1 > 0$, the trade balance must improve but there could be a decrease in real income. Real income increases only if the upward shift in the trade balance curve is greater than the upward shift in the net saving curve (that is, $\mathrm{d}A_2 > \mathrm{d}A_1$), as shown in Figure 4.6.
2. If $\mathrm{d}A_2 > 0$ and $\mathrm{d}A_1 < 0$, real income must rise but the trade balance will only improve if $\mathrm{d}A_2 > |\mathrm{d}A_1|$ (that is, the upward shift in the net exports curve is greater than the downward shift in the net saving curve). This is depicted in Figure 4.7.
3. If $\mathrm{d}A_2 < 0$ and $\mathrm{d}A_1 > 0$, it is impossible to make any improvement in real income. The trade balance could, however, improve only if

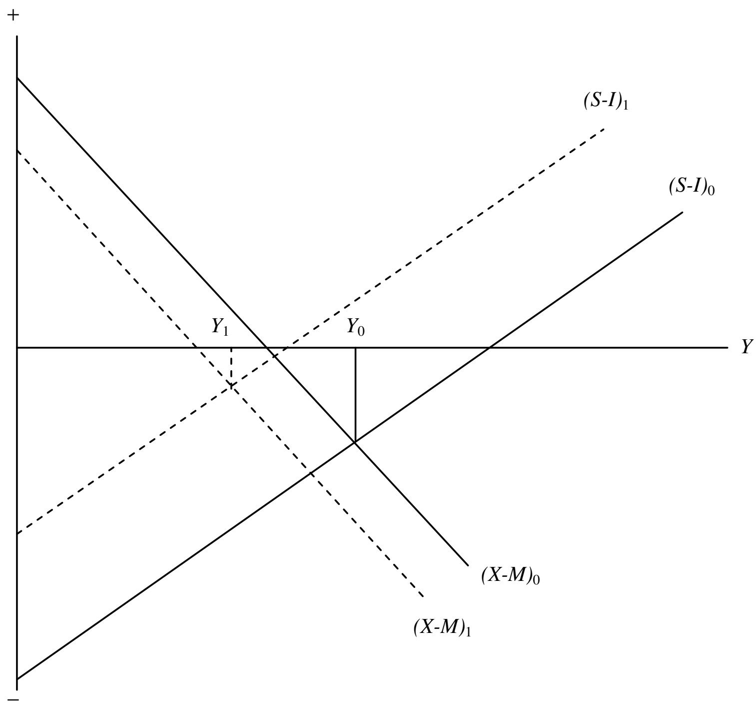

Figure 4.8. The effect of a fall in saving and exports.

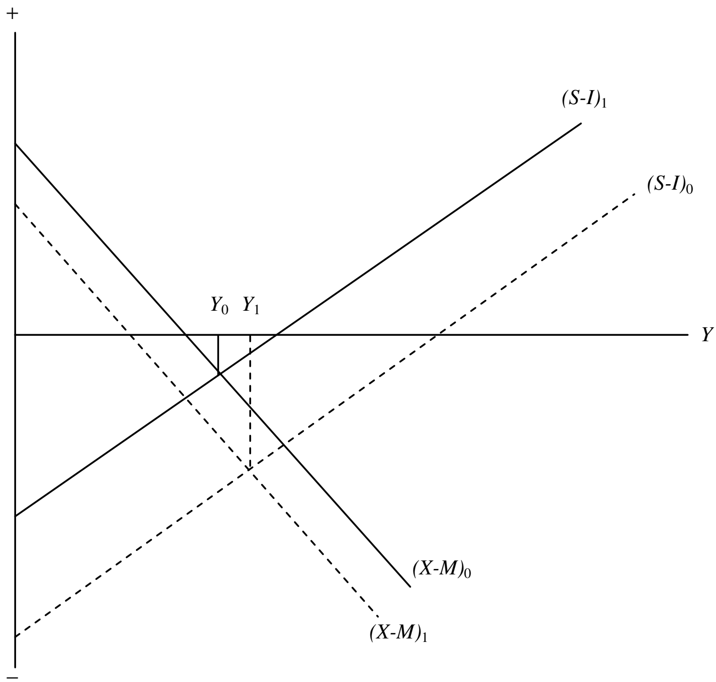

Figure 4.9. The effect of a rise in saving and a fall in exports.

$|dA_2| < dA_1$. This means that the downward shift in the net exports curve is less than the upward shift in the net saving curve, as shown in Figure 4.8.

4. If $dA_2 < 0$ and $dA_1 < 0$, it is impossible for the trade balance to improve. However, real income will rise only if $|dA_2| < dA_1$. This means that the downward shift in the trade balance curve is less than the downward shift in the net saving curve, as illustrated in Figure 4.9.

4.5. The Monetary Approach to the Balance of Payments

The elasticities, Keynesian, and income absorption approaches to the balance of payments were popular for a long time. They proved unsatisfactory in the immediate post-war period of full employment or over full employment because of their implicit assumption of the existence of unemployed resources that could be mobilized to produce additional exports and import substitutes that are required for a favorable effect of devaluation. These approaches emphasize trade in real goods and have little to say about the capital account. But the world today is characterized by well-developed financial markets and large-scale international capital flows. To understand economic linkages across countries and how they affect balance of payments positions, we must look beyond merchandise trade and incorporate the important role of financial assets. It was with this background that the monetary approach to the balance of payments became popular in the 1970s. This approach emphasizes the monetary aspects of the balance of payments.

The monetary approach to the balance of payments was formally developed by Johnson (1972a) and popularized subsequently by Mussa (1974, 1976) and Kemp (1975).[8] Johnson (1972a) argues that the theoretical basis for the monetary approach can be traced back to the work of Koopmans and Mundell, whereas the practical basis for it can be traced back to the failure of the 1967 devaluation of the pound to have the desired results. The essence of this approach is to put at the forefront of analysis monetary rather than relative price aspects of international adjustment.

It is noteworthy that most proponents of the monetary approach to the balance of payments argue that the monetary approach is not a new approach. Rather, they argue that the underlying fundamental proposition can be traced back to 1752 when David Hume developed the price-specie flow mechanism of international adjustment to refute the mercantilists' policies aimed at bringing about a balance of payments surplus by accumulating precious metals within the country.[9] On the basis of the price-specie flow mechanism, Hume demonstrated that, as the amount of money adjusts automatically to the demand for it (through surpluses and deficits in the balance of payments), the mercantilists' desire to accumulate "treasure" could only be ephemerally successful.

The monetary approach to the balance of payments postulates that economic transactions recorded in the balance of payments reflect aggregate portfolio decisions by the residents of the home and foreign countries.

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[8]For a detailed discussion of Johnson's contributions to the monetary approach, see Helliwell (1978).

[9]Fausten (1979, pp. 656–57) argues that although the proponents of the monetary approach trace its origin back to Hume's price-specie flow mechanism, the substantive evidence on the specifically Humean origin of the monetary approach remains exceedingly tenuous. He casts doubt on the proposition that the monetary approach constitutes a continuation of the characteristic classical approach as encapsulated in Hume's theory of the price-specie flow mechanism.

While the balance of payments transactions can be decomposed into different accounts (trade, services, short-term capital, long-term capital, private and government transfers, and official settlement), the monetary approach attempts to provide a theory of only the official settlement account (the money account) and not of other accounts or the decomposition of the balance of payments. Under a system of fixed exchange rates, the overall surpluses and deficits in the balance of payments are viewed as flows associated either with excess demand for or excess supply of money. Thus, the basic premise of the monetary approach is that balance of payments disequilibrium is caused primarily by a monetary disequilibrium (that is, inequality of the amount of money that people wish to hold and the amount of money supplied by the monetary authorities).

Suppose that a country's actual money stock is smaller than the stock its residents desire to hold. To replenish their cash balances, these residents will cut their spending, thereby releasing resources for exports. As a result, the country will run a current account surplus, exporting goods, and importing money until the gap between the actual and desired money stocks is eliminated. Conversely, if the existing stock of money is greater than that desired by the residents, national spending will exceed national output, and the country will run a current account deficit, importing goods, and exporting money until excess money balances are worked off.

For example, suppose that there is an autonomous increase in the money supply, which leads to an increase in the demand for goods, services, and securities. Under a system of fixed exchange rates, any such increase in domestic demand produces upward pressure on the prices of domestic (real and financial) assets relative to the prices of foreign assets. Consequently, residents of the home country react by reducing demand for domestic assets in favor of foreign assets and seek to sell more at home than abroad. At the same time, residents of foreign countries reduce demand for domestic assets and attempt to sell more of their assets to the residents of the home country. The net effect of all of these operations is an increase in the imports and a decrease in the exports of the home country, with a consequent deterioration in the balance of payments as represented by a fall in international reserves.

The monetary approach is in sharp contrast with conventional theories of the balance of payments (namely, the elasticities and absorption approaches). An implicit assumption underlying both approaches is that either there are no monetary consequences of balance of payments transactions or that these consequences are absorbed (sterilized) by the monetary authorities. The monetary approach postulates that inflows (outflows) of international reserves are associated with balance of payments surpluses (deficits) and that these inflows (outflows) cannot be sterilized in the long run but instead influence the domestic money supply. As the demand for money is demand for a stock and not a flow, variation of supply relative to demand must work toward equilibrium between demand and supply with a corresponding equilibrium in the balance of payments. In fact, the demand for and supply of money play a key role in explaining changes in international reserves, which means that a surplus or a deficit in the balance of payments is essentially a monetary phenomenon. This does not imply that real variables (such as income and interest rates) do not influence the balance of payments: they do play a part in the process, but only indirectly by affecting the demand for money.

Mussa (1976, pp. 237 and 238) emphasizes that the demand for and supply of money are the proximate determinants of exchange rates and the balance of payments. He argues that real variables (most importantly growth in real income) affect the exchange rate and the balance of payments via its effects on the demand for money. He refers to Mundell's argument that countries with rapid growth in real income tend to experience rapid growth in the demand for money and that, unless the domestic credit component expands more rapidly than demand, high-growth countries should experience balance of payments surpluses and/or appreciating currencies. In addition, fluctuations in real income around its normal trend affect the exchange rate and the balance of payments by affecting the demand for money. Real disturbances also affect the balance of payments and the exchange rate via the induced response of the authorities to such disturbances. Governments are likely to pursue expansionary monetary and fiscal policies in response to shrinking output and employment, which means that these policies result in monetary consequences in the form of balance of payments deficits and/or depreciating currencies.

4.5.1. *Fundamental Propositions of the Monetary Approach*

The monetary approach to the balance of payments has been developed for a small open economy that cannot affect prices and interest rates in the rest of the world. This approach is based on the following fundamental propositions.[10]

[10]For detailed discussions on the fundamental propositions of the monetary approach to the balance of payments, see Johnson (1972a, 1977), Mussa (1974, 1976), Kemp (1975, pp. 15–21), and Humphrey (1981).

Proposition 1

In a small open economy, output is assumed to be uniquely determined at the natural rate of unemployment by the supply conditions in the labor market. Consequently, the aggregate supply curve is vertical, which implies that monetary and fiscal policies have no real effects on the economy.

Proposition 2

Prices and interest rates are determined on the world markets by the world money supply and demand, which means that they are determined exogenously. The home country is so small that it is considered as a price taker on world markets.

Proposition 3

Balance of payments analysis is often complicated in the short run by the fact that the postulated adjustment in the balance of payments is incomplete in the short run. For example, the adjustment of actual money balances to their desired level (and the consequent adjustment in the balance of payments) does not occur instantaneously, but rather over time. Consequently, disequilibrium in the balance of payments may arise in the short run, but it will be corrected automatically over time by the adjustment of actual money balances to the desired level.

Proposition 4

Markets for goods, services, and securities are considered to be competitive and efficient. Under a system of fixed exchange rates, prices and interest rates in a small open economy can change only in the short run. It follows that (in the long run) price levels and interest rates in all countries must move rigidly in line with one another. In fact, attempts to arbitrage intercountry price and interest rate differentials are the driving force leading to a reduction or accumulation of money balances and a temporary balance of payments deficit or surplus. This implies that goods and interest arbitrage conditions (purchasing power parity and uncovered interest, respectively) must hold in the long run.

Proposition 5

Relative price effects (such as those envisaged in Hume's price-specie flow mechanism) play no role in the international adjustment process. Instantaneous commodity arbitrage and the law of one price preclude discrepancies between price levels of the type described by Hume. With prices determined on world markets, and given exogenously to a small open economy, there is no way that domestic prices can get out of line with world prices for any significant time.

Proposition 6

Adjustment occurs through spending (real balance) effects rather than through relative price effects. With relative price effects ruled out, the monetary approach postulates a direct spending channel whereby excess supply of money induces a rise in spending as cash holders attempt to get rid of excess money by converting it into goods. With prices given and real output at full capacity, increased spending spills over to the balance of payments in the form of higher demand for imports. Thus an import deficit is financed by money outflow, which means that excess money is worked off through the balance of payments in exchange for net imports of foreign goods and securities. Spending ceases when the excess money supply is eliminated and money balances are restored to their desired levels. No relative price changes are involved.

Proposition 7

Johnson (1977, pp. 224 and 225) argues that both in a closed and an open economy, excess demand at current notional or "auctioneer's" prices for goods, bonds, and money must follow Walras's law (as imposed by the overall budget constraint), which means that the algebraic sum of excess demands is zero. Hence

$$(D_{\mathrm{G}} - S_{\mathrm{G}}) + (D_{\mathrm{S}} - S_{\mathrm{S}}) + (D_{\mathrm{M}} - S_{\mathrm{M}}) \equiv 0 \tag{4.38}$$

where D is excess flow demand and the subscripts G, S and M represent the goods, securities, and money markets, respectively. In a closed economy, excess demand gives rise to (and is eliminated by) changes in auctioneer's prices. In an open economy (in which prices and interest rates are fixed in world markets), excess demand reveals itself entirely in net international flows in the balance of payments accounts, constrained by the identity

$$(X_{\mathrm{G}} - M_{\mathrm{G}}) + (X_{\mathrm{S}} - M_{\mathrm{S}}) + (X_{\mathrm{M}} - M_{\mathrm{M}}) \equiv 0 \tag{4.39}$$

where X and M denote exports and imports, respectively. Put differently, the current account surplus plus the capital account surplus plus the net outflow of international reserves (sometimes referred to as the balance on money account) must sum identically to zero. Johnson (1977) argues that

Walras's law, as represented by equation (4.39), may suggest that the net international money flow can be treated as the residual of the other two flows (or one, if capital flows are given). Hence the balance of payments (which is equal to the sum of the balances on the current and capital accounts) must be written as

$$B_t = X_{\mathrm{M},t} - M_{\mathrm{M},t} = g(D_{\mathrm{M},t} - S_{\mathrm{M},t}) \tag{4.40}$$

where B_t is the balance of payments at time t, X_{M} and M_{M} are exports and imports of money in exchange for imports and exports of goods and bonds, D_{M} and S_{M} are the stock demand for and stock supply of international reserves, and g is a general functional form relating current flows to stock disequilibrium in a stock adjustment relation.

Proposition 8

Transactions recorded in the balance of payments are essentially a reflection of a monetary phenomenon, which means that they are a manifestation of the direct effect of excess demand for or supply of money on the balance of payments. Implicit in this assumption is that the quantity theory of money holds and that the demand and supply functions are stable and depend on a limited number of variables. This does not imply that changes in the money supply constitute the only factor that affects the balance of payments, but rather that money demand and money supply are the proximate determinants of the balance of payments.

Proposition 9

Any disequilibrium in the balance of payments reflects disparity between actual and desired money balances that corrects itself automatically. This implies that the balance of payments adjustment process is automatic and that the impact of external money flows on the behavior of the domestic money stock cannot be neutralized or sterilized in the long run via open market operations or any other policy instrument. This is because sterilization creates international interest rate differentials to the extent that would induce sufficient capital flows to undermine the sterilization policy.

Proposition 10

As the money supply under fixed exchange rates is equal to the sum of the domestic credit generated by the banking system and the quantity of foreign exchange reserves held by the central bank, the money stock in a small open economy is an endogenous variable that adapts to any given money demand. An important implication of this proposition is that monetary policy does not determine the domestic money supply but rather the volume of domestic credit. Therefore, the burden of adjustment to changes in the exogenous variable falls on the foreign currency reserves held by the central bank.

This proposition also implies that money adjusts to prices, not vice versa. When money demand exceeds money supply, an exogenous rise in the price level (for example, via devaluation) induces a net inflow of money (through the balance of payments) that is sufficient to eliminate excess demand and support higher prices. This means that devaluation results in a temporary improvement in the competitiveness of the home country and consequently a balance of payments surplus, leading in turn to a rise in foreign currency reserves. However, the accompanying inflation will (as time passes) erode the country's competitive price advantage, until the economy returns to its original equilibrium position, with a higher price level, larger foreign exchange reserves, and larger nominal money supply.

Proposition 11

Domestic monetary policy is ineffective under fixed exchange rates. Expansion (contraction) of the monetary base results in an outflow (inflow) of international reserves and (as a consequence) the money supply returns to its former level. Thus, the inflationary (deflationary) impact of domestic monetary policy is mitigated with respect to the domestic economy and is imposed on the rest of the world via intercountry flows of international reserves. Similarly, the domestic economy experiences the impact of inflation or deflation caused by the monetary policies of other countries.

Proposition 12

There is at least one country whose currency is held as a form of international reserves by other countries (reserve currency country, RCC). This implies that the adjustment process in the RCC is not similar to those in the rest of the world. It is assumed that while expansionary (contractionary) monetary policies in all non-RCCs are completely offset by a balance of payments deficit (surplus), and the resulting depletion (accumulation) of the international reserve component of the monetary base, this may not be the case in the RCC. An expansionary (contractionary) monetary policy in the RCC may have no effect on its balance of payments. However, policies of the RCC always lead to balance of payments surplus (deficit) and inflow (outflow) of international reserves in non-RCCs.

4.5.2. *A Simple Monetary Model of the Balance of Payments*

Now that the fundamental propositions underlying the monetary approach to the balance of payments have been spelled out, we turn to the derivation of a simple monetary model of the balance of payments in which these propositions are expressed as a set of equations. The simple monetary model is constructed by assuming the home country to have a small open economy with stable monetary conditions and a fixed exchange rate. The country is assumed to be so small and adequately diversified in relation to the rest of the world that it cannot affect the international goods prices and interest rates it faces. The simple model is based on the following equations:

$$M^{\mathrm{d}} = M^{\mathrm{s}} \tag{4.41}$$

$$M^{\mathrm{d}} = kPY \tag{4.42}$$

$$M^{\mathrm{s}} = R + D \tag{4.43}$$

$$P = SP^{*}. \tag{4.44}$$

Equation (4.41) represents the money market equilibrium condition, obtained when money demand (M^{d}) is equal to money supply (M^{s}). Equation (4.42) is a behavioral relation representing the manner in which money demand is determined, whereas equation (4.43) is a definitional equation specifying the components of the money supply. Money demand is determined by prices (P) and income (Y). A higher level of income means that more money is held by people to buy more goods, whereas a higher price level means that more money is required to buy any given quantity of goods. This means that the demand for money should rise when P or Y rises. It is postulated that the demand for money function is stable, implying that the relation among money demand, income, and prices does not change significantly over time.

Under a system of fixed exchange rates, the money supply is assumed to be equal to the sum of international reserves held by the central bank (R) and domestic credit (D), which is generated by the banking system. Under these conditions, the monetary authorities can no longer control the money supply but instead they can control the volume of domestic credit. Following an exogenous rise or fall in domestic credit, adjustment to monetary equilibrium (equation (4.41)) is established via a reduction or accumulation of foreign exchange reserves at the central bank, which are reflected in a balance of payments deficit or surplus. In this model, therefore, the whole burden of adjustment falls on international reserves (while under flexible exchange rates it falls on prices). As for domestic prices, they tend to adjust to foreign prices.

Let us now derive the monetary model that sets a framework in which the monetary approach is used to analyze the behavior of the balance of payments. Substituting equation (4.41) into equations (4.42)–(4.44) and solving the resulting equation for R, we obtain

$$R = kSP^{*}Y - D. \tag{4.45}$$

Equation (4.45) says that, under fixed exchange rates, the foreign exchange reserves held by the central bank (R) must adjust to offset changes in real output (Y), foreign prices (P^{*}), and domestic credit expansion (D). In short, the model states that reserves flow through the balance of payments adjustment process to maintain monetary equilibrium in the face of shifts in the determinants of money supply and demand. As changes in reserves ($\dot{R}$) are recognized to be defining the state of the balance of payments (B), the self-equilibrating role of reserve flows through the balance of payments can be represented by the expression

$$B = \dot{R} = b(M^{\mathrm{d}} - M^{\mathrm{s}}). \tag{4.46}$$

Equation (4.46) implies that the state of the balance of payments and the associated change in foreign exchange reserves ($\dot{R}$) depend on whether or not money demand exceeds money supply. This also implies that flows of foreign exchange reserves tend to offset the excess of money demand over money supply to correct the very monetary disequilibrium that induces them. In essence, the monetary model postulates that when actual cash balances fall short of desired balances, the discrepancy is corrected by exporting domestic goods and securities for imports of money, leading (eventually) to equilibrium in the money market.

By taking logs on both sides of equation (4.45), differencing the resulting expression, and setting $\Delta s = 0$, we obtain

$$\Delta r = \Delta p^{*} + \Delta y - \Delta d. \tag{4.47}$$

Equation (4.47) indicates that under fixed exchange rates ($\Delta s = 0$) the change in reserves is equal to the foreign inflation rate plus the percentage growth of real income, minus the change in domestic credit. In essence, the monetary model of the balance of payments postulates that if foreign prices and domestic real income are given (and thus money demand is constant), an increase in domestic credit leads to a proportional decrease in international reserves. This means that if the central bank expands domestic credit, creating an excess supply of money, foreign exchange reserves will flow out of the home country or there will be a balance of payments deficit as people spend more to reduce excess cash balances. Conversely, if the central bank reduces domestic credit, leading to an excess money demand, foreign exchange reserves will flow into the home country or there will be a balance of payments surplus as people spend less to adjust to smaller cash balances.

Likewise, the model postulates that if domestic credit and real income are unchanged, then a rise in the rest of the world's price level boosts the home country's competitiveness, leading to a surplus in the trade balance and a consequent rise in reserves. This in turn brings about a rise in the domestic money stock, pushing up the domestic price level until it reaches parity with that of the outside world. On the other hand, given domestic credit and the foreign price level, a rise in domestic real income boosts the home country's competitiveness by pushing down the prices of domestic goods, leading to a surplus in the trade balance and a consequent rise in reserves. This process will come to an end only when the domestic money stock has risen sufficiently to match the increased demand for money.

4.5.3. *A Diagrammatic Representation of the Monetary Approach*

The simple monetary approach to the balance of payments and the partial effects on the balance of payments of domestic credit (monetary policy), foreign prices, real income, and devaluation can be explained with the aid of Figures 4.10–4.13.

First, the effect of an increase in domestic credit (an expansionary monetary policy) on the balance of payments under fixed exchange rates is illustrated in Figure 4.10. Assume that a small open economy is initially in equilibrium at points A, A' and a with domestic prices at P_0, the (fixed) exchange rate at $\bar{S}_0$, output at the full employment level (Y_0), the stock of (endogenous) money supply at M_0, and the stock of foreign exchange reserves at R_0. At point A in Figure 4.10(a), the exchange rate ($\bar{S}_0$) is consistent with purchasing power parity because it is equal to the ratio of domestic to foreign prices (P_0/P_0^*). Hence, there is equilibrium in the external sector because at $\bar{S}_0$ there is neither excess supply of, nor excess demand for, foreign exchange. At any exchange rate lower than $\bar{S}_0$, domestic output becomes uncompetitive on world markets, thereby resulting in excess demand for the foreign currency, and vice versa. At point A' in Figure 4.10(b), the domestic price level (P_0) is consistent with the quantity theory of money, and hence there is equilibrium in the goods market, where aggregate demand, $AD_0(M_0 = kPY)$ is equal to aggregate supply (AS_0) at the full-employment level of output (Y_0). There is also equilibrium in the money market at point a in Figure 4.10(c), where the supply of money

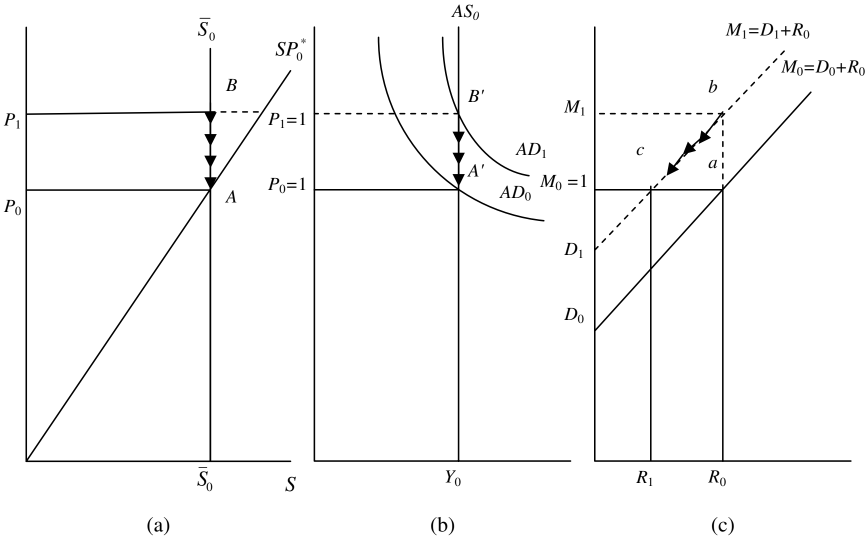

Figure 4.10. The effect of expansion in domestic credit under fixed exchange rates.

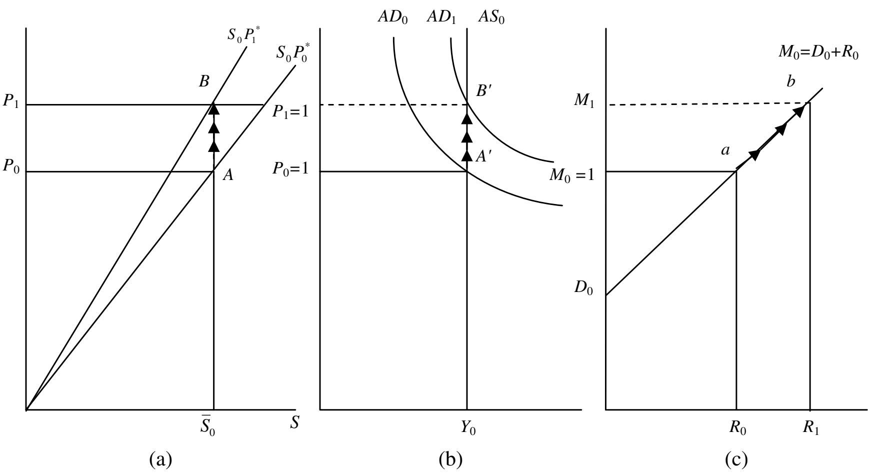

Figure 4.11. The effect of a rise in the foreign price level under fixed exchange rates.

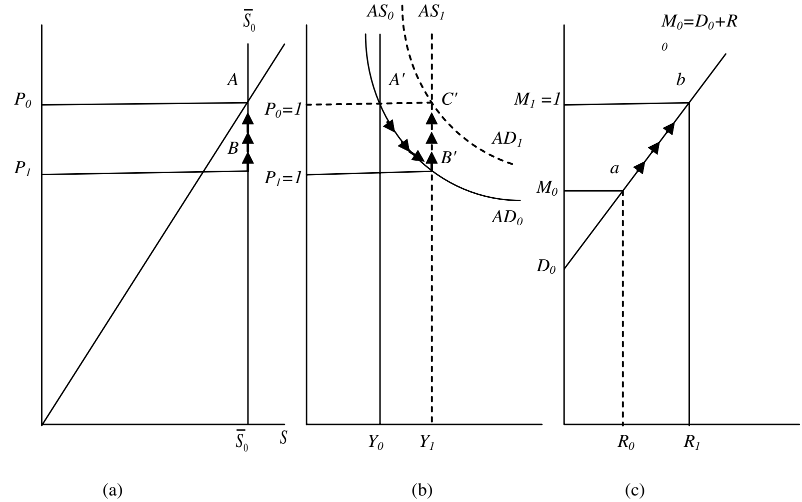

Figure 4.12. The effect of a rise in real income under fixed exchange rates.

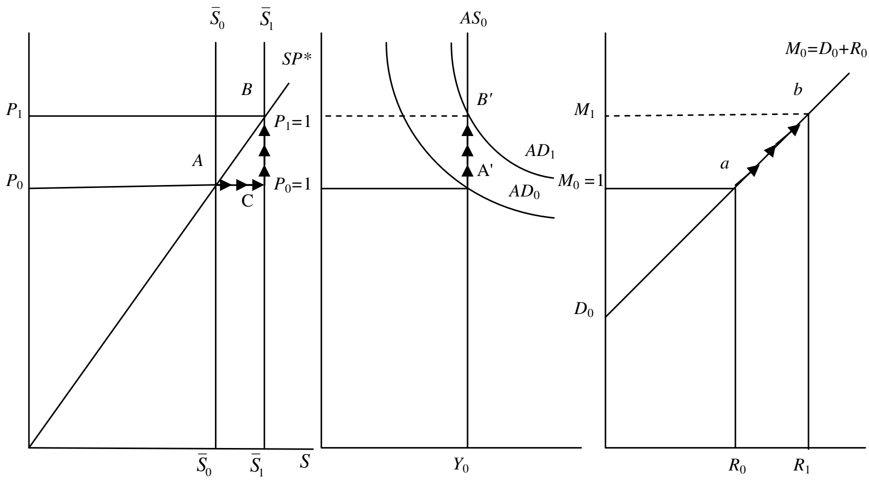

Figure 4.13. The effect of devaluation.

(made up of domestic credit (D_0) and reserves (R_0)) is equal to the demand for money. Note that at the equilibrium exchange rate ($\bar{S}_0$), the initial values of the domestic price level (P_0) and money supply (M_0) are equal to unity ($P_0 = M_0 = 1$). The foreign price level (P^*) is taken as given, because it is assumed to be determined by the foreign money supply, real income, and so on.

Now let us assume that there is an exogenous expansion in domestic credit from D_0 to D_1, leading to an upward shift in the money supply curve from $M_0 = D_0 + R_0$ to $M_1 = D_1 + R_0$. Given that foreign exchange reserves are still at the previous level of R_0, expansion in domestic credit leads to an increase in the money stock from M_0 to M_1 in Figure 4.10(c). The rise in domestic credit also causes an upward shift in the aggregate demand schedule from $AD_0(M_0 = kPY)$ to $AD_1(M_1 = kPY)$. Given that a vertical aggregate supply schedule implies that real income is fixed at the full-employment level, the upward shift in the aggregate demand schedule raises the domestic price level from P_0 to P_1, as at point B' in Figure 4.10(b). As a result of higher domestic prices and the given level of foreign prices (as shown by the purchasing power parity line in Figure 4.10(a)), foreign goods are now more competitive than domestic goods. Consequently, there is (at point C) an incentive for traders to import goods from abroad and no incentive for foreigners to buy domestic goods, producing a deficit in the balance of payments.

The balance of payments deficit causes depreciation of the domestic currency if the authorities allow that, which is not the case if the exchange rate is pegged at $\bar{S}_0$. So the authorities must avert domestic currency depreciation, financing the deficit by selling foreign exchange reserves, which (as a result) start to fall. Each successive decline in foreign exchange reserves reduces the money supply, pushing the economy along the arrowed paths in the three quadrants. Eventually, the economy moves from b to c, from B' back to A', and from B to A. As a consequence of the fall in reserves from R_0 to R_1 at point c, the money supply falls from M_1 to M_0. This in turn restores domestic prices (at point A') to the previous level of P_0, which is consistent with the pegged exchange rate ($\bar{S}_0$). Clearly (as is evident from equation (4.47)), foreign exchange reserves must be equal to the gap between the demand for domestic money and the supply generated by the local banking system, through the process of domestic credit expansion.

Now let us consider the effect on the trade balance of a rise in the world price level, which is illustrated in Figure 4.11. The economy is initially in equilibrium at points A, A' and a (in Figures 4.11(a), 4.11(b), and 4.11(c), respectively), with real income Y_0, domestic price level P_0, fixed exchange rate $\bar{S}_0$, domestic money supply M_0, and foreign reserves R_0. A rise in the world price level causes the purchasing power parity line to rotate to the left and become steeper than before (Figure 4.11(a)). The rise in the world price level boosts the competitiveness of domestic goods, producing a surplus in the trade balance and a consequent rise in reserves from R_0 to R_1 (Figure 4.11(c)). As a result of this increase in the foreign component (reserves), the domestic money supply rises from M_0 to M_1, which shifts the aggregate demand curve to the right from $AD_0(M_0 = kPY)$ to $AD_1(M = kPY)$, as in Figure 4.11(b). This rise in aggregate demand (with real income remaining unchanged at the full-employment level) leads to an increase in the domestic price level from P_0 to P_1. Now, the domestic price level P_1 at point B' in Figure 4.12(b) is no longer proportional to the domestic money supply at point a in Figure 4.12(c), and as such the link between Figures 4.12(b) and 4.12(c) is broken. This process continues until the domestic price level rises proportionately to the world price level to preserve purchasing power parity at $\bar{S}_0$. The economy reaches a new equilibrium position at points B, B' and b, in Figures 4.11(a), 4.11(b), and 4.11(c) respectively, with higher levels of domestic prices and money supply.

The effect on the trade balance of a rise in real income is illustrated in Figure 4.12. We begin with the initial equilibrium position represented by the three points A, A', and a in Figures 4.12(a), 4.12(b), and 4.12(c), respectively. A rise in real income, as shown in Figure 4.12(b), shifts the aggregate supply curve to the right from AS_0 to AS_1. As a result, equilibrium moves from A' to B', and the domestic price level falls from P_0 to P_1. A fall in the domestic price level boosts the competitiveness of the domestic economy, leading to a surplus in the trade balance and a consequent rise in reserves from R_0 to R_1. This process comes to an end when the domestic money supply has risen sufficiently to match the new (higher) level of demand and when domestic prices return to the level that is consistent with purchasing power parity.

The effect of devaluation on the trade balance is illustrated in Figure 4.13. The economy begins with an initial equilibrium position at points A, A', and a (in Figures 4.13(a), 4.13(b), and 4.13(c)), where the exchange rate is pegged at $\bar{S}_0$, the domestic price level is P_0 (consistent with purchasing power parity), and the domestic money supply is M_0 (made up of D_0 and R_0). Suppose that the home country devalues its currency, raising the domestic currency price of a unit of foreign currency from $\bar{S}_0$ to $\bar{S}_1$. The economy instantaneously moves from A to B in Figure 4.13(a). Other things being equal (that is, given the domestic and foreign price levels), the home country becomes over-competitive. If the home country started from a position of being uncompetitive (that is, above the purchasing power parity line), the impact effect would be to move it to the right, making it more competitive than previously. But this is just the beginning of the story, not the end. With both domestic and foreign prices unchanged, real and nominal exchange rates rise via the devaluation of the domestic currency, making domestic goods cheaper relative to foreign goods. As a result, home country consumers tend to buy more domestic goods, and less imported goods, than previously. Foreigners also tend to buy more of the home country's goods, which are now more attractive. This causes a surplus in the trade balance and a consequent rise in the reserves of the home country. More realistically, if the home country started from a position of trade deficit, it would experience improvement in its trade balance.

What happens next, as the economy adjusts to devaluation, can be illustrated by looking at the adjustment process in different sectors. First, consider what happens to equilibrium in the foreign exchange market when the economy moves from A to B in Figure 4.13(a). With a surplus in its trade balance, the home country must be accumulating reserves (hence money market equilibrium moves from a to b, as shown in Figure 4.13(c)). As the quantity of domestic credit is unchanged, the money supply must rise from M_0 to M_1, shifting the aggregate demand schedule in Figure 4.13(b) from $AD_0(M_0 = kPY)$ to $AD_1(M_1 = kPY)$. As real income is unchanged at the full-employment level, excess aggregate demand over the available supply of output must push the domestic price level up from P_0 to P_1. As the domestic price level rises, the whole gain from devaluation (in terms of both competitive advantage and the consequent external surplus) will be offset when the economy eventually settles at point B in Figure 4.13(a).

In the goods market, with output remaining unchanged at Y_0, increased demand for domestic goods by domestic residents (for cheaper import substitutes) and by foreign residents (for the home country's exports) cannot be satisfied. Consequently, excess demand must give rise to inflation, offsetting completely all gains from devaluation as the economy moves from A to B and the domestic price level rises from P_0 to P_1 to restore purchasing power parity at $\bar{S}_1$. The labor market may also react to devaluation when wage inflation takes place, induced either by a cost-push process (as workers react to the higher price of imports by demanding compensating wage rises) or by a demand-pull mechanism (as employers bid up the wage rate in an attempt to satisfy excess demand for goods by hiring more labor). No matter which of these adjustment processes is dominant, the economy ends up at B, where purchasing power parity is restored and the real exchange rate is back to its previous level.

4.5.4. *An Expanded Monetary Model of the Balance of Payments*

The monetary model of the balance of payments as represented by equation (4.47) is very simple. It neglects the effects of conditions in the foreign money market and the effect of the interest rate differential on the balance of payments. A more complex version of the model can be derived by extending the simple model, as represented by equation (4.47), to take these factors into account. Stable domestic and foreign money market conditions, including the impact of interest rates, are represented by the following set of equations:

$$M^{\mathrm{d}} = PY^{\alpha}\mathrm{e}^{-\beta i} \tag{4.48}$$

$$M^{*\mathrm{d}} = P^{*}Y^{*\alpha}\mathrm{e}^{-\beta i^{*}} \tag{4.49}$$

$$M^{\mathrm{s}} = M \tag{4.50}$$

$$M^{*\mathrm{d}} = M^{*\mathrm{s}} \tag{4.51}$$

$$M^{\mathrm{s}} = M^{*}. \tag{4.52}$$

By combining equations (4.48)–(4.52), we obtain

$$\frac{M}{M^{*}} = \left[\frac{P}{P^{*}}\right]\left[\frac{Y}{Y^{*}}\right]^{\alpha}\left[\frac{\mathrm{e}^{-\beta i}}{\mathrm{e}^{-\beta i^{*}}}\right]. \tag{4.53}$$

Substituting equation (4.53) into equation (4.43), we obtain

$$R + D = S\left[\frac{Y}{Y^{*}}\right]^{\alpha}\left[\frac{\mathrm{e}^{-\beta i}}{\mathrm{e}^{-\beta i^{*}}}\right]M^{*}. \tag{4.54}$$

By taking logs on both sides of equation (4.54), differencing the resulting expression, and setting $\Delta s = 0$, we obtain

$$\Delta r = \alpha\Delta(y - y^{*}) - \beta\Delta(i - i^{*}) + \Delta m^{*} - \Delta d. \tag{4.55}$$

Equation (4.55) is the reduced form equation of the balance of payments that represents the monetary model. As evident from equation (4.55), we can derive four propositions underlying the monetary model under fixed exchange rates. First, the model states that the balance of payments improves if domestic real income is higher than foreign real income. Second, the balance of payments deteriorates if the domestic interest rate is relatively higher than the foreign rate. Third, the balance of payments improves if there is monetary expansion in the reserve currency country. Fourth, the balance of payments deteriorates proportionately to an expansion in domestic credit.

4.5.5. *Policy Implications of the Monetary Approach*

The policy implications that generally stem from the monetary model depend largely on the assumptions underlying the model. It must be noted that the implications of the model for a small open economy are in sharp contrast with those for a large open economy. Furthermore, many of the assumptions often leading to the key implications of the model are open to serious criticism. This is particularly true of the assumptions of (i) full employment, (ii) perfect international arbitrage, (iii) exogeneity of real income, (iv) nonsterilization of international money flows, and (v) the existence of an inherently stable self-regulating world economy. While these assumptions may hold in the long run, the empirical evidence suggests that they may not hold over any realistic current policy-making horizon, or over the transitional adjustment period following a monetary shock. What follows from this argument is that any policy prescription based on the model would certainly undergo modifications when any of the underlying assumptions turns out to be invalid. Subject to these assumptions, the policy implications of the monetary model for a small open economy are summarized below.[11]

Irrelevance of Macroeconomic Policies

The first most radical implication that follows from the monetary approach is that traditional macroeconomic, monetary, and balance of payments policies are unnecessary and useless. They are unnecessary because the international adjustment mechanism works automatically to correct economic disequilibria and to provide each country with sufficient money to accommodate full capacity levels of output. They are useless because the authorities are unable to control the money supply or the balance of payments, both of which are determined endogenously by the public's demand for money. To improve the country's balance of payments, for example, the authorities may decide to devalue the domestic currency, a measure that has no permanent effect on the trade balance. Devaluation produces favorable effects on the trade balance in the short run, but these effects will be completely offset over time when domestic prices rise proportionately to the rise in the exchange rate to preserve purchasing power parity.

An important conclusion that emerges from the discussion is that devaluation does indeed generate a balance of payments surplus, or at least reduces the deficit of a country that starts off in disequilibrium. Devaluation does

[11] See Humphrey (1977b, pp. 19–22) and Johnson (1977, pp. 226–228).

help in replenishing reserves, or in slowing down the rate of reserve loss for a deficit country. However, the beneficial effect of devaluation is only temporary and short-lived. It cannot affect competitiveness permanently but it causes inflation, thereby neutralizing over time the initial gains from devaluation.

The monetary authorities of a small open economy can control the composition of the money supply (that is, the mix between domestic credit and international reserves), but not the money supply itself. As shown in Figure 4.13, an expansion in the controllable domestic credit component results in a balance of payments deficit and outflow of international reserves (the uncontrollable component) until the money stock returns to its initial level. Thus, an increase in domestic credit leads to an equivalent offsetting fall in international reserves, eventually re-establishing equilibrium in the money market by keeping the money supply unchanged.

The Monetary Authorities are Solely to Blame for Balance of Payments Deficits

The second policy implication is that (assuming the absence of monetary expansion or contraction abroad) disequilibrium in the balance of payments is solely a manifestation of disequilibrium in the money market. This also implies that the monetary authorities are solely to blame for the deficit, as there can be no deficit unless there is excess supply of money. It should be noted, however, that deficits are inherently transitory phenomena. The monetary model asserts that deficits vanish as soon as the redundant money is diffused throughout the world economy by the operation of the international adjustment mechanism.

No Control over Domestic Prices and Inflation Rates

The third policy implication is that, in a world of fixed exchange rates, a small open economy can control neither its price level nor its inflation rate, because both are determined in world markets. This implies that it is impossible for an individual country to avoid inflating at the world rate. It also implies that inflation rates around the world must eventually converge. This conclusion can be demonstrated by looking at the purchasing power parity equation in its first difference form (that is, $\Delta p = \Delta s + \Delta p^*$), showing that domestic and foreign inflation rates may differ only by the proportional rate of change of the exchange rate. Under a system of fixed exchange rates, where $\Delta s = 0$, the two inflation rates (Δp and Δp^*) must converge.

This also implies that if a country wishes to insulate itself from world inflation, it must operate with flexible exchange rates. Only under flexible exchange rates can a country maintain an inflation rate that is independent of the rest of the world. This is because, by letting its currency float, a country can gain control over its money supply and hence its inflation rate.

4.6. A Comparison of the Monetary and Keynesian Models

To compare the propositions underlying the monetary and Keynesian models of the balance of payments, let us reconsider and summarize both models. By substituting equation (4.53) into equation (4.43), taking logs on both sides of the resulting expression, differencing, and then solving for changes in reserves, we obtain

$$\Delta r = \Delta(p - p^*) + \alpha\Delta(y - y^*) - \beta\Delta(i - i^*) + \Delta m^* - \Delta d. \qquad (4.56)$$

Equation (4.56) implies the following monetary propositions:

1. When relative prices rise, the balance of payments improves, for given $y - y^*$, $i - i^*$, m^*, and d.
2. When relative income rises, the balance of payments improves, for given $p - p^*$, $i - i^*$, m^*, and d.
3. When the interest rate differential rises, the balance of payments deteriorates, for given $p - p^*$, $y - y^*$, m^*, and d.
4. When the foreign money supply rises, the balance of payments improves, for given $p - p^*$, $y - y^*$, $i - i^*$, and d.
5. When domestic credit rises, the balance of payments deteriorates by the same amount.
6. When the exchange rate rises (devaluation), the balance of payments does not change, for given $p - p^*$, $y - y^*$, $i - i^*$, m^*, and d.

On the other hand, the Keynesian approach may be summarized by the following equations:

$$\ln B = a(s - p + p^*) - b(y - y^*) \qquad (4.57)$$

$$F = c(i - i^*) \qquad (4.58)$$

$$\Delta r = \ln B + F. \qquad (4.59)$$

Equation (4.57) states that net exports vary directly with the ratio of domestic to foreign prices adjusted by the nominal exchange rate (or the real exchange rate), which implies that the price elasticity of exports is positive

($a > 0$). Net exports vary indirectly with relative incomes ($b < 0$) if the Marshall–Lerner condition is satisfied. Equation (4.58) states that the net inflow of capital varies directly with the domestic interest rate and indirectly with the foreign interest rate ($c > 0$), while equation (4.59) defines the balance of payments as the sum of nominal net exports and net capital inflows.

Substituting equations (4.57) and (4.58) into equation (4.59), we obtain

$$\Delta r = a(s - p + p^*) - b(y - y^*) + c(i - i^*). \tag{4.60}$$

The following Keynesian propositions can be derived from equation (4.60):

1. Given relative prices and interest rates, a rise in domestic income relative to foreign income leads to balance of payments deterioration.
2. Given relative incomes and interest rates, a rise in domestic prices relative to foreign prices leads to balance of payments deterioration.
3. Given relative incomes and prices, a rise in the domestic interest rate relative to the foreign interest rate leads to balance of payments improvement.
4. Given relative prices, incomes, and interest rates, a rise in the nominal exchange rate (devaluation) leads to balance of payments improvement.
5. An expansion in domestic credit (D) does not give rise to any change in the balance of payments unless there is a change in domestic income, prices, and interest rates.

4.7. A Synthesis of Monetary and Keynesian Approaches

Johnson (1972b, p. 14) argued that the real challenge facing economists dealing with the theory and empirics of the balance of payments is to develop a synthesis of the monetarist and Keynesian analysis, a synthesis that is relevant to the short-run context with which policymakers are concerned. This challenge was taken up by Frenkel *et al.* (1980) who developed a synthesis along the lines suggested by Johnson (1972b).

According to Frenkel *et al.*, the Keynesian approach to the balance of payments can be represented by the following set of equations:

$$B = B(Y, S/P); \quad B_Y < 0, \quad B_{S/P} > 0 \tag{4.61}$$

$$F = F(i); \quad F_i > 0 \tag{4.62}$$

$$\Delta R = B + F. \tag{4.63}$$

Equation (4.61) states that net exports vary inversely with the level of income ($B_Y < 0$) and directly with the relative price of foreign to domestic goods ($B_{S/P} > 0$), implying that the Marshall–Lerner condition is satisfied. Equation (4.62) states that the net inflow of capital varies directly with the domestic interest rate ($F_i > 0$). Equation (4.63) defines the balance of payments as the sum of net exports and net capital inflow. By combining equations (4.61)–(4.63), we obtain

$$\Delta R = B(Y, S/P) + F(i). \tag{4.64}$$

Likewise, the monetary approach to balance of payments theory may be summarized by the following set of equations:

$$M^{\mathrm{d}} = L(P, Y, i); \quad L_P > 0, \ \ L_Y > 0, \ \ L_i < 0 \tag{4.65}$$

$$M^{\mathrm{s}} = m(D + R) \tag{4.66}$$

$$B = \Delta R = M^{\mathrm{S}} - M^{\mathrm{d}}. \tag{4.67}$$

Equation (4.65) states that money demand varies positively with prices and real income but negatively with the interest rate, while equation (4.66) states that money supply is, by definition, equal to a multiple m of the monetary base. Substituting equations (4.65) and (4.66) into equation (4.67), we obtain

$$\Delta R = \Delta \frac{1}{m} L(P, Y, i) - \Delta D. \tag{4.68}$$

There are two main differences between the monetary approach and the Keynesian approach to the balance of payments.[12] First, the monetary approach, emphasizing a long-run perspective, assumes that a surplus or deficit in the balance of payments arises when the money supply exceeds money demand or falls short of it, and when the monetary authorities cannot sterilize surpluses and deficits. Second, although prices, interest rates, and real incomes are treated as exogenous variables in both approaches, the standard Keynesian approach assumes implicitly that these variables are determined elsewhere in a more complete model. In contrast, the monetary approach assumes that real income is supply-determined in the long run, while prices and interest rates may be taken to be fixed abroad for a small open economy operating under fixed exchange rates.

To derive a synthesis of the short-run monetary and Keynesian approaches, Frenkel *et al.* (1980) assume that income, prices, and interest rates are determined endogenously. Real income is the sum of private final

[12] See Johnson (1972b, Chapter 9).

expenditures (E), government expenditure (G), and net exports (B). Hence

$$Y = E(Y, i) + G + B(Y, S/P);$$
$$E_Y > 0, \quad E_i < 0, \quad B_Y < 0, \quad B_{S/P} > 0 \tag{4.69}$$
$$Y = Y(P); \quad Y_P > 0. \tag{4.70}$$

Equation (4.69) is a standard aggregate demand function, while equation (4.70) is a standard supply function derived from the equilibrium conditions in the labor market for a state of expectations. Substituting equation (4.70) into equation (4.69) and solving for i, we obtain

$$i = i(Y, G, S); \quad Y_i < 0, \quad G_i > 0, \quad S_i > 0. \tag{4.71}$$

Substituting equations (4.70), (4.71), and (4.69) into (4.64) and (4.68) (which represent the Keynesian and monetary approaches, respectively), we obtain

$$R = k_1 Y + k_2 G + k_3 S + R_{-1}; \quad k_1 < 0; \; k_2 > 0; \; k_3 > 0 \tag{4.72}$$
$$R = m_1 Y + m_2 G + m_3 S - D; \quad m_1 > 0; \; m_2 > 0; \; m_3 > 0. \tag{4.73}$$

Which define the K schedule and the M schedule, respectively. $R - R_{-1}$ has been substituted for ΔR, where R_{-1} stands for the stock of international reserves held at the beginning of the period. The K schedule relates R negatively to Y, for given G, S, and R_{-1}, whereas the M schedule relates R positively to Y, for given G, S, and R_{-1}. The slopes of the two schedules (the sings of k_1 and m_1) reflect not only the effect of income changes on the trade balance and the demand for money, respectively, but also the price and interest rate effects.

Figure 4.14 shows the K and M schedules. A rise in government spending or the exchange rate causes both schedules to shift (unequally, except by chance) to the right. Domestic credit expansion shifts the M schedule to the right, while larger beginning-of-period foreign exchange reserves shift the K schedule to the right. Figure 4.14 shows that it is potentially misleading to regress ΔR or R on Y to find out if they are positively (negatively) related to income, as predicted by the monetary (Keynesian) approach. In the general model, R (or ΔR) and Y can move (in the short run) in the same direction or in opposite directions, depending on what kind of shock moves them. The following are some examples:

1. When D changes, the M schedule shifts, so that R and Y move in opposite directions.

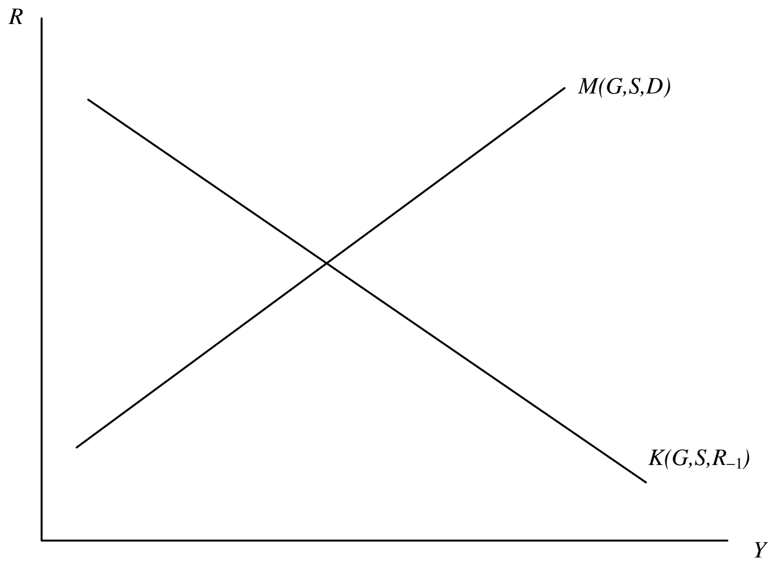

Figure 4.14. A synthesis of the Keynesian and monetary approaches.

2. When G changes, the two schedules shift in the same direction, leading Y and R to move either in the same direction or in opposite directions.
3. When S changes, the two schedules shift in the same direction, in which case Y and R move in the same direction.

4.8. Recapitulation

The theory of the balance of payments may be traced back to the work of Hume on the price-specie flow mechanism, which may also be viewed as a theory of the balance of payments, although Johnson (1977) believed that it was no more than a theory of the mechanism of international adjustment under the gold standard. This adjustment mechanism was followed by the ealsticities, Keynesian, and income absorption approaches to the balance of payments. These approaches are based on trade flows and have nothing to say about capital account transactions.

Just like the monetary model of exchange rates came as an alternative to the Mundell–Fleming flow model, the monetary approach to the balance of payments has been suggested as an alternative to the flow-based approaches. Most proponents of this approach, however, argue that the monetary approach can be traced back to the price-specie flow mechanism. According to this approach, the overall position of the balance of payments is viewed as a flow associated with excess demand for or excess supply of money. The balance of payments, according to this approach, is a purely monetary phenomenon.

The policy implications of the monetary approach depend on whether the underlying economy is small or large. For a small open economy the policy implications of this approach are (i) irrelevance of macroeconomic policy, (ii) the monetary authorities are solely to blame for balance of payments deficit, and (iii) there is no control over domestic inflation. The third implication means that if a country wishes to insulate itself from world inflation, it must adopt flexible exchange rates.

CHAPTER 5

Exchange Rate Determination in the Dornbusch Model

5.1. Introduction

Dornbusch (1976a–c) kept the Mundell–Fleming model alive in policy-making circles.[1] His 1976a paper was stimulated by a study of Niehans (1975) who cast doubt on the widely accepted proposition established, *inter alia*, by Mundell (1961b, 1963a), Krueger (1965) and Sohmen (1967), that monetary policy is effective under flexible exchange rates by drawing a distinction between actual and expected exchange rates and noting the implications of that distinction for the trade balance and capital flows. Specifically, Niehans (1975) was concerned that a monetary expansion may worsen the trade balance and lead to capital inflow and that, in extreme cases, it may actually reduce income and employment.[2] In defense of the widely accepted proposition about the efficacy of monetary policy under flexible exchange rates, Dornbusch (1976a) restated the Mundell–Fleming model under rational expectations to demonstrate that following a monetary expansion, output and exchange rates adjust over time to reverse an incipient fall in interest rates, which initially causes the exchange rate to overshoot its long-run value, leading to trade balance deterioration in the short run. Real trade flows adjust until eventually long-run Mundell–Fleming equilibrium is attained.

[1]Rogoff (2002) argues that Dornbusch's (1976c) paper (which everyone calls the "overshooting paper") marked the birth of modern international macroeconomics and that the rational expectations reformulation of the Mundell–Fleming model extended the latter's life by 25 years, keeping it at the forefront of practical policy analysis.

[2]Niehans (1975, p. 275) argues that "if the price elasticities of the demand for exports and imports are affected by the transition to flexible rates, and capital flows are dependent on the exchange rate, the efficacy of monetary policy under flexible exchange rates will not necessarily follow."

In his 1976b paper, Dornbusch developed a long- as well as a short-run view of exchange rate determination.[3] The long-run view links monetary and real variables as jointly influencing the equilibrium exchange rate. On the other hand, the short-run view (which presumes a limited scope for commodity arbitrage) links the conditions of equilibrium in the asset markets and expectations as determining the equilibrium exchange rate through interest arbitrage. It is demonstrated that over time the exchange rate is determined by interaction between goods and asset markets because the price level will rise to match the expansion in the nominal quantity of money until (in the long run) the monetary expansion is exactly matched by a higher price level so that real balances and interest rates are unchanged. The domestic currency depreciates in the same proportion as the increase in the nominal quantity of money.

In his 1976c paper, Dornbusch developed a "hybrid" model, which is known more widely as the "overshooting" model of exchange rates. In the short run, the model displays features of the Mundell–Fleming model, with its emphasis on price stickiness in goods markets. In the long run, it displays the characteristics of the flexible-price monetary model, with its emphasis on the proportional adjustment of prices and exchange rates in reaction to monetary expansion. A major problem with the flexible-price monetary model is that it assumes continuous purchasing power parity, under which the real exchange rate is constant. Yet, the current floating exchange rate regime is characterized by wide fluctuations in real exchange rates, which cause shifts in international competitiveness.[4] This also implies that the flexible-price model is not consistent with the observed behavior of exchange rates and the underlying determinants. On the contrary, a major problem with the Mundell–Fleming model is that it assumes total absence of purchasing power parity even in the long run, thereby neglecting the role (in the exchange rate determination process) of stock equilibria. To begin with, the Dornbusch (1976c) model reinstates the Mundell–Fleming result that a small country can conduct its monetary policy effectively in the short run. Furthermore, it rehabilitates the monetary model with its classical result that monetary policy is neutral in the long run. In this perspective, the Dornbusch (1976c) model constitutes a

[3] This paper also investigates the effects of exogenous speculative disturbances and proceeds from there to a discussion of a dual exchange rate system that considers the influence of speculation on the real sector.

[4] See, for example, Dornbusch (1987).

second generation of monetary models, which has led to the development of several other models, such as the real interest differential model of Frankel (1979b) and the equilibrium real exchange rate model of Hooper and Morton (1982).

The originality of the Dornbusch (1976c) model lies in its rationalization of short-run exchange rate overshooting (relative to its long-run value), which is attributed to differences in the adjustment of financial and goods markets to disturbances in the short run. While financial markets appear to adjust instantaneously, goods markets adjust only gradually to disturbances in the economy. Rather, financial markets tend to over-adjust to disturbances to compensate for the stickiness of goods prices, which makes a change in the nominal money supply amount to a change in the real money supply. Following a rise in the real money supply, there is also an instantaneous rise in the demand for real money balances if the money market is to clear, leading to a downward movement in the interest rate, particularly when output is fixed. In the short run, therefore, a rise in the money supply leads to a fall in the interest rate (because of the "liquidity effect") and to a rise in the exchange rate. However, the deviation of the domestic interest rate from the world level can only be temporary under perfect capital mobility. Eventually, as goods prices begin their delayed response, an incipient rise in the real money supply starts to reverse itself. Actually, the whole process goes into reverse, forcing the domestic interest rate, aggregate demand, and the real exchange rate back toward their original values. This process comes to an end when all of the real magnitudes go back to where they started from (as in the flexible-price monetary model). At this stage, the nominal exchange rate settles at a new long-term level, which shows a proportional increase to the change in the money supply. Thus, the exchange rate overshoots its long-run value in the short run, but it tends to converge on the long-run value when the goods market has adjusted to disturbances in the long run.

5.2. Fundamental Propositions of the Dornbusch Model

The Dornbusch model begins with the macroeconomic foundations for goods, capital, and foreign exchange markets, providing the very basis for the determination of the equilibrium exchange rate. The following are the fundamental propositions and features that underlie the Dornbusch model.

Proposition 1

Because prices are sticky in the short run, the goods market reaches equilibrium only in the long run. This leads to two important implications: (i) purchasing power parity holds in the long run only and (ii) output and employment in the short run are determined in the goods market, as they are in the Mundell–Fleming model. However, when prices adjust fully to monetary disturbances in the long run, output and employment will be determined in the labor market, clearing at the natural rate of unemployment, as in the standard monetary model.

Proposition 2

The aggregate supply curve is horizontal in the short run and vertical in the long run. This implies that the supply conditions in the labor market fix the natural levels of output and employment uniquely only in the long run.

Proposition 3

Financial markets adjust instantaneously, giving rise to three important implications for interest rates. First, the domestic nominal interest rate adjusts fully to the market's expectations about inflation, which means that the real interest rate remains constant (that is, the Fisher condition holds continuously). Second, the interest rate differential is equal to the market's expectations of the inflation differential (which means that real interest parity holds continuously). Third, the nominal interest rate differential adjusts to the expected change in the exchange rate (thus uncovered interest parity holds at all times). The implication that follows from real interest parity and uncovered interest parity is that investors are risk neutral, so that nominal and real returns are equal.

Proposition 4

The short-run implications that follow from the Dornbusch open-economy macroeconomic model are similar to those of Friedman's (1968) closed economy macroeconomic model. Monetary and fiscal policies have real effects in the short run, but monetary policy is considered to be much more powerful than fiscal policy.

Proposition 5

The long-run policy implications of the Dornbusch model are also similar to those of Friedman's model. The quantity theory of money holds only in the long run, so that an increase in the money supply leads to higher prices, which means that money is neutral (in the long run). There is also a 100% crowding-out of private expenditure by government spending.

Proposition 6

Market agents hold rational expectations with respect to expected inflation and the expected change in the exchange rate. This implies that market participants make full use of all publicly relevant information to forecast prices and exchange rates. Accordingly, any increase in the nominal money supply is reflected immediately in a corresponding increase in the general price level and the nominal exchange rate to keep the real money supply, real income, and the real exchange rate constant.

5.3. In Defense of the Mundell–Fleming Model

Dornbusch (1976a) reformulates the Mundell–Fleming model under rational expectations to reassess the effects of monetary policy under flexible exchange rates. In the following subsections, we describe the aspects of this reformulation.

5.3.1. *A Restatement of the Mundell–Fleming Model*

In the rational expectations version of the Mundell–Fleming model, it is demonstrated that a monetary expansion may worsen the trade balance in the short run and lead to capital inflow that (in extreme cases) may reduce income and employment in the short run when the actual exchange rate deviates from the anticipated exchange rate. However, with the adjustment of exchange rate expectations over time (and the associated adjustment of interest rates), trade flows move the economy eventually to the Mundell–Fleming equilibrium. Under these conditions, a monetary expansion leads to an expansion in output and employment, as well as to a trade surplus and capital outflows. Another important result of the Dornbusch (1976a) model is that (under rational expectations, with perfect capital mobility and flexible exchange rates) the short-run depreciation of the currency caused by an expansion in the money supply overshoots the eventual long-run depreciation.

To reformulate the Mundell–Fleming model, we consider a small country that faces a given world interest rate and a perfectly elastic supply of imports at a given price in foreign currency terms. We also assume perfect capital mobility that leads to the equalization of net expected yields on domestic and foreign assets so that the domestic interest rate, less the expected rate of depreciation, will be equal to the world interest rate. With these assumptions, the Mundell–Fleming model can be expressed precisely in terms of three equations: (i) a national income equilibrium equation, where national income is decomposed into aggregate spending and the composition of spending between domestic goods and imports (trade balance or exports minus imports); (ii) a money market equilibrium equation, where the demand for money is a function of income and interest rate; and (iii) an equation for equilibrium in the domestic and foreign securities markets, showing that when domestic and foreign securities are perfect substitutes, then domestic and foreign interest rates will be identical. Therefore

$$Y = E(Y, i) + T(S, Y) \tag{5.1}$$

$$L = L(Y, i) \tag{5.2}$$

$$i = i^*. \tag{5.3}$$

Equation (5.1) shows that aggregate spending (E) by domestic residents on domestically produced goods goes down as the interest rate rises and goes up as real income increases. It also shows that the trade balance (T) deteriorates as imports rise (when there is an increase in real income) and improves as exports rise due to a rise in the exchange rate. Equation (5.3) implies that domestic and foreign assets are perfect substitutes, which means that arbitrage will force the equality of domestic and foreign interest rates.

By substituting equation (5.3) into equations (5.1) and (5.2), we can, for a given interest rate, derive the home country's $X\bar{X}$ schedule for the goods market and the $L\bar{L}$ schedule for the money market (Figure 5.1). The $X\bar{X}$ schedule represents combinations of the exchange rate and real income that clear the market for goods, whereas the $L\bar{L}$ schedule shows the unique level of income (Y_0) at which the money market clears.

Initial equilibrium is at point A, as shown in Figure 5.1, with the exchange rate at S_0 and real income at Y_0. Consider now the effect on real income and the trade balance of an increase in the money supply. At the initial equilibrium level of income (Y_0), an increase in the money supply

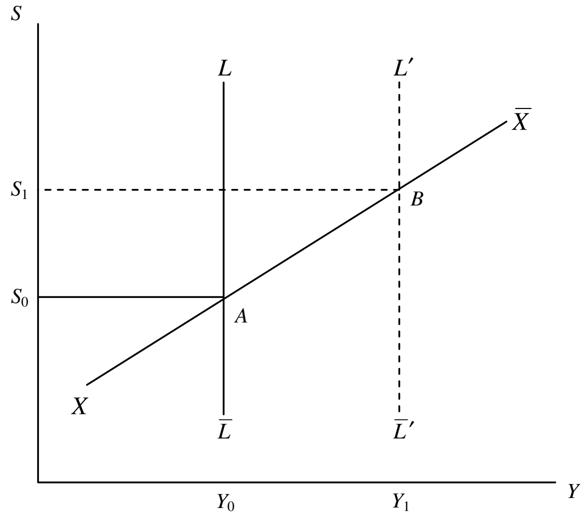

Figure 5.1. The effect of monetary expansion in the Mundell–Fleming model.

leads to a shift in the $L\bar{L}$ schedule from $L\bar{L}$ to $L'\bar{L}'$. As a result, a new equilibrium position is established at B, where the markets for goods and money clear at Y_1 and S_1. Adjustment toward the new equilibrium position at B occurs in the following manner. The excess supply of money at A causes a fall in the interest rate, which would induce capital outflow. This, in turn, leads to a rise in the exchange rate from S_0 to S_1, which boosts the demand for domestic goods, resulting in a rise in real income until the demand for money matches the higher money supply. Corresponding to the higher income level at B, we have a trade surplus, as the increase in income is not matched by an equal increase in absorption or spending. The trade surplus, in turn, is matched by capital outflow (acquisition by domestic residents of claims on the rest of the world). The extent of the exchange rate change required to restore equilibrium is inversely related to the substitutability between domestic and foreign goods. The higher the substitutability, the smaller is the change in the equilibrium exchange rate or terms of trade.

5.3.2. *Exchange Rate Expectations and Adjustment to Monetary Expansion*

If exchange rate expectations are not static, the domestic interest rate may differ from the world rate by the extent to which the domestic currency is anticipated to depreciate, which gives

$$i = i^* + \left(\frac{S^e}{S} - 1\right). \tag{5.4}$$

It follows from equation (5.4) that if the exchange rate is expected to rise, the domestic interest rate will be higher than the foreign interest rate to compensate the holders of domestic assets for the anticipated depreciation or capital gain foregone on foreign currency holdings.

Dornbusch (1976a) argues that exchange rate expectations play a critical role in the adjustment process by allowing the economy to accommodate a monetary expansion before the output response raises the demand for money to match the higher money supply. The adjustment of output and the exchange rate over time serves to raise the interest rate and adjusts trade flows until the long-run Mundell–Fleming equilibrium is attained at higher levels of output and employment. It is argued that the elasticity of expectations is less than unity in the short run and equal to unity in the long run. In the short run, therefore, currency depreciation gives rise to anticipated currency appreciation and consequently to a decline in the domestic interest rate. In the long run, variations in the exchange rate have no effect on the domestic interest rate because exchange rate expectations adjust fully[5]:

$$\mathrm{d}i/\mathrm{d}S = \sigma - 1 \leq 0 \tag{5.5}$$

where σ is the elasticity of expectations. Thus, the Mundell–Fleming model, as represented by equations (5.1)–(5.3), can be modified by allowing the domestic interest rate to depend on exchange rate expectations in the short run. By substituting equation (5.4) into equations (5.1) and (5.2), we note that the money demand and aggregate spending functions become responsive to the spot exchange rate. As a result, the $L\bar{L}$ schedule turns out to be negatively sloped because a higher exchange rate (lower interest rate) has to be matched by a lower level of income to maintain monetary equilibrium. On the other hand, the $X\bar{X}$ schedule becomes flatter than before because a higher exchange rate (lower interest rate) will have to be matched by a higher level of income to maintain equilibrium in the goods market. Currency depreciation raises aggregate demand for domestic output, both via the substitution effect (resulting from the effect of a rise in the exchange

[5]At the initial equilibrium, we assume that $S = S^e = 1$ and $i = i^*$.

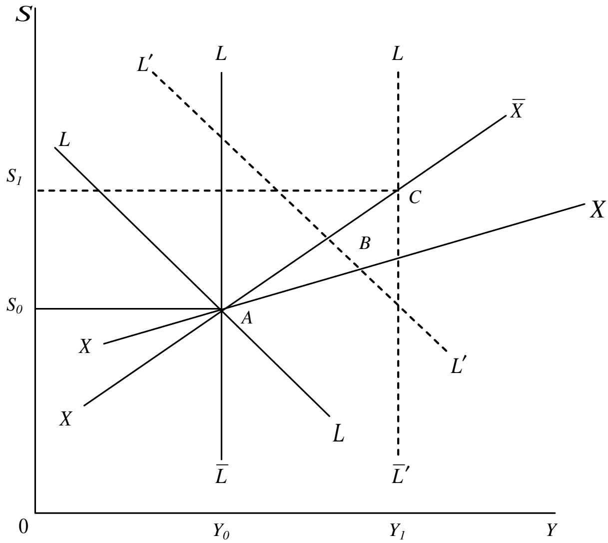

Figure 5.2. The effect of monetary expansion in the short- and long-run.

rate on the terms of trade) and via the effect of a rise in the exchange rate on interest rates and consequently on spending.

In Figure 5.2, we observe the negatively sloped money market equilibrium schedule, *LL*, and the flatter goods market equilibrium schedule, *XX*, derived under the assumption that exchange rate expectations are not static. These schedules are superimposed on those of the Mundell–Fleming model, which are derived under the assumption that expectations are static (that is, $L\bar{L}$ and $X\bar{X}$. Initial equilibrium is reached at A, where the goods and money markets clear at Y_0 and S_0. A monetary expansion in this framework creates excess money supply at the initial equilibrium point A, which requires an increase in income or currency depreciation to restore monetary equilibrium. This is represented by a shift in the money market equilibrium schedules from LL to $L'L'$ and from $L\bar{L}$ to $L\bar{L}'$, respectively. Short-run equilibrium moves to B (with an increase in income and currency depreciation), whereas long-run equilibrium moves to point C, with a higher level of income and further currency depreciation. Clearly, income expansion at B falls short of that in the Mundell–Fleming model because the domestic interest rate declines so that the induced decline in velocity dampens income expansion.

To determine the effect on income of a given change in the money supply, we take the differentials of equations (5.1), (5.2), and (5.4) and rearrange to obtain

$$(1 - E_Y - T_Y)\mathrm{d}Y - E_i\mathrm{d}i - T_S\mathrm{d}S = 0 \tag{5.6}$$

$$L_y\mathrm{d}Y + L_i\mathrm{d}i = \mathrm{d}\bar{L} \tag{5.7}$$

$$-\mathrm{d}i + (\sigma - 1)\mathrm{d}S = 0. \tag{5.8}$$

Formally, the increase in income at B is given by the monetary policy multiplier represented by

$$\frac{\mathrm{d}Y}{\mathrm{d}\bar{L}} = \frac{[E_i(\sigma - 1) + T_S]}{L_i(\sigma - 1)(1 - E_Y - T_Y) + [E_i(\sigma - 1) + T_S]L_Y} > 0. \tag{5.9}$$

It is clear from equation (5.9) that if the elasticity of expectations is less than unity, income expansion falls short of the traditional Mundell–Fleming result of the monetary policy multiplier given by equation (2.20) (that is, $\mathrm{d}Y/\mathrm{d}\bar{L} = 1/L_Y$).

Consider now the adjustment process that is induced by the revision of exchange rate expectations. Dornbusch (1976a) argued that equilibrium at point B in Figure 5.2 is sustained only if market participants make expectation errors. It is argued that exchange rate expectations are revised over time and that in the long run (when the elasticity of exchange rate expectations becomes unity), the economy will converge on the Mundell–Fleming equilibrium at C, where the actual and expected exchange rates are equal. This adjustment process can be explained as follows. At the short-run equilibrium point B, an increase in the expected exchange rate will (from equation (5.4)) raise the domestic interest rate, creating excess money supply and excess supply of goods. As a result, the money market equilibrium schedule shifts upward and to the right, while the goods market equilibrium schedule shifts upward and to the left. The money market equilibrium schedule shifts upward in proportion to the increase in the expected exchange rate, as the interest rate stays unchanged only under these conditions. With unchanged income, money market equilibrium is sustained. The goods market schedule shifts upward by less, as the exchange rate affects aggregate demand for domestic output, not only via the interest rate but also via the relative price effect. The upward shift of the goods market schedule is represented by

$$\left.\frac{\mathrm{d}S}{\mathrm{d}S^{\mathrm{e}}}\right|XX = \frac{E_i(\sigma - 1)}{E_i(\sigma - 1) + T_S} < 1. \tag{5.10}$$

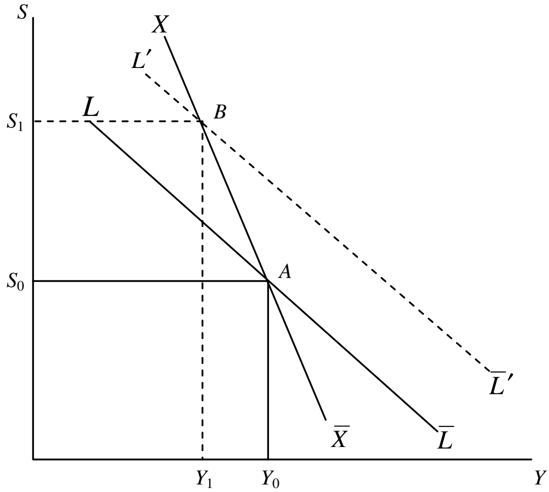

Figure 5.3. The effect of monetary expansion in the absence of Marshall–Lerner condition.

5.3.3. *Failure of the Marshall–Lerner Condition*

In this subsection, we consider the case where the Marshall–Lerner condition fails. In this case, the goods market equilibrium schedule is negatively sloped, and the short-run effect of a monetary expansion would be lower output and currency depreciation, as shown in Figure 5.3.

The interpretation of this result is that the decline in interest rates following a monetary expansion gives rise to capital outflow that in turn leads to currency depreciation, thereby exerting a net deflationary effect on domestic aggregate spending. This very orthodox result is noted by Niehans (1975) as an extreme possibility and that it is consistent with stability if we take the expected rate as given. Allowing for subsequent adjustment of the expected rate and further depreciation makes the process unstable, as it involves progressive depreciation and continuing decline in output.

5.3.4. *Exchange Rate Overshooting and Aggregate Spending*

Our objective in this subsection is to explore the effects of a rise in actual and expected exchange rates on the level and composition of aggregate spending. The reason why we are concerned with these effects is very simple. It is recognized that physical trade flows are less responsive to exchange rate changes in the short run than in the long run when substitutability between goods is high. To determine formally the effect of changes in exchange rates on physical trade flows, it is initially assumed that these flows respond only to changes in the expected exchange rate. Accordingly, we can write the trade balance in equation (5.1) as follows

$$\begin{gathered} T = X(S^{\mathrm{e}}) - S \times M(S^{\mathrm{e}}), \\ T_S = -M, \quad T_{S^{\mathrm{e}}} > 0, \quad T_S + T_{S^{\mathrm{e}}} > 0 \end{gathered} \tag{5.11}$$

where X and M stand for physical exports and imports. Equation (5.11) implies that, given the expected exchange rate, a rise in the exchange rate worsens the trade balance by exactly the effect of the terms of trade on income (that is, by $-M\mathrm{d}S$). In contrast, a rise in the expected exchange rate improves the trade balance, as it raises exports and reduces imports. Eventually, a proportional rise in both the current and expected exchange rates is likely to improve the trade balance. Thus aggregate spending is affected not only by interest rate and real income, but also by the actual and expected exchange rates. Accordingly, the expression for aggregate spending in equation (5.1) can be written as

$$E = E(i, Y, S, S^{\mathrm{e}}) \tag{5.12}$$

where $E_S = -T_S = -E_{S^{\mathrm{e}}} = M$. It is possible then to modify the goods market equilibrium condition (implied by equation (5.1)) to the following:

$$Y = E(i, Y, S, S^{\mathrm{e}}) + T(S, S^{\mathrm{e}}, Y). \tag{5.13}$$

Thus, a rise in the exchange rate will, in the short run, raise the demand for domestic goods to the extent that it lowers interest rates and causes a rise in the expected exchange rate. Let us assume that the short-run effect falls short of the long-run effect that is due to a full adjustment of the spending pattern to a change in the terms of trade. This is given by

$$E_i(\sigma - 1) + (E_{S^{\mathrm{e}}} + T_{S^{\mathrm{e}}}) < T_S + T_{S^{\mathrm{e}}} \tag{5.14}$$

or

$$\theta \equiv E_i + T_S + T_{S^{\mathrm{e}}} > 0. \tag{5.15}$$

The condition represented by equation (5.15) is satisfied if aggregate spending is relatively unresponsive to the interest rate.

Figure 5.4 shows that the preceding arguments can be summarized in the short- and long-run goods market equilibrium schedules ($X\bar{X}(\sigma < 1)$ and $X\bar{X}(\sigma = 1)$), respectively. The interest rate is constant along the long-run

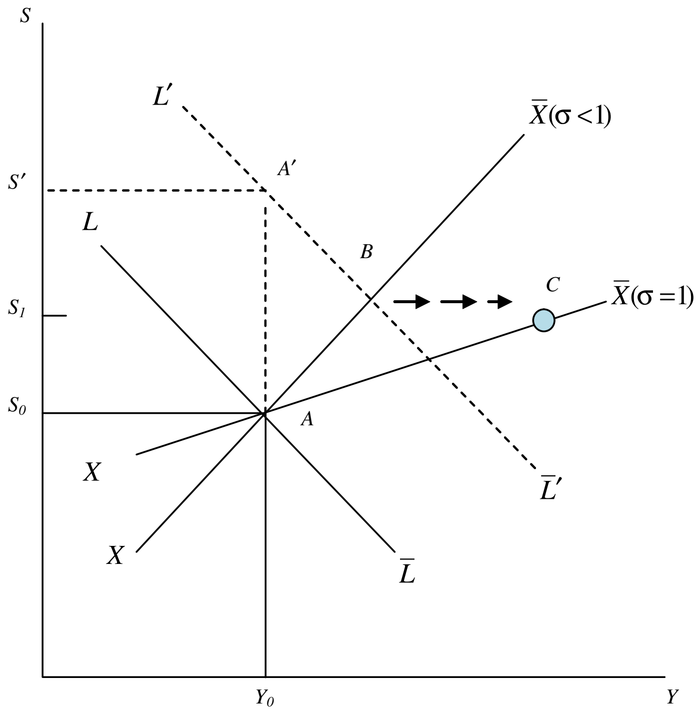

Figure 5.4. Monetary expansion and the overshooting in the exchange rate.

schedule ($X\bar{X}(\sigma = 1)$), which implies full adjustment to a change in the terms of trade. This makes it equivalent to the Mundell–Fleming treatment of the goods market in Figure 5.1. In contrast, the short-run goods market schedule ($X\bar{X}(\sigma < 1)$) allows only partial adjustment of expectations, which makes aggregate demand less responsive to changes in the exchange rate, as implied by equations (5.14) and (5.15).

Consider now the adjustment process to a monetary expansion, which is explained by invoking the assumption that while the money market clears instantaneously, goods market adjustment occurs over time. Accordingly, excess money supply at point A shifts the money market equilibrium schedule to the right from $L\bar{L}$ to $L'\bar{L}'$, as shown in Figure 5.4. Monetary expansion reduces the interest rate at a given level of income (Y_0), producing capital outflow that leads to a rise in the exchange rate to point A' (from S_0 to S'). The rise in the actual exchange rate relative to the expected exchange rate at A' matches the decline in the interest rate. Therefore, the impact effect of a monetary expansion is to induce a sharp rise in the exchange rate.

But the rise of the exchange rate and the fall of the interest rate at A' will be temporary. The changes at A' imply an increase in the demand for domestic output (and therefore an expansion in income), which will move the short-run equilibrium position to B. The adjustment comes about through the effect of output expansion on the interest rate. Rising output boosts money demand, pushes the interest rate up, and consequently creates an incipient capital inflow that in turn causes currency appreciation. Therefore, the exchange rate will overshoot in the short run, and this depreciation of the domestic currency will be offset once the income adjustment tightens up the money market.

5.4. Short- and Long-Run Views of Exchange Rates

In this section, we illustrate how exchange rates are determined in the short run and in the long run according to the propositions put forward by Dornbusch. We start with Dornbusch's view of exchange rates in the short run.

5.4.1. *Exchange Rate Determination in the Short Run*

Dornbusch (1976b) argued that, in the short run, the exchange rate is exclusively determined by the asset markets, more specifically by capital mobility and money market equilibrium. The scope for goods arbitrage is limited in the short run, which means that purchasing power parity may hold for a limited set of commodities or traded goods only. Under the circumstances, it is useful to abstract altogether from the details of the goods market, looking instead at the exchange rate as being determined by interest arbitrage. According to this view, which assigns a critical role to capital mobility, the exchange rate is determined by interest arbitrage together with speculation about its future value.

Assuming that domestic and foreign assets are perfect substitutes on a covered basis, covered interest arbitrage requires the domestic interest rate, less the forward spread $((F - S)/S)$ to be equal to the foreign interest rate. The covered interest parity condition can be written as

$$i = i^* + (F/S) - 1. \tag{5.16}$$

Given real income and other determinants of real money balances, the equilibrium interest rate (at which the existing quantity of money is held willingly) is a function of the real quantity of money. Mathematically, it is given by

$$i = i(M/P, \ldots). \tag{5.17}$$

Substituting equation (5.16) into equation (5.17), we obtain a relation between the real money supply and the spot and forward rates:

$$i(M/P, \ldots) = i^* + (F/S) - 1. \tag{5.18}$$

Differentiating equation (5.18) and denoting the interest sensitivity of money demand by σ, we obtain[6]

$$\dot{S} = \dot{F} + \left(\frac{1}{\sigma}\right)\dot{M} \tag{5.19}$$

where (by assumption) the foreign interest rate and the price level are held constant. Equation (5.19) implies that a change in the forward rate induces a proportional change in the spot rate, while an increase in the money supply causes a rise in the spot rate that is inversely proportional to the interest sensitivity of money demand. Dornbusch (1976b, p. 158) argued that as the interest sensitivity of the money demand function is of the order of 0.5 a monetary expansion will be matched by a significantly more than proportional expected depreciation of the domestic currency.

In equation (5.19), the forward rate is determined exogenously. We may assume that the forward rate is set by speculators in a perfectly elastic manner at the expected spot rate and that expectations about the latter are formed in an adaptive manner. With these assumptions, we have

$$F = \phi S + (1 - \phi)S_{t-1} \tag{5.20}$$

where $0 < \phi < 1$. Equation (5.20) implies that the forward rate is a weighted average of the current and last period spot rate, and that the forward rate increases as the spot rate increases but less proportionately. Thus, the price of foreign exchange is set at a forward discount. From equation (5.20), let us substitute the expression $\dot{F} = \phi\dot{S}$ in equation (5.19) to obtain the total impact effect of a monetary expansion on the spot rate, which is represented by

$$\dot{S} = \frac{1}{(1 - \phi)\sigma}\dot{M}. \tag{5.21}$$

[6]Given the money market equilibrium condition $(M/P = L(i, \ldots))$, we have $\mathrm{d}i = \dot{M}(M/P)/L_i = -(1/\sigma)\dot{M}$. The interest responsiveness of money demand (that is, the semi-logarithmic derivative $\sigma \equiv -L_i/L$) is significantly less than unity in the short run.

Clearly, adaptive expectations serve to increase the impact effect of money on the exchange rate. In fact, the more closely the forward rate is determined by the current spot rate (the closer ϕ is to unity), the larger the exchange rate fluctuations induced by variation in the money supply.

Three conditions stand out while interpreting the effect of monetary expansion on the exchange rate. First, domestic and foreign assets are perfect substitutes on a covered basis, implying that (independently of any particular assumptions about expectations) a fall in domestic interest rates must be matched by a forward discount on the foreign currency to equalize net yields on domestic and foreign assets. Second, for asset market equilibrium, a fall in the domestic interest rate has to be matched by an expected fall in the spot exchange rate. If the elasticity of expectations is less than unity, a rise in the spot rate is accompanied by a less than proportional rise in the expected spot rate, or an anticipated fall in the actual spot rate (appreciation of the domestic currency). Finally, the magnitude of the rise in the spot rate that is required depends on both the interest rate sensitivity of money demand (σ) and the elasticity of expectations (ϕ). The smaller the interest rate sensitivity of money demand, the larger the interest rate change caused by a monetary expansion, and the larger the expected fall in the spot rate. Moreover, currency depreciation gives rise to expected appreciation that is smaller, the larger the elasticity of expectations. Consequently, large exchange rate expectations are likely to arise in circumstances where the interest rate response of money is small and the elasticity of expectations is large.

In the short run, therefore, the exchange rate is determined entirely by the conditions prevailing in asset markets and by expectations. Moreover, the liquidity-induced decline in the domestic interest rate appears to be the main channel through which a monetary expansion leads to an immediate rise in the exchange rate that is sufficient for the existing stock of domestic assets to be held. It is in this sense that in the short run the exchange rate is determined in asset markets.

5.4.2. *Exchange Rate Determination in the Long Run*

In the long run, the exchange rate is determined by interaction between the goods and asset markets via both interest and commodity arbitrage. The equilibrium exchange rate is determined jointly by monetary and real variables. One critical ingredient of the long-run view of exchange rates is that purchasing power parity holds for traded goods only. Thus

$$S = P_{\mathrm{T}}/P_{\mathrm{T}}^{*} \tag{5.22}$$

where $P_{\mathrm{T}}(P_{\mathrm{T}}^{*})$ is the domestic (foreign) currency price of traded goods. By assuming that the price level is a weighted average of the prices of traded and non-traded goods, we have

$$P = P_{\mathrm{N}}^{\theta} P_{\mathrm{T}}^{1-\theta} \tag{5.23}$$

$$P^{*} = P_{\mathrm{N}}^{*\theta} P_{\mathrm{T}}^{1-*\theta} \tag{5.24}$$

where $\theta(\theta^{*})$ is the share of non-traded goods in the domestic (foreign) price index. Given equal weights for nontraded and traded goods at home and abroad ($\theta = \theta^{*}$), combining equations (5.22)–(5.24) yields

$$S = \left(\frac{P}{P^{*}}\right)\left(\frac{P_{\mathrm{T}}/P_{\mathrm{N}}}{P_{\mathrm{T}}^{*}/P_{\mathrm{N}}^{*}}\right)^{\theta}. \tag{5.25}$$

Another critical ingredient of the long-run view of exchange rates is the equilibrium condition in the money market, stated in terms of stable real money demand functions and exogenously determined real money supply. These functions and equilibrium conditions are written as

$$\left(\frac{M}{P}\right)^{\mathrm{d}} = Y^{\alpha} \mathrm{e}^{-\beta i} \tag{5.26}$$

$$\left(\frac{M^{*}}{P^{*}}\right)^{\mathrm{d}} = Y^{*\alpha} \mathrm{e}^{-\beta i^{*}} \tag{5.27}$$

$$\left(\frac{M}{P}\right)^{\mathrm{s}} = \left(\frac{M}{P}\right) \tag{5.28}$$

$$\left(\frac{M^{*}}{P^{*}}\right)^{\mathrm{s}} = \left(\frac{M^{*}}{P^{*}}\right). \tag{5.29}$$

Combining equations (5.26)–(5.29) and then substituting the resulting expression for (P/P^{*}) into (5.25), we obtain

$$S = \left(\frac{M}{M^{*}}\right)\left(\frac{Y^{*}}{Y}\right)^{\alpha} \mathrm{e}^{-\beta(i-i^{*})} \left(\frac{P_{T}/P_{\mathrm{T}}^{*}}{P_{\mathrm{N}}/P_{\mathrm{N}}^{*}}\right)^{\theta}. \tag{5.30}$$

equation (5.30) shows that the equilibrium exchange rate is determined in the long run by conditions of equilibrium in the goods and money markets. The usefulness of equation (5.30) can be enhanced by considering the log difference version:

$$\Delta s = (\Delta m - \Delta m^*) - \alpha(\Delta y - \Delta y^*) - \beta(\Delta i - \Delta i^*) + \theta[(\Delta p_{\mathrm{T}} - \Delta p^*_{\mathrm{T}}) - (\Delta p_{\mathrm{N}} - \Delta p^*_{\mathrm{N}})]. \tag{5.31}$$

In equation (5.31), the first term captures the impact of monetary changes on the exchange rate. Other things being equal, the country with the higher monetary growth rate tends to have a depreciating currency. This particular term captures the effect on the exchange rate of differences in long-run inflation rates.

The second and third terms capture the effect of differential changes in real money demand. The country that experiences a relative increase in real money demand tends to experience currency appreciation. The terms representing real money demand in equation (5.31) constitute one of the links between the exchange rate, the monetary sector, and the real sector. The last term in equation (5.31) captures the effect of changes in the relative price structures. Given the nominal quantity of money and the demand for real money balances (and therefore the price level), an increase in the equilibrium relative price of traded goods causes domestic currency depreciation.

5.4.3. *Interaction Between Goods and Asset Markets*

Let us now focus on how the interaction between goods and asset markets affects the exchange rate over time. Consider first the domestic goods market, where the excess demand for domestic goods depends on the relative price of traded goods in terms of the price level (P_{T}/P). The interest rate determines absorption for given levels of real income and government spending on non-traded goods (g). Therefore we have

$$N\left(\frac{P_{\mathrm{T}}}{P}, i, g\right) = 0 \tag{5.32}$$

such that $N_{P_{\mathrm{T}}/P} > 0$, $N_i < 0$ and $N_g = 1$. This means that an increase in the relative price of traded goods generates excess demand as consumers substitute domestic goods. Equation (5.32) also shows that an increase in interest rate reduces absorption, whereas an increase in government spending adds directly to the demand for domestic goods. The equation can be solved for the equilibrium relative price of traded goods (in terms of the interest rate and government spending) to obtain

$$\frac{P_{\mathrm{T}}}{P} = \theta(i, g) \tag{5.33}$$

such that $\theta_i > 0$ and $\theta_g < 0$.[7]

Let us now consider the equilibrium condition in the money market. As the demand for real balances depends on interest rates and real income, we can solve the money market equilibrium condition for the equilibrium interest rate as a function of the real money balance and real income as follows:

$$i = i\left(\frac{M}{P}, Y\right) \tag{5.34}$$

such that $i_{M/P} < 0$ and $i_Y > 0$. Assuming that Y is constant, substituting equation (5.33) into equation (5.34), and noting that purchasing power parity holds with a given price of foreign goods ($P_{\mathrm{T}} = SP_{\mathrm{T}}^*$), we can write the equilibrium condition for domestic goods as

$$\bar{N}\left(\frac{SP_{\mathrm{T}}^*}{P}, i\left(\frac{M}{P}\right), g\right) = 0 \tag{5.35}$$

where $\bar{N}$ is the reduced form equilibrium condition for the domestic goods market, which embodies the money market equilibrium condition (the constant level of income is suppressed as an argument). Figure 5.5 shows the domestic goods market equilibrium schedule $\overline{NN}_0$, which is positively sloped and flatter than the 45-degree line. This is because at a high price level, real balances are low, interest rates are high, and real spending is low. The $\overline{NN}_0$ schedule is drawn for given nominal quantity of money and foreign currency price of traded goods.

Let us now turn to the asset market equilibrium schedule. The asset market reaches equilibrium when interest rates across countries are equalized on a covered basis, which means that equation (5.16) must hold continuously. The forward rate in equation (5.16) is set by speculators, according to the adaptive expectations scheme, as in equation (5.20).

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[7] Similarly, excess demand for traded goods depends on the relative price of traded goods in terms of the price level and the interest rate term reflecting absorption or the level of spending, which is given by $T = T(P_{\mathrm{T}}/P, i)$. Accordingly, an increase in the relative price of traded goods leads to a deteriorating trade balance, whereas an increase in the interest rate leads to trade balance improvement.

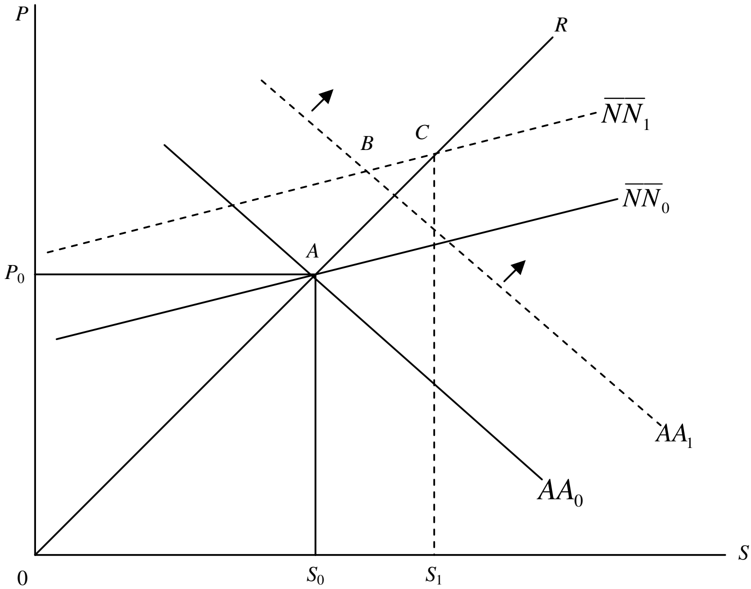

Figure 5.5. Equilibrium in the goods market and asset market.

Substituting the expression for the forward rate in equation (5.18), and using the equilibrium interest rate in equation (5.34), we obtain the condition for money market equilibrium together with covered interest arbitrage:

$$i\left(\frac{M}{P}\right) - (1-\phi)\left(\frac{S_{t-1}}{S-1}\right) = i^*. \tag{5.36}$$

A critical property of speculative behavior is that an increase in the spot rate creates a forward discount, as it will cause the forward rate to rise less than proportionately. To maintain interest parity, a forward discount on the foreign currency has to be accompanied by a fall in domestic relative to foreign interest rates. Given the nominal quantity of money, such a decline in interest rates would arise if the domestic price level declined. Equation (5.36) can be plotted to derive the AA_0 schedule for an asset market, as shown in Figure 5.5. The asset market schedule is derived for a given foreign interest rate, a given quantity of money, and a given last period spot rate, S_{t-1}.

At the initial equilibrium position A, goods and asset markets clear together, the forward rate is at par (so that no revision of expectations is required), and the relative price structure is measured by the slope of OR. The equilibrium exchange rate and price level are S_0 and P_0, respectively. To see the effect of monetary expansion on the equilibrium exchange rate, we allow an increase in the quantity of money at the initial equilibrium exchange rate (S_0). An expansion in the money supply reduces the domestic interest rate, which in turn creates excess demand for domestic goods and departure from covered interest parity. For domestic goods market equilibrium to be restored, the exchange rate and goods prices must rise in the same proportion as the nominal quantity of money. This is indicated by an upward shift of the goods market equilibrium schedule from $\overline{NN}_0$ to $\overline{NN}_1$ in the proportion $AC/OA = \dot{M}$.

Asset market equilibrium in the short run does not possess the homogeneity property, as the elasticity of exchange rate expectations is less than unity. Accordingly, the asset market schedule shifts upward in a smaller proportion, from AA_0 to AA_1. Short-run equilibrium is reached at B, where the exchange rate and goods prices rise less than proportionately relative to the increase in the money supply. Therefore, point B represents a transitory equilibrium. Under short-run equilibrium, the relative price of domestic goods is higher at B compared with A, which is a reflection of the decline in the interest rate and the expansion of absorption. The adjustment of expectations over time shifts the asset market schedule (AA_1) to the right until long-run real equilibrium is restored at C, where expectation errors have subsided and where prices and the exchange rate fully reflect the monetary change.

5.5. The Overshooting Model of Exchange Rates

Since the advent of floating, exchange rates have been more volatile than most analysts had previously expected. In particular, the observed large fluctuations in exchange rates have not been consistent with the observed movements in the underlying macroeconomic fundamentals as predicted by the proponents of the flexible-price monetary model. Dornbusch (1976c) developed an alternative hybrid macroeconomic model that is suggestive of the observed large fluctuations in exchange rates, while at the same time establishing that exchange rate movements are consistent with rational expectations formation. The overshooting model is in fact an extension of both the flexible-price monetary model and the Mundell–Fleming model.

The adjustment process to a monetary expansion in the overshooting model is used to identify two important features of exchange rate movements that are suggestive of the observed currency experience. First, a monetary expansion that leads to an incipient fall in the interest rate and an increase in real income in the short run induces currency depreciation that overshoots its long-run value. Second, during the adjustment process, prices start rising to match the expansion in the money supply until (in the long run) the monetary expansion is exactly matched by a rise in prices so that real money balances and interest rates are unchanged and the domestic currency depreciates in the same proportion as the increase in the money supply. The exact dynamics of the adjustment process depends on the speed at which prices respond as compared to expectations.

5.5.1. *The Structure of the Dornbusch Model*

The Dornbusch model begins with the premises of perfect capital mobility, monetary-induced rational exchange rate expectations, stable monetary conditions, rapid adjustment of financial markets, and sluggish adjustment of goods markets. It assumes a country that is so small that it faces a given interest rate. Capital mobility is assumed to ensure equalization of expected net yields, so that the domestic interest rate less the expected rate of depreciation is equal to the world interest rate. Moreover, the model assumes that in the goods market the world price of imports is given. It also assumes that domestic goods are imperfect substitutes for imports, which means that aggregate demand for domestic goods determines their absolute and relative prices. More precisely, the Dornbusch model is made up of three equations representing: (i) a condition for the equalization of interest rates adjusted for anticipated changes in the exchange rate, (ii) a condition for money market equilibrium, and (iii) a condition for goods market equilibrium.

Equalization of Expected Net Yields on Domestic and Foreign Assets

If capital is perfectly mobile, financial assets denominated in domestic and foreign currencies will become perfect substitutes, in the sense that a proper premium on them will offset anticipated changes in exchange rates. This is represented by the uncovered interest parity condition:

$$\Delta s^{e} = i - i^{*}. \tag{5.37}$$

Equation (5.37) shows that if the domestic currency is expected to depreciate, the domestic interest rate will exceed the foreign interest rate by the extent to which the domestic currency is expected to depreciate. A question that arises here is: how is the expected change in the exchange rate (Δs^{e} equation (5.37)) determined? To answer this question, let us consider the expectation formation mechanism whereby the expected rate of depreciation is proportional to the discrepancy between the long-run exchange rate, on which the economy tends to converge ($\bar{s}$), and the current exchange rate (s). This mechanism can be expressed as

$$\Delta s^{e} = \theta(\bar{s} - s) \tag{5.38}$$

where θ is the coefficient of adjustment of the current exchange rate toward its long-run value, which is determined by relative prices. The parameter θ measures the sensitivity of market expectations to the proportional over- or undervaluation of the domestic currency to the discrepancy between the long run and current values of the exchange rate. For any given degree of overvaluation, the higher the value of θ, the more rapidly the exchange rate is expected to rise. If the prices of goods adjust continuously to changes in the money supply, the current exchange rate tends to converge on its long-run value. In this case, the coefficient of adjustment is infinite (that is, $\theta = \infty$). As goods prices are sticky in the short run, the exchange rate does not adjust to relative prices quickly, which means that θ is finite (that is, $\theta > 0$). This is the essential characteristic of the Dornbusch model. To explain this characteristic, let us substitute equation (5.37) into equation (5.38) and solve for s to obtain

$$s = \bar{s} - \frac{1}{\theta}(i - i^{*}). \tag{5.39}$$

Equation (5.39) implies that, given the long-run exchange rate ($\bar{s}$), there is a negative relation between the current exchange rate and the interest rate differential. This relation can be illustrated with the aid of the *RP* (interest rate parity) line, as shown in Figure (5.6).

The relation represented by the *RP* line may be explained as follows. For any equilibrium long-run exchange rate (such as S_0 or S_3, at which $i = i^{*}$), the *RP* line, which slopes downward from left to right, represents the feasible

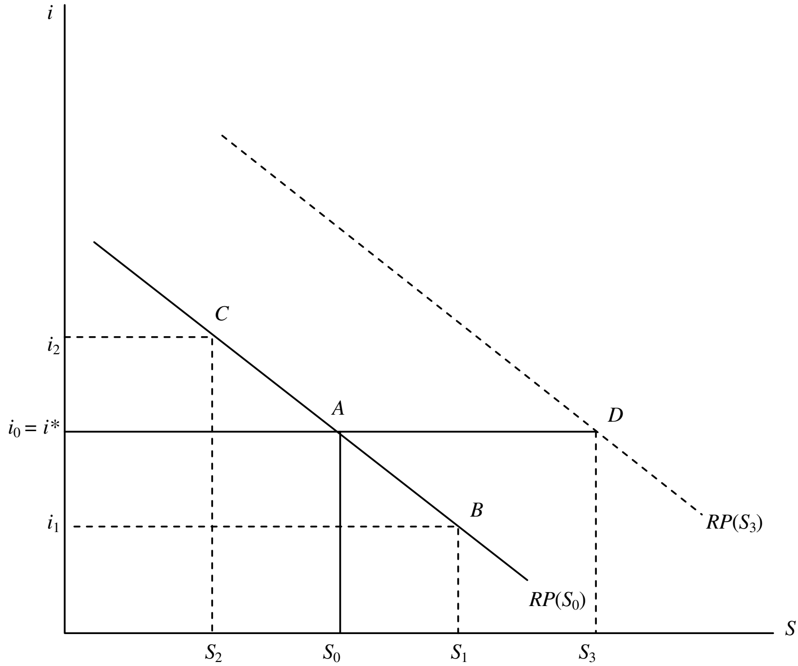

Figure 5.6. Short-run equilibrium in the securities market and exchange rate overshooting.

combinations of the exchange rate and domestic interest rate that are consistent with short-run equilibrium in the asset market. Along the *RP* line, the domestic currency is either depreciating or appreciating at points below or above i^*, respectively. Thus a decline in the domestic interest rate at point *B* (from i_0 to i_1) reduces the yield on domestic bonds relative to that on foreign bonds, inducing domestic bond holders to move their funds out of domestic bonds into foreign bonds. This reaction will result in capital outflow and hence a deficit in the capital account that will be eliminated by depreciation of the domestic currency (from S_0 to S_1). Similarly, a rise in the domestic interest rate from i_0 to i_2 at point *C* raises the yield on domestic bonds relative to that on foreign bonds, inducing bond holders to move their funds into domestic bonds. The resulting capital inflow and the surplus in the capital account may be eliminated by appreciation of the domestic currency (from S_0 to S_2). Clearly the same argument applies to short-run divergence from any other long-run equilibrium, such as at point *D*. Note that the gradient of the *RP* line is equal to (minus) the value of the expectation–adjustment parameter (θ).

This analysis raises a question about how the domestic interest rate and the interest rate differential are determined. In the Dornbusch model, the interest rate differential (rather than the exchange rate) provides an immediate equilibrating mechanism in the money market. It is therefore necessary to determine the relative money market equilibrium condition and rationalize why (in the short run) the exchange rate overshoots the long-run value that is determined by relative prices.[8] The model describes how financial and goods markets adjust to disturbances in the economy, thereby giving rise to the overshooting phenomenon.

The Money Market

The interest rate differential is determined by the equilibrium conditions in the domestic and foreign money markets. The demand for real money balances, which is equal to the money supply in equilibrium, is assumed to depend on interest rates and real incomes. The relative money market equilibrium condition may be derived directly by combining equations (5.26)–(5.29) and then writing the resulting expression in logarithmic form as

$$(m - m^*) - (p - p^*) = \alpha(y - y^*) - \beta(i - i^*). \tag{5.40}$$

Equation (5.41) may be viewed as determining the interest rate differential in the short run because prices are assumed not to adjust instantaneously. For this purpose, it is useful to rewrite equation (5.40) for the interest rate differential as

$$i - i^* = -\frac{1}{\beta}[(m - m^*) - \alpha(y - y^*) - (p - p^*)]. \tag{5.41}$$

By substituting equation (5.40) into equation (5.39), we obtain

$$s = \bar{s} + \frac{1}{\theta\beta}\left[\left(m - m^*\right) - \alpha\left(y - y^*\right) - \left(p - p^*\right)\right]. \tag{5.42}$$

If purchasing power parity holds in the long run, the current exchange rate tends to converge on long-run equilibrium relative prices ($\bar{p} - \bar{p}^*$), which in turn converge on the homogeneity properties of relative money

[8]Financial and goods markets equilibrium as discussed here is based on two-country analysis, and not on a single-country analysis as found in Dornbusch (1976c).

supplies and relative real income if the quantity theory of money holds at home and abroad. Therefore

$$\bar{s} = (\bar{p} - \bar{p}^*) \tag{5.43}$$
$$\bar{p} - \bar{p}^* = (m - m^*) - \alpha(y - y^*). \tag{5.44}$$

By substituting equations (5.42) and (5.43) into equation (5.44), we obtain

$$\begin{aligned} s = {} & (m - m^*) - \alpha(y - y^*) \\ & - \frac{1}{\beta\theta}[(m - m^*) - \alpha(y - y^*) - (p - p^*)] \end{aligned} \tag{5.45}$$

or

$$s = (\bar{p} - \bar{p}^*) - \frac{1}{\beta\theta}[(p - p^*) - (\bar{p} - \bar{p}^*)] \tag{5.46}$$

where $\bar{p} - \bar{p}^* = (m - m^*) - \alpha(y - y^*)$.

Equation (5.45) shows that, for a given level of income, a change in the money supply affects the exchange rate via two channels: (i) the proportional increase in the equilibrium exchange rate ($\bar{s}$) and (ii) the liquidity effect brought about by the short-run rigidity of prices. Through the second effect, an increase in relative prices results in a fall in domestic interest rates relative to foreign rates, while the interest parity condition is maintained through the induced premium on the domestic currency. As prices adjust through time, the liquidity effect will be eliminated, and a proportional relation between the exchange rate and relative prices materializes in the long run.

The important point is that the exchange rate overshoots its equilibrium value in the short run. The extent to which overshooting occurs in the sticky-price model is illustrated with the help of a downward sloping *MM* schedule in Figure 5.7, which represents equation (5.46). The *MM* schedule represents combinations of exchange rates and prices that are consistent with monetary equilibrium (that is, points where the supply of and demand for money are equal). Suppose initially that the money market is in equilibrium at *A*, where the domestic price level and the exchange rate are at $\bar{P}_0$ and $\bar{S}_0$, respectively. Note that at point *A*, the economy is in full equilibrium with a long-run price level $\bar{P}_0$ and a corresponding long-run exchange rate $\bar{S}_0$. Note also that *A* lies on the *OL* line, which passes through the origin, implying that the domestic price level is proportional to the domestic money supply via the quantity theory of money, whereas the exchange rate is proportional to the domestic price level via purchasing power parity.

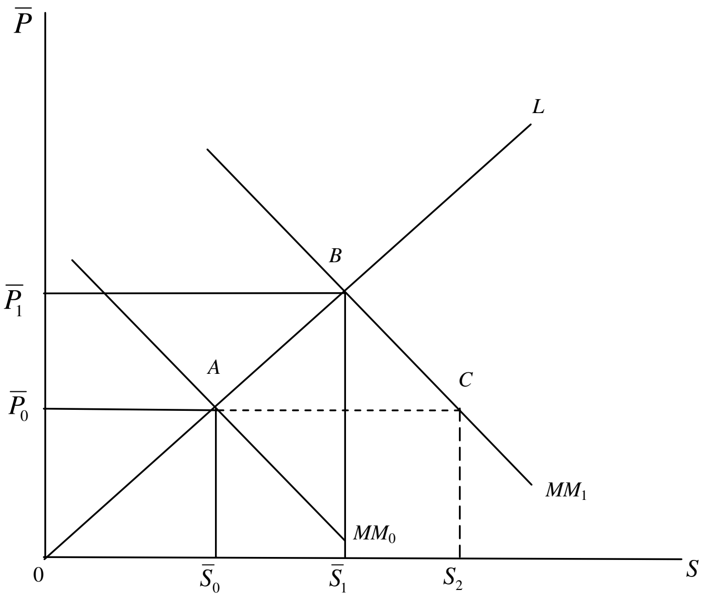

Figure 5.7. The money market equilibrium and exchange rate overshooting.

Now, suppose that there is an increase in the domestic money supply, which shifts the money market schedule to the right from MM_0 to MM_1. As domestic prices are fixed at $\bar{P}_0$ (and since asset market equilibrium must be maintained continually), the exchange rate must rise immediately from $\bar{S}_0$ to S_2 to match the decline in the domestic interest rate. Consequently, the economy moves from A to C, which does not lie on the OL line. At point C, the exchange rate (S_2) overshoots its long-run value ($\bar{S}_1$), which is consistent with an expansion in the money supply and hence a rise in the domestic price level to $\bar{P}_1$. As goods prices adjust over time, the economy moves up the MM_1 curve. Higher domestic prices reduce the real value of the domestic money supply, which means that an increase in the domestic interest rate is required to maintain money market equilibrium. This increase in interest rates will be associated with the appreciation of the domestic currency (a move from S_2 to $\bar{S}_1$). In the long run, an expansion in the domestic money supply gives rise to a proportional increase in domestic prices from $\bar{P}_0$ to $\bar{P}_1$ and to a proportional depreciation of the domestic currency from $\bar{S}_0$ to $\bar{S}_1$. Thus the long-run results derived from the sticky-price and flexible-price models are the same, because $d\bar{P} = d\bar{M} = d\bar{S}$ at point$B$ (in the long run).

The Goods Market

To complete the model, it is necessary to specify the price adjustment mechanism. In the short run, depreciation of the domestic currency reduces the relative price of domestic goods, inducing an increase in demand. Demand will be greater if the decline in domestic interest rates also leads to a higher level of expenditure on domestic goods and if the Keynesian multiplier mechanism is present. Thus the demand for domestic goods depends on relative prices (the real exchange rate, $s - p + p^*$), the domestic interest rate, and real income. The demand functions for domestic and foreign output are assumed to have the form

$$\ln D = u_1 + \delta_1(s - p + p^*) + \gamma_1 y - \sigma_1 i \tag{5.47}$$

$$\ln D^* = u_2 + \delta_2(s - p + p^*) + \gamma_2 y^* - \sigma_2 i^* \tag{5.48}$$

where $D(D^*)$ denotes the demand for domestic (foreign) output, $\delta_1(\delta_2)$ is the price elasticity of domestic (foreign) goods, $\gamma_1(\gamma_1)$ is the income elasticity of domestic (foreign) goods, $\sigma_1(\sigma_2)$ is the interest elasticity of demand for domestic (foreign) goods, and $u_1(u_2)$ is a shift parameter. By combining equations (5.47) and (5.48) and assuming a given level of relative output, we obtain

$$\begin{aligned} \dot{p} - \dot{p}^* &= \pi \ln\left[\frac{D/D^*}{Y/Y^*}\right] \\ &= \pi[u + \delta(s - p + p^*) + (\gamma - 1)(y - y^*) - \sigma(i - i^*)] \end{aligned} \tag{5.49}$$

where $u = u_1 - u_2$, $\delta = \delta_1 - \delta_2$, $\gamma = \gamma_1 - \gamma_2$, and $\sigma = \sigma_1 - \sigma_2$. Equation (5.49) shows that the relative demand for domestic and foreign output determines relative prices and that the rate of increase in relative prices is proportional to relative excess demand. Because of perfect capital mobility, $i = i^*$ and $\dot{p} - \dot{p}^* = 0$, which means that equation (5.49) reduces to

$$\bar{s} = (\bar{p} - \bar{p}^*) + \frac{1}{\delta}[\sigma i^* + (1 - \gamma)(y - y^*) - u] \tag{5.50}$$

which implies that the long-run exchange rate depends on monetary variables (long-run relative prices), as well as real variables.

The price adjustment equation (5.49) can be simplified by using equation (5.50) and the fact that the interest rate differential is equal to expected depreciation (hence, $i - i^* = \theta(\bar{s} - s)$). This gives

$$\dot{p} - \dot{p}^* = -\pi\left(\frac{\delta + \sigma\theta}{\theta\beta + \delta}\right)[(p - p^*) - (\bar{p} - \bar{p}^*)]$$
$$= v[(\bar{p} - \bar{p}^*) - (p - p^*)] \tag{5.51}$$

or

$$\dot{p} - \dot{p}^* = v[\bar{s} - s] \tag{5.52}$$

where

$$v \equiv \pi\left(\frac{\delta + \sigma\theta}{\theta\beta + \delta}\right). \tag{5.53}$$

As equation (5.52) shows, v measures the rate at which the current exchange rate converges on its equilibrium value in the long run.[9] It is also evident from equation (5.52) that the rate of convergence is a function of the expectations coefficients, θ. For the expectation formation process in equation (5.38) to predict correctly the actual path of the exchange rate, the condition $\theta = v$ must be satisfied. Accordingly, the expectation coefficient (θ) must correspond to perfect foresight, which means that it is consistent with the model that is given by the solution of v in terms of θ as follows[10]:

$$\tilde{\theta}(\beta, \delta, \sigma, \pi) = \frac{\pi(\sigma/\beta + \delta)}{2} + \left[\frac{\pi^2(\sigma/\beta + \delta)^2}{4} + \frac{\pi\delta}{\beta}\right]^{1/2}. \tag{5.54}$$

Equation (5.54) shows that the expectation coefficient (θ) is a function of the structural parameters of the economy: the semi-interest elasticity of the demand for money (β), the interest elasticity of capital flows (σ), the real exchange rate elasticity of trade flows (δ), and the inflation rate (π). To predict the exchange rate correctly, market participants need to predict the structural parameters of the domestic and foreign economies correctly. The assumption underlying this model is that the domestic and foreign structural parameters are identical.

[9]For the sticky-price model to hold, expected changes in the exchange rate must converge on changes in relative prices. However, it may not be necessarily true that the actual exchange rate will also converge on relative prices in the long run, eventually forcing the real exchange rate to remain constant over time. The actual exchange rate will not converge on relative prices unless (i) deviations of the current exchange rate from relative prices sum to zero at each point in time and (ii) deviations of the future exchange rate from future relative prices sum to zero over time. If condition (ii) is not satisfied, purchasing power parity will be invalid even in the long run.

[10]For this solution, see Dornbusch (1976c, p. 67).

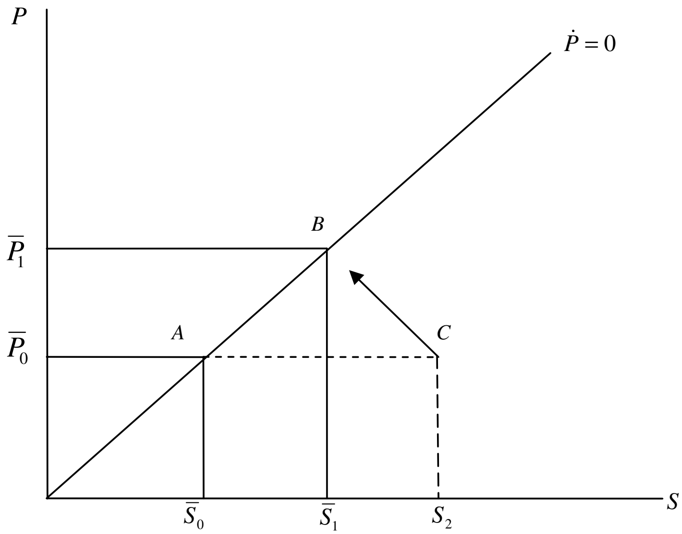

Figure 5.8. The goods market equilibrium in the long run.

The price adjustment equation (5.52) can be used to derive the locus of combinations of relative prices and exchange rates for which the goods and money markets are in equilibrium (defined in Figure 5.8 as the $\dot{P} = 0$ line). As the goods market moves sluggishly in the short run, every point on the $\dot{P} = 0$ line can only be achieved in the long run when domestic prices and exchange rates adjust proportionately to a monetary disturbance. Suppose that the economy is initially in equilibrium at point A, where both the goods market and the money market are in equilibrium, establishing a proportional relation between domestic prices, exchange rates, and money supply in the long run. Now imagine that the economy moves up on the $\dot{P} = 0$ line from point A to point B over time, leading to a proportional increase in both domestic prices and exchange rates. As long-run purchasing power parity is not valid unless prices and exchange rates increase in the same proportion as an increase in the domestic money supply, points above or below the $\dot{P} = 0$ schedule indicate that purchasing power parity does not hold in the short run, implying excess supply of or excess demand for domestic goods. Thus, conditions in the goods market are critical in moving the economy to long-run equilibrium by inducing rising or falling prices.

Consider an initial position to the right of and below the $\dot{P} = 0$ line, such as C, with a price level ($\bar{P}_0$) below its equilibrium level ($\bar{P}_1$) and, correspondingly, a higher exchange rate (S_2). Given a domestic price level ($\bar{P}_0$), a higher exchange rate (S_2) implies excess demand for domestic goods because domestic output commands a low relative price and because the interest rate is low. As a result, prices will be rising, thereby inducing (over time) lower demand for domestic goods. The path of rising prices will be accompanied by a fall in the exchange rate. The rise in prices also causes a fall in the domestic real money supply, which in turn causes a rise in the domestic interest rate. As a consequence, the exchange rate approaches its long-run value, which is proportional to the increase in the domestic price and the money supply.

5.5.2. *Adjustment to Monetary Expansion*

Figure 5.9 shows that the adjustment process of the economy can be described with the help of the *RP*, *MM*, and $\dot{P} = 0$ schedules, which are derived respectively from equations (5.39), (5.46), and (5.52). In Figure 5.9(a), the money market (*MM*) schedule (drawn from equation (5.46) for a given nominal quantity of money) represents the price level and exchange rate combinations that maintain equilibrium in the money market. An important assumption underlying this schedule is that the money market clears continuously at each and every point on the money market curve. Notice that money market has a gradient of (minus) $1/\theta\beta$, where θ is the sensitivity of market expectations to the (proportional) over- or undervaluation of the currency relative to equilibrium and β is the semi-interest elasticity of money demand.

The positively sloped $\dot{P} = 0$ schedule (derived from equation (5.51)) shows combinations of relative prices and exchange rates for which the goods and money markets are in equilibrium. Points above and to the left of $\dot{P} = 0$ indicate excess supply of goods and falling prices. Conversely, points to the right of and below this schedule correspond to excess demand and rising prices. The $\dot{P} = 0$ schedule is positively sloped and flatter than the 45-degree line for the following reason. An increase in the exchange rate creates excess demand for domestic goods by reducing relative prices. To restore equilibrium, domestic prices must rise (though less than proportionately), as the increase in domestic prices affects aggregate demand, via the relative price effect and higher interest rate.

For any given price level, the exchange rate adjusts instantaneously to clear the asset market. Accordingly, the economy falls continuously on the money market schedule with money market equilibrium and international

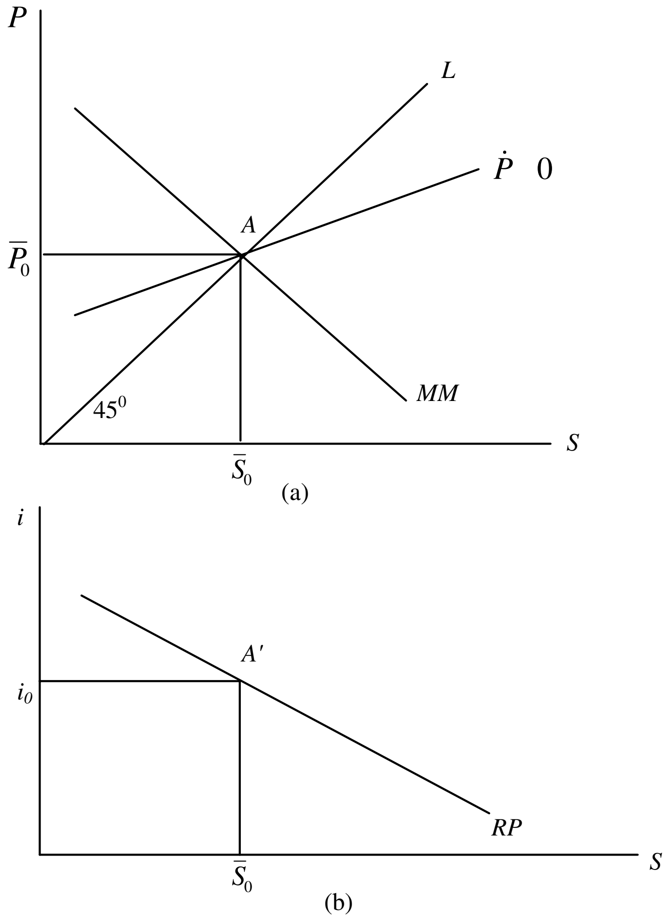

Figure 5.9. Equilibrium exchange rate.

arbitrage of net expected yields. On the contrary, goods market equilibrium is only achieved in the long run. Conditions in the goods market, however, are critical in moving the economy to long-run equilibrium by changing a rise or a fall in prices. Specifically, an initial position at any point to the right of A (with a relative price below the long-run level and an exchange rate in excess of the long-run equilibrium level) implies excess demand for domestic goods and lower interest on domestic assets. Accordingly, prices will be rising, thereby inducing (over time) a fall in excess demand. Rising prices is accompanied by a fall in the exchange rate. As domestic interest rates rise (as a consequence of declining real balances), the exchange rate will approach its long-run level. Once long-run equilibrium at point *A* is attained, interest rates are equal internationally, goods markets clear, prices are constant, and the expected exchange rate change is zero.

The behavior of the interest rate differential and the exchange rate is illustrated by drawing the *RP* schedule from equation (5.39), as shown in Figure 5.9(b). The *RP* schedule shows a negative relation between the exchange rate and the interest rate differential. For a given value of the long-run exchange rate ($\bar{S}$), a decline in domestic interest rates reduces the yield on domestic assets relative to that on foreign assets, inducing domestic asset holders to move out of these instruments into foreign assets. This reaction results in a capital account deficit that will be eliminated by currency depreciation.

Any initial position to the right of *A* in Figure 5.9(a) indicates that relative prices are below the long-run level and that the exchange rate is in excess of its long-run equilibrium value (implying excess demand for domestic goods). Correspondingly, we have a position to the right of point A' in Figure 5.9(b) with an exchange rate in excess of its long-run value and a lower interest on domestic assets relative to foreign rates. These conditions give rise to a deficit in the capital account and currency depreciation. As a result, prices rise over time, inducing a fall in excess demand, which will be accompanied by a rise in domestic interest rates and hence currency appreciation. As domestic interest rates rise (a consequence of declining real money balances), the exchange rate approaches the long-run value. Once the long-run equilibrium at point *A* is reached in Figure 5.9(a), interest rates are also equal internationally at point A' in Figure 5.9(b), goods markets clear, prices are constant, and the expected change in the exchange rate is zero.

The adjustment process to a monetary expansion is illustrated in Figure 5.10. The economy is initially in full equilibrium at points *A* and A' in Figures 5.10(a) and 5.10(b), respectively. In equilibrium, the long-run price level is $\bar{P}_0$, the long-run exchange rate is $\bar{S}_0$, and the domestic interest rate is i_0. An increase in the domestic money supply shifts both the money market and *RP* schedules to the right (from MM_0 to MM_1 and from RP_0 to RP_1). In the long run, the economy moves from *A* and A' to *C* and C', and consequently an increase in the domestic money supply leads to a proportional rise in domestic prices (from $\bar{P}_0$ to $\bar{P}_1$) and the exchange rate (from $\bar{S}_0$ to $\bar{S}_1$), but the domestic interest rate returns to its previous level, i_0. It is obvious that at the new equilibrium points (*C* and C'), goods and asset markets clear while the exchange rate and prices reflect exactly the increase

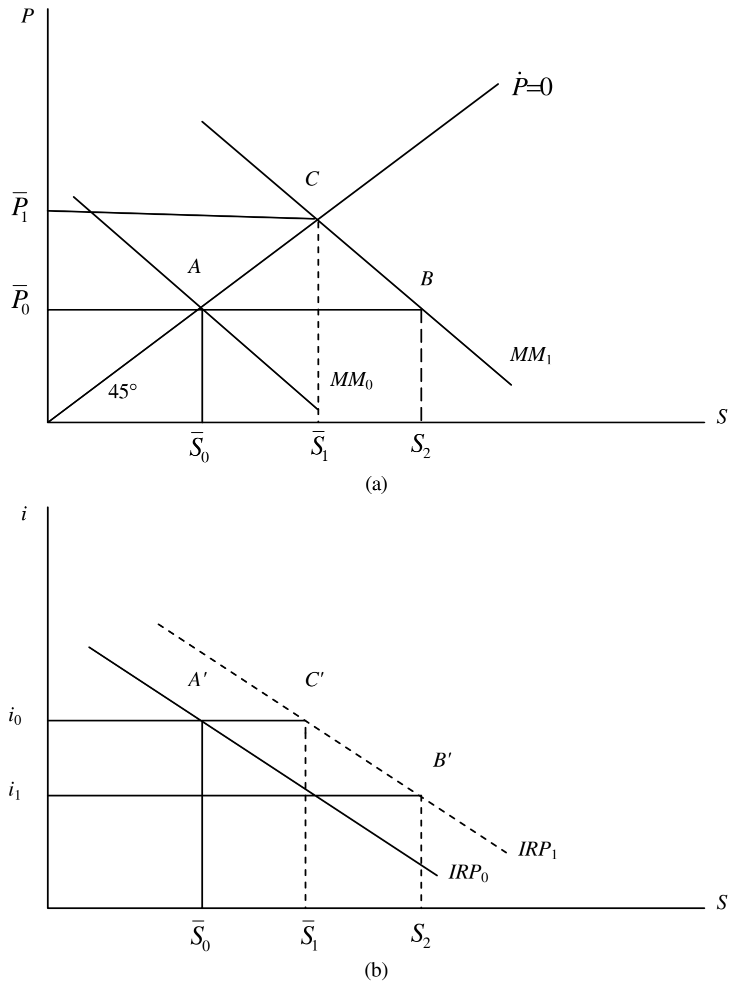

Figure 5.10. Exchange rate overshooting in the short run.

in the money supply. This long-run homogeneity result is not surprising, as there is no source of money illusion or long-run price rigidity in the system. Therefore, this result of the sticky-price monetary model is similar to that of the flexible-price monetary model.

In the short run, the sticky-price model assumes that prices are initially fixed at $\bar{P}_0$. With the domestic price level unchanged at $\bar{P}_0$, a rise in the domestic money supply shifts the money market schedule to the right (from MM_0 to MM_1) and a new equilibrium position is established at B. The money market does not clear at B because, with the domestic price level fixed at $\bar{P}_0$, the nominal and real money supply exceeds real money demand at B (as measured by the horizontal distance AB in Figure 5.10(a)). For the money market to clear, the domestic interest rate must fall from i_0 to i_1 (as shown in Figure 5.10(b)), so that the real demand for money may increase by a sufficient amount to accommodate the increased money supply. The decline in domestic interest rates relative to foreign rates causes capital outflow and consequently domestic currency depreciation (from $\bar{S}_0$ to S_2). Clearly, the depreciation of the domestic currency in the short run (from $\bar{S}_0$ to S_2) overshoots the long-run depreciation (from $\bar{S}_0$ to $\bar{S}_1$), which is consistent with the move of domestic prices from $\bar{P}_0$ to $\bar{P}_1$. At the exchange rate S_2, the domestic interest rate is lower than the foreign interest rate.

According to uncovered interest parity (equation (5.37)), the domestic currency is expected to appreciate to the extent that domestic interest rates are lower than foreign interest rates. Consequently, the exchange rate must rise from S_2 to S_1 because only this gap between the exchange rates $(S_2 - S_1)$ is equal to the gap between domestic and foreign interest rates. When market expectations are realized over time, the spot exchange rate will move in the long run toward its long-run equilibrium level ($\bar{S}_1$), and equilibrium moves from B to C and from B' to C' (in Figures 5.10(a) and 5.10(b), respectively). The movement of equilibrium to points C and C' can be attributed to the observation that the domestic currency is undervalued at S_2, which in due course leads to improvement in the trade balance. As a result, there is a rise in economic activity, a rise in domestic prices and a rise in domestic interest rates. Eventually, higher domestic interest rates (by inducing capital inflow) lead to appreciation of the domestic currency from S_2 to $\bar{S}_1$. Finally, the domestic currency depreciates from $\bar{S}_0$ to $\bar{S}_1$ (after experiencing a temporary overshooting to S_2) while the domestic price level rises from $\bar{P}_0$ to $\bar{P}_1$.

5.6. The Reduced Form Equation of the Equilibrium Exchange Rate

The sticky-price monetary model yields an equation that does not differ (at least on the surface) from that of the flexible-price monetary model. The long-run exchange rate ($\bar{s}$) is determined by purchasing power parity via the relative money supply, relative income, and the nominal interest rate differential:

$$\bar{s} = (\bar{m} - \bar{m}^*) - \alpha(\bar{y} - \bar{y}^*) + \beta(\bar{i} - \bar{i}^*). \tag{5.55}$$

The short-run exchange rate (s) may deviate from the long-run equilibrium level ($\bar{s}$), but the former tends to converge on the latter in the long run. Thus, the expected change in the exchange rate depends on the deviation of the current rate from the long-run rate as represented by equation (5.38). By combining equations (5.55) and (5.39), we obtain

$$s = (\bar{m} - \bar{m}^*) - \alpha(\bar{y} - \bar{y}^*) + \left(\beta - \frac{1}{\theta}\right)(\bar{i} - \bar{i}^*). \tag{5.56}$$

If we assume that the current values of the explanatory variables are long-run equilibrium values, then

$$s = (m - m^*) - \alpha(y - y^*) + \left(\beta - \frac{1}{\theta}\right)(i - i^*). \tag{5.57}$$

Although, on the surface, the Dornbusch sticky-price model appears to be identical to the flexible-price model, the coefficient on the interest differential is negative in the former but positive in the latter. This is because the interest differential reflects differences in expected inflation rates in the latter, whereas it reflects relative liquidity conditions in the former. Consequently, a rise in domestic interest rates relative to foreign interest rates (which reflects a relative worsening of domestic inflation prospects in the flexible-price model) leads to a weakening of the domestic currency. Conversely, a relative rise in domestic interest rates (which reflects a relative tightening of domestic liquidity conditions in the sticky-price model) gives rise to capital inflow and domestic currency appreciation.

5.7. Recapitulation

The overshooting model is an extended monetary model, derived by relaxing the key restrictive assumption of continuous purchasing power parity. The model postulates that the exchange rate is determined by relative interest rates in the short run when goods prices are fixed, but by relative money supplies in the long run when goods prices fully adjust to a monetary expansion and when monetary neutrality is maintained across steady states. Because goods prices react sluggishly to a disturbance, a nominal increase in the domestic money supply, which is translated into a real increase in the domestic money supply, causes a liquidity-induced decline in the domestic interest rate, which in turn causes overshooting of the exchange rate from its long-run value. In the long run, however, a real increase in the domestic money supply is totally offset as domestic prices and the exchange rate increase in the same proportion to a nominal increase in domestic money. As a result, interest rates, relative prices, and real income return to their previous levels, eventually maintaining monetary neutrality. Conversely, an increase in the domestic money supply in the flexible-price monetary model leads to a rise in the exchange rate directly by driving up domestic prices immediately. Via purchasing power parity, this rise in prices causes the domestic currency to depreciate in the same proportion as the increase in the domestic money supply. Because domestic prices rise immediately in the flexible-price model, a nominal increase in the domestic money supply does not translate into a real increase, which means that there is no liquidity-induced decline in domestic interest rates.

The Dornbusch model is also an extended Mundell–Fleming model because it relaxes the three key restrictive assumptions of the total absence of purchasing power parity, the fully demand-determined level of output, and the absence of exchange rate expectations. Rational expectations and long-run neoclassical features of full employment are included in the extended Mundell–Fleming model to confirm once more the Mundell–Fleming result that, under conditions of capital mobility and flexible exchange rates, a small country can (in the short run) conduct effective monetary policy. More importantly, the exchange rate proves to be a critical channel for the transmission of monetary changes in aggregate demand and output. But unlike the Mundell–Fleming world, this analysis (as an extension of the monetary model) shows that the effects of a monetary expansion are only transitory, as the inflation that is induced by output expansion serves to reduce real balances, thereby interest rates, relative prices, and real income return to their initial levels. An increase in demand for domestic goods, induced by the depreciation of the domestic currency, brings an immediate nominal and real appreciation that restores demand to the full employment level by offsetting deterioration in the current account. Hence, the monetary expansion leads to an immediate nominal and real depreciation in the domestic currency. Moreover, the exchange rate must overshoot, rising more proportionately than the expansion in the money supply if asset markets adjust more rapidly than goods markets. The domestic interest rate falls relative to the foreign rate, and the asset market will be in balance only if the exchange rate overshoots initially (so that there are corresponding expectations of currency appreciation).

CHAPTER 6

Other Sticky-Price Monetary Models of Exchange Rates

6.1. Introduction

The asset market model of exchange rate determination underwent considerable development during the first decade following the floating of major currencies (1973–83). This is because simple models were found to explain the behavior of the post-Bretton Woods floating exchange rates poorly and also because the availability of a larger set of data on the floating period provided the opportunity to carry out more empirical work.[1] The very high volatility of the real exchange rates of major currencies in the late 1970s casts doubt on PPP and inspired the development of further versions of the monetary model, including the sticky-price monetary model of Dornbusch (1976c).

During the late 1970s and early 1980s, a wide range of overshooting models were constructed to explain new stylized facts or events associated with the floating rate period. Included in these models are the real interest differential sticky-price monetary model of Frankel (1979b), the stock-flow model of Driskell (1981), and the equilibrium real exchange rate sticky-price model of Hooper and Morton (1982). Yet, the empirical validity of these variants of the sticky-price model has proven to be more elusive.

In the simple flexible-price model, the exchange rate is determined by stock equilibrium in money markets, which is achieved very quickly (if not instantaneously) through continuous adjustment of prices in the goods and asset markets, while complete neutrality of monetary policy is maintained

[1] For a detailed analysis of the development of the asset-market model of exchange rate determination and the events of the current floating rate period leading to modifications and extensions in the theory, see Dornbusch (1980b) and Shafer *et al.* (1983).

on a continuous basis. This model appears to fit the data fairly well for the first four years of flexible exchange rates (1973–76), as indicated by the evidence presented by Hodrick (1978) and Bilson (1978a). In subsequent studies (which tested the model for a slightly larger set of data incorporating the period 1977–78), the performance of this model deteriorated severely. This led to considerable concern with respect to a reconciliation of the simple monetary model with the observed large fluctuations in exchange rates.

By late 1975, little correspondence was found between exchange rates and prices in many major industrial countries (at least in the short run) and it was also found that changes over time in the real exchange rates were much larger than those under fixed exchange rates. Inflation rates diverged widely between these countries, while exchange rates showed some tendency to change over time to contain deviation from purchasing power parity. Nevertheless, most fluctuations in nominal exchange rates over the period March 1973 to September 1975 were reflected in the movements of real exchange rates. It was against this backdrop that Dornbusch (1976c) developed the sticky-price version of the monetary model. This model is consistent with several stylized facts that do not fit well with the flexible-price model. Not only does it rationalize deviations from purchasing power parity in the short run, it also provides an explanation for periods when a rising nominal interest rate is associated with a strong currency. In the flexible-price model, a rise in the nominal interest rate is always associated with an increase in the inflation rate and more rapid depreciation (or less rapid appreciation) of the currency. In the sticky-price model, a persistently higher level of the interest rate reflects higher inflation, which makes it associated with a weaker currency. But an increase in the interest rate and declining inflationary expectations may be produced by a shift to tight monetary policy, leading to currency appreciation.

The sticky-price model suggests that the relation between changes in the exchange rate and monetary aggregates is not simple even when monetary disturbances are the underlying cause. Expectations concerning future levels of the money supply are more important than the current levels of the money supply, which means that poor correlation between contemporaneous changes in monetary aggregates and exchange rates is explainable. It must be noted, however, that evidence on the sticky-price model is not very much different from the evidence on the flexible-price model, particularly during the first 4 years of the current flexible exchange rate period. This is why the empirical basis for a choice between the flexible- and sticky-price versions of the monetary model is not clear.

Frankel (1979b) modified the Dornbusch (1976c) sticky-price model by allowing a role for differences in secular inflation rates, hence including the real interest differential as an additional explanatory variable. He argues that changes in long-term nominal interest rates are a measure of changes in inflation expectations. According to this view, only short-term interest rates are viewed as moving somewhat independently of inflation. Therefore, Frankel includes the long-term interest rate differential in the exchange rate equation either because long-term interest rates measure the cost of holding money or because they are considered as a proxy for the anticipated inflation differential. In either view, a rise in the domestic long-term interest differential leads to a reduction in real money demand and thus to higher prices and currency depreciation.

Frankel (1979b) tested the real interest differential model for the mark/dollar rate from July 1974 to February 1978 and found evidence that clearly supported the model against the flexible- and the sticky-price versions of the monetary model. However, subsequent attempts by Dornbusch (1980b), Haynes and Stone (1981), and Frankel (1981) to explain movements in the mark/dollar exchange rate after February 1978 were unsuccessful, showing insignificant coefficients and a "reversed sign" on the relative money coefficient. An important phenomenon that was not directly explainable by the sticky-price models of Dornbusch (1976c) and Frankel (1979b) was the large and growing deficit in the U.S. current account and the surpluses of Germany and Japan. Many observers began to view the 1978–79 slide of the U.S. dollar as primarily an adjustment to this large and growing deficit in the U.S. current account and surpluses in Germany and Japan.[2] In early 1975, a surplus arose in the U.S. current account as the sharp U.S. recession reduced imports. But with the recovery of the economy and the dollar, the current account began to decline rapidly. This phenomenon induced many economists to turn to models that assign a role to the current account in the process of exchange rate determination.

One popular model that gives a role to the current account in exchange rate determination is the equilibrium real exchange rate model of Hooper

[2]Note that current account imbalances have been larger and more volatile during the floating period than they had been during the Bretton Woods period.

and Morton (1982).[3] They modified the Dornbusch–Frankel sticky-price models by allowing large and sustained changes in real exchange rates, which are related to movements in the current account (both through changes in expectations about the long-run real exchange rate and through changes in the risk premium). In particular, they show that the equilibrium real exchange rate (defined as the rate that is consistent with the long-run current account balance) can be expressed as a function of the initial equilibrium rate and the cumulative sum of past non-transitory unexpected changes in the current account. Hooper and Morton (1982) tested this model empirically for the dollar's weighted average exchange rate (against the currencies of Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, and the U.K.) over the flexible rate period of 1973–78. They obtained results indicating that the current account affected the exchange rate predominantly through its impact on expectations about the long-run equilibrium real exchange rate. According to them, these results are a reflection of the period extending between the end of 1976 and the end of 1978, when the dollar depreciated steadily in real terms as the U.S. ran a series of large current account deficits.

Frankel (1982a) adopts an alternative strategy to take account of the role of the current account in the Dornbusch–Frankel sticky-price model. He modifies money market conditions (stated in terms of the domestic and foreign money demand functions and the exchange rate equation) by adding relative wealth as an additional explanatory variable. The logic underlying this formulation goes as follows. A foreign current account surplus represents a redistribution of wealth from domestic residents to foreign residents, simultaneously raising foreign money demand, lowering domestic money demand, and raising the exchange rate.

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[3] Other models that give a specific role to the current account in the determination of exchange rates are the portfolio balance models that were originated by Branson (1976), Girton and Henderson (1976), Kouri *et al.* (1978), Dooley and Isard (1979, 1982, 1983), Dornbusch (1980a), and Allen and Kenen (1980). Within the theoretical framework of slowly adjusting commodity prices, an alternative to Dornbusch's view of exchange rate dynamics, the portfolio balance models emphasize stock-flow interaction and relative-price trade-balance effects. In contrast to the monetary models, domestic and foreign bonds are assumed to be imperfect substitutes. Thus, an increase in a country's wealth (which is caused by a surplus in its current account) leads to an increase in the demand for domestic bonds and hence appreciation of the domestic currency. For a detailed discussion of portfolio balance models, see Chapter 8.

Another interesting variant of the sticky-price model (developed in the context of the portfolio balance effect) is due to Driskell (1981). He developed a stock-flow model that generalizes the Dornbusch (1976c) model, permitting imperfect substitutability between domestic and foreign assets and allowing trade flows to affect financial markets through the balance of payments. In this model, portfolio allocation may affect the exchange rate. He derives a reduced form exchange rate equation by replacing the uncovered interest parity condition in Dornbusch's (1976c) framework with a balance of payments equation.

6.2. The Real Interest Differential Monetary Model

Frankel (1979b) argues that the flexible-price monetary model (what he called the "Chicago theory of exchange rate") and the sticky-price monetary model (what he called the "Keynesian theory of exchange rate") have conflicting implications, particularly for the relation between exchange and interest rates. In the following two subsections, the real interest differential model is described.

6.2.1. *Moderate Inflation and the Exchange Rate Expectations Scheme*

The real interest differential model draws upon the sticky-price model by assuming that while purchasing power parity fails to hold in the short run, it is valid in the long run. The two models are similar except for the expectation formation mechanisms. The mechanism used in the real interest differential model postulates that the expected change in the exchange rate is a function of (i) the gap between the current spot rate and the long-run equilibrium rate and (ii) the expected long-run inflation differential. Formally, this expectation formation mechanism is represented as follows:

$$E(\Delta s) = i - i^* \tag{6.1}$$

$$E(\Delta s) = \theta(\bar{s} - s) + (\Delta p^{\mathrm{e}} - \Delta p^{*\mathrm{e}}). \tag{6.2}$$

Equation (6.1) states that (under perfect capital mobility) if there is no uncertainty and if market participants are neutral, the expected rate of depreciation of the domestic currency will be equal to the interest differential. On the other hand, equation (6.2) states that in the short run, the exchange rate (s) is expected to return to its long run equilibrium value $\bar{s}$ at a rate that is proportional to the current gap. In the long run (when $\bar{s} = s$), the exchange rate is expected to change at a rate that is equal to the long-run inflation differential ($\Delta p^{e} - \Delta p^{*e}$), which is equal to the expected long-run relative monetary growth rate that is known to the public. By combining equations (6.1) and (6.2) and then solving for s, we obtain

$$s = \bar{s} - \frac{1}{\theta}[(i - \Delta p^{e}) - (i^{*} - \Delta p^{*e})]. \tag{6.3}$$

Equation (6.3) shows that the exchange rate s tends to overshoot its long-run value ($\bar{s}$) when goods prices are sticky in the short run and to converge on the long-run value when goods prices adjust in the long run. It must be noted that the current exchange rate overshoots its long-run equilibrium value by an amount that is proportional to the nominal interest differential in the Dornbusch model, whereas in the Frankel model it overshoots by an amount that is proportional to the expected real interest differential. In the long run (when $s = \bar{s}$), the nominal interest differential will be equal to the inflation differential (that is, $\bar{i} - \bar{i}^{*} = \Delta p^{e} - \Delta p^{*e}$), and therefore the expression in brackets reduces to $[(i - i^{*}) - (\bar{i} - \bar{i}^{*})]$. Intuitively, equation (6.3) can be described as follows. When tight monetary policy causes the nominal interest differential to rise above its long-run level, capital inflow causes the domestic currency to rise above its equilibrium value proportionately to the expected real interest differential.

6.2.2. *A More General Model of Exchange Rate Determination*

Frankel's (1979b) real interest differential model is a more general model that combines the features of the flexible-price and sticky-price models. This model can be derived from equation (6.3) by identifying the determinants of the long-run equilibrium exchange rate, which is determined by equilibrium relative prices ($\bar{p} - \bar{p}^{*}$). These are, in turn, determined by the domestic and foreign equilibrium monetary conditions. Assuming money market equilibrium and that the nominal interest differential is equal to the inflation differential ($\bar{i} - \bar{i}^{*} = \Delta p^{e} - \Delta p^{*e}$), the expected equilibrium relative prices can be expressed as a function of the relative money supply, relative income, and the long-run expected inflation differential. Hence

$$(\bar{p} - \bar{p}^{*}) = (\bar{m} - \bar{m}^{*}) - \alpha(\bar{y} - \bar{y}^{*}) + \beta(\Delta p - \Delta p^{*}). \tag{6.4}$$

Substituting equation (6.3) into (6.4), and assuming that the equilibrium relative money supply and income are given by their current actual levels, we obtain a complete equation that represents the real interest differential model:

$$s = (m - m^*) - \alpha(y - y^*) - \frac{1}{\theta}(i - i^*) + \left(\frac{1}{\theta} + \beta\right)(\Delta p^e - \Delta p^{*e}). \tag{6.5}$$

The real interest differential model is a general monetary model of exchange rate determination because it allows for (i) the direct effect of the relative money supply on the exchange rate as in all monetary models; (ii) the indirect effect of expectations of higher or lower inflation as in the flexible-price model; and (iii) the liquidity-induced effect of the money supply on interest rates, capital flows, and hence on the exchange rate, as embodied in the sticky-price model.

By rearranging a number of terms on the right-hand side of equation (6.5), we can also arrive at a specification showing that Frankel's real interest differential model is identical to the flexible-price monetary model, except that the real interest differential is added as an explanatory variable:

$$s = (m - m^*) - \alpha(y - y^*) + \beta(\Delta p^e - \Delta p^{*e}) - \frac{1}{\theta}[(i - \Delta p^e) - (i^* - \Delta p^{*e})]. \tag{6.6}$$

It can be shown that the real interest differential model includes both the flexible- and the sticky-price monetary models as polar special cases. To this end, equation (6.5) is rewritten as

$$s = (m - m^*) - \alpha(y - y^*) + \gamma(i - i^*) + \delta(\Delta p^e - \Delta p^{*e}). \tag{6.7}$$

The sticky-price model can be viewed as a special case of the real interest differential model, as the latter reduces to the former when the coefficient on the expected inflation differential in equation (6.7) is zero (that is, $\delta = 0$). The sticky-price model is empirically valid if the joint hypothesis $\delta = 0$ and $\gamma < 0$ is not rejected. Likewise, the flexible-price monetary model is a special case of the real interest differential model when the price adjustment to equilibrium is instantaneous (that is, $\theta = \infty$ in equation (6.5)) and when real interest parity holds (that is, $i - i^* = \Delta p^e - \Delta p^{*e}$). The flexible-price model turns out to be valid empirically if the joint hypothesis $\delta = 0$ and $\gamma > 0$ is not rejected.

6.3. Driskell's Generalized Stock-Flow Sticky-Price Model

Driskell (1981) argues that two striking implications follow from the Dornbusch (1976c) model. First, in response to a change in relative money supplies, the exchange rate may change immediately by more than the long-run equilibrium value determined by purchasing power parity. In other words, the exchange rate may overshoot its long-run purchasing power parity value in the short run. Second, following this initial overshooting, the exchange rate approaches monotonically its long-run equilibrium value. He argues that both of these implications result from the key assumptions of sticky prices and perfect capital mobility. Following the work of Branson (1976), Niehans (1977), and Henderson (1980) (who have developed an alternative view of exchange rate dynamics emphasizing stock-flow interactions and relative-price trade-balance effects), Driskell (1981) developed a generalized stock-flow variant of the Dornbusch model, leading to contrasting results of short-run undershooting and non-monotonic exchange rate and price level adjustments.

Driskell (1981) generalizes the Dornbusch (1976c) overshooting model to develop two structural models (what he calls the Dornbusch model in discrete time and a stock-flow model) by allowing imperfect substitutability between domestic and foreign assets. He argues that both of these structural models impose *a priori* constraints on the reduced-form parameters and thus can (in principle) be rejected by the data.

6.3.1. *The Dornbusch Model in Discrete Time*

To derive the Dornbusch model in discrete time, Driskell (1981) begins with three basic building blocks: a money market equilibrium condition, a price level adjustment equation, and the uncovered interest parity condition. Assuming that the structural parameters of the domestic and foreign money demand functions are identical and that the money supply (in both countries) is exogenously controlled by the central bank, the money market equilibrium condition can be rewritten as

$$(m - m^*) = (p - p^*) + \alpha(y - y^*) - \beta(i - i^*). \qquad (6.8)$$

Equilibrium is obtained in the (domestic and foreign) goods markets when the demand for output is equal to the supply of output. Therefore, equilibrium in the domestic and foreign goods markets can be specified in terms of the logarithm of the ratio of relative demand to relative supply of output in the two markets, which is a function of the relative inflation rate. The ratio of the relative demand to the relative supply of output depends on relative real income, relative interest rate, and relative prices. This relation can be written in a logarithmic form as

$$\ln D - \ln D^* = \gamma(y - y^*) - \sigma(i - i^*) + \omega(s - p + p^*). \tag{6.9}$$

Relative inflation, $(p_{(+1)} - p^*_{(+1)}) - (p - p^*)$, which represents relative excess demand in both countries, is proportional to the logarithm of the ratio of relative demand to relative supply in the domestic and foreign goods markets. Hence

$$(p_{(+1)} - p^*_{(+1)}) = (p - p^*) + \delta\lfloor(\ln D - \ln D^*) - (y - y^*)\rfloor. \tag{6.10}$$

As purchasing power parity does not hold in the short run, Driskell assumes that relative prices are determined by a relative Phillips curve relation, as represented by equation (6.10). Therefore, equation (6.10) is a price adjustment equation, suggesting that current relative prices depend on the current inflation rate and the gap between aggregate demand and aggregate output in both countries.

Solving equation (6.8) for relative interest rates, substituting the resulting expression together with equation (6.9) into equation (6.10), and then taking one period lag on both sides of the resulting equation, we obtain

$$\begin{aligned}(p - p^*) = a_0(y_{(-1)} - y^*_{(-1)}) + a_1(p_{(-1)} - p^*_{(-1)})\\ + a_2(m_{(-1)} - m^*_{(-1)}) + a_3 s_{(-1)}\end{aligned} \tag{6.11}$$

where $a_0 = \delta[(1-\gamma)+\alpha/\beta]$, $a_1 = (1-\delta\sigma/\beta-\delta\omega)$, $a_2 = \delta\sigma/\beta$, and $a_3 = \delta\omega$. The final building block of the Dornbusch model is a joint assumption of uncovered interest parity and exchange rate expectations. Uncovered interest parity is given as

$$(i - i^*) - \Delta s^{\mathrm{e}} = 0. \tag{6.12}$$

Driskell (1981) follows Dornbusch (1976c) in assuming that exchange rate expectations are regressive, and that the long-run exchange rate is proportional to the relative money supply.

Hence

$$\Delta s^{\mathrm{e}} = \vartheta(\bar{s} - s) = \vartheta[(m - m^*) - s], \quad 0 < \vartheta < 1. \tag{6.13}$$

By combining equations (6.8), (6.11), and (6.12) and writing the resulting equation in a testable form, we obtain

$$\begin{aligned}s_t = \alpha_0 + \alpha_1 s_{t-1} + \alpha_2(m - m^*)_t + \alpha_3(m - m^*)_{t-1} + \alpha_4(p - p^*)_{t-1}\\ + \alpha_5(y - y^*)_t + \alpha_6(y - y^*)_{t-1} + u_t.\end{aligned} \tag{6.14}$$

The restrictions that Driskell (1981) imposes on the parameters are as follows: $\alpha_1 < 0, \alpha_2 > 1, \alpha_3 < 0, \alpha_4 < 0, \alpha_5 < 0$, and $\alpha_6 < 0$. If $\alpha_2 > 1$, then the hypothesis that the exchange rate overshoots in the short run cannot be rejected.

6.3.2. *The Stock-Flow Model*

Driskell (1981) developed a stock-flow model that generalizes the Dornbusch model to allow for the possibility of imperfect capital mobility. In this model, the demand for net capital flows (or foreign assets) is a linear function of the expected net yield, which gives:

$$F = \kappa[\Delta s^{\mathrm{e}} - (i - i^*)] \tag{6.15}$$

where $\kappa > 0$. The demand for net trade flows is determined by relative prices and relative incomes, which gives

$$B = a(s - p + p^*) - b(y - y^*). \tag{6.16}$$

The foreign exchange market clears when net capital flows are equal to net trade flows:

$$\Delta F = B. \tag{6.17}$$

Replacing equation (6.12) by (6.17) in the Dornbusch model and substituting (6.8) and (6.11) into (6.17), we obtain the following reduced-form exchange rate equation

$$\begin{aligned} s_t = {} & \beta_0 + \beta_1 s_{t-1} + \beta_2(m - m^*)_t + \beta_3(m - m^*)_{t-1} + \beta_4(p - p^*)_{t-1} \\ & + \beta_5(y - y^*)_t + \beta_6(y - y^*)_{t-1} + v_t \end{aligned} \tag{6.18}$$

where the parameters of the reduced-form equation (that is, the β_i's) must satisfy the following constraints: $\sum_{i=1}^{4} \beta_i = 1$, $\beta_1 < 1$, $\beta_2 > 0$, $\beta_3 \neq 0$, $\beta_4 > 0$, $\beta_5 \neq 0$, and $\beta_6 < 0$. Like the reduced-form model represented by equation (6.14), for purchasing power parity to hold in the long run the sum of the estimates of all of the slope parameters must be equal to 1 (that is, $\sum_{i=1}^{4} \beta_i = 1$). However, the other constraints imposed on the reduced-form equation (6.18) are quite different. In particular, the coefficients on lagged exchange rate and lagged price level coefficients (that is, β_1 and β_4) may be positive. Also, note that the coefficient on the relative money supply needs to be greater than 1. The model, therefore, implies that exchange rate overshooting or undershooting is an empirical issue.

Driskell's model yields predictions that are clearly different from those of the Dornbusch (1976c) and Frankel (1979b) models. The long-run neutrality of money still holds but exchange rate overshooting is no longer essential. With perfect substitutability between domestic and foreign assets, α_2 in the model represented by equation (6.14) would exceed one as a result of exchange rate overshooting. With imperfect substitutability, however, the initial response of the exchange rate to a monetary shock may be to overshoot or undershoot its long-run value.

6.4. The Equilibrium Real Exchange Rate Monetary Model

Hooper and Morton (1982) argue that the most serious deficiency of the monetary model is that it neglects changes in external trade imbalances and the impact these changes have on the exchange rate. The current account, however, does not affect the exchange rate directly but only indirectly through its impact on exchange rate expectations. Hooper and Morton developed the equilibrium real exchange rate model that draws from monetary and portfolio balance models. This model allows explicitly for the short-run impact on the exchange rate of both the current account and imperfect substitutability of assets.

The Hooper–Morton model is, in fact, an extension of the Dornbusch–Frankel model that allows for large and sustained changes in real exchange rates. The Dornbusch–Frankel model is modified to allow for shifts in the long-run equilibrium real exchange rate and the existence of risk premium. The Hooper–Morton model assumes that there is an equilibrium real exchange rate that is expected to maintain current account equilibrium in the long run. But at any point time, the equilibrium real exchange rate is determined by the cumulative sum of past and present current account balances. Thus, an unexpected permanent rise in the cumulative current account surplus will require an upward adjustment in the equilibrium long-run real exchange rate if the current account is to be eventually balanced. This upward adjustment in the equilibrium long-run real exchange rate in turn affects the equilibrium long-run nominal exchange rate through the purchasing power parity channel.

6.4.1. *The Expectation Mechanism and Exchange Rate Determination*

Hooper and Morton begin by arguing that unexpected changes in the current account provide information about shifts in the underlying determinants that make it necessary for offsetting shifts in the real exchange rate to maintain current account equilibrium in the long run. An important point is that it is only the unexpected component of the current account that affects the exchange rate (the expected component is already taken into account by the foreign exchange market). Therefore, the release by the government of unexpected figures on the trade balance or current account appears to have large immediate announcement effects on the exchange rate.

To derive an exchange rate determination equation in which the current account affects the exchange rate through its impact on expectations about the long-run equilibrium real exchange rate, Hooper and Morton begin with modeling expectations of changes in the equilibrium real exchange rate. To identify the expected rate of change in the exchange rate, they begin with Frankel's (1979b) expectations scheme and assume that the expected rate of change in the exchange rate is a function of the gap between the current rate and the long-run equilibrium rate, as well as the expected rate of change in the long-run equilibrium rate:

$$E(\Delta s) = \theta(\bar{s} - s) + E(\Delta \bar{s}) \tag{6.19}$$

where θ is the speed of adjustment in the current exchange rate. The current rate (s) deviates from its long-run equilibrium value ($\bar{s}$) because prices are sticky. The equilibrium exchange rate ($\bar{s}$) is defined as the rate that is consistent today with the current and expected future values of its underlying determinants. To derive current and future equilibrium values of these determinants, the equilibrium nominal exchange rate is decomposed into the difference between domestic and foreign prices and the real exchange rate:

$$\bar{s} = (\bar{p} - \bar{p}^*) + \bar{q}. \tag{6.20}$$

Hooper and Morton argue that if changes in the equilibrium real exchange rate are zero (that is, $\Delta \bar{q} = 0$), then the first difference of equation (6.20) will imply that PPP holds in the long run.[4] Consequently, the expected change in the equilibrium nominal exchange rate is equal to the expected equilibrium inflation differential:

$$E(\Delta \bar{s}) = (\Delta \bar{p} - \Delta \bar{p}^*). \tag{6.21}$$

[4]If changes in the equilibrium real exchange rates are zero, then the first difference form of equation (6.20) may not necessarily imply that purchasing power parity holds in the long run. Moosa and Bhatti (1999, pp. 156 and 157) demonstrate that the implication of the first difference purchasing power parity model $\Delta s_t = \Delta p_t - \Delta p_t^* + \Delta q_t$ and the *ex ante* purchasing power parity model $\Delta s_{t+1}^{\mathrm{e}} = \Delta p_t + \Delta p_{t+1}^{\mathrm{e}} + \Delta q_{t+1}^{\mathrm{e}}$ is that the real exchange rate follows a random walk in both cases (either $\Delta \bar{q} = 0$ or $\Delta q_{t+1}^{\mathrm{e}} = 0$). Therefore, purchasing power parity will not hold if the changes in the equilibrium real exchange rate are zero.

Substituting equations (6.1), (6.19), (6.20), and (6.21) and solving for s, we obtain

$$s = (\bar{p} - \bar{p}^{*}) - \frac{1}{\theta}[(i - \Delta\bar{p}) - (i^{*} - \Delta\bar{p}^{*})] + \bar{q}. \tag{6.22}$$

Equation (6.22) states that the spot exchange rate moves directly with the underlying long-run equilibrium relative prices, the long-run real interest differential, and the long-run real equilibrium exchange rate. Long-run equilibrium relative prices, $(\bar{p} - \bar{p}^{*})$, are determined by domestic and foreign money market conditions, as represented by equation (6.4). By substituting equation (6.4) into equation (6.22), we obtain

$$s = (\bar{m} - \bar{m}^{*}) - \alpha(\bar{y} - \bar{y}^{*}) + \beta(\Delta p^{\mathrm{e}} - \Delta p^{\mathrm{e}*}) - \frac{1}{\theta}[(i - \Delta\bar{p}) - (i^{*} - \Delta\bar{p}^{*})] + \bar{q}. \tag{6.23}$$

Equation (6.23) implies that if purchasing power parity holds in the long run, the exchange rate is determined not only by relative money supplies, relative incomes, relative inflation rates and relative real interest rates, but also by the equilibrium real exchange rate.

6.4.2. *The Equilibrium Real Exchange Rate and Current Account*

In equation (6.23), the equilibrium real exchange rate is the rate that is consistent with long-run equilibrium in the current account in the long run. The long-run current account equilibrium or "sustainable" current account is determined by the real exchange rate at which domestic and foreign residents wish to accumulate or decumulate domestic assets net of foreign assets in the long run.[5] Typically, the relation between the real exchange rate and the current account can be derived from the current account equation

$$ca_t = \sum_{i=0}^{t} a_{1i} q_{t-i} + a_2 X_t + a_3 \tilde{X}_t \tag{6.24}$$

where the current account (ca_t) is determined over time by the current and lagged values of the real exchange rate and a vector of transitory or cyclical variables denoted by $\tilde{X}$ (such as cyclical swings in income), and permanent

[5]The Hooper–Morton model implicitly assumes that domestic and foreign assets are perfect substitutes. This implies that current account imbalances are financed at unchanged exchange rates because asset holders are assumed to be indifferent toward the wealth accumulation or decumulation arising out of current account transactions.

or secular variables denoted by X, all of which are assumed to be exogenous. In the long run, therefore, equilibrium in the current account depends on the equilibrium real exchange and the vector of non-transitory factors other than the real exchange rate. Consequently, equation (6.24) boils down to

$$\overline{ca} = a_1\bar{q} + a_2X_t \tag{6.25}$$

where $a_1 = \sum a_{1i}$ is the long-run response of the current account to the real exchange rate.[6] If the Marshall–Lerner condition holds, the price elasticity of domestic exports is positive (that is, $a_1 > 0$). Solving equation (6.25) for the equilibrium real exchange rate, we obtain

$$\bar{q}_t = \frac{\overline{ca}_t}{a_1} - \frac{a_2}{a_1}X_t. \tag{6.26}$$

The equilibrium real exchange rate is determined by the desired rate of net foreign asset accumulation in the long run ($\overline{ca}$) and all non-transitory factors (other than the real exchange rate) that affect the current account (X). If $\overline{ca}$ is constant over time, then changes in the real exchange rate will be directly related to unexpected changes in the current account, which are in turn caused by changes in non-transitory variables, as shown in equation (6.26). Hence

$$\bar{q}_t - \bar{q}_{t-1} = -\frac{1}{a_1}[ca_t - E_{t-1}ca_t - c\tilde{a}_t] \tag{6.27}$$

where $c\tilde{a}_t$ is the transitory component of the current account. Integrating equation (6.27) over time yields:

$$\bar{q}_t = \bar{q}_0 - \frac{1}{a_1}\sum_{i=0}^{t}[ca_{t-i} - E_{t-1-i}ca_{t-1-i} - c\tilde{a}_{t-i}] \tag{6.28}$$

where the equilibrium real exchange rate is expressed as a function of its initial equilibrium value and the cumulative sum of past non-transitory unexpected changes in the current account.

Two simplifying assumptions are made to deal with expectations and the transitory elements in equation (6.28) to make the model empirically testable. First, the expected current account at time t is equal to the initial

[6] Equation (6.24) is not identical to equation (6.25). The former is more general where the current account balance is assumed to be determined not only by the real exchange rate and income, but also by some other variables that have permanent effects on current account flows. Transitory variables (such as cyclical swings in income) do not affect current account flows permanently. Therefore, the current account depends on the real exchange rate and the vector of permanent factors.

equilibrium current account at $t-1$ plus an adjustment by a fraction (λ) of the gap between the actual and the initial equilibrium accounts. Symbolically

$$E_{t-1}ca_t = ca_{t-1} + \lambda(\overline{ca} - ca_{t-1}). \tag{6.29}$$

This expectations hypothesis can be shown to be consistent with a restricted form of the current account equation (6.24) and that it is rational only with respect to a model in which the current account responds completely within one period to changes in q, X, and $\tilde{X}$ (that is, $\lambda = 1$), and where X and $\tilde{X}$ follow a random walk. If ca responds to q with a distributed lag, the value of λ is only an approximation to the distributed lag parameters, in which case equation (6.29) provides only an approximation to rational expectations about changes in ca, based on past changes in q. To determine the transitory changes in the current account, it is assumed that a constant proportion (η) of any deviation of the current account from its expected level is transitory. Formally

$$c\tilde{a}_t = \eta[ca_t - E_{t-1}(ca)_t]. \tag{6.30}$$

By substituting equations (6.29) and (6.30) into equation (6.28), the equilibrium real exchange rate can be expressed as follows:

$$\bar{q}_t = \bar{q}_0 - \frac{1-\eta}{a_1}\sum_{i=0}^{t}[ca_{t-i} - (1-\lambda)ca_{t-1-i}] + \frac{1-\eta}{a_1}\lambda\overline{ca}\cdot t. \tag{6.31}$$

Equation (6.31) expresses the equilibrium real exchange rate as a function of a base period real exchange rate, the cumulative partial first difference of the current account, and the cumulative equilibrium current account ($\overline{ca}\cdot t$).

6.4.3. *The Reduced-Form Equation of Exchange Rate Determination*

The equilibrium real exchange rate model is identical to the real interest differential model except that it has the relative cumulative current account as an additional explanatory variable to proxy the equilibrium real exchange rate. This model yields an equation in which the exchange rate is a function of (i) relative money supply; (ii) relative income; (iii) expected long-run inflation differential; (iv) expected real interest differential (which identifies deviations of the exchange rate from its expected equilibrium value); and (v) cumulative movements in the current account and a time trend (as determinants of the equilibrium real exchange rate). The reduced-form equation can be derived by substituting equation (6.31) into equation (6.23) with an assumption that the equilibrium relative money supply, relative income, and relative inflation are expressed in terms of their current actual levels. Thus, we have

$$s=(m-m^{*})-\alpha(y-y^{*})+\beta(\Delta p^{\mathrm{e}}-\Delta p^{\mathrm{e}*})-\frac{1}{\theta}[(i-\Delta\bar{p})-(i-\Delta\bar{p}^{*})]$$
$$+q_{0}-\frac{1-\eta}{a_{1}}\sum_{i=1}^{t}[ca_{t-i}-(1-\lambda)ca_{t-i-1}]+\frac{1-\eta}{a_{1}}\lambda\overline{ca}\cdot t. \qquad (6.32)$$

In the special case where the current account is expected to return to equilibrium in the next period ($\lambda = 1$), and where the equilibrium current account is zero ($c\bar{a} = 0$), the equilibrium real exchange rate is a linear function of the cumulative current account. Therefore, we can rewrite equation (6.32) as[7]

$$s=(m-m^{*})-\alpha(y-y^{*})+\beta(\Delta p^{\mathrm{e}}-\Delta p^{\mathrm{e}*})-\frac{1}{\theta}[(i-\Delta\bar{p})-(i-\Delta\vec{p})]$$
$$-\frac{1-\eta}{a_{1}}\sum_{i=1}^{t}ca_{t-i}. \qquad (6.33)$$

Equation (6.33) can be rearranged to include the cumulative current account balance of the foreign country and to separate the nominal interest differential from the expected inflation differential. This gives

$$s=(m-m^{*})-\alpha(y-y^{*})+\gamma(i-i^{*})+\delta(\Delta p^{\mathrm{e}}-\Delta p^{\mathrm{e}*})$$
$$+\varphi\left(\sum ca-\sum ca^{*}\right). \qquad (6.34)$$

For the real equilibrium exchange rate model to be empirically valid, the restrictions $\gamma < 0$, $\delta > 0$, and $\varphi < 0$ must not be rejected. As evident from equation (6.34), the equilibrium real exchange rate model is a more general model because it incorporates features of the flexible-price model, the sticky-price model, and the real interest differential model. The flexible-price model is empirically valid if the restrictions $\delta = 0$, $\varphi = 0$, and $\gamma > 0$ are not rejected. In contrast, the sticky-price model holds when the restrictions $\delta = 0$, $\varphi = 0$, and $\gamma < 0$ are valid. The real interest differential model cannot be rejected if the restrictions that $\delta < 0$, $\varphi = 0$, and $\gamma < 0$ are valid.

[7] In equation (6.32), q_0 is the initial equilibrium real exchange rate, which is constant.

6.4.4. *The Impact of the Risk Premium on the Exchange Rate*

Portfolio preferences influence the exchange rate to the extent that they play a role in the determination of the equilibrium real exchange rate (by identifying the long-run current account). Now, we relax this assumption and allow for imperfect substitutability of assets in the short run and the existence of a risk premium, which gives

$$E(\Delta s) = i - i^* - \rho \tag{6.35}$$

where ρ is the risk premium that asset holders demand on domestic assets relative to foreign assets, given wealth, asset stocks, and the expected relative rates of return on those assets. Hooper and Morton (1982) employed an abbreviated specification, expressing the risk premium as a linear function of the cumulative current account, intervention flows, and an initial condition:

$$\rho = \phi_0 - \phi_1 \sum_{j=2}^{T} (ca_{-j} + I_{-j}) \tag{6.36}$$

By allowing for the risk premium in equation (6.22), we obtain

$$s = \bar{s} - \frac{1}{\theta}[(i - \Delta\bar{p}) - (i^* - \Delta\bar{p}^*)] + \bar{q} + \frac{\rho}{\theta}. \tag{6.37}$$

Substituting equations (6.37) and (6.31) into equation (6.23), we obtain

$$\begin{aligned} s = {} & (\bar{m} - \bar{m}^*) - \alpha(\bar{y} - \bar{y}^*) + \beta(\Delta p^{\mathrm{e}} - \Delta p^{\mathrm{e}*}) \\ & - \frac{1}{\theta}[(i - \Delta\bar{p}) - (i^* - \Delta\bar{p}^*)] + \bar{q}_0 \\ & - \frac{1-\eta}{a_1} \sum_{i=1}^{t} [ca_{t-i} - (1-\lambda)ca_{t-i-1}] \\ & + \frac{1-\eta}{a_1} \lambda \overline{ca} \cdot t + \frac{\phi_0}{\theta} - \frac{\phi_1}{\theta} \sum_{j=1}^{T} (ca_{-j} + I_{-j}). \end{aligned} \tag{6.38}$$

In equation (6.38), the current account affects the exchange rate via two channels: expectations and short-run portfolio rebalancing. In the former case, the announcement of a current account deficit (that is, unexpected and nontransitory) affects the exchange rate (through changes in expectations about the equilibrium exchange rate) in such a way as to restore long-run equilibrium or a "sustainable" current account. In the latter case, if the current account deficit is not financed by official intervention during the length of time it takes to return to equilibrium, the necessary private financing is attracted with an increase in the risk premium, which causes the real exchange rate to overshoot its expected equilibrium level.

6.5. The Buiter–Miller Model with Core Inflation Rate

Buiter and Miller (1981) developed a variant of the Dornbusch (1976c) sticky-price model that incorporates a core inflation rate, which is used to analyze the dynamic effects of natural resource discoveries on output and the exchange rate. Their analysis is designed to be suggestive of the U.K.'s experience with the discovery of oil in the North Sea in the 1970s.

Buiter and Miller begin by specifying a money market equilibrium condition, and a rational expectations augmented version of the UIP condition. These two relations are written as

$$m_t - p_t = \phi y_t - \lambda i_t \tag{6.39}$$

$$\Delta s_{t+1} = (i_t - i_t^*). \tag{6.40}$$

In equation (6.40), the actual change in the exchange rate appears instead of the expected change, reflecting the assumption of rational expectations. The aggregate demand function explicitly incorporates the (negative) effect of the real interest rate. Hence

$$d_t = \alpha(\dot{p}_t - i_t) + \beta(s_t - p_t). \tag{6.41}$$

Inflation is assumed to be proportional to the level of excess demand over the full employment level of output plus a core inflation rate:

$$\dot{p}_t = (d_t - y_t) + \mu_t. \tag{6.42}$$

The core inflation rate (μ) is equal to the rate of growth in the money supply:

$$\mu_t = \dot{m}_t \tag{6.43}$$

In the sticky-price monetary model, long-run equilibrium is achieved when the current and long-run exchange rates are equal. In the Buiter–Miller model, however, the presence of a core inflation rate implies a nonzero difference between the current exchange rate and the long-run rate. This result arises because, in equilibrium, the nominal interest rate is equal to the real interest rate plus the core inflation rate through the Fisher effect:

$$r_t = i_t + \mu_t. \tag{6.44}$$

By combining equations (6.39)–(6.44), the following expression is derived

$$s_t = m_t + \left(\frac{1}{\beta} - \phi\right) y_t + \left(\frac{\alpha}{\beta} + \lambda\right) i_t + \lambda \mu_t \tag{6.45}$$

which tells us that the exchange rate is determined by income, interest rate, and the core inflation rate.

6.6. Frankel's Sticky-Price Model with a Wealth Effect

Frankel (1982a) developed an alternative version of the real interest differential model that takes into account the wealth effect. To derive this model, the money market condition represented by equation (6.4) is modified by incorporating into the domestic and foreign money demand functions relative wealth level as an additional explanatory variable. Formally, we have

$$(\bar{p} - \bar{p}^*) = (\bar{m} - \bar{m}^*) - \alpha(\bar{y} - \bar{y}^*) + \beta(\Delta p - \Delta p^*) - \phi(w - w^*). \tag{6.46}$$

By substituting equation (6.46) into equation (6.3), we obtain

$$s = (m - m^*) - \alpha(y - y^*) - \phi(w - w^*) - \frac{1}{\theta}(i - i^*) + \left(\frac{1}{\theta} + \beta\right)(\Delta p^{\mathrm{e}} - \Delta p^{*\mathrm{e}}). \tag{6.47}$$

Notice that the coefficients on relative income, relative wealth, and relative interest rate are negative, whereas those on relative money supplies and relative inflation rates are positive. Thus, an increase in domestic wealth relative to foreign wealth (caused by a surplus in the current account of the home country) leads to appreciation of the domestic currency because of the increase in the demand for domestic money relative to foreign money. Similarly, given the expected inflation rate, if the domestic interest rate is higher than the foreign rate, there is an incipient capital inflow that causes the domestic currency to appreciate. Frankel tested this model for the mark/dollar exchange rate over the period 1974–80 and found results that were supportive of the real interest differential model with wealth as an additional explanatory variable.

6.7. Recapitulation

The sticky-price monetary model of Dornbusch allows substantial short-term overshooting of nominal and real exchange rates beyond the long-run equilibrium values determined by purchasing power parity because the "jump variables" in the system (exchange rates and interest rates) compensate for sluggishness in other variables, notably goods prices. This model is a representation of long-run equilibrium toward which the economy tends to adjust, while in the short run it is possible for the exchange rate to overshoot its long-run value.

During the late 1970s and early 1980s, a wide range of sticky-price models were developed to account for some observations pertaining to the behavior of flexible exchange rates. These models include the real interest differential model of Frankel (1979b), the stock-flow model of Driskell (1981), and the equilibrium real exchange rate sticky-price model of Hooper and Morton (1982). While these models appeared to have made some useful additions to the Dornbusch model, their empirical validity remained as questionable as their predecessors.

CHAPTER 7
The Monetary Model of Exchange Market Pressure

7.1. Introduction

The monetary model may be viewed as a dual relation that offers a monetary explanation for (i) movements in the external value of a country's currency when exchange rates are flexible and (ii) disequilibrium in a country's balance of payments when exchange rates are fixed.[1] Based on Walras's law, monetary models view the money market as a reflection of all other markets taken jointly, where excess supply of domestic money reveals itself as excess domestic demand for goods, services, and securities. Excess supply of domestic money spills into foreign markets, eventually leading to currency depreciation or a deficit in the balance of payments. As an exchange rate model, the monetary model yields an exchange rate equation derived from equilibrium monetary conditions, the quantity theory of money, and purchasing power parity. Being the relative price of two national monies, the equilibrium exchange rate is determined in terms of the demand for and the supply of two national monies.

The monetary model predicts that excess of domestic money supply over domestic money demand relative to foreign money leads to a proportional rise in relative prices, which in turn leads to a proportional rise in the exchange rate as a result of the neutrality of money. As a model of the balance of payments, it assumes a small country facing fixed exchange rates and employs the same monetary building blocks to produce a reduced form equation for the balance of payments. It shows that, under fixed exchange rates, an increase in domestic credit leads to a proportional reserve outflow and a rise in domestic prices, thereby maintaining the neutrality of monetary policy over time. The only difference between the monetary model of exchange rates and that of the balance of payments lies in the way

[1] See Frenkel (1976, pp. 200 and 201) and Mussa (1976, p. 231).

international reserves and the exchange rate behave in the two models. The exchange rate model is derived under the postulation that changes in international reserves are zero, while the balance of payments model is derived under the postulation that changes in the exchange rate are zero. However, these monetary models may not explain adequately movements in the exchange rate and international reserves in countries where central banks permit some degree of exchange rate flexibility but at the same time intervene in the foreign exchange market. For such regimes, it may be misleading to focus on either the exchange rate or reserve movements alone.

Even after the move to a system of "generalized floating" in the early 1970s, many countries continued to have heavily managed floating rates by relying on both direct and indirect intervention.[2] Moreover, this "floating rate" period has been characterized by substantial fluctuations in exchange rates. In such a framework of a hybrid system of "managed floating," disequilibrium in the foreign exchange market is often dealt with partly by exchange rate changes and partly by reserve changes. Prior to the advent of generalized floating in March 1973, it was taken for granted that the use of official reserves would be eliminated under floating exchange rates. But since then, exchange market pressure has been felt by central banks attempting to stabilize their international reserve positions to avoid undesirable exchange rate movements. Thus, the monetary model that holds for flexible exchange rates alone is unlikely to hold for an exchange rate regime in which central banks face exchange market pressures of this kind. The model needs to be modified (by taking into account exchange market pressure) to explain movements in the exchange rate and also in international reserves. Another crucial issue facing a central bank opting for a system of managed floating is to determine the degree to which its exchange rate target undermines its monetary autonomy.

Girton and Roper (1977) suggested that the monetary model that holds for a pure float or a pure peg cannot perform well for an exchange rate regime in which there is market pressure on central banks to stabilize partially their international reserve positions and changes in exchange rates. They developed a version of the monetary model that holds for all exchange rate regimes. This model postulates that under a system of managed floating, in which exchange market pressure exists, exchange rates and foreign exchange reserves are determined simultaneously by the demand for and supply of money. Girton and Roper use, as a proxy, the sum of the rate of change in international reserves deflated by the level of the monetary base

[2]For a detailed discussion, see Whitman (1975).

(Δr) and the rate of change in the exchange rate (Δs) to measure the extent of exchange market pressure. This measure of exchange market pressure $(\Delta r + \Delta s)$ is then substituted for the exchange rate as the dependent variable in the monetary model, assuming that all explanatory variables are expressed in rates of change.

The Girton–Roper model was designed specifically to explain the Canadian experience with managed floating during the period 1952–62. Subsequent studies undertaken by Connolly and da Silveira (1979), Modeste (1981), Kim (1985), and by Wohar and Lee (1992) applied the model to examine the effect of exchange market pressure on the simultaneous determination of the exchange rate and international reserves in Brazil during the period 1955–75, in Argentina during the period 1972–78, in Korea over the period 1980–83, and in Japan over the period 1959–86.

7.2. The Exchange Market Pressure Model of Exchange Rates

Girton and Roper (1977) developed what they termed a "monetary model of exchange market pressure" that takes into account the observations that exchange rates often do not float completely freely and that changes in the international reserves held by central banks are often not zero, even in countries operating under the so-called "independent floating". The Girton–Roper monetary model was developed without invoking the small-country assumption, with the objective of explaining the pressure on foreign exchange reserves and the exchange rate that arises when there is excess of domestic money supply over domestic money demand under managed floating.

This model draws on a combination of the monetary approaches to the balance of payments and exchange rate determination. The fundamental proposition underlying the exchange market pressure model is that if there is an excess of money supply over money demand, it will be relieved by some combination of a loss in the external value of a country's currency and a loss of international reserves. In essence, the Girton–Roper model is firmly rooted in the monetary approaches to exchange rates and the balance of payments. In a small open economy under managed floating, the combined variations in the balance of payments and the exchange rate represent an important mechanism for attaining and maintaining equilibrium. For example, if there is excess money supply in the economy, then asset holders' portfolios will be thrown into disequilibrium, and consequently (in an attempt to restore equilibrium to their portfolios), asset holders will dispose of excess money balances by spending to acquire goods, services, and financial assets. Partly, this adjustment would involve domestic residents exchanging the domestic currency for a foreign currency, thereby reducing the supply of money. Partly, the demand for foreign currency results in depreciation of the domestic currency, thereby leading to an increase in the domestic price level, which in turn reduces the supply of money. Equilibrium in the monetary sector is restored by an increase in the demand for money and/or a decrease in the supply of money.[3]

The Girton–Roper model focuses on two key issues, which are of significant concern for policymakers under managed floating. The first issue pertains to the optimal volume of intervention necessary to achieve a desired exchange rate target, while the second relates to determining the degree to which the central bank can pursue an independent monetary policy in an open economy. This model provides a useful framework that can be used to measure the volume of intervention necessary to achieve any desired exchange rate target and to estimate the degree of monetary autonomy.[4] Girton and Roper argue that the empirical estimation of a monetary model can be related to (but is not identical with) the empirical estimation of the degree of monetary independence. Moreover, monetary independence can be tested without explaining the balance of payments, and similarly an official settlement can be explained without testing monetary independence. As for monetary independence, it can be measured by the degree to which variations in the domestic source of the monetary base lead to changes in the demand for the base and consequently the total quantity outstanding. If the policy actions employed to alter the domestic source of the base fail to influence demand, the change in the domestic source will be offset by the official intervention necessary to achieve a fixed rate target.

To derive the Girton–Roper model formally, we begin by specifying equilibrium monetary conditions for the home and foreign countries (i and j), which are expressed in terms of their money demand functions and money market equilibrium conditions, respectively:

$$H_i = D_i + R_i = P_i Y_i^{\alpha_i} \mathrm{e}^{-\beta_i i_i} \tag{7.1}$$

$$H_j = D_j + R_j = P_j Y_j^{\alpha_j} \mathrm{e}^{-\beta_j i_j} \tag{7.2}$$

[3] See Johnson (1972a) and Connolly and Taylor (1976).

[4] An enormous amount of work has been conducted on the relation between exchange market pressure and monetary policy by, *inter alia*, Tanner (2001), Garcia and Malet (2005), and Kumah (2007).

where $H_i(H_j)$ is the domestic (foreign) supply of base money (high-powered money) issued by the domestic (foreign) central bank. Base money consists of the component $D_i(D_j)$, created by credit expansion in the home (foreign) country, and the component $R_i(R_j)$, created against purchases of foreign assets or foreign exchange reserves in the home (foreign) country. $P_i(P_j)$ is the general domestic (foreign) price level, $Y_i(Y_j)$ is domestic (foreign) real income, and $\alpha_i(\alpha_j)$ and $\beta_i(\beta_j)$ are respectively the domestic and foreign income and interest elasticities of money demand functions.

Taking logs on both sides of equations (7.1) and (7.2), differencing the resulting expression and then solving for the percentage change in reserves, we obtain

$$\Delta r_i = -\Delta d_i + \Delta p_i + \alpha_i \Delta y_i - \beta_i \Delta i_i \tag{7.3}$$

$$\Delta r_j = -\Delta d_j + \Delta p_j + \alpha_j \Delta y_j - \beta_j \Delta i_j \tag{7.4}$$

where $\Delta x = (\mathrm{d}x/\mathrm{d}t)(1/x)$ for any of the variables appearing in equations (7.3) and (7.4).

Now, assuming that purchasing power parity holds at all times, we have

$$Q_{ij} = \left(\frac{P_j S_{ij}}{P_i}\right) \tag{7.5}$$

where $S_{ij}(Q_{ij})$ is the nominal (real) exchange rate, defined in currency i terms per one unit of currency j. By taking logs on both sides of equation (7.5), the equation can be re-written in first difference form as

$$\Delta q_{ij} = \Delta s_{ij} - \Delta p_i + \Delta p_j \tag{7.6}$$

where $\Delta s_{ij}(\Delta q_{ij})$ is the percentage change of the nominal (real) exchange rate and $\Delta p_i(\Delta p_j)$ is the domestic (foreign) inflation rate. By subtracting equation (7.4) from equation (7.3), then substituting the resulting expression into equation (7.6) under the assumption of identical inter-country coefficients on interest rates (that is, $\beta = \beta_i = \beta_j$), we obtain

$$\begin{aligned}\Delta r_i - \Delta r_j + \Delta s_{ij} = {} & -\Delta d_i + \Delta d_j + \alpha_i \Delta y_i - \alpha_j \Delta y_j \\ & + \Delta q_{ij} - \beta \Delta (i_i - i_j).\end{aligned} \tag{7.7}$$

Equation (7.7) can be used to explain interaction between two countries and whether or not they are able to pursue independent monetary policies. It is worth noting that interaction between the two countries depends on whether or not one of them is sufficiently "large" in the sense of being able to pursue an independent monetary policy. If the two countries under consideration are of comparable size, the left-hand side of equation (7.7) would represent the bilateral balance of payments if the exchange rate was perfectly fixed ($\Delta s_{ij} = 0$). If both countries refrained from intervention in the foreign exchange market ($\Delta r_i = 0 = \Delta r_j$), the left-hand side would reduce to the percentage change in the exchange rate. On the other hand, if the monetary authorities of the two countries intervened in the foreign exchange market without a commitment to maintaining a particular constant value of the exchange rate, then the composite variable $\Delta r_i - \Delta r_j + \Delta s_{ij}$ measures exchange market pressure.

7.3. Exchange Market Pressure and Monetary Independence

Primarily, the model was developed to apply to the case of a small country, Canada, and a center or key currency country, the U.S. Since the U.S. is a key currency country, it has the ability to force most and perhaps the entire adjustment burden on those countries making efforts to stabilize their exchange rates. Equation (7.7) can be rewritten as

$$\begin{aligned}\Delta r_i + \Delta s_{ij} &= -\Delta d_i + \Delta h_j + \alpha_i \Delta y_i - \alpha_j \Delta y_j \\ &\quad + \Delta q_i - \beta \Delta(i_i - i_j) \qquad (7.8)\end{aligned}$$

where Δr_j has been subsumed under Δh_j ($=\Delta r_j + \Delta d_j$). The large country's balance of payments may be taken to the right-hand side of equation (7.8) and considered as exogenous if Δh_j is not influenced by the remaining variables in equation (7.8). As a result, Δh_j will be managed independently of the exchange rate in the small country like Canada. Girton and Roper argue that if the U.S. monetary policy had been independent of the balance of payments (and it has in fact been insulated in the post-war period), monetary interaction between the U.S. and other countries would have worked through both the supply and demand sides of the base money markets. With Δh_j unaffected by market intervention, the link between the U.S. and the rest of the world is only through the demand side or substitution between securities and commodities. It is argued that this link is recursive, going from U.S. prices and interest rates to prices and interest rates in the rest of the world, to the demand for their base, to the induced supply of base. In the absence of the supply link (the fact that Δr_i does not feedback on Δh_j), there is no need for Δh_j to appear in equation (7.8). And to capture linkages on the demand side, U.S. prices and interest rates may be included on the right-hand side of equation (7.8) instead of Δh_j. However, to determine the effect of U.S. monetary policy on exchange market pressure in the rest of the world, it is useful to include a one-variable index of U.S. monetary policy (Δh_j) rather than the two variables (prices and interest rates) over which the U.S. authorities have less control.

The monetary model of exchange market pressure as implied by equation (7.8) is different from other monetary models of exchange rates and the balance of payments in two ways. First, unlike other monetary models of the exchange rate (and the balance of payments), the dependent variable in this model is exchange market pressure (defined as the sum of the rate of change in official reserves and the rate of change in the exchange rate) rather than the exchange rate (or the balance of payments). If the value of exchange market pressure is unaffected by its composition (as will be subsequently measured by S/R), then the exchange pressure is independent of whether or not the authorities absorb the pressure in reserves or in exchange rates. Second, the model of exchange market pressure can be used to find out if domestic monetary policy is tight or easy only with reference to what is happening in the rest of the world.

It is important to note that equation (7.8) in its present form can be estimated to explain exchange market pressure, but it does not provide a measure of monetary independence. For the model to hold, the coefficient on domestic credit should be equal to minus one. The crucial issue in determining the degree that a fixed exchange rate target undermines monetary autonomy is whether or not the authorities can make interest rates and prices diverge from those of the U.S. by using monetary policy. More precisely, the degree of monetary independence depends on whether changes in exchange rates and interest rate differentials depend on the base money created by domestic credit expansion, which is under the control of the domestic monetary authorities. To test the hypotheses of exchange market pressure and monetary independence, let us impose purchasing power parity (which implies that $\Delta q_i = 0$) and rewrite equation (7.8) in a testable form as:

$$\begin{aligned}\Delta r_i + \Delta s_i = \phi_0 + \phi_1 \Delta d_i + \phi_2 \Delta h_j + \phi_3 \Delta y_i \\ + \phi_4 \Delta y_j + \phi_5 \Delta(i_i - i_j) \qquad (7.9)\end{aligned}$$

such that $\phi_1 = -1$, $\phi_2 = 1$, $\phi_3 = 1$, $\phi_4 = -1$ and $\phi_5 < 0$. Equation (7.9) states that joint changes in international reserves and the exchange rate are proportionately related to changes in domestic credit, foreign money supply, domestic income, foreign income, and the interest rate differential.

To the extent that the monetary base created through domestic credit expansion affects changes in the exchange rate and changes in interest rate differentials, the coefficient on the domestic credit creation term should be less than unity (that is, $\phi_1 < 1$). Thus, the loss of reserves or currency depreciation associated with an expansionary monetary policy will be mitigated if the policy reduces domestic interest rates relative to foreign rates, or if it raises domestic prices relative to foreign prices. Girton and Roper (1977) found the coefficients on the domestic source of Canadian base money (d_i) to be -0.96 and -0.97, interpreting the results as indicating that the Canadian monetary authorities (under a fixed exchange rate regime) have little scope for pursuing an independent monetary policy.

It is important to note that if exchange rates are fixed, then $\Delta s_{ij} = 0$ in equation (7.9), which means that the percentage change in international reserves alone is used as the dependent variable. On the contrary, if exchange rates are perfectly flexible, then $\Delta r_i = 0$ and consequently only the percentage change in the exchange rate is used as the dependent variable. However, if the central banks of the two countries intervened without commitment to a fixed exchange rate, both percentage changes in the exchange rate and international reserves would be used as the dependent variable.

7.4. A Simple Version of the Girton–Roper Market Pressure Model

Connolly and da Silveira (1979) applied the exchange market pressure model of Girton and Roper to the post-war Brazilian monetary experience. They argue that Brazil provides a particularly good example for the application of this model, because it is in many senses a unique example of the post-war experience with managed floating and also because it can be treated as a small open economy for which world prices and monetary conditions are taken as given. Moreover, being a small open economy, Brazil permits us to derive a simple one-country version of this model to be applied to its managed floating rate experience over the period 1955–75. This simple version of the Girton–Roper exchange market pressure model can be derived from four basic relations: (i) a stable money demand function based on the quantity theory of money, (ii) a specification for the money supply in line with Mundell (1971), (iii) purchasing power parity, and (iv) a monetary equilibrium condition. Thus, we have

$$M^D = kPY \tag{7.10}$$

$$M^S \equiv R + D \tag{7.11}$$

$$P = SP^* \tag{7.12}$$

$$M^D = M^S \tag{7.13}$$

where k is the fraction of nominal income that is held in the form of money balances, which is assumed to be constant for simplicity. Equation (7.11) is an identity, telling us that changes in the money supply can be attributed to either foreign or domestic sources (a change in foreign exchange reserves via the balance of payments or a change in the domestic credit extended by the consolidated banking system). Equation (7.12) is the purchasing power parity relation whereby domestic prices are related to foreign prices via the exchange rate. Finally, equation (7.13) states that the actual money stock adjusts rapidly to the quantity of money demanded, either via a deficit running down the money stock, via currency depreciation, or via some combination of the two.

Let us take the logarithms on both sides of equations (7.10)–(7.13) and then substitute equation (7.12) into equation (7.10) and equation (7.11) into equation (7.13). Following Connolly and da Silveira (1979), international reserves and domestic credit are expressed as a proportion of the money supply. The resulting equation can be expressed in first log differences as

$$\Delta r + \Delta s = -\Delta d + \Delta p^* + \Delta y \tag{7.14}$$

where Δr is the rate of change in international reserves (or the balance of payments) as a proportion of the money supply, Δs is the rate of change in the exchange rate, Δd is the rate of change in domestic credit as a proportion of the money supply, Δp^* is the world inflation rate, and Δy is rate of growth of income. Equation (7.14) states that an increase in the rate of growth of domestic credit (for a given rate of growth of world prices and permanent income) results in a proportional loss of international reserves (with no change in the exchange rate) or a proportional currency depreciation, or some combination of the two. Therefore, two other variants of equation (7.14) can be written as

$$\Delta r = -\Delta d + \Delta p^* + \Delta y \tag{7.15}$$

$$\Delta s = -\Delta d + \Delta p^* + \Delta y \tag{7.16}$$

where both the rate of change in international reserves and the rate of change in the exchange rate are proportionately related to changes in domestic credit, foreign inflation rate, and domestic income, respectively.

Equations (7.14)–(7.16), representing a single-country simple version of the model of exchange market pressure, are restrictive. The difference between the exchange pressure model represented by equations (7.14)–(7.16) and the one represented by equation (7.9) is that the former do not include the variables reflecting changes in the foreign money supply, foreign income, and foreign interest rates. These equations have been derived under the assumptions that purchasing power parity holds ($\Delta q_i = 0$) and that there are no changes in the interest differential ($\Delta(i_i - i_j) = 0$). By ignoring the foreign money demand function and imposing purchasing power parity on equation (7.8), we obtain the restricted equations (7.14) or (7.15)–(7.16). Moreover, as is evident from equations (7.14)–(7.16), the foreign inflation rate reflects the excess of foreign money supply over foreign demand, which means that the sign on the foreign inflation rate is positive.

Thornton (1995) applied the Girton–Roper model to the experience of Costa Rica in the period 1986–92. He argues that Costa Rica provides a good case study for this model, because it is a small open economy in which world prices and monetary conditions are taken as given. The country has experienced wide variations in the external value of its currency and international reserves. Over the period under consideration, the Banco Central de Costa Rica (BCCR) has managed a flexible exchange regime, including "maxi-" and "mini-" devaluations, which saw the domestic currency move from 53.7 to 173.41 against the U.S. dollar. Moreover, there were wide variations in net official reserves between August 1990 and December 1992.

Thornton tested a slightly modified version of the simple exchange market pressure model employed by Connolly and da Silveira (1979). The modification was introduced by rewriting equation (7.11) as

$$M^S \equiv A(R + D) \tag{7.17}$$

where A is defined as the money multiplier. By substituting the logarithmic versions of equations (7.10), (7.12), (7.13), and (7.17), taking the first difference of the resulting expression and then solving for $\Delta r + \Delta s$, we obtain

$$\Delta r + \Delta s = -\Delta d + \Delta p^* + \Delta y - \Delta a \tag{7.18}$$

where Δa is the percentage change of the money multiplier ($\Delta a = (\mathrm{d}A/\mathrm{d}t)(1/A)$). This equation states that (for a given world inflation rate, real income, and the money multiplier), an increase in domestic credit results in a proportional loss of international reserves, proportional currency depreciation, or some combination thereof.

7.5. An Expanded Version of the Girton–Roper Market Pressure Model

Wohar and Lee (1992) proposed an expanded and less restrictive version of the Girton-Roper model that allows for (i) deviations from purchasing power parity, (ii) changes in domestic and foreign interest rates, and (iii) alternative transmission channels for foreign disturbances. To derive this version of the model, we rewrite equations (7.1) and (7.2) as follows:

$$M_i = A_i H_i = A(D_i + R_i) = P_i Y_i^{\alpha_i} \mathrm{e}^{-\beta_i i_i} \tag{7.19}$$

$$M_j = A_j H_j = A(D_j + R_j) = P_j Y_j^{\alpha_j} \mathrm{e}^{-\beta_j i_j} \tag{7.20}$$

where $M_i(M_j)$ is the domestic (foreign) money supply defined as the product of the money multiplier, $A_i(A_j)$, and high-powered money, $H_i(H_j)$. The latter is composed of the domestic (foreign) currency value of net foreign reserves $(R_i(R_j))$ and net domestic credit of the central bank $(D_i(D_j))$.

Equations (7.19) and (7.20) are differenced in logarithms to obtain

$$\Delta m_i = \Delta a_i + \Delta r_i + \Delta d_i = \Delta p_i + \alpha_i \Delta y_i - \beta_i \Delta i_i \tag{7.21}$$

$$\Delta m_j = \Delta a_j + \Delta r_j + \Delta d_j = \Delta p_j + \alpha_j \Delta y_j - \beta_j \Delta i_j. \tag{7.22}$$

Following Wohar and Lee (1992), we take the inverse of the real exchange rate by rewriting equation (7.5) as

$$Z = \frac{1}{Q_{ij}} = \frac{P_i}{S_{ij} P_j} \tag{7.23}$$

where $Z = 1/Q_{ij}$ (implying deviation of the domestic price level from purchasing power parity) measures the ratio of the actual domestic price level to the the level predicted by purchasing power parity. If $Z = 1$, then purchasing power parity holds, and the domestic price level will be precisely equal to the value predicted by purchasing power parity. On the contrary, if Z is greater (less) than 1, then purchasing power parity does not hold, which means that the domestic price level must be higher (lower) than what is predicted by purchasing power parity. This implies that the larger the value of Z, the higher the domestic price level relative to the foreign price level adjusted by the nominal exchange rate. From equation (7.19), this also implies that the higher the domestic price level (relative to that predicted by purchasing power parity) the greater will be the domestic demand for money, which leads to an increase in reserves growth and/or appreciation of the domestic currency. Therefore, the larger the value of Z, the more likely that reserves are gained and/or the domestic currency appreciates.

By taking first log differences on both sides of equation (7.23), we obtain

$$\Delta q_{ij} = \Delta p_i - (\Delta p_j + \Delta s_{ij}). \tag{7.24}$$

By substituting equation (7.21) into equation (7.24) and then the resulting equation into equation (7.22), we obtain[5]

$$\begin{aligned}\Delta r_i - \Delta s_{ij} = -\Delta a_i - \Delta d_i + \Delta m_j + \Delta q_{ij} + \alpha_i \Delta y_i \\ - \alpha_j \Delta y_j - \beta(\Delta i_i - \Delta i_j).\end{aligned} \tag{7.25}$$

Equation (7.25) can be rewritten as

$$\begin{aligned}\Delta r_i - \Delta s_{ij} = \phi_0 + \phi_1 \Delta d_i + \phi_2 \Delta m_j + \phi_3 \Delta y_i + \phi_4 \Delta y_j \\ + \phi_5(\Delta i_i - \Delta i_j) + \phi_6 \Delta a_i + \phi_7 \Delta q_{ij}.\end{aligned} \tag{7.26}$$

Equation (7.26) represents an unrestricted version of the exchange market pressure model. In this model, the estimated coefficients on Δd_i and Δm_j serve as indicators of monetary independence. This model is reduced to the Girton–Roper model (as represented by equation (7.9)) when the coefficients on the terms representing the percentage changes in the real exchange rate and money multiplier are zero (that is, $\phi_6 = 0$ and $\phi_7 = 0$). If the Girton and Roper model is empirically valid, the joint restrictions $\phi_1 = -1, \phi_2 = 1, \phi_3 = 1, \phi_4 = -1$ and $\phi_5 < 0$ must hold.

To obtain an alternative model specification from the full unrestricted model represented by equation (7.25), let us substitute Δm_j in equation (7.25) for its value as given in equation (7.22). Thus, we have:

$$\begin{aligned}\Delta r_i - \Delta s_i = -\Delta a_i - \Delta d_i + \Delta p_j - \beta_j \Delta i_j + \alpha_i \Delta y_i \\ + \Delta q_{ij} - \beta \Delta(i_i - i_j).\end{aligned} \tag{7.27}$$

The difference between equations (7.27) and (7.8) lies in the transmission of foreign disturbances. In equation (7.27), foreign disturbances are transmitted to the exchange market pressure variable by foreign money supply growth, controlling for real foreign income growth. In equation (7.8),

[5] In equation (7.24), inter-country interest elasticities are assumed to be identical, $\beta = \beta_i = \beta_j$.

foreign disturbances are transmitted to the exchange market pressure variable through foreign inflation and changes in foreign interest rates.

Wohar and Lee argue that a crucial issue that needs to be examined is the international transmission of economic disturbances from one country to another. This includes both the transmission of variables (such as inflation and unemployment) and macroeconomic policy. One channel of international transmission that has been suggested under fixed exchange rates is that the balance of payments directly links domestic money growth in a small open economy to foreign money growth. In another channel of transmission, suggested by the monetary approach to the balance of payments, domestic inflation is directly linked to foreign inflation via the law of one price. Under this transmission mechanism, foreign money growth could influence domestic inflation through its effect on foreign and/or world inflation in addition to the effect on domestic money growth.[6]

Wohar and Lee (1992) argue that even in the absence of intervention in the foreign exchange market, flexible exchange rates may not insulate the domestic economy completely from external shocks. It is argued that domestic inflation can be affected by foreign monetary growth through changes in interest rates and exchange rate expectations. Examining the international transmission of economic disturbances under floating exchange rates and rational expectations, Saidi (1980) obtained the important finding that macroeconomic policy changes in a large economy can impact a small economy through their impact on world prices. Burdekin (1989) examined the impact of U.S. macroeconomic policy (in particular U.S. monetary policy, government budget deficit, and inflation) on the economies of France, Italy, the U.K. and Germany, producing results in support of a significant impact of the U.S. variables across all four countries.

7.6. Recapitulation

Girton and Roper suggest that the monetary model is valid for either a pure float or a pure peg (the monetary approach to the balance of payments), but not for an intermediate regime such as managed floating. Under a system of pure float, only the exchange rate changes, whereas under a system of pure peg, only the level of reserves changes. However, both the exchange rate and the level of international reserves change under an intermediate regime such as managed floating.

[6]See, for example, Parkin (1977).

In the Girton–Roper model, exchange rates and international reserves are determined simultaneously by the demand for and supply of money. Unlike other exchange rate models, the dependent variable in this model is not the exchange rate (or its rate of change) but rather the sum of the rates of change of international reserves and the exchange rate. This model has become to be known as the monetary model of exchange market pressure. The fundamental proposition underlying this model is that if there is excess money supply it will be relieved by a combination of currency depreciation and loss of international reserves. This model can be used to study monetary independence.

CHAPTER 8
The Portfolio Balance Model of Exchange Rates

8.1. Introduction

During a few years just after the advent of floating exchange rates in 1973, empirical studies that applied first and second-generation monetary models to explain movements in the exchange rates of major currencies produced results that were supportive of all versions of the monetary model.[1] Subsequent studies, aiming to update the empirical evidence on the basis of these models to account for the sharp depreciation of the U.S. dollar in 1978, were quite unsuccessful for all versions of the monetary model.[2] The sharp depreciation of the U.S. dollar (particularly against the German mark) prompted increasing criticism of the non-interventionist policies of the U.S. government, which did not come to an end until the November package of increased monetary restraint and direct intervention to support the dollar. Depreciation of the U.S. dollar was simply attributed to the rapid increase in the money supply prompted by the Federal Reserve.[3]

Another explanation for the decline of the dollar in 1978 is that the U.S. experienced a large current account deficit against Germany and Japan. The correlation between current account deficits and exchange rates was undeniably strong, not only in 1978 (when the dollar depreciated against the currencies of surplus countries), but also in 1979 and 1980 when this pattern was reversed. Frankel (1983a) argues that current account developments can affect the exchange rate in three ways without reverting to the traditional

[1]See, for example, Frenkel (1976), Humphrey and Lawler (1977), Bilson (1978a,b), and Frankel (1979b).

[2]See, for example, Dornbusch (1980b), Haynes and Stone (1981), and Frankel (1981).

[3]Dornbusch (1980b) and Frankel (1983a) point out that the popular impression in 1978 that the Federal Reserve Board was increasing the supply of dollar faster than the Bundesbank was increasing the supply of mark was, in fact, contrary to reality.

flow view of exchange rates. First, as current account developments are largely dominated by oil, the sharp increase in oil prices in 1979 raised the demand for the dollar at the expense of the mark and yen, much as did the increase that took place in late 1973. Second, Hooper and Morton (1982) argued that the release by a country of unexpected figures on its trade account appears to have a large immediate "announcement effect" on the exchange rate. Third, a current account surplus may lead to currency appreciation through the transfer of wealth from foreign residents to domestic residents via any of the following three channels: (i) it can raise domestic expenditure, thereby raising domestic income and the transaction demand for money; (ii) it can raise the demand for domestic money directly if wealth is an argument in the demand for money function; and (iii) it can boost the demand for domestic bonds if domestic and foreign bonds are imperfect substitutes and domestic residents have greater tendency to hold wealth in the form of domestic bonds.

It is argued that while each of the three wealth effects generated by changes in the current account might play a role in a comprehensive model, the last of these effects (which is referred to as the "portfolio balance effect") has led many economists to develop versions of the portfolio balance model for the purpose of providing an explanation for the depreciation of the U.S. dollar (for example, Branson, 1977; Branson *et al.*, 1977; Dooley and Isard, 1979, 1982, 1983).[4] The development of the portfolio balance model was stimulated by evidence indicating that uncovered interest parity might not hold, the casual observation that exchange rates appeared to be affected by cumulative changes in the current account, and the expressed desire of official and private portfolio managers to manage foreign exchange risk and expected rates of return on foreign currencies. In essence, the portfolio balance model postulates that when non-money assets are imperfect substitutes, the exchange rate is one of the asset prices that clear asset markets. Thus, when we move from a world in which non-money assets are perfect substitutes to another world in which non-money assets are imperfect substitutes, the exchange rate becomes a price determined jointly with other asset prices, such as the interest rate.

[4]For example, in a model of exchange rate determination developed by Dornbusch and Fischer (1980), the expenditure channel is used to take into account the effect of the current account on the exchange rate, whereas in Frankel's (1982a) real interest differential model with wealth effect, wealth enters not only in the money demand equations of the home and foreign countries but also in the equation of exchange rate determination.

8.2. The Portfolio Balance Effect of Wealth and the Exchange Rate

A shift in a country's wealth caused by a deficit or a surplus in its current account is one of the important channels that may give rise to the portfolio balance effect on the exchange rate. However, the portfolio balance effect of wealth does not presuppose imperfect substitutability between domestic and foreign assets, although it is entirely compatible with it. It may arise when domestic and foreign assets are perfect substitutes and also when they are not (Dornbusch, 1980b). A starting point in the portfolio balance effect is the proposition that money demand depends not only on income (the conventional transaction variable), but also on wealth. In the context of perfect asset substitutability, this specification of the money demand function implies that real money demand rises in a country with a balance of payments surplus and falls in a country with a balance of payments deficit. Thus, the relative price level of the country with a surplus declines, which in turn causes the currency of that country to appreciate for given terms of trade. Dornbusch (1980b) argues that this proposition does not go far in explaining movements in the exchange rate unless there is empirical support for it. This line of research has been particularly pursued by Frankel (1982b) who suggested that the money demand function should include, besides real income, wealth level as an additional explanatory variable. Consequently, the derived exchange rate equation should also have relative wealth level as an explanatory variable.[5]

An alternative and more persuasive role for the portfolio balance effect arises in the context of imperfect asset substitutability.[6] With uncertain real returns, portfolio diversification makes assets imperfect substitutes and gives rise to determinate demands for the respective securities and to real yield differential or risk premium. If domestic and foreign securities are

[5]There are theoretical as well as empirical grounds to support the inclusion of wealth in the money demand function. In his survey of the literature on the money demand function, Laidler (1977, p. 139) concludes that there seems to be fairly strong evidence in favor of a wealth variable. In contrast, Goldfeld (1973) found that income appeared significant, but wealth did not, in money demand regressions with both variables. However, when Goldfeld (1976) used more recent data, he found that wealth appeared significant. Friedman (1978) argued that the empirical evidence supported the inclusion of wealth because it might explain the "mystery of the missing money."

[6]Financial assets may be imperfect substitutes for a number of reasons, including liquidity, tax treatment, default risk, political risk, and foreign exchange risk.

imperfect substitutes, shifts in wealth or relative supplies of securities play an important role in affecting balance in securities markets, which means that money demand depends not only on conventional variables such as real income, but also on wealth. Shifts in wealth across countries (induced by current account imbalances) create monetary imbalances, which in turn lead to adjustment in long-run price expectations and hence the exchange rate. Thus domestic holdings of foreign currency can only accumulate or decumulate through trade surpluses or deficits (or, more generally, through current account imbalances). A current account surplus implies a transfer of wealth from foreign residents to domestic residents, and vice versa. Thus, a country with a current account surplus tends to experience a rise in wealth and a consequent rise in the demand for money, which in turn leads to currency appreciation.

If bonds are imperfect substitutes, investors allocate their bond portfolios between domestic and foreign securities in proportions that depend on the expected rates of return. This gives

$$B/W = \beta(i - i^* - \Delta s^{\mathrm{e}}) \tag{8.1}$$

where B is the total stock of domestic bonds held willingly, W is the total financial wealth consisting of the supply of domestic bonds and the exchange rate-adjusted supply of foreign bonds (that is, $W = B + SF$), and $\beta > 0$ is a parameter that relates the share of domestic bonds to the expected relative return $(i - i^* - \Delta s^{\mathrm{e}})$.

In the monetary model, the bond demand function is assumed to be infinitely sensitive to the expected return, while bond market arbitrage maintains uncovered interest parity ($\Delta s^{\mathrm{e}} = i - i^*$) at all times. If uncovered interest parity holds, bond supplies become irrelevant, and the responsibility of determining the equilibrium exchange rate is shifted to the money markets. Thus, the equilibrium exchange rate (as the relative price of two national monies) depends positively on relative money supply and negatively on relative money demand, where relative money demand is specified as a function of the income differential and the interest rate differential or the expected inflation differential.

In the portfolio balance model, domestic and foreign bonds are imperfect substitutes and are (at least in part) complements within a well-diversified portfolio, which means that the bond demand function is not infinitely sensitive to the expected relative return. In this case, the asset demand function depends not only on the expected relative return, but also on the variances and covariances of the values of the two currencies and the degree of risk aversion. The portfolio balance model postulates that risk-averse investors construct their portfolios in proportions that depend on the expected rates of return (or risk premium) to diversify the risk arising from exchange rate variability. In this model, therefore, the demand for and supply of domestic and foreign bonds (along with the demand for and supply of domestic and foreign money) determine the exchange rate.

The problem for investors is how to choose the proportion of their wealth they should hold in each possible form: money, domestic bonds, and foreign bonds. Moreover, their objective in selecting a particular portfolio is taken to be the maximization of expected utility. If only domestic and foreign securities are part of the portfolio of international assets, what would be the shares of domestic and foreign bonds in a well-diversified portfolio held by risk-averse rational investors? The respective shares of these assets can be determined on the basis of the Markowitz–Sharpe–Tobin asset market models. Let W be the initial level of real wealth, r and r^* the real returns on domestic and foreign securities, and x the portfolio share of foreign securities. The end-of-period wealth is expressed as

$$\bar{W} = xW(1 + r^*) + (1 - x)W(1 + r) \tag{8.2}$$

or

$$\bar{W} = W(1 + r) + xW(r^* - r). \tag{8.3}$$

Let us assume that utility is a function of the mean and variance of end-of-period wealth, which gives

$$U = U(\bar{W}, \sigma_W^2) \tag{8.4}$$

where the mean and variance of wealth are defined as

$$\bar{W} = W(1 + \bar{r}) + xW(\bar{r}^* - \bar{r}) \tag{8.5}$$

$$\sigma_W^2 = W^2[x^2\sigma_{r^*}^2 + (1 - x)^2\sigma_r^2 + 2x(1 - x)\sigma_{rr^*}] \tag{8.6}$$

where a bar denotes the mean value of the underlying variable. Maximizing utility with respect to x yields the optimal portfolio share, which is[7]

$$x = \frac{(\bar{r} - \bar{r}^*) + \varphi(\sigma_r^2 - \sigma_{rr^*})}{\varphi\sigma_n^2} \tag{8.7}$$

[7]The first term, $(\bar{r} - \bar{r}^*)/\varphi\sigma_n^2$, measures the speculative portfolio share in the domestic currency, which depends on the mean real yield differential and the variance of the nominal rate of depreciation. The second term, $(\sigma_r^2 - \sigma_{rr^*})/\sigma_n^2$, represents the hedging (or minimum-variance) portfolio that depends only on the variances (Dornbusch, 1980a, p. 127).

where $\varphi = -U_2W/U_1$ is the coefficient of relative risk aversion, σ_{rr^*} is the covariance of real returns and $\sigma_n^2 = \sigma_r^2 + \sigma_{r^*}^2 - 2\sigma_{rr^*}$ is the variance of the nominal rate of depreciation. Equation (8.7) represents the conventional result that portfolio selection depends on yield differentials, risk aversion, and return structure.

8.3. The Current Account in the Portfolio Balance Model

The portfolio balance model begins with an identity postulating that changes in the foreign asset position of a country are equal to the current account of that country. A country with a current account surplus during a particular period of time experiences an increase in its net foreign asset position at the end of the period as compared with the beginning of the period. The opposite is true of a country with a current account deficit. We can write this identity as

$$CA_t = NF_t - NF_{t-1} \tag{8.8}$$

where $NF_t(NF_{t-1})$ is the net foreign asset position of the country at time $t(t-1)$ and CA_t is the current account position at time t. The net foreign asset position of a country can be decomposed into the net foreign asset position of the monetary authority (NFO_t) and the net foreign asset position of the private sector (NFP_t). Hence

$$NF_t = NFO_t + NFP_t. \tag{8.9}$$

Substituting equation (8.9) into equation (8.8), we obtain

$$NFO_t - NFO_{t-1} = CA_t - (NFP_t - NFP_{t-1}). \tag{8.10}$$

In a fixed exchange rate system, the left-hand side of equation (8.10) is a residual variable, which adjusts to whatever values appear on the right-hand side of the equation. This means that agents decide how much to export and import (which determines the current account) and how much of their wealth is held in domestic and foreign assets (which determines the capital account). In general, these two decisions may not produce current and capital account balances that offset each other. As a result, the central bank has to intervene in the foreign exchange market by selling or buying foreign exchange to match exactly the current and capital accounts. Failure to do so would inevitably lead to a change in the exchange rate. By contrast, in a system of flexible exchange rates, the monetary authorities abstain from market intervention, which means that the left-hand side of equation (8.10) is always equal to zero. Therefore, we can rewrite equation (8.10) as

$$CA_t = (NFP_t - NFP_{t-1}). \tag{8.11}$$

Equation (8.11) shows that the exchange rate has to be such that the decisions that determine the current account are consistent with the decisions that determine the capital account.

It is important here to invoke the assumption that the current account adjusts slowly over time. In other words, imports and exports cannot adjust instantaneously, giving rise to important implications for the capital account. Therefore, if economic agents wish to increase their net foreign asset holdings, they cannot do so instantaneously because the current account cannot change instantaneously. For an increase in net foreign asset holdings, the current account would have to show an increase in the surplus. But the net foreign asset position is essentially fixed in the short run, because there is no change in the current account. Therefore, the exchange rate has to adjust instantaneously to make sure that agents hold the existing stock of net foreign assets willingly. Only over time (when the current account changes) can the stock of net foreign assets change in such a way as to reflect the agents' desire to accumulate (or decumulate) foreign assets.

8.4. The Structure of the Portfolio Balance Model

In portfolio balance models, the exchange rate is determined (at least in the short run) jointly with other asset prices (such as the interest rate). The exchange rate, however, is a principal determinant of the current account of the balance of payments and a surplus (deficit) in a country's current account results in a rise (fall) in that country's net holdings of foreign assets, which in turn affects the level of wealth. A shift in the level of wealth eventually affects the exchange rate via its effect on asset demand. In fact, the portfolio balance model is an inherently dynamic model, in the sense that the exchange rate moves to clear asset markets in the short run and adjusts to changes in wealth (and hence the current account) over time to maintain monetary neutrality across steady states. Like the sticky-price model, therefore, the portfolio balance model makes it possible to distinguish between short-run equilibrium in asset markets and the dynamic adjustment to long-run equilibrium (a static level of wealth and no tendency of the system to move over time). Unlike the sticky-price model, it also allows for full interaction between the exchange rate, the balance of payments the level of wealth, and stock equilibrium.

A wide variety of portfolio balance models have been developed, *inter alia*, by Branson (1977), Branson *et al.* (1977), Kouri *et al.* (1978), Dooley and Isard (1979, 1982, 1983), Dornbusch (1980a), and by Allen and Kenen (1980). According to Frankel (1983a), these models can be classified into three main categories. First, there are the portfolio balance models developed by Branson (1977), Branson *et al.* (1977), Kouri (1976), and Dornbusch and Fischer (1980), who assume that the home country is adequately small (in relation to the foreign country) and that its assets are not held by the residents of the foreign country. Therefore, it is the residents of the home country alone who hold domestic assets.

Second, there are portfolio balance models that fall under the "preferred local habitat" models developed by Kouri *et al.* (1978) and Dooley and Isard (1979, 1982, 1983), who assume that residents of both the home and foreign countries hold domestic and foreign assets. However, it is maintained that domestic residents wish to hold a greater proportion of their wealth as domestic assets and that foreign residents wish to hold a greater proportion as foreign assets. Third, the portfolio balance models developed by Dornbusch (1980a) and Frankel (1979a) can be classified as "uniform preference" models. These models are built on the assumption that market participants have the same portfolio preferences, which implies that the indebtedness of the residents of one country to the residents of another country is inconsequential.

Notwithstanding differences in assumptions with respect to asset preferences, all portfolio balance models postulate that the total financial wealth of the private sector in a country (W) can be divided into three financial assets: money (M), domestically issued bonds (B), and foreign bonds denominated in foreign currency (F). The models also assume that the demand for these assets by the private sector depends on the domestic interest rate, the foreign interest rate, and the level of wealth. The domestic interest rate is given (and it is not tied to the foreign interest rate) because domestic and foreign assets are assumed to be imperfect substitutes. The exchange and the interest rates are considered to be determined endogenously, whereas the stock of domestic money, domestic bonds, foreign bonds, and the foreign interest rate are determined exogenously. The portfolio balance model is based on the following asset market equilibrium conditions and a wealth constraint:

$$M = m(i, i^*)W, \qquad m_i < 0, \quad m_{i^*} < 0 \tag{8.12}$$

$$B = b(i, i^*)W, \qquad b_i > 0, \quad b_{i^*} < 0 \tag{8.13}$$

$$SF = f(i, i^*)W, \qquad f_i < 0, \quad f_{i^*} > 0 \tag{8.14}$$

$$W = M + B + SF \tag{8.15}$$

where M is the total stock of domestic money, B is the total stock of domestic bonds, F is the total stock of foreign currency bonds, S is the exchange rate, i is the interest rate on domestic bonds, i^* is the interest rate on foreign bonds, W is the domestic wealth held as domestic money, domestic bonds, and foreign bonds (as shown by equation (8.15)), m is the fraction of wealth held as money, b is the fraction of wealth held as domestic bonds, and f is the fraction of wealth held as foreign assets denominated in foreign currency and converted into domestic currency terms at the spot exchange rate.

Equations (8.12)–(8.14) show respectively that the fraction of wealth held in domestic money falls as both domestic and foreign interest rates rise ($m_i < 0$, $m_{i^*} < 0$), the fraction of wealth held in domestic bonds rises when the domestic interest rate rises and when the foreign interest rate falls ($b_i > 0$, $b_{i^*} < 0$), and the fraction of wealth in foreign bonds rises (falls) as both domestic and foreign interest rates rise ($f_i < 0$, $f_{i^*} > 0$). Thus the demand for money declines when the domestic or foreign rate of return falls, whereas the demand for each type of bond is affected positively by higher own return and negatively by higher return on the other type.

Given the stocks of money (M), domestic bonds (B), and foreign bonds (F), the model contains only three variables: domestic interest rate, foreign interest rate, and the exchange rate. But because the foreign interest rate is determined exogenously, there are two endogenous variables only (domestic interest rate and exchange rate) and hence only two behavioral equations (8.12) and (8.13). Thus, interest and exchange rates are jointly determined by equations (8.12) and (8.13) for given supplies of domestic money, domestic bonds, and foreign bonds. It must be borne in mind that both the exchange rate (S) and the domestic interest rate (i) are assumed to be endogenously determined, even in the short run, and that the stocks of money and bonds and the foreign interest rate are exogenously determined in the short run as well as in the long run.

Four points are worth noting about the portfolio balance model. First, the model can be extended to include additional assets (for example, bank lending as suggested by Kearney and MacDonald, 1986). However, it is noteworthy that complications may get out of hand, as each additional asset involves not only one more equation, but an extra rate of return in each equation as well as an extra asset in the wealth constraint. Second, nothing is specified with respect to the form of the demand functions for the underlying assets, other than a number of restrictions on the partial derivatives. For example, it is assumed that the demand for each type of asset depends positively on own rate of return and negatively on the rate of return on the other (competing) assets. It must be noted that the own-rate effect is usually assumed to be greater (in absolute terms) than the cross-return effect. In other words, $b_i + b_{i^*} > 0$ and $f_i + f_{i^*} > 0$. Third, the definition of wealth in equation (8.15) means that for a change in either rate of return, the sum of the impact effects on all of the three assets must be zero. In other words, the two restrictions $m_i + b_i + f_i = 0$ and $m_{i^*} + b_{i^*} + f_{i^*} = 0$ must be satisfied. If there is no risk, the partial derivatives of the functions B and SF would be infinite, reflecting the observation that as investors view domestic and foreign bonds as perfect substitutes, the slightest deviation from the common world rate of return would result in massive movement of capital flows into and out of the country under consideration. By contrast, a rise in the return on domestic bonds causes domestic investors to reallocate their portfolios instantaneously in favor of domestic securities at the expense of both of the other assets. It must be borne in mind, however, that the shift in portfolio composition is marginal (not necessarily small, but certainly not infinite). In other words, instead of holding the whole portfolio as domestic bonds (as if they were risk neutral), investors hold a greater proportion of the portfolio in domestic bonds and less in money and foreign bonds. In other words, investors remain appropriately diversified after the change.

The portfolio balance model provides a simple framework for analyzing the short-run effects of monetary and fiscal policies on exchange and interest rates. An expansionary monetary policy (a rise in M) leads to a higher level of nominal financial wealth through equation (8.15) and consequently a higher level of demand for both domestic and foreign bonds through equations (8.13) and (8.14), respectively. The effects of fiscal policy (operating through changes in B) on the exchange rate are more ambiguous, depending on the degree of substitution between domestic and foreign bonds.

To investigate the relative effect of monetary and fiscal policies on exchange and interest rates, a comparative static analysis can be conducted. To this end, it is customary to limit the analysis to "small" changes in the exogenous variables and consequent "small" changes in the endogenous variables, which means that all of the underlying functions in the model are assumed to be approximately linear. By differentiating totally equations (8.12)–(8.15), we obtain

$$\mathrm{d}M = Wm_i d_i + Wm_{i^*} d_{i^*} + m\mathrm{d}W \tag{8.16}$$

$$\mathrm{d}B = Wb_i d_i + Wb_{i^*} d_{i^*} + b\mathrm{d}W \tag{8.17}$$

$$F\mathrm{d}S + S\mathrm{d}F = f_i d_i + f_{i^*} d_{i^*} + \mathrm{d}W \tag{8.18}$$

$$\mathrm{d}W = \mathrm{d}M + \mathrm{d}B + S\mathrm{d}F + F\mathrm{d}S. \tag{8.19}$$

Having done that, the comparative statics of the portfolio balance model can be considered in the following section.

8.5. Short-Run Properties of the Portfolio Balance Model

Let us substitute equations (8.16) and (8.17) into equation (8.19) and rearrange them in such a way that the endogenous variables appear on the left-hand side while the exogenous variables appear on the right-hand side. Thus we obtain

$$\begin{bmatrix} Wm_i & mF \\ Wb_i & bF \end{bmatrix} \begin{bmatrix} \mathrm{d}i \\ \mathrm{d}S \end{bmatrix} = \begin{bmatrix} 1-m & -m & -mS & -Wm_{i^*} \\ -b & 1-b & -bS & -Wb_{i^*} \end{bmatrix} \begin{bmatrix} \mathrm{d}M \\ \mathrm{d}B \\ \mathrm{d}F \\ \mathrm{d}i^* \end{bmatrix}. \tag{8.20}$$

Equation (8.20) can be used to carry out comparative static analysis of the impact of exogenous variables (domestic money, domestic bonds, and foreign bonds) on endogenous variables (interest and exchange rates). Eight multipliers can be derived from equation (8.20). Three of the multipliers measure the impact of the exogenous variables on the exchange rate ($\mathrm{d}S/\mathrm{d}M$, $\mathrm{d}S/\mathrm{d}B$, and $\mathrm{d}S/\mathrm{d}F$), another three measure the impact of exogenous variables on the interest rate ($\mathrm{d}i/\mathrm{d}M$, $\mathrm{d}i/\mathrm{d}B$, and $\mathrm{d}i/\mathrm{d}F$), and the remaining two measure the impact of the foreign interest rate on exchange and interest rates ($\mathrm{d}S/\mathrm{d}i^*$ and $\mathrm{d}i/\mathrm{d}i^*$). The first three policy multipliers ($\mathrm{d}S/\mathrm{d}M$, $\mathrm{d}S/\mathrm{d}B$, and $\mathrm{d}S/\mathrm{d}F$) are as

Table 8.1. The effect of expansion in asset stocks on short-run equilibrium.

Effects on	Effects of accumulation of stocks			Effects of open-market operations	
	ΔM	ΔB	ΔF	$\Delta B = -\Delta M$	$S\Delta F = -\Delta M$
i	$-$	$+$	0	$-$	$-$
S	$+$	?	$-$	$+$	$+$

Source: Branson *et al.* (1977, p. 307).

follows:

$$\frac{\mathrm{d}S}{\mathrm{d}M} = \frac{-b_i(1-m) - m_i b}{m_i bF - b_i mF} \tag{8.21}$$

$$\frac{\mathrm{d}S}{\mathrm{d}B} = \frac{m_i(1-b) + b_i m}{m_i bF - b_i mF} \tag{8.22}$$

$$\frac{\mathrm{d}S}{\mathrm{d}F} = \frac{[b_i m - m_i b]S}{m_i bF - b_i mF} \tag{8.23}$$

where $\mathrm{d}S/\mathrm{d}M > 0$, $0 < \mathrm{d}S/\mathrm{d}B < 1$, and $\mathrm{d}S/\mathrm{d}F < 0$ (since $b_i > m_i$ and $(1-m) > b$).

Thus, an expansion in the domestic money supply (either through a budget deficit or a swap transaction with foreign assets) raises the equilibrium exchange rate to clear financial markets in the short run. However, if the stock of domestic bonds increases, the equilibrium exchange rate must either fall or rise (depending on the wealth and substitution effects) to clear financial markets. On the other hand, if the country runs a surplus in its current account, so that there is an increase in the net stock of foreign assets (F), then the equilibrium exchange rate must fall to restore equilibrium in financial markets. The direction of the effects on the equilibrium exchange and interest rates of an expansion in the stocks of money, domestic bonds, and foreign bonds is summarized in Table 8.1.

8.6. Stable Portfolio Balance and Short-Run Exchange Rate Determination

The portfolio balance model can be illustrated with the aid of three portfolio balance schedules: *MM*, *BB*, and *FF* for domestic money, domestic bonds, and foreign bonds, as shown in Figure 8.1. The portfolio balance curves

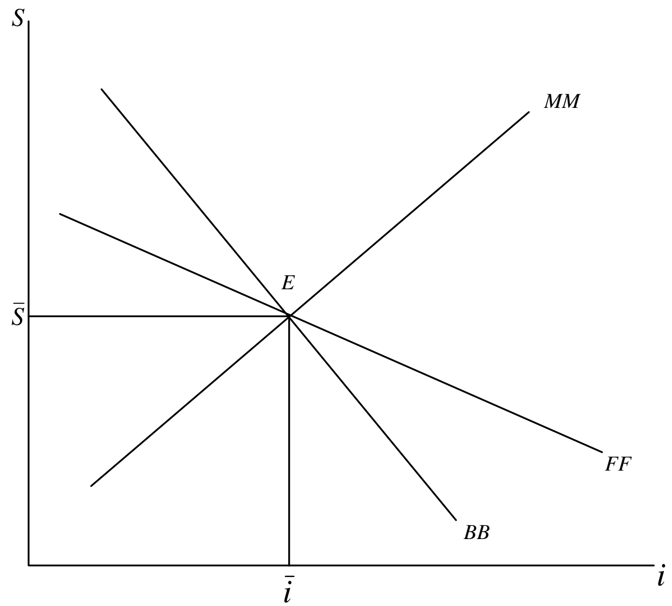

Figure 8.1. Portfolio balance.

represent equilibrium combinations of exchange and interest rates, given the initial return on foreign assets, the value of total wealth, and the stocks of money and (domestic and foreign) bonds. The slope expressions for the *MM*, *BB*, and *FF* schedules can be derived from equations (8.16)–(8.18) by substituting them first into equation (8.19), setting them equal to zero changes in the exogenous variables ($\mathrm{d}M = 0, \mathrm{d}B = 0, \mathrm{d}F = 0$, and $\mathrm{d}i^* = 0$), and then solving the resulting expressions for $\mathrm{d}S/\mathrm{d}i$. Hence

$$\text{Slope } MM = \frac{\mathrm{d}S}{\mathrm{d}i} = -\frac{Wm_i}{mF} > 0 \tag{8.24}$$

$$\text{Slope } BB = \frac{\mathrm{d}S}{\mathrm{d}i} = -\frac{Wb_i}{bF} < 0 \tag{8.25}$$

$$\text{Slope } FF = \frac{\mathrm{d}S}{\mathrm{d}i} = -\frac{f_i}{(1 - fF)} < 0. \tag{8.26}$$

The money market schedule represents all combinations of interest and exchange rates that are consistent with equilibrium in the domestic money market. For a given initial level of the money supply, the money market schedule slopes upward (as represented by equation (8.24)), establishing a positive relation between exchange and interest rates. This is because a rise in the exchange rate leads to an increase in domestic wealth (foreign assets are worth more following domestic currency depreciation). The increase in wealth boosts the demand for money and, if the money supply remains unchanged, will in turn result in a higher domestic interest rate to clear the domestic money market.

The *BB* schedule represents combinations of interest and exchange rates along which the domestic bond market is in equilibrium. This schedule (as represented by equation (8.25)) slopes downward and hence maintains an inverse relation between exchange and interest rates. This is because, *ceteris paribus*, depreciation raises the demand for domestic bonds and leads to a higher price of domestic bonds and lower interest rate, which will in turn reduce the demand for domestic bonds. Depreciation must therefore be offset by a fall in the interest rate to maintain equilibrium in the domestic bond market for a given stock of domestic bonds.

The *FF* schedule represents all combinations of interest and exchange rates that are consistent with equilibrium in the foreign bond market. As shown by equation (8.26), the *FF* schedule slopes downward, implying a negative relation between exchange and interest rates. The reason for this is that a rise in the exchange rate leads to increased demand for domestic bonds, which makes investors inclined to sell domestic money and foreign bonds to buy domestic bonds. Alternatively, a rise in the interest rate makes domestic bonds more attractive than foreign bonds, in which case the exchange rate must rise to maintain equilibrium in the market for foreign bonds. As the impact of a lower interest rate is likely to be greatest in the domestic bond market, the *BB* schedule must be steeper than the *FF* schedule, which is required for stable portfolio equilibrium in the asset markets. To have stable equilibrium across asset markets, we must assume that changes in the interest rate affect the demand for domestic bonds more than they affect the demand for foreign bonds ($|\mathrm{d}F/\mathrm{d}i| < |\mathrm{d}B/\mathrm{d}i|$), which makes the *BB* schedule steeper than the *FF* schedule.

To find out if this assumption implies stability, consider Figure 8.2 for a point where the exchange rate is equal to $\bar{S}$ but where the interest rate is above its equilibrium value ($\bar{i}$). The *BB* schedule is steeper than the *FF* schedule, implying the tendency for a stable equilibrium in the underlying asset markets at E. Consider, for example, point A (point D) where the exchange rate is equal to $\bar{S}$ while the interest rate is above (below) its equilibrium level ($\bar{i}$). If the exchange rate is fixed at $\bar{S}$ and the interest rate is above its equilibrium level, the demand for domestic money and

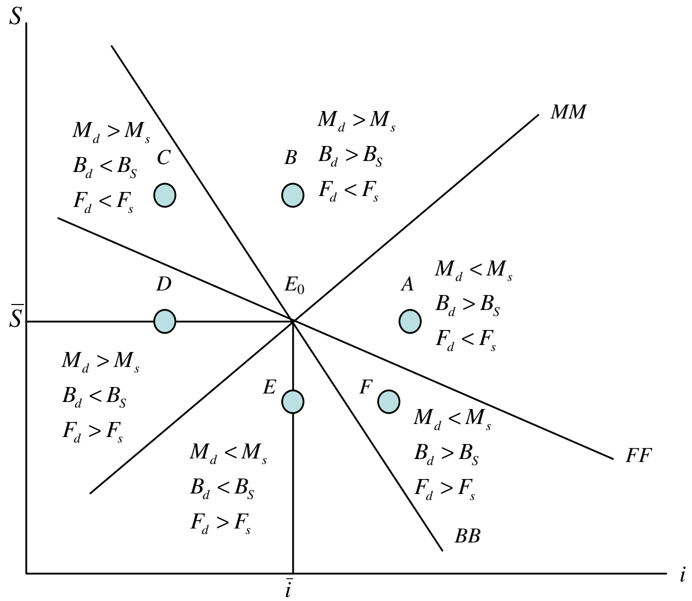

Figure 8.2. Portfolio balance and stability.

foreign bonds at A must be lower and the demand for domestic bonds must be higher, leading eventually to downward pressure on the interest rate and hence the tendency toward equilibrium at E_0. On the other hand, if the exchange rate remains fixed at $\bar{S}$, but the interest rate is below its equilibrium level ($\bar{i}$), then at point D the demand for domestic money and foreign bonds must be higher and the demand for domestic bonds must be lower, leading eventually to upward pressure on the interest rate and hence a tendency toward equilibrium at E_0. Similarly, consider a point $B(E)$ where the interest rate is fixed at $\bar{i}$ and the exchange rate is above (below) its equilibrium level ($\bar{S}$). If the interest rate is fixed at $\bar{i}$ and the exchange rate is above (below) its equilibrium value, then at point $B(E)$ the demand for domestic money and domestic bonds must be higher (lower), whereas the demand for foreign bonds must be lower (higher), leading to appreciation (depreciation) of the domestic currency or a fall (a rise) in the exchange rate, and hence a tendency toward equilibrium at E_0.

It must also be noted that all points below the money market schedule represent excess money supply, whereas all points above the MM schedule correspond to excess money demand. Similarly, if the interest rate is above its equilibrium level (indicating lower prices of, and therefore greater demand for, domestic bonds), there is excess demand for domestic bonds above the *BB* schedule and excess supply below the *BB* schedule. By contrast, the demand for foreign bonds (at the same combination of interest and exchange rates) must decline as a higher interest rate boosts the demand for domestic bonds and reduces the demand for domestic money and foreign bonds. Therefore, there is excess supply of (demand for) foreign bonds at points above (below) the *FF* schedule. If the exchange rate is below its equilibrium value (that is, $S < \bar{S}$), there is excess demand for foreign bonds, which leads to domestic currency depreciation so that equilibrium in the foreign exchange market is restored.

8.7. Monetary Policy Effects on Exchange and Interest Rates

Consider first the short-run effects of monetary policy on interest and exchange rates, by examining three different operations. First, the monetary authorities expand the money supply via open market operations. Second, the monetary authorities expand the money supply via foreign exchange operations, where the central bank intervenes in the foreign exchange market by exchanging domestic money for foreign bonds. This open market operation is called a non-sterilized intervention. Third, the monetary authorities expand the money supply via sterilized foreign exchange operations, where the central bank exchanges domestic bonds for foreign bonds, leaving the money supply unchanged.

8.7.1. *Monetary Expansion via Open Market Purchases of Domestic Bonds*

Assume that the monetary authorities boost the private sector's holdings of money by purchasing domestic bonds. In other words, the increase in the money supply results from an open market purchase of bonds from the public against newly printed money. In this case, the government induces equal and opposite changes in the stocks of money and bonds.

Consider Figure 8.3, which illustrates the effect on the equilibrium exchange and interest rates of an expansion in the money supply via an open market purchase of domestic bonds. Initially the markets for money, domestic bonds and foreign bonds are in equilibrium at point E_0, with the interest rate at $\bar{i}_0$ and the exchange rate at $\bar{S}_0$. An expansion in the money

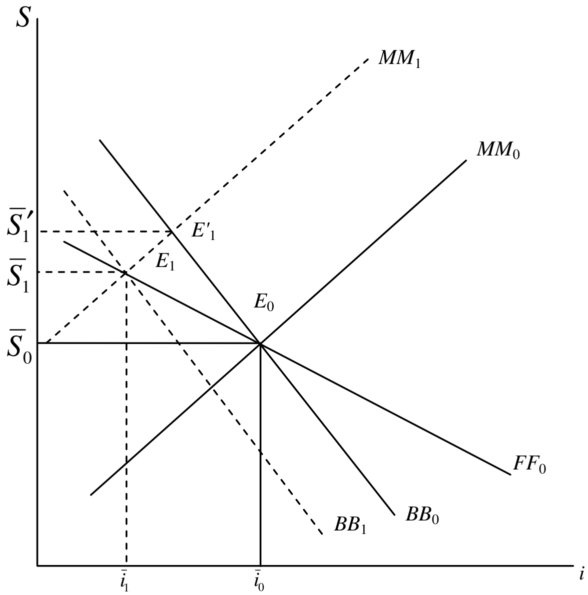

Figure 8.3. The effect of an open market purchase of domestic bonds.

supply via an open market purchase of domestic bonds by the central bank causes an increase in the demand for domestic bonds and hence a shift in the money market schedule from MM_0 to MM_1 and a shift in the BB schedule from BB_0 to BB_1. The money market schedule moves further than the BB schedule because the direct effect on the money market is greater than the impact on the bond market. This is because the latter is in part dissipated by a spillover effect on the demand for foreign bonds, which become more attractive when domestic interest rates fall. The excess supply of money in the portfolios held by the public boosts the demand for domestic and foreign bonds, which results in a fall in the interest rate from $\bar{i}_0$ to $\bar{i}_1$ and an increase in the exchange rate from $\bar{S}_0$ to $\bar{S}_1$.

It must be noted that an expansion in the domestic money supply causes a smaller increase in the exchange rate when the supply of domestic bonds declines than when it does not decline. At point E'_1, where BB_0 and MM_1 intersect, the money supply rises, leaving the supply of domestic bonds constant, which means that there is a greater rise in the equilibrium exchange rate and a smaller fall in the equilibrium interest rate. By contrast, when the money supply is increased via a reduction in the stock of domestic bonds (as represented by point E_1), there is a smaller rise in the exchange rate because $\bar{S}_1 < \bar{S}_1'$. Unlike the monetary model, the portfolio balance model predicts that the effect of a change in the money supply on the exchange rate depends on how the money supply changes. It is also worth noting that a higher exchange rate, which boosts domestic wealth, makes foreign bonds attractive. Increased demand for foreign bonds explains the rise in the exchange rate at the new equilibrium position, E_1.

8.7.2. *Monetary Expansion via Open Market Purchases of Foreign Bonds*

The monetary authorities can expand the money supply via an open market purchase of foreign bonds. For the purpose of simplicity, we assume that foreign bonds are held by domestic residents (otherwise, the whole framework of asset market equations, wealth constraint, and so on breaks down). As shown in Figure 8.4, the effect of expansion in the money supply via an open market purchase of foreign bonds is the same as in the previous case. The MM schedule shifts from MM_0 to MM_1, and the FF schedule shifts from FF_0 to FF_1, moving the portfolio balance equilibrium from E_0

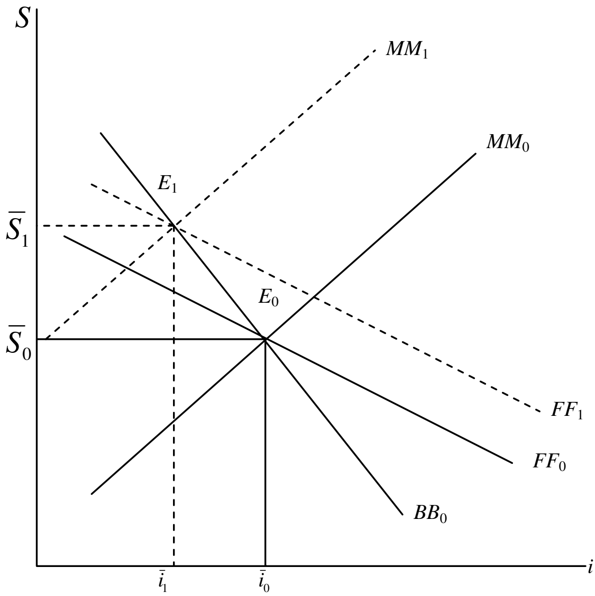

Figure 8.4. The effect of an open market purchase of foreign bonds.

to E_1, and resulting in a rise in the exchange rate from $\bar{S}_0$ to $\bar{S}_1$ and a fall in the interest rate from $\bar{i}_0$ to $\bar{i}_1$.

Consequently, the effect of an increase in the money supply will be the same, irrespective of whether it results from an open market purchase of domestic bonds or an open market purchase of foreign bonds. There is, however, a quantitative rather than a qualitative difference. Given the underlying assumptions, it can be shown that open market operations in domestic bonds have a greater effect on the interest rate and a smaller effect on the exchange rate than do purchases of foreign bonds.

8.7.3. *Sterilized Open Market Foreign Exchange Operations*

Let us now combine the two market operations described above. For this purpose, assume that the monetary authorities buy foreign bonds from the public in the first stage and sell domestic bonds in the second stage, such that the money supply is unchanged. This can be illustrated with the aid of

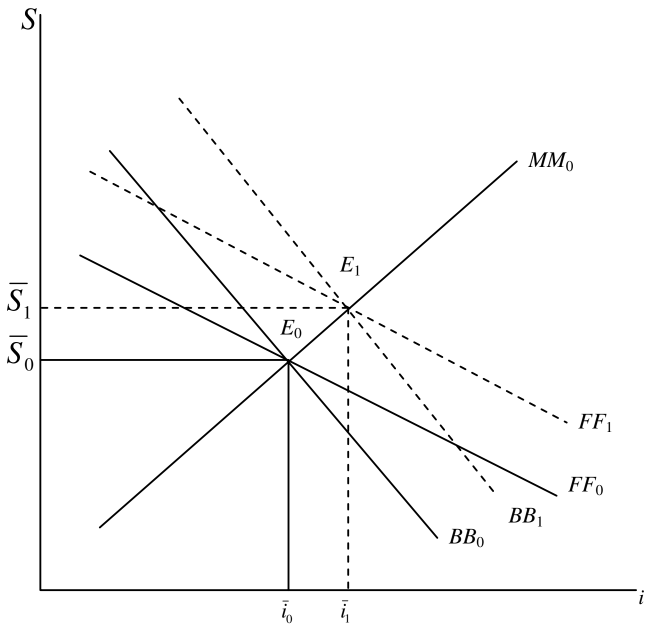

Figure 8.5. The effect of a non-sterilized open market purchase of foreign bonds.

Figure 8.5, where the economy is initially in equilibrium at point E_0 with the exchange rate at $\bar{S}_0$ and the interest rate at $\bar{i}_0$. The *FF* schedule shifts from FF_0 to FF_1 when the monetary authorities buy foreign bonds. When domestic bonds are sold to neutralize the effect of an open market purchase of foreign bonds, the *BB* schedule also shifts to the right from BB_0 to BB_1. The net effect is therefore a higher domestic interest rate ($\bar{i}_1$) and a higher exchange rate ($\bar{S}_1$). The reason why the domestic currency depreciates is that there is excess demand for foreign bonds requiring the exchange rate to rise to restore equilibrium. On the other hand, excess supply of domestic bonds leads to a fall in bond prices and thus a rise in the domestic interest rate. Note that if domestic and foreign bonds are perfect substitutes (as in the flexible-price and sticky-price models), a swap of domestic for foreign bonds is an exchange of identical assets that cannot have any effect whatsoever on interest and exchange rates.

8.7.4. *A Rise in Wealth via Accumulation of Foreign Assets*

Consider now the effect on exchange rates and interest rates of a rise in wealth caused by an accumulation of foreign assets, which is the central feature of the portfolio balance model. This case differs in two respects from those examined above. First, there is a net increase in wealth, rather than the exchange of one type of asset for another. In other words, the stock of foreign assets held by the public increases via saving. Second, not only is an increase in the stock of foreign assets equivalent to saving, it is also the only form saving can take, given the structure of the portfolio balance model. Thus, saving implies accumulation of foreign assets via the current account surplus.[8] As long as a country operates under floating exchange rates, a deficit in its capital account (that is, the accumulation of its claims on a foreign country) must be the counterpart of an equal surplus on the current account. Conversely, a deficit in the current account must be associated with a net import of capital, implying dissaving in the form a reduction in net foreign currency claims.

To analyze the effect of an increase in wealth, let us further assume that prices (and output) are fixed in the short run due to the relative sluggishness of goods and labor markets. This implies that short-run adjustment is confined to financial markets, which may clear on such a combination of exchange and interest rates that is not compatible with equilibrium in the

[8]The accumulated stock of foreign assets at a particular point in time is "savings." There is, therefore, a stock-flow distinction between "savings" and "saving."

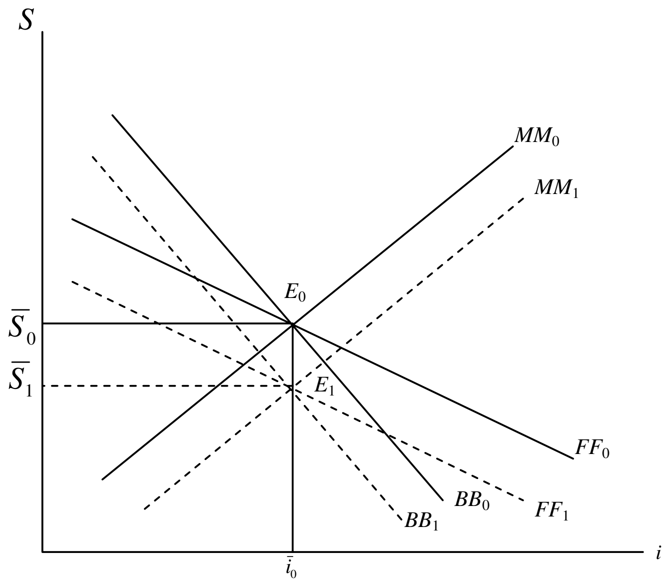

Figure 8.6. The effect of a rise in wealth.

goods markets (that is, zero current account balance), given the initial price level and national income. As a result, capital flows across countries continue, adding to or subtracting from the stock of claims on the rest of the world, and causing a perpetual shift in financial markets.

These points are summarized in Figure 8.6. Because of a surplus in the current account, residents of the home country accumulate foreign assets. Consequently, the *FF* schedule must shift downward from FF_0 to FF_1. This is because the increased supply of foreign assets cannot be absorbed unless the domestic currency appreciates (there is a fall in the exchange rate), neutralizing the rise in the value of *F* through a fall in the domestic currency price of foreign assets and keeping the product *SF* constant. In an attempt to accumulate foreign currency assets, residents of the home country must exchange domestic assets for foreign assets, thereby generating excess supply of the foreign currency and driving down the exchange rate. This induced excess demand for domestic money would, in other circumstances, require a rise in the domestic interest rate, while excess demand for domestic bonds would require the very opposite. The induced increase in the demand for domestic assets shifts the money market and *BB* schedules from MM_0 to MM_1 and from BB_0 to BB_1.

8.8. Fiscal Policy Effects on Exchange and Interest Rates

An increase in government expenditure can be financed in two ways. First, it can be financed simply by borrowing from the central bank. In this case, the central bank prints money, which means that both M and W increase by an amount that is equivalent to the increase in the fiscal deficit (or the increase in government expenditure). Second, increased expenditure can be financed by borrowing from the public. In this case, the central bank sells bonds to the public, which means that B and W increase as much as the deficit. In the context of the portfolio balance model, the short-term implications of these two alternative methods of financing government expenditure are explained using the money market, BB, and FF curves.

8.8.1. *Money-Financed Government Budget Deficit*

The effect on exchange and interest rates of an increase in government expenditure financed by printing new money is explained in Figure 8.7. Asset markets are initially in equilibrium at E_0, where the money market

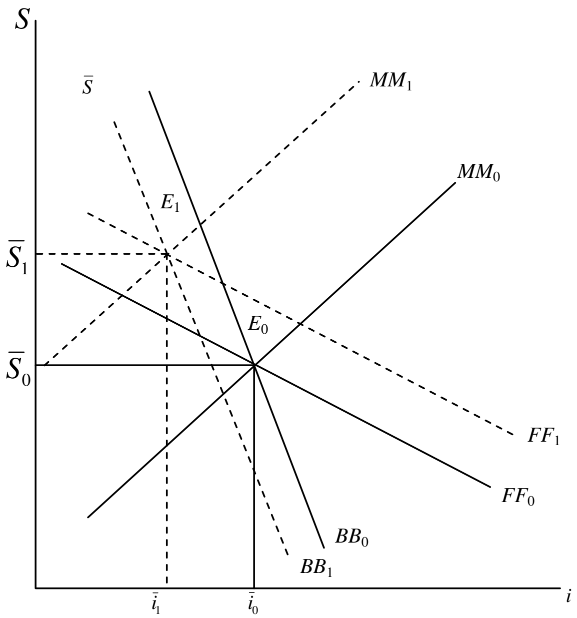

Figure 8.7. The effect of money-financed government expenditure.

schedule (MM_0), the domestic bond market schedule (BB_0), and the foreign bond market schedule (FF_0) intersect, establishing the equilibrium exchange and interest rates at $\bar{S}_0$ and $\bar{i}_0$, respectively. An increase in the money supply shifts the money market schedule to the left from MM_0 to MM_1. As mentioned earlier, increased money supply implies that M and W rise by an amount that is equivalent the increase in government expenditure. The rise in wealth boosts the demand for domestic and foreign bonds, as wealth holders attempt to re-balance their portfolios. Thus, there is excess supply of money and excess demand for domestic and foreign bonds, which in turn leads to shifting of the BB curve from BB_0 to BB_1 and the FF curve from FF_0 to FF_1. Eventually, asset markets clear simultaneously at E_1, with a higher level of the exchange rate ($\bar{S}_1$) and a lower interest rate ($\bar{i}_1$). Thus, an expansionary fiscal policy financed by borrowing from the central bank causes the exchange rate to rise from $\bar{S}_0$ to $\bar{S}_1$ and the interest rate to fall from $\bar{i}_0$ to $\vec{i}_1$.

8.8.2. *Bond-Financed Government Budget Deficit*

The effect of an increase in government expenditure financed by borrowing from the public through the sale of domestic bonds is ambiguous. Ambiguity is attributed to the substitution and wealth effects generated when government expenditure is financed by selling bonds to the public. This case is depicted in Figure 8.8(a,b).

An increase in government expenditure financed by selling domestic bonds to the public gives rise to an equivalent increase in the supply of domestic bonds (B) and wealth (W). The increase in the supply of domestic bonds shifts the BB schedule from BB_0 to BB_1, which leads to lower prices of domestic bonds and a higher domestic interest rate. The higher interest rate reduces the demand for money, thereby leading to a shift in the money market schedule from MM_0 to MM_1, and inducing a move from foreign bonds to domestic bonds (if domestic and foreign bonds are close substitutes).

As investors hold more domestic bonds than previously and the same amount of domestic money and foreign bonds, their wealth must have increased. This increase in wealth leads to an increase in the demand for foreign bonds, thereby producing a wealth effect and shifting in the FF schedule from FF_0 to FF_1. The increase in wealth also leads to an increase in the demand for domestic bonds, which reduces the extent of the rightward shift of the BB schedule and leads to an increase in the demand for money,

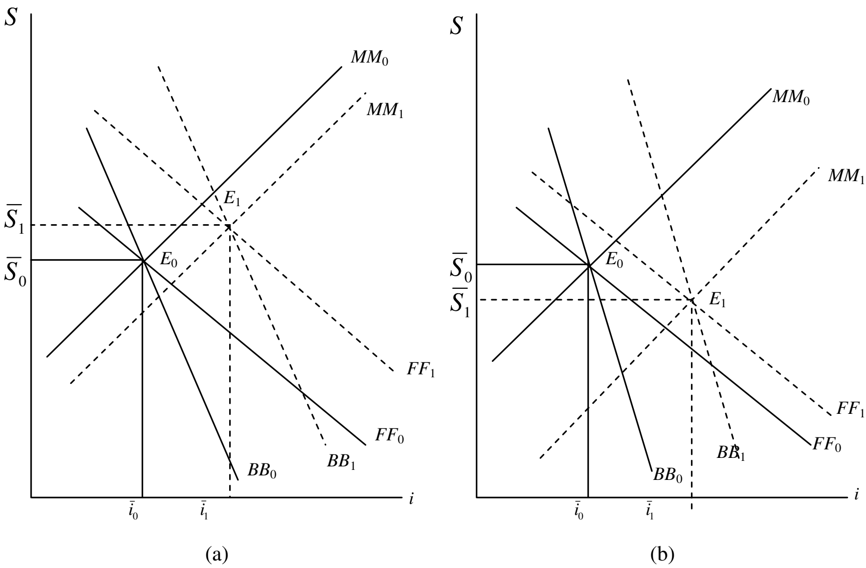

Figure 8.8. The effect of bond-financed government expenditure.

as represented by a rightward shift of the money market schedule. The net effect on the demand for foreign bonds is uncertain, as it depends on the magnitude of substitution and wealth effects.

If the wealth effect dominates the substitution effect, the domestic currency will depreciate because the demand for foreign bonds increases more than the demand for domestic bonds, and consequently there is a larger shift in the *FF* and *BB* schedules to the right, as shown in Figure 8.8(a). Alternatively, if the substitution effect (the interest rate effect) dominates the wealth effect, the domestic currency will appreciate because the effect of the interest rate on the demand for money and the demand for domestic bonds is large and consequently there is a larger shift in the *BB* and the money market schedules to the right, as shown in Figure 8.8(b).

8.9. Alternative Specifications of the Portfolio Balance Model

While the exchange and interest rates are determined jointly in the portfolio balance model, we will only concentrate on deriving the reduced form equation of exchange rate determination. Branson *et al.* (1977, pp. 310 and 311) used equations (8.12)–(8.15) to derive the reduced form equation that underlies the portfolio balance model. It can be expressed in an empirically testable stochastic form as[9]

$$S_t = \Phi(M_t, B_t, F_t, M_t^*, B_t^*, F_t^*) + u_t \tag{8.27}$$

where S is a bilateral exchange rate, and not some weighted index or effective exchange rate against the rest of the world, $M(M^*)$ is the stock of domestic (foreign) money, $B(B^*)$ is the stock of domestic (foreign) bonds denominated in the domestic currency, and $F(F^*)$ is the stock of domestic (foreign) bonds denominated in the foreign currency. In the portfolio balance model, an expansion in the domestic relative to the foreign money supply is expected to cause domestic currency depreciation. An expansion in the supply of domestic bonds relative to foreign bonds may lead to appreciation or depreciation of the domestic currency, depending on the relative asset substitutability and the wealth effect. An increase in the stock of foreign bonds relative to that in the foreign country is expected to cause domestic currency appreciation.[10]

It is, however, not clear from the structure of the portfolio balance model why Branson *et al.* (1977) included M^*, B^*, and F^* in the reduced form equation (8.27). Bisignano and Hoover (1982) justify the inclusion of these variables on the grounds that they are the key variables that determine the foreign interest rate, which is assumed to be exogenous. We know from equations (8.12) and (8.15) that the exchange rate is determined not only by the domestic money supply, domestic bonds, and foreign bonds, but also by the foreign interest rate (which is determined by the supplies of money and bonds in the foreign country). Hence

$$S_t = \psi(M_t, B_t, F_t, i_t^*) + v_t \tag{8.28}$$

where the behavioral equation for the foreign interest rate is

$$i_t^* = \lambda(M_t^*, B_t^*, F_t^*) + w_t. \tag{8.29}$$

Substituting equation (8.28) into (8.29), we obtain

$$S_t = \psi[M_t, B_t, F_t, \lambda(M_t^*, B_t^*, F_t^*)] + w_t + v_t \tag{8.30}$$

where $u_t = w_t + v_t$ and $\Phi = \psi\lambda$.

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[9]Because it is difficult to determine *a priori* the sign of the coefficients on B and B^* (as evident from Table 8.1 column 3), Branson *et al.* (1977, p. 311) dropped the variables representing the supplies of domestic bonds from equation (8.27).

[10]See also Table 8.1 for the signs of the coefficients on the variables underlying equation (8.26).

Bisignano and Hoover argue that the small country assumption may have not been taken seriously. This is because, instead of using the underlying structural equations (8.12)–(8.15), Branson *et al.* (1977) derived the exchange rate equation (8.27) from an unspecified two-country portfolio selection model, which creates difficulties for interpreting F and F^*. In fact, Branson *et al.* (1977) used net private international investment positions against the world as proxies for F and F^* because they had difficulties obtaining bilateral data. However, they proposed that it would be better to use bilateral data and asserted, rather offhandedly, that F would be equal to $-F^*$ in the bilateral case because one country's asset is the other country's debt. It must be noted, as argued by Bisignano and Hoover, that as long as the model applies to the private sector only, F is not equal to $-F^*$.

Bisignano and Hoover also argue that there are at least three problems with the simple portfolio balance model that Branson *et al.* (1977) applied empirically: (i) it is bilateral when what is required a multilateral approach; (ii) it involves the small country assumption without testing its appropriateness; and (iii) it implies that all internationally traded assets collapse into a single net asset stock for each county. They point out that as relatively good bilateral data are available on the international investment position of the U.S. and Canada, and as it is not difficult to obtain complete data on a third country (representing the rest of the world), only a bilateral model could be readily estimated. They also argue that the problem with the small country assumption can be resolved easily in a general model in which (i) the home and foreign countries are explicitly modeled and (ii) a separate internationally traded asset can be allowed for each country. The internationally traded assets should be distinguished from domestic assets for each country because foreign financial assets in private hands consist of claims against the government and against the private sectors of other countries, while only claims against the government of other countries are assets of their own private sectors.

Bisignano and Hoover developed a general bilateral portfolio balance model in which the demand and supply functions for the underlying three assets held by the private sector in both countries are specified explicitly. This model yields an equation in which the exchange rate is determined by the relative supply of money, relative supply of domestic bonds, relative supply of foreign bonds and relative supply of government assets. Hence

$$S_t = \Psi(M_t, B_t, F_t, G_t, M_t^*, B_t^*, F_t^*, G_t^*) + \omega_t. \tag{8.31}$$

Frankel (1983a) proposed a different specification for the reduced form equation of exchange rate determination. It begins with the assumption that there are no barriers segmenting international capital markets, while relaxing the assumption that domestic and foreign bonds are perfect substitutes. Although domestic and foreign assets may differ in several respects (such as liquidity, tax treatment, default risk, political risk, and foreign exchange risk), the portfolio balance equation derived by Frankel (1983a) assumes that domestic and foreign bonds differ only with respect to the currency of denomination. It is argued that in order for investors to diversify foreign exchange risk, they balance their bond portfolios between the home and foreign countries in proportions that depend on the expected relative rate of return (or risk premium). This gives

$$\frac{B_j}{SB_j^*} = \mathrm{e}^{[\gamma_0+\gamma_1(i-i^*-\Delta s^{\mathrm{e}})]} \tag{8.32}$$

where $B_j(B_j^*)$ is the stock of domestic (foreign) bonds held by investor j. An increase in the interest differential, or a fall in the expected rate of depreciation, induces investors to move out of foreign bonds and into domestic bonds. Let us assume that all active participants in asset markets have the same portfolio preferences, as represented by γ_1. This assumption allows us to add up individual asset demand functions to obtain the aggregate asset demand equation, which can be expressed as

$$\frac{B}{SB^*} = \mathrm{e}^{[\gamma_0+\gamma_1(i-i^*-\Delta s^{\mathrm{e}})]} \tag{8.33}$$

where $B = \sum B_j$ is the net supply of domestically issued bonds and $B^* = \sum B_j^*$ is the net supply of foreign-issued bonds. Taking logarithms on both sides of equation (8.33), expressing the logarithmic values of the underlying variables in lower case letters, and then solving the resulting equation for the exchange rate, we obtain

$$s = -\frac{\gamma_0}{1+\gamma_1} + \frac{1}{1+\gamma_1}(b-b^*) + \frac{\gamma_1}{1+\gamma_1}[s^{\mathrm{e}} - (i-i^*)] \tag{8.34}$$

where $b = \ln B$ and $B^* = \ln B^*$.

It must be noted that equation (8.34) cannot be used to demonstrate that the exchange rate is determined by the demand for and supply of assets unless expectations are specified. In other words, the exchange rate cannot be determined uniquely unless, for example, the value of the expected exchange rate (s^e) is determined. The rational expectations mechanism may be applied to determine the equilibrium value of the exchange rate. But specifying expectations to be formed rationally is not sufficient to determine a unique exchange rate. As is so in many rational expectations problems, the assumption of stability is required in this respect. In the simplest portfolio balance model, in which expectations are assumed to be static ($\Delta s^e = 0$), the exchange rate is simply determined by relative bond supplies and the interest rate differential, which gives

$$s = \alpha_0 + \alpha_1(i - i^*) + \alpha_2(b - b^*). \tag{8.35}$$

A question that arises with respect to equation (8.35) is the following: how are b and b^* defined precisely? Frankel (1983a) argues that if the market consists of the whole world and the portfolio preferences of the residents of all countries are similar, the supplies of foreign assets in the domestic market include only the government-issued liabilities held by the private sector. Looked at from this perspective, b and b^* must be interpreted as net domestic and foreign government indebtedness. Thus b and b^* will be the same as domestic and foreign government debt, respectively, under the assumption that government-issued debt denominated in their own currencies.

The proposition that residents of all countries have the same portfolio preferences holds in the models developed, *inter alia*, by Frankel (1979a) and Dornbusch (1980a), in which the asset demand functions are derived from the maximization of expected utility by risk-averse agents. As argued by Frankel (1983a), the proposition underlying equation (8.33) contrasts with the macroeconomic models of portfolio balance in which the home country is assumed to be too small for its assets to be of interest to foreign residents and whose residents only wish to hold domestic assets. One motivation for making this assumption is the desire to simplify the accounting problem of allowing for capital inflow or outflow with an increase or a decrease in the supply of foreign assets in the domestic market (by assuming away the problem of currency of denomination of capital flow). Another motivation for this assumption is that, under floating exchange rates, it leads to the result that a current account deficit (which represents capital outflow) causes currency depreciation, whereas a current account surplus causes currency appreciation. As an alternative to equation (8.33), we aggregate equation (8.31) over all domestic residents to obtain

$$\frac{B_H}{SB_H^*} = e^{[\gamma_{H0} + \gamma_{H1}(i - i^* - \Delta s^e)]} \tag{8.36}$$

where B_H and B_H^* are defined as the sum of all domestic and foreign bonds held by domestic residents (which is equal to the accumulation of past current account surpluses under the small country assumption) and γ_H is the asset demand function shared by all domestic residents. Assuming static expectations, the exchange rate equation is

$$s = \gamma_{H0} - \gamma_{H1}(i - i^*) + \gamma_{H2}(b_H - b_H^*). \tag{8.37}$$

Frankel (1983a) argues that the small country assumption (implying that foreign residents do not hold domestic bonds) is particularly unrealistic if the home country is the U.S. One alternative is to assume that the foreign country is the small country (that domestic residents do not hold foreign bonds). Then equation (8.36) is replaced by

$$s = \gamma_{F0} + \gamma_{F1}(i - i^*) + \gamma_{F2}(b_F - b_F^*) \tag{8.38}$$

where b_F is the logarithm of domestic bonds held by foreign residents (which is equal to the accumulation of past foreign surpluses under the small country assumption), such that $\gamma_{F0} < 0$, $\gamma_{F1} < 0$ and $\gamma_{F2} > 0$.

It is argued that a realistic portfolio balance model for large countries must recognize the observation that the residents of both countries hold assets issued by both countries. The (cumulated) current account is still expected to affect the exchange rate, provided that domestic residents wish to hold a greater proportion of their wealth as domestic assets and foreign residents wish to hold a greater proportion as foreign assets. These models are classified under the name "preferred habitat."

8.10. A Synthesis of the Monetary and Portfolio Balance Models

In the simple portfolio balance model, as represented by equation (8.33), the exchange rate is determined by relative bond supplies and the interest differential. If we rewrite equation (8.33) in a logarithmic form and solve it for the exchange rate, we obtain

$$s = -\gamma_0 - \gamma_1(i - i^* - \Delta s^e) + (b - b^*). \tag{8.39}$$

The sticky-price models, as represented by equations (5.57) and (6.6), can be integrated with the simple portfolio balance model, as represented by equation (8.39). First, we integrate the Dornbusch (1976c) sticky-price model with the portfolio balance model. The expectation mechanism associated with the Dornbusch (1976c) model can be written as

$$\Delta s^{\mathrm{e}} = -\theta(s - \bar{s}). \tag{8.40}$$

By adding and subtracting the interest differential from equation (8.40), it can be shown that the exchange rate overshoots its long-run value by an amount that is proportional to the nominal interest differential and the risk premium:

$$s - \bar{s} = -\frac{1}{\theta}(i - i^*) + \frac{1}{\theta}(i - i^* - \Delta s^{\mathrm{e}}). \tag{8.41}$$

By substituting equation (8.41) into equation (3.7), we obtain

$$\begin{aligned} s = {} & (m - m^*) - \alpha(y - y^*) - \left(\frac{1}{\theta} - \beta\right)(i - i^*) \\ & + \frac{1}{\theta}(i - i^* - \Delta s^{\mathrm{e}}). \end{aligned} \tag{8.42}$$

Synthesis of the sticky-price and portfolio balance equations is obtained by substituting uncovered interest parity in equation (8.42) with the imperfect asset substitutability condition, as represented by equation (8.39):

$$\begin{aligned} s = {} & -\frac{\gamma_0\gamma_1\theta}{\theta\gamma_1 + 1} + \frac{\theta\gamma_1}{\theta\gamma_1 + 1}(m - m^*) - \frac{\alpha\gamma_1\theta_1}{\theta\gamma_1 + 1}(y - y^*) \\ & - \left(\beta - \frac{1}{\theta}\right)\left(\frac{\theta\gamma_1}{\theta\gamma_1 + 1}\right)(i - i^*) + \frac{\gamma_1\theta}{\theta\gamma_1 + 1}(b - b^*). \end{aligned} \tag{8.43}$$

To integrate the real interest differential model with the portfolio balance model, we begin with the expectations formation mechanism associated with the real interest differential model. This is given as follows:

$$\Delta s^{\mathrm{e}} = -\theta(s - \bar{s}) + (\Delta p^{\mathrm{e}} - \Delta p^{*\mathrm{e}}). \tag{8.44}$$

By adding and subtracting the nominal interest differential, we can show that equation (8.44) implies that the exchange rate deviates from its long-run value by an amount that is proportional to the real interest differential and the risk premium. Hence

$$s - \bar{s} = -\frac{1}{\theta}[(i - \Delta p^{\mathrm{e}}) - (i^* - \Delta p^{*\mathrm{e}})] + \frac{1}{\theta}(i - i^* - \Delta s^{\mathrm{e}}). \tag{8.45}$$

Let us assume that the long-run equilibrium exchange rate ($\bar{s}$) is determined by monetary fundamentals (as represented by equation (3.19)).

By substituting equation (8.45) into equation (3.19), we obtain

$$s = (m - m^*) - \alpha(y - y^*) + \beta(\Delta p^{\mathrm{e}} - \Delta p^{*\mathrm{e}}) - \frac{1}{\theta}[(i - \Delta p^{\mathrm{e}}) - (i^* - \Delta p^{*\mathrm{e}})] + \frac{1}{\theta}(i - i^* - \Delta s^{\mathrm{e}}). \quad (8.46)$$

Equation (8.46) represents a general model of exchange rate determination, implying that the exchange rate is determined by the relative money supply, relative income, relative inflation, real interest differential, and the risk premium. Equation (8.46) reduces to equation (3.19), representing the flexible-price model, when goods prices adjust continuously, real interest parity holds, and the risk premium is zero. It also reduces to equation (8.23) of the sticky-price model when the assumption of continuous adjustment of goods prices (PPP) is relaxed. Equation (8.45) reduces to equation (6.6) of the real interest differential model when PPP and uncovered interest parity are relaxed.

The synthesis of the real interest differential model and the portfolio balance model can be derived by substituting equation (8.46) into equation (8.39) for the value of uncovered interest parity:

$$s = -\frac{\gamma_0}{\theta\gamma_1 + 1} + \frac{\theta\gamma_1}{\theta\gamma_1 + 1}(m - m^*) - \frac{\alpha\gamma_1\theta_1}{\theta\gamma_1 + 1}(y - y^*) + \left(\frac{\gamma_1(\beta\theta + 1)}{\gamma_1\theta + 1}\right)(\Delta p^{\mathrm{e}} - \Delta p^{*\mathrm{e}}) - \frac{\gamma_1}{\gamma_1\theta + 1}(i - i^*) + \frac{1}{\theta\gamma_1 + 1}(b - b^*). \quad (8.47)$$

This is a more general model, which tells us that the exchange rate is determined by monetary fundamentals (relative money, relative income, inflation differential, and interest differential), as well as the relative stocks of bonds. Equation (8.47) can be rewritten as

$$s = \beta_0 + \beta_1(m - m^*) - \beta_2(y - y^*) + \beta_3(\Delta p^{\mathrm{e}} - \Delta p^{*\mathrm{e}}) - \beta_4(i - i^*) + \beta_5(b - b^*). \quad (8.48)$$

The flexible price model holds if $\beta_4 = 0$ and $\beta_5 = 0$, the sticky-price model is valid if $\beta_3 = 0$ and $\beta_5 = 0$, and the real interest differential model is valid if $\beta_5 = 0$.

8.11. The Portfolio Balance Model with a Banking Sector

The portfolio balance model described so far disregards the role of assets supplied by the domestic banking sector in the determination of the exchange rate. de Grauwe (1982) developed a simple portfolio model for an open economy with a flexible exchange rate that incorporates the assets supplied by the domestic banking system. This model overlooks the role of international bond markets, instead allowing a role for international banking and shedding light on the effects of monetary instruments (such as reserve requirements, credit controls, and the discount rate) on the equilibrium exchange rate.

8.11.1. *The Model*

This model assumes that the residents of each country allocate their net financial wealth among four assets: domestic currency, domestic bank deposits, domestic loans, and net foreign assets. The domestic sector supplies domestic deposits and domestic loans, while the central bank supplies domestic currency (base money). The model consists of the following equations:

$$C_D = c(i_D, i_L, i_D^{*\mathrm{e}})W \tag{8.49}$$

$$D_D = d(i_D, i_L, i_D^{*\mathrm{e}})W \tag{8.50}$$

$$L_D = l(i_D, i_L, i_D^{*\mathrm{e}})W \tag{8.51}$$

$$FS_D = f(i_D, i_L, i_D^{*\mathrm{e}}, i_L^{*\mathrm{e}})W \tag{8.52}$$

$$W = C + D - L + FS \tag{8.53}$$

$$i_D^{*\mathrm{e}} = i_D^* + \Delta s^{\mathrm{e}} \tag{8.54}$$

$$i_L^{*\mathrm{e}} = i_L^* + \Delta s^{\mathrm{e}} \tag{8.55}$$

where C is the currency, D is the bank deposits, L is the bank loans, F is the net foreign assets, $i_D(i_D^*)$ is the interest rate on domestic (foreign) bank deposits, and $i_L(i_L^*)$ is the interest rate on domestic (foreign) loans. It is worth noting that if agents hold a portion of their wealth in a foreign bank deposit or have foreign loans, the interest rate they actually obtain on a foreign deposit or pay on a foreign loan can increase (decrease) in domestic currency terms by the extent to which the domestic currency depreciates (appreciates). As shown by equations (8.54)–(8.55), the expected interest on foreign bank deposits (loans) is equal to the actual interest that agents receive (pay) on foreign bank deposits (loans) adjusted by the expected depreciation of the domestic currency.

Equation (8.53) involves the restriction $c+d-l+f=1$, which implies that the sum of proportions of wealth invested in the underlying assets is equal to unity. A country can be a net creditor or a net debtor to the rest of the world, which gives $F>0$ or $F<0$. Another important relation is the asset side of the balance sheet of the banking sector, which consists of (required) reserves and domestic loans. The liability side consists of deposits. Hence the constraint for the banking sector is given by

$$kD + L = D \tag{8.56}$$

where k is the required reserve ratio and kD appears as an additional demand component in the currency market.

So far we have dealt with the demand side for the banking assets held by the public. The supply functions of bank loans and deposits are

$$L_S = L_S(i_L - i_D, k) \tag{8.57}$$

$$D_S = D_S(i_L - i_D, k). \tag{8.58}$$

The supply of domestic bank loans and deposits is an increasing function of the spread between lending and deposit rates, whereas it is a decreasing function of the reserve ratio (k). On the other hand, the supply of currency is exogenously determined by the monetary base, defined as currency with the public and bank reserves ($C_S = C + kD$). Finally, we make the following assumption regarding the exchange rate expectations mechanism:

$$\Delta s^{\mathrm{e}} = \theta(\bar{s} - s), \quad \theta > 0. \tag{8.59}$$

Equilibrium in the markets for domestic currency, domestic bank deposits, domestic bank loans, foreign bank deposits, and foreign loans is reached when the demand for the underlying asset is equal to its supply. The equilibrium conditions are represented by the following equations:

$$C_S = c[i_D, i_D^* + \theta(\bar{S} - S)] + kd[i_D, i_D^* + \theta(\bar{S} - S)]W \tag{8.60}$$

$$D_S[i_L - i_D, k] = d[i_D, i_D^* + \theta(\bar{S} - S)]W \tag{8.61}$$

$$L_S[i_L - i_D, k] = l[i_L, i_L^* + \theta(\bar{S} - S)]W \tag{8.62}$$

$$FS = f[i_D, i_L, i_D^* + \theta(\bar{S} - S), i_L^* + \theta(\bar{S} - S)]W. \tag{8.63}$$

As changes in foreign assets over time are equal to changes in the current account, we have

$$\frac{\mathrm{d}F}{\mathrm{d}t} = CA_t. \tag{8.64}$$

A non-zero current account implies an increase (or a decrease) in the supply of net foreign assets. In the present model, the current account is exogenous, implying that F is also exogenous. The banks' balance sheet $L = (1 - k)D$ can be substituted into the wealth definition to obtain

$$W = C + FS. \tag{8.65}$$

This implies that the wealth of the private sector includes only "outside" assets. Using this wealth constraint we can drop one equilibrium condition, which is represented by equation (8.63). Using the bank's balance sheet to substitute L in equation (8.62), we obtain a system of three equations ((8.60), (8.61), and (8.62)) that determine three variables (i_D, i_L, and S).

8.11.2. *The Impact of Monetary Policy on Exchange and Lending Rates*

The portfolio balance model with a banking sector can be illustrated diagrammatically. For this purpose, we use the *LD* (loan demand) and *CC* (currency demand) curves. The *LD* curve represents combinations of loan and deposit rates for which deposit and loan markets are in equilibrium. It is derived by linearizing and solving equation (8.61) for the interest rate on domestic bank deposit (i_D) and substituting the resulting expression into equation (8.62). Likewise, the *CC* curve is derived by substituting the deposit rate equation (8.61) into equation (8.60). The curve defines combinations of loan rate and exchange rate that maintain equilibrium in the money market. The *LD* curve is negatively sloped, whereas the *CC* curve is positively sloped.[11]

The effect of an expansion in the monetary base is shown in Figure 8.9. An increase in the monetary base shifts the *LD* curve from LD_0 to LD_1 because the higher level of money boosts private wealth, leading to excess demand for both loans and deposits. This causes the loan rate to rise to reduce

[11] For derivation of the *CC* and *LD* curves and their respective slopes see de Grauwe (1982, pp. 230 and 231).

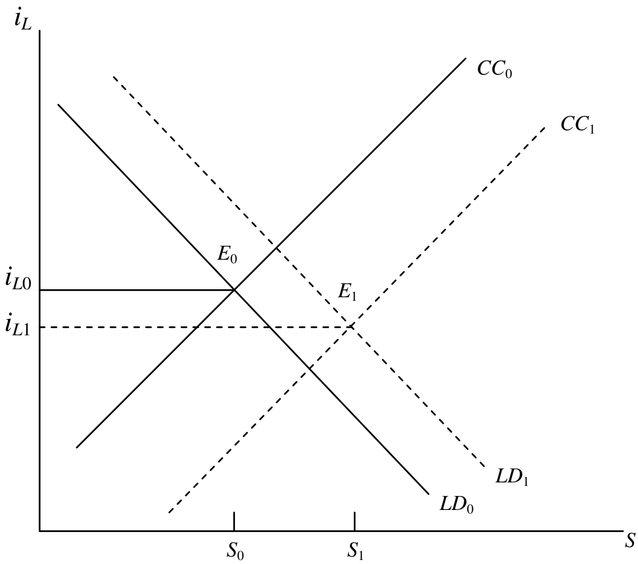

Figure 8.9. The effect of monetary expansion.

the deposit rate. The effect on the *CC* curve is ambiguous. In Figure 8.9, a normal case is shown, in which the increase in the supply of currency leads to excess supply in the currency market. The new portfolio equilibrium is reached at E_1 with a higher exchange rate. The effect on the loan rate is ambiguous as a result of the offsetting wealth and substitution effects. The wealth effect of the monetary expansion causes the loan rate to rise, whereas the substitution effect induced by the higher exchange rate leads residents to increase foreign borrowing. This effect tends to reduce the domestic loan rate. If the substitution effect dominates, the loan rate will decline.

The effect of a decline in the legal reserve requirements is shown in Figure 8.10. A reduction in reserve requirements shifts the *LD* curve downward from LD_0 to LD_1. As a result, banks can operate with a lower margin and increase the supply of loans and deposits. This will reduce the loan rate (and increase the deposit rate). The *CC* curve shifts to the right because the reduction in reserve requirements leads to excess supply of the monetary base. Thus equilibrium moves from E_0 to E_1, with a lower loan rate (i_L) and a higher exchange rate (S_1).

The effect of a relaxation of officially imposed limits on the supply of loans can be shown by assuming that the supply of loans is exogenous,

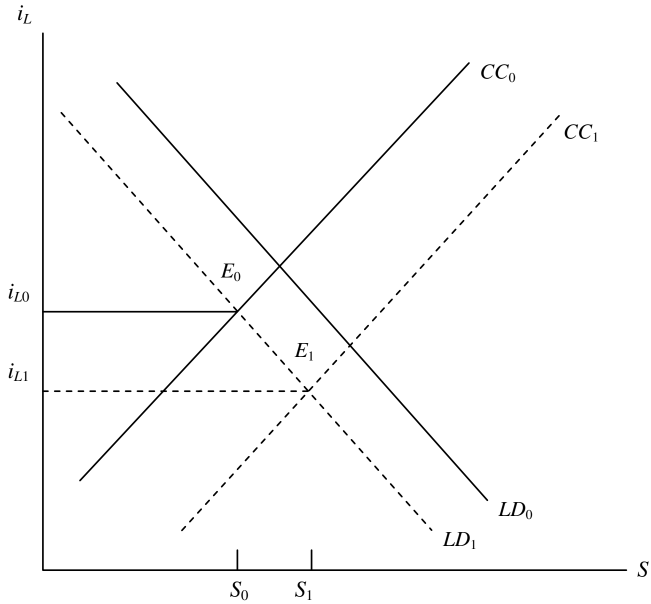

Figure 8.10. The effect of a change in reserve requirement.

which means that equation (8.62) changes to the following

$$\bar{L}_S = l[i_L, i_L^* + \theta(\bar{S} - S)]W. \tag{8.66}$$

A relaxation of the credit ceiling means that there is an exogenous increase in the supply of loans ($\bar{L}_S$), which makes the credit ceiling binding. Using the banks' balance sheet ($L_S = (1-k)$), it follows that the supply of deposits (D_S) becomes exogenous, which means that equation (8.61) becomes

$$\bar{D}_S = \frac{\bar{L}_S}{1-k} = d[i_D, i_D^* + \theta(\bar{S} - S)]W. \tag{8.67}$$

As a consequence, the *CC* curve turns vertical, whereas the *LD* curve has the normal negative slope. This implies that there is only one exchange rate that is compatible with equilibrium in the money market.

The effect of a relaxation in the credit ceiling, which is shown in Figure 8.11, is excess supply in the money market, shifting the *LD* curve downward and inducing a decline in the loan rate. On the other hand, the *CC* curve shifts to the right. Thus, the economy moves from an initial equilibrium at E_0 to E_1, with a lower loan rate (i_{L1}) and a higher exchange rate (S_1).

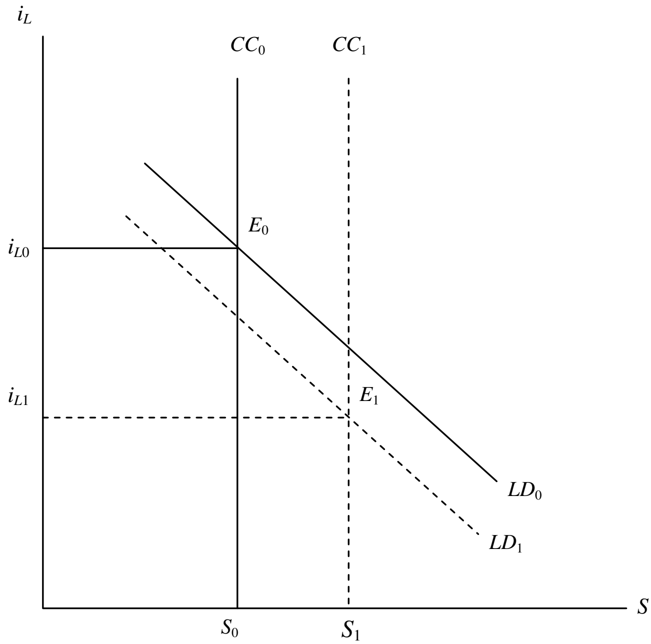

Figure 8.11. The effect of a relaxation in credit ceiling.

8.12. The Portfolio Balance Model with Bank Lending

Kearney and MacDonald (1986) extended the small country simple portfolio balance model of Branson *et al.* (1977) to allow for bank lending. In this model, agents hold wealth in the form of four assets: domestic money, domestic bank loans, domestic bonds, and foreign bonds. The demand functions for these four assets and the wealth constraint are

$$M = m(i_L, i_B, \bar{i}^* + \Delta s^e)W \tag{8.68}$$

$$L_B = l(i_L, i_B, \bar{i}^* + \Delta s^e)W \tag{8.69}$$

$$B = b(i_L, i_B, \bar{i}^* + \Delta s^e)W \tag{8.70}$$

$$SF = f(i_L, i_B, i^* + \Delta s^e)W \tag{8.71}$$

$$W = M + B + L + SF. \tag{8.72}$$

Equations (8.68)–(8.71) represent the demand functions for money, domestic bank loans, domestic bonds, and foreign assets, respectively.

They are specified to depend upon wealth, the own rate, and all cross rates. Equation (8.72) defines the wealth constraint of the non-bank private sector as the sum of the four assets. Substituting equation (8.71) into equations (8.68)–(8.70) yields the market equilibrium conditions. Given the stocks of money (M), domestic bank loans (L), domestic bonds (B), and foreign bonds (F), the model contains four variables: interest rate on domestic bank loans, interest rate on domestic bonds, the foreign interest rate, and the exchange rate. As the foreign interest rate is given, there are only three endogenous variables and hence three behavioral equations (8.68)–(8.70). The domestic interest rate, domestic lending rate, and the exchange rate are determined jointly for given supplies of money, domestic bonds, domestic bank loans, and foreign bonds.

In this model, the exchange rate is determined in the short run by conditions of asset market equilibrium. But the value of the exchange rate so determined (given income, absorption, and the price level) generally leads to a non-zero current account. With flexible exchange rates, a non-zero current account yields a non-zero capital account of the opposite sign. For example, an increase in the money supply (resulting in domestic currency depreciation) leads to a current account surplus and hence accumulation of foreign assets by the private sector in the home country.

Comparative statics are obtained by totally differentiating equations (8.68)–(8.70). In a matrix form, we have

$$\begin{bmatrix} Wm_{i_L} & Wm_{i_b} & mF \\ Wl_{i_L} & Wl_{i_b} & lF \\ Wb_{i_L} & Wb_{i_b} & bF \end{bmatrix} \begin{bmatrix} \mathrm{d}i_L \\ \mathrm{d}i_b \\ \mathrm{d}S \end{bmatrix}$$

$$= \begin{bmatrix} (1-m) & -m & -m & -mS & -Wm_{i^*} \\ -l & (1-l) & -l & -lS & -Wl_{i^*} \\ -b & -b & (1-b) & -bS & -Wb_{i^*} \end{bmatrix} \begin{bmatrix} \mathrm{d}M \\ \mathrm{d}L \\ \mathrm{d}B \\ \mathrm{d}F \\ \mathrm{d}i^* \end{bmatrix}. \quad (8.73)$$

Equation (8.73) can be solved using Cramer's rule to determine the effects on the endogenous variables of the accumulation of assets and open market operations. Table 8.2 reports the direction of changes in interest and exchange rates following: (i) an increase in the stock of each asset (the first four columns) and (ii) an expansionary open market operation, whereby money is exchanged for either domestic bonds or foreign assets (the last two columns). As shown in Table 8.2, a monetary expansion causes domestic

Table 8.2. Effects of increases in asset stocks on interest and exchange rates.

	Effects of accumulation of asset stocks				Effects of open markets operations	
Effects on	ΔM	ΔB	ΔL_B	ΔF	$\Delta B = -\Delta M$	$S\Delta F = \Delta M$
i_L	$-$	?	$+$	0	?	$+$
i_B	$-$	$+$	?	0	$+$	$+$
S	$+$	?	?	$-$	?	$-$

Source: Kearney and MacDonald (1986, p. 482).

currency depreciation, whereas current account surplus raises net foreign assets and results in currency appreciation. Accumulation of other assets has indeterminate effects on the exchange rate, as does an open market operation in domestic bonds.

As proposed by Kearney and MacDonald (1986), the portfolio balance model can be specified in an empirically testable form as

$$\Delta a_i/W = \alpha + \sum_{j=1}^{n} \beta_{ij} \ln i_j + \sum_{j=1}^{n} \beta_{ij}(a_{it-1}/W) \tag{8.74}$$

where a_i represents the desired stock of asset $i(i = M, L_B, B, SF)$ and i_j represents the relevant interest rate variables. Equation (8.74) shows that the desired stock of wealth held in money, domestic bonds, and foreign bonds depends on the variables that appear on the right-hand side of the demand function of each underlying asset. It is argued that although the model is short term in nature, the asset demand equations are consistent with short- and long-run portfolio balance.

8.13. Recapitulation

The monetary model may be viewed as being restrictive in the sense that agents only hold money, in which case the exchange rate moves to equilibrate the international demand for stocks of money. For example, the flexible-price monetary model assumes not only that there are no barriers segmenting international goods markets (such as transportation costs and trade barriers), but also that domestic and foreign goods are perfect substitutes. Similarly, the model makes an analogous assumption for bond markets. Not only are there no barriers segmenting international bond markets (such as transaction costs and capital controls), it is also the case that domestic and foreign bonds are perfect substitutes. In essence, the flexible-price model postulates that there is only one good (perfect price flexibility, implying PPP) and only one bond (perfect asset substitutability, implying uncovered interest parity). In the flexible-price model, the exchange rate is determined by stock equilibrium in money markets, which is achieved very quickly through continuous adjustment of goods prices and bond returns, thereby maintaining complete neutrality of monetary policy on a continuous basis. The model yields an equation in which the exchange rate is determined by relative prices, which are in turn determined by the relative money supply, relative income, and interest differential under stable domestic and foreign monetary conditions. We have already derived several versions of the flexible-price model as represented by equations (3.7) and (3.19).

In the Dornbusch sticky-price monetary model, the price flexibility assumption is relaxed. This model also determines the exchange rate by equilibrium conditions in money markets with rapid adjustment in asset markets, but assumes that there is a slow adjustment in goods markets and that monetary neutrality is maintained across steady states. The sticky-price monetary model is represented by equation (5.57). Frankel's real interest differential model is a modification of the sticky-price model that allows for differences in secular inflation rates (and hence in real interest rates), producing an equation that is identical to that representing the sticky-price monetary model except that it adds the real interest differential as an additional explanatory variable. This model is represented by equation (6.6).

In contrast, the portfolio balance model retains the assumption that there are no barriers segmenting international capital markets and relaxes the assumption that domestic and foreign bonds are perfect substitutes. This model assumes that agents do not only hold stocks of money but also stocks of bonds, which means that exchange and interest rates move together to equilibrate the demand for stocks of money and bonds. The desired proportions of these assets are assumed to depend on their respective yields. The outstanding stocks of these assets are fixed at any point in time so that the exchange rate and the two interest rates are equal to the values at which wealth holders are just willing to hold existing assets. The portfolio balance model assumes that asset markets clear continuously and that money neutrality is maintained across steady states.

CHAPTER 9
The Currency Substitution Model of Exchange Rates

9.1. Introduction

Advocates of the flexible exchange rates (for example, Friedman, 1953; Mundell, 1963a; Sohmen, 1967) have long argued that the system would allow countries autonomy with respect to the conduct of domestic monetary policy. They argued that the transition from fixed to flexible exchange rates would insulate a country's money supply from monetary developments in the rest of the world, thereby increasing the efficacy of monetary policy in stabilizing domestic output. These advocates have always proclaimed high hopes for freely-floating exchange rates and have held the view that floating exchange rates would secure (without the use of foreign exchange controls or other trade distortions) national monetary independence or autonomy for all countries (big or small). This view, which has been put forward by both Keynesians (such as Meade, 1955) and monetarists (such as Johnson, 1972b), was influential in persuading policymakers to accept (albeit under pressure) the adoption of flexible exchange rates among industrial countries in 1973. By 1974, all of the major industrial countries had already floated their currencies by abandoning the system of fixed exchange rates agreed upon 30 years earlier at Bretton Woods. To maintain monetary autonomy under flexible exchange rates, the main proposal put forward by the monetarists was for each country to pursue its own fixed monetary growth rule as if the demand for national money was stable and independent of that in other countries.

Economists, however, soon became skeptical of the ability of flexible exchange rates to provide monetary autonomy under currency substitution, a situation where individuals and businesses tend to alter the composition of their money holdings between domestic and foreign currencies (Miles, 1978; McKinnon, 1982; Girton and Roper, 1981; Bordo and

Choudhri, 1982; Ortiz, 1983). These studies have demonstrated that if the domestic and foreign currencies are close substitutes from the perspective of money demanders, the central banks of the underlying countries would be unable to conduct monetary policies independently, even under flexible exchange rates. This is because when both domestic and foreign monies are held, variations in foreign interest rates or expected exchange rates make the domestic money demand function unstable because resources are shifted in response to changes in prospective relative returns. Thus, if a significant number of individuals and businesses hold diversified currency portfolios, this would undermine seriously the independence and effectiveness of monetary policy under floating exchange rates.

Calvo and Rodriguez (1977) developed a model of exchange rate determination (built on the postulates of full price flexibility, currency substitution, perfect capital mobility, and rational expectations) to demonstrate that a higher rate of monetary expansion results in an instantaneous rise in both the exchange rate and the price level, but the jump of the former would exceed that of the latter. This implies that, under a system of flexible exchange rates with flexible prices and perfect capital mobility, if the degree of currency substitution is high, even a small increase in the money supply results in an overshooting of the exchange rate from its equilibrium value.[1] Thus another important implication that follows from currency substitution is that the more highly substitutable domestic and foreign currencies are, the more volatile exchange rates may be in response to even small changes in the underlying economic fundamentals.

9.2. Currency Substitution and Dollarization

Currency substitution is a term that is used to describe a phenomenon whereby multinational corporations have a strong incentive to diversify the currency composition of their cash balances to facilitate their operations

[1] Since the advent of the flexible exchange rate system in 1973, large fluctuations in exchange rates have led to the development of various versions of the overshooting hypothesis. Explanations for overshooting in exchange rates vary, but they all rely on the short-run fixity of some nominal quantity. Some economists rationalize the exchange rate overshooting phenomenon by assuming that goods prices adjust more slowly than asset prices in the short run (Dornbusch, 1976c); others attribute it to the differential effects of new information on goods and asset markets (Dornbusch, 1979; Frenkel, 1981a,b); and other economists attribute it to the implications of the process whereby asset holders restore portfolio balance in the face of disturbances (Branson, 1976; Branson *et al.*, 1977, 1979).

in different countries. Even individuals and businesses domiciled in a particular country often have transaction, precautionary or even speculative motives for diversifying the currency composition of their money holdings (Miles, 1978). Diversification helps individuals and businesses reduce the costs of foreign transactions and provides certain risk-reducing benefits typically associated with asset diversification. The mere holding of a diversified portfolio of currencies, however, is not a sufficient condition for meaningful currency substitution to occur. This is because a certain level of foreign currency holdings may exist within every country, for institutional or historical reasons. For currency substitution to take place in a country, these holdings must change in response to changes in the relative opportunity costs of holding foreign currencies (thus, a currency that seems likely to depreciate rapidly is substituted for another currency that looks set to appreciate). Moreover, currency substitution requires that there exist a group of individuals and businesses who hold both domestic and foreign currencies and who are indifferent at the margin between holding more domestic and more foreign currencies.

Ludwig von Mises (1923) provided a concise description of the phenomenon of currency substitution, illustrating how the expected depreciation of the domestic currency reduces its relative appeal as a medium of exchange and store of value, thereby encouraging its replacement in residents' portfolios by strong foreign currencies. Furthermore, he asserted that currency substitution tends to rise with the expected rate of currency depreciation itself, intensifying during periods of hyperinflation. On this basis, he predicted that strong foreign currencies would be used to supplant the depreciated mark, thus reducing its usage. This pattern was evident in the latter stages of the German hyperinflation, when residents increasingly used the U.S. dollar as a unit of account, store of value, and medium of exchange.[2]

Currency substitution can be classified as "symmetrical," when residents and nonresidents simultaneously hold domestic and foreign money, and "asymmetrical" when nonresidents do not hold domestic money.[3] Many Latin American countries (such as Argentina, Mexico, and Uruguay) underwent the experience of asymmetrical currency substitution, when the

[2]For a detailed discussion of German hyperinflation and five similar episodes, see Gazos (2008).

[3]Studies conducted by Miles (1978), Girton and Roper (1981), McKinnon (1982), and Bordo and Choudhri (1982) examined symmetrical currency substitution, whereas those conducted by Ortiz (1983) and Ramirez-Rojas (1985) examined asymmetrical currency substitution.

residents of these countries substituted the U.S. dollar for their domestic currencies to use it as a unit of account or store of value (Ramirez-Rojas, 1985). This phenomenon has been referred to as "dollarization." Although the term "dollarization" has been often used interchangeably with currency substitution, it specifically depicts the phenomenon of currency substitution when referring to Latin American countries. Broadly speaking, dollarization pertains more to the use of the U.S. dollar as a unit of account and store of value, and not necessarily as a means of payment, whereas currency substitution more narrowly relates to substitution between currencies as means of payment.[4] Dollarization also implies the degree to which real and financial transactions are performed in U.S. dollar relative to those settled in the domestic currency (Ortiz, 1983).

Dollarization occurs when the residents of a country use a foreign currency, particularly the U.S. dollar, parallel to or instead of the domestic currency.[5] It occurs in three ways. First, dollarization may be *de jure* (official) when a nation adopts *de jure* the U.S. dollar to replace wholly its domestic currency. In this case of *de jure* dollarization, a country ceases to issue the domestic currency and uses only the U.S. dollar as legal tender. This implies a "full" dollarization of the economy (that is, adopting the U.S. dollar as the only legal tender, as in Panama and Liberia). Second, dollarization may be *de facto* (unofficial) when firms and individuals of a country voluntarily substitute the U.S. dollar for the domestic currency as a means of payment (currency substitution) and/or choose to hold foreign rather than domestic monetary assets as stores of value (asset substitution). *De facto* dollarization arises when the residents of a country lose confidence in the domestic currency, often resulting from episodes of inflation, currency devaluation, and/or currency confiscation. It may give rise to the growth of underground or "unrecorded" economic activities, with the foreign currency being the preferred medium of exchange for such transactions. *De facto* dollarization leads to a loss of seigniorage, thwarts the monetary authority from pursuing inflationary finance, and inhibits its effectiveness in controlling exchange rates. Third, dollarization may semiofficially (or officially) lead to a bi-monetary system, where the U.S. dollar is legal tender but plays a secondary role to the domestic currency.

[4]See, for example, Ramirez-Rojas (1985) and Heimonen (2008).

[5]In a similar fashion, when the euro is substituted for a domestic currency to act as a unit of account and store of value, it leads to a phenomenon known as "Euroization" (see, for example, Fiege, 2003; Heimonen, 2008; Ritter and Rowe, 2002).

9.3. Implications of Currency Substitution

Two important implications follow from the existence of currency substitution under flexible exchange rates: (i) domestic monetary policy cannot be conducted independently of monetary developments in the rest of the world and (ii) the exchange rate becomes more volatile.

Monetary independence is not possible when exchange rates are fixed. This is because by pegging the domestic currency to a foreign currency, the central bank makes the latter a perfect substitute for the former on the supply side. The central bank alters the supply of the domestic currency to maintain the exchange rate. If the central bank raises the money supply in excess of money demand, the resulting capital outflow would produce a deficit in the balance of payments. This deficit must be matched by a surplus in the foreign balance of payments, which implies that the foreign money supply must also rise, leading to a common inflation rate among all the countries operating under fixed exchange rates. This also implies that if country A maintains a fixed exchange rate with country B, then A must follow a monetary policy that is similar to that of B. If, however, A follows an inflationary monetary policy, in which prices are rising by 10% per year, while B follows a policy aimed at price stability, then maintaining a fixed exchange rate between the currencies of the two countries will not be possible. Under flexible exchange rates, on the other hand, A and B can choose independently any monetary policy they wish to pursue, in which case the exchange rate changes over time to adjust for the inflation differential. As a result, a system of flexible exchange rates helps eliminate supply side substitutability between domestic and foreign assets, which incapacitates domestic monetary policy. In addition, floating is supposed to allow exchange rates to reflect in a better way the underlying economic fundamentals and hence make exchange rates relatively more predictable than under fixed exchange rates.

However, experience with the post-1973 floating exchange rates has proved to be very disappointing with respect to both of the claims made in defense of the system. The first claim that floating exchange rates would insulate a country's money supply from monetary developments in the rest of the world was questioned on theoretical and empirical grounds in a series of studies conducted, *inter alia*, by Miles (1978), McKinnon (1982), and Girton and Roper (1981). Miles (1978) argued that the implicit assumption underlying the claim of monetary independence under flexible exchange rates is that currencies are not substitutable on the demand side. This assumption appears to be quite dubious under the existing global economic environment. Multinational corporations have strong incentives to hold diversified currency portfolios to facilitate their operations in various countries. Likewise, individuals and businesses that are domiciled in a particular country may have strong motives to diversify the currency composition of their money holdings.

But the question that needs to be answered here is the following: why do individuals and businesses hold foreign currency balances? Although domestic currency balances may dominate under normal circumstances, it may be useful to hold foreign currencies for at least two reasons. The first reason is that foreign currencies may provide services that domestic currencies are incapable of providing. The second reason is that foreign currencies may be held at a lower opportunity cost. The best example in this case is that, under hyperinflation, the domestic currency cannot perform the two functions of serving as a unit of account and as a store of value. It only performs the function of a medium of exchange at a high cost and inconvenience, represented by holding a large amount of banknotes. This is why in countries that experience hyperinflation, the U.S. dollar is used to perform this function alongside (and perhaps dominates) the domestic currency. Under normal circumstances, foreign currencies are held for reasons that pertain to hedging, investment, and financing.

If economic agents hold diversified portfolios of domestic and foreign currencies, the proposition of monetary policy independence will no longer be valid. To understand this argument, consider the following example. If currencies were perfect substitutes from the perspective of money demanders, then all countries would have to have the same inflation rate, otherwise the demand for the high-inflation currency would fall to zero (as the inflation rate determines the loss of purchasing power of money). But if the cost of holding currency A rises relative to the cost of holding currency B (say because of a higher inflation rate for currency A), demand will shift away from A to B if currencies A and B are substitutes. This would cause currency A to depreciate even further than what was initially called for by the inflation rate of that country. For instance, suppose that Canada and the U.S. have annual inflation rates of 6% and 4%, respectively. In the absence of currency substitution, the Canadian dollar is expected to depreciate by 2% against the U.S. dollar if purchasing power parity holds between the two countries. Now, suppose that the Canadians wish to hold stocks of U.S. dollars because they believe that the U.S. dollar is a good substitute for the Canadian dollar. In this case, the higher inflation rate in Canada means that the stocks of Canadian dollar will lose more value than the stocks of U.S.

dollar, which means that there will be a higher demand for the U.S. dollar in Canada. The tendency to exchange Canadian dollars for U.S. dollars results in further depreciation of the Canadian dollar.

Shifts in the demand for different currencies cause exchange rate volatility, making it difficult for central banks to maintain stability in the foreign exchange market. Thus if money demanders substitute currencies to force each country to follow a similar inflation rate, the supposed independence of monetary policy under flexible exchange rates is illusory. Although central banks may attempt to follow independent monetary policies, money demanders will adjust their portfolios away from high- to low-inflation currencies. This produces more volatile exchange rates because (i) the exchange rate adjusts to compensate for the original inflation differential and (ii) it also adjusts as currency portfolios are altered. Thus, if the degree of currency substitution is high, even small changes in the money supply would induce large changes in the exchange rate. Furthermore, currency substitution would transmit the effect of monetary disturbances from one country to another. Therefore, significant currency substitution would undermine seriously the ability of flexible exchange rates to provide monetary independence.

The second claim that flexible exchange rates would reflect in a better way the underlying economic fundamentals has not received much support on empirical grounds. In particular, the monetary model of exchange rates was successful in explaining exchange rate movements in few years immediately after the inception of floating rates in 1973, but it failed to keep up empirical support in subsequent periods. In 1978, the dollar depreciated sharply, which prompted increasing political criticism of the non-interventionist policies of the U.S. government. It did not come to an end until the November package of increased monetary restraint and direct intervention to support the dollar.

9.4. Determinants of Currency Substitution

What constitutes the demand for foreign money by domestic residents, and how is the demand for foreign money determined? Domestic residents' demand for foreign money covers a wide variety of possibilities, including foreign currency deposits held either domestically or abroad and foreign currency notes circulating domestically. The demand for foreign money depends on the level of real wealth, institutional factors, and the expected change in the exchange rate. If we allow for domestic and foreign interest-bearing assets, neither the demand for the former, nor the demand for the latter will constitute currency substitution (rather, it represents capital outflow).

The institutional factors that determine the demand for foreign money by domestic residents may include the volume of international transactions, lack of development of the domestic capital market, and the transaction costs incurred in the exchange of currencies. The demand for foreign money to carry out international transactions is a stable function of the volume of international transactions. If there is lack of development in the domestic capital market, alternatives available for holding wealth by domestic residents will be restricted to goods, domestic money, and foreign money. There will also be lack of financial investment opportunities for nonresidents, which will contribute to the asymmetrical nature of currency substitution. Finally, in the absence of severe controls or other types of deterrents to the holding of foreign currency, the transaction costs incurred in the exchange of domestic for foreign money will be smaller than those involved in the exchange of money for goods. Hence, bias toward the holding of foreign money in the domestic economy will be intensified.

Under normal conditions and otherwise, the crucial factor that explains the demand for foreign money by domestic residents is the expected change in the exchange rate. If the exchange rate is expected to rise (that is, the domestic currency is expected to depreciate), there will be a shift toward the foreign currency, and vice versa. The extent of the expected change in the exchange rate determines the relative holdings of domestic and foreign currencies. The larger the expected depreciation, the larger is the shift toward foreign currency holdings. Another factor that affects the demand for foreign currency is the rate of return on domestic interest-bearing assets. To simplify the exposition, however, these assets are not included in the currency substitution model that follows. For the derivation of a simplified model of asymmetrical currency substitution under flexible exchange rates, we begin with two money demand functions (one for the home country and another for the foreign country), the purchasing power parity condition and a wealth constraint:

$$M = PL(W, \dot{S}) \tag{9.1}$$

$$M^* = P^*L^*(W, \dot{S}) \tag{9.2}$$

$$P = SP^* \tag{9.3}$$

$$W = (M + SM^*)(1/P). \tag{9.4}$$

Equations (9.1) and (9.2) show that nominal holdings of domestic money (M) by domestic residents and nominal holdings of foreign money (M^*) by foreign residents in each country are functions of real wealth and the expected rate of depreciation of the domestic currency ($\dot{S}$). Equation (9.3) implies that purchasing power parity holds between the two countries, whereas equation (9.4) represents the wealth constraint.

By combining equations (9.1)–(9.3), we obtain

$$\frac{M}{SM^*} = \left[\frac{L(W, \dot{S})}{L^*(W, \dot{S})}\right]. \tag{9.5}$$

Two important points emerge from equation (9.5). First, the scale variable is the same for the two money demand functions (which is a relevant assumption when dealing with asymmetrical currency substitution). Second, only the expected change in the exchange rate is included in the relative money demand function as an opportunity cost of holding money.

Assuming that the demand for money in the two countries is homogenous in real wealth, the ratio of the holdings of domestic to foreign money can be expressed as a function of the expected change in the exchange rate:

$$\frac{M}{SM^*} = \beta(\dot{S}), \quad \beta' < 0. \tag{9.6}$$

Equation (9.6) shows that the relative holdings of domestic currency and foreign currency are determined by the expected change in the exchange rate. The relation between the expected change in the exchange rate and currency holdings is illustrated in Figure 9.1. On the right-hand side of Figure 9.1, the line $\overline{MS}\bar{M}^*$ represents the budget constraint (equation (9.4)), showing combinations of the relative holdings of domestic currency (measured on the vertical axis) and foreign currency (measured on the horizontal axis). Both quantities are measured in domestic currency terms, and this is why the quantity of foreign currency holdings is multiplied by the exchange rate. The slope of the line $\overline{MS}\bar{M}^*$ is -1, which is the rate at which the two currencies are substituted. This line shows that if economic agents decide not to hold any foreign currency balances, the maximum amount of domestic currency they can hold is $\bar{M}$. Alternatively, if they decide not to hold any domestic currency balances, the maximum amount of foreign currency they can hold is $\overline{SM}^*$. On the left-hand side of Figure 9.1, the line $M/SM^*(W)$ represents equation (9.5), expressing the demand for domestic currency relative to foreign currency for a given level of real wealth. The line $M/SM^*(W)$ represents the negative relation between the quantity of

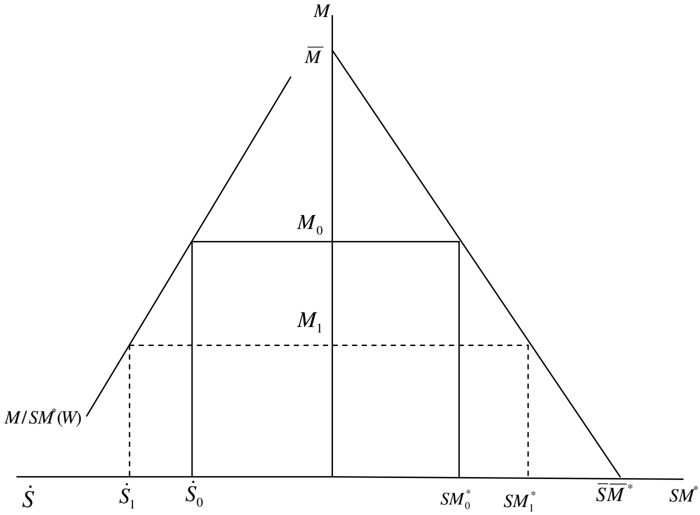

Figure 9.1. The relation between expected depreciation and currency holdings.

domestic currency held and the expected change in the exchange rate, $\dot{S}$ (measured on the horizontal axis). The slope of this line measures the sensitivity of domestic currency holdings with respect to the expected change in the exchange rate. If it is $\dot{S}_0$, the quantity of domestic currency held is M_0, while the quantity of foreign currency held is SM_0^*. When the expected change in the exchange rate rises from $\dot{S}_0$ to $\dot{S}_1$ (that is, the domestic currency is expected to depreciate even further), the quantity of domestic currency held will decline from M_0 to M_1, which means that the quantity of foreign currency held will rise from SM_0^* to SM_1^*.

The sensitivity of the holdings of domestic currency with respect to the expected change in the exchange rate determines the extent to which domestic currency holdings fall (foreign currency holdings rise) in response to a rise in the expected change in the exchange rate. Figure 9.2 shows cases of low sensitivity, as indicated by the slope of the money demand function $M/SM^*(W)_0$, and high sensitivity, as indicated by the slope of the money demand function $M/SM^*(W)_1$. When the expected change in the exchange rate rises from $\dot{S}_0$ to $\dot{S}_1$, the quantity of domestic currency holdings falls from M_0 to M_1 when sensitivity is low. When sensitivity is high, the quantity of domestic currency holdings falls by a larger amount, from M_0 to M_1'.

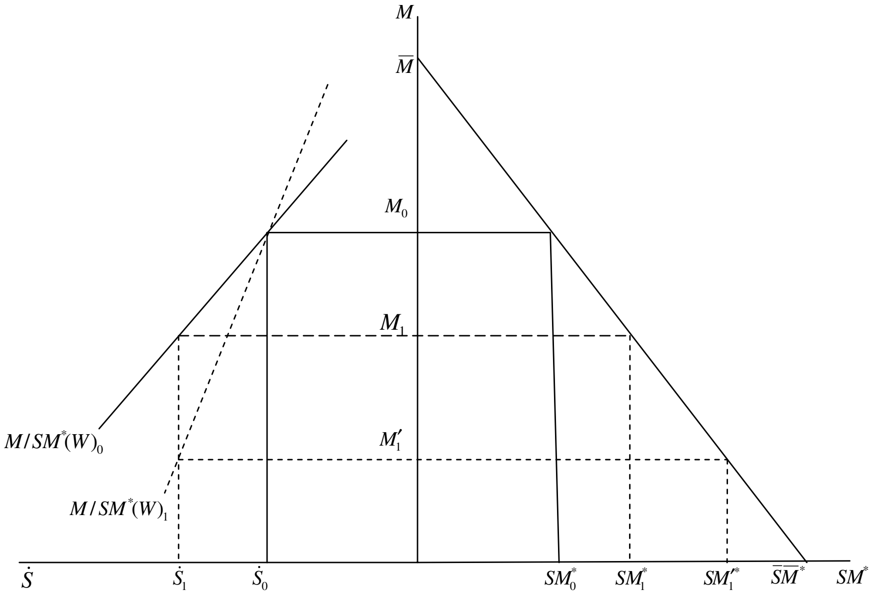

Figure 9.2. Exchange rate sensitivity of the holdings of domestic currency.

9.5. Exchange Rate Determination Under Currency Substitution

To capture the effect on the exchange rate of currency substitution, let us reconsider the currency substitution model represented by equations (9.1)–(9.4). In the absence of currency substitution, domestic and foreign monetary conditions are expected to be stable under flexible exchange rates. Consequently, standard domestic and foreign money demand functions will be stable and hence valid, in which case the demand for money in each country is typically expressed as a function of a scale variable (income or wealth) and a set of variables representing the opportunity cost of holding money. However, if foreign money is a substitute for domestic money, then it is not only the return on domestic money, but also the expected return on foreign money, that would become the appropriate opportunity cost of holding money. Assuming that no interest is paid on foreign money balances, the expected rate of return on foreign money would simply be equal to the expected depreciation of the domestic currency. If it is significant, the effect of currency substitution on the exchange rate can be embodied in the simple monetary model of exchange rates. To derive an exchange rate equation capturing currency substitution, we rewrite equations (9.1) and (9.2) by using real income instead of the real level of wealth as the scale variable and the interest rate as another opportunity cost of holding money. Hence we have

$$M = PY^{\alpha}\mathrm{e}^{-\beta i}\mathrm{e}^{-\gamma\Delta s^{\mathrm{e}}} \tag{9.7}$$

$$M^{*} = P^{*}Y^{*\alpha}\mathrm{e}^{-\beta i*}\mathrm{e}^{-\gamma\Delta s^{\mathrm{e}}}. \tag{9.8}$$

Taking the logarithms of equations (9.7), (9.8), and (9.3) and then combining them to solve for the exchange rate, we obtain

$$s = (m - m^{*}) - \alpha(y - y^{*}) + \beta(i - i^{*}) + 2\gamma\Delta s^{\mathrm{e}}. \tag{9.9}$$

As $i - i^{*} = \Delta p^{\mathrm{e}} - \Delta p^{*\mathrm{e}} = \Delta m^{\mathrm{e}} - \Delta m^{*\mathrm{e}}$, it follows that

$$s = (m - m^{*}) - \alpha(y - y^{*}) + (\beta + 2\gamma)(\Delta m^{\mathrm{e}} - \Delta m^{*\mathrm{e}}). \tag{9.10}$$

Equation (9.10) represents the simple monetary model that explicitly incorporates the phenomenon of currency substitution. It differs from the simple monetary model represented by equation (3.7) only in the sense that inflationary expectations resulting from expected monetary growth lead to currency substitution. If there is no currency substitution, then $\gamma = 0$, in which case equation (9.10) collapses to equation (3.7). If there is perfect substitutability between the two currencies, then $\gamma = \infty$, implying that the equilibrium exchange rate is indeterminate. If currency substitution is present, then $0 < \gamma < \infty$, which means that the exchange rate will be extremely volatile in response to changes in the expectations of monetary growth.

9.6. The Calvo–Rodriguez Overshooting Currency Substitution Model

The volatility of real exchange rates, which has been a striking development in the history of the current floating exchange rates, can be explained in terms of currency substitution, Calvo and Rodriguez (1977) developed the first model of exchange rate determination incorporating the features of full price flexibility, currency substitution, and rational expectations. In this model, the real exchange rate is shown to depend on monetary variables in the short run and on real variables in the long run. They analyze the case of a fully employed small open economy, with flexible prices and exchange rates, producing traded and non-traded goods and in which residents are assumed to hold foreign exchange besides their own currency to account for the overshooting of the real exchange rate.[6] The key building blocks of this model are the specification of the markets for assets and goods. Before we describe the specification of these markets and describe the formal structure of the currency substitution model, it is necessary to give a brief account of the main assumptions underlying this model.

9.6.1. *Assumptions of the Model*

The Calvo–Rodriguez currency substitution model is based on the following assumptions:

Assumption 1

The home country is a fully employed small open economy in which residents hold portfolios of domestic and foreign currencies.

Assumption 2

The economy produces traded and non-traded goods. For a given state of technology and factor endowments, the rates of production of the two types of goods depend on their relative prices. The relative price that is relevant for production in the home country is the ratio of domestic prices of traded goods to domestic prices of non-traded goods ($P_\mathrm{T}/P_\mathrm{N}$).

Assumption 3

The domestic price of traded goods (P_T) is linked to the corresponding foreign price (P^*_T) through international commodity arbitrage, so that $P_\mathrm{T} = SP^*_\mathrm{T}$. The small country is assumed to face a given foreign price for traded goods, which is normalized to unity (that is, $P^*_\mathrm{T} = 1$) to obtain $S = P_\mathrm{T}$. Thus, the relative price that governs the allocation of productive resources can be expressed in terms of the real exchange rate (Q), which is defined as

$$Q = S(P_\mathrm{T}/P_\mathrm{N}) = S/P_\mathrm{N}. \tag{9.11}$$

It also follows that the domestic price of traded goods is equal to the exchange rate ($S = P_\mathrm{T}$).

[6]For a detailed discussion see Frenkel and Rodriguez (1982, pp. 17–28).

Assumption 4

Asset holders are assumed to hold portfolios of domestic money (M) and foreign money (F). Therefore, portfolio choice is restricted to two assets: non-interest bearing currencies issued by the domestic and foreign monetary authorities. If W is the value of financial assets or wealth held by economic agents in terms of the same currency (that is, the level of wealth in terms of foreign currency), we have

$$W = M/S + F \tag{9.12}$$

or

$$W = M' + F \tag{9.13}$$

where $M' = M/S$ is the foreign currency value of the fraction of wealth held in domestic currency terms and F is the fraction of wealth held in foreign currency terms.

Assumption 5

Agents form rational expectations about expected changes in exchange rates. The assumption of rational expectations (which here amounts to perfect foresight) means that the expected rate of change in the exchange rate is equal to the actual rate, which gives $(S^e/S) - 1 = \dot{S}$.

9.6.2. *The Asset Market*

The specification of the portfolio equilibrium relation for the relative demand for money (the currency substitution function) is the crux of the currency substitution model. The desired ratio of domestic to foreign money holdings is assumed to depend on the expected percentage change in the exchange rate, which measures the expected difference between the real rates of return on domestic and foreign assets. This portfolio balance relation between the relative demand for money and expected change in the exchange rate can be expressed as

$$\frac{M'}{F} = L(\dot{S}) \tag{9.14}$$

where $L_{\dot{S}} < 0$. Equation (9.14) shows that the desired ratio of domestic money to foreign money declines when the domestic currency is expected to depreciate. It is useful to look at the inverse of equation (9.14).

If the ratio M'/S is a function (L) of $\dot{S}$, the reverse must be equally true: $\dot{S}$ must depend on the desired ratio of domestic money to foreign money. Solving for $\dot{S}$, equation (9.14) can be written as

$$\dot{S} = \ell\left(\frac{M'}{F}\right) \tag{9.15}$$

where $\ell_{M'/F} < 0$. Equation (9.15), which is simply the inverse of equation (9.14), shows that for the money market to clear, the expected change in the exchange rate must rise when the ratio of domestic to foreign currency falls. It follows that higher expected changes in the exchange rate are associated with lower values of M'/S, and vice versa.

9.6.3. *The Goods Market*

The fully employed small open economy produces two types of goods, traded and non-traded goods. For a given state of technology and factor endowment, the rates of production of traded and non-traded goods depend on their relative prices. Under competitive conditions, the economy produces more traded goods than non-traded goods, hence transferring its productive resources from the non-traded goods sector to the traded goods sector, provided that prices in the former are higher than those in the latter. Thus, the ratio of the prices of traded to non-traded goods governs the allocation of productive resources and hence the level of production of traded and non-traded goods at which the markets for traded and non-traded goods are in equilibrium. At this point, domestic prices of traded goods tend to be equal to the exchange rate adjusted for the foreign prices of traded goods (that is, $P_{\mathrm{T}} = SP_{\mathrm{T}}^{*}$, and $P_{\mathrm{T}}^{*} = 1$). This means that the relative price, or the ratio of the price of traded to non-traded goods $(P_{\mathrm{T}}/P_{\mathrm{N}})$, is equal to S/P_{N} or the real exchange rate $(Q = S/P_{\mathrm{N}})$.

It follows that the higher the real exchange rate, the greater the supply of traded goods and the lower the supply of non-traded goods. The demand for traded and non-traded goods by consumers in the home country depends on the real exchange rate and the value of assets held by domestic residents. The demand for traded goods is inversely related to the real exchange rate and positively related to the value of assets held by domestic residents. The demand for non-traded goods is positively related to the real exchange rate and negatively related to the value of assets.

At each point in time, the stock of domestic holdings of foreign assets (F) is given and the assumption that the small country's currency is not held by foreigners ensures that F cannot be adjusted instantaneously. Asset holders can, however, alter the stock of foreign assets gradually by running a surplus or deficit in the trade balance. Thus, the market for traded goods is in equilibrium only in the long run. In the short run, the excess supply of traded goods ($X_{\mathrm{T}}^{\mathrm{ES}}$) is equal to the surplus in the current account of the balance of payments or equivalently an accumulation of foreign currency stocks. Hence,

$$X_{\mathrm{T}}^{\mathrm{ES}} = H(Q, W) = \dot{F} \tag{9.16}$$

where $H_Q > 0$, $H_W < 0$, and $\dot{F} = \mathrm{d}F/\mathrm{d}t$ denotes the rate of change of F. Equation (9.16) implies that a rise in the real exchange rate leads to an increase in the supply of traded goods and reduces the supply of non-traded goods. To restore equilibrium in the markets for traded goods and non-traded goods, the stock of foreign currency and the level of wealth must rise via a surplus in the trade balance.

The market for non-traded goods is assumed to be in equilibrium at all times, which requires the rate of domestic production to be always equal to domestic demand, so that the excess supply of non-traded goods is always zero:

$$X_{\mathrm{N}}^{\mathrm{ES}} = J(Q, W) = 0 \tag{9.17}$$

where $J_Q < 0$ and $J_W < 0$. Equation (9.17) implies that there is a specific relation between the real exchange rate and the value of assets that is consistent with equilibrium in the market for non-traded goods. An increase in the value of assets must be accompanied by a decline in the real exchange rate, as the former creates excess demand for non-traded goods while the latter reduces excess supply. This relation can be written as

$$Q = Q(W) \tag{9.18}$$

where $Q_W < 0$. As prices are flexible, equation (9.18) must hold at all times. Substitution of equation (9.18) into equation (9.16) yields a relation between the rate of change of F and the value of assets, which is

$$\dot{F} = F(W) \tag{9.19}$$

where $F_W \equiv (H_Q Q_W - H_W) < 0$. Equation (9.19) shows that the value of assets (wealth) held by economic agents in a country is uniquely related to the equilibrium real exchange rate (and consequently to the rate of excess supply of traded goods and to the rate of accumulation of foreign currency stocks). Therefore, knowledge of the time path of assets is necessary for determining the time path of these variables.

Changes in asset holdings arise from changes in the domestic and foreign asset components of the portfolio. By differentiating equation (9.13), we obtain

$$\dot{W} = \dot{M}' + \dot{F}. \tag{9.20}$$

As $M' = M/S$, it follows that $\dot{M}' = \dot{M}(\mu + \dot{S})$, where μ is the percentage change in the nominal money supply (that is, $\mu = \dot{M}/M$). As $M' = W - F$, the change in M' can be written as

$$\dot{M}' = (W - F)(\mu - \dot{S}). \tag{9.21}$$

By substituting equation (9.18) into equations (9.15), (9.19), and (9.21), we can rewrite equation (9.20) as

$$\dot{W} = (W - F)\left\{\mu - \ell\left(\frac{W - F}{F}\right)\right\} + F(W). \tag{9.22}$$

Equations (9.19) and (9.22) characterize the dynamics of the system. In the steady state $\dot{F} = \dot{W} = 0$ and $F(W) = 0$ in equation (9.19), and $\mu = \dot{S}$ in equation (9.22). The steady-state values of W and F are denoted $\bar{W}$ and $\bar{F}$, and by using equation (9.18) the implied steady-state real exchange rate is $\bar{Q}$. It is also noteworthy that the system satisfies the homogeneity postulate, implying that a once-and-for-all rise in the nominal quantity of money results in an instantaneous proportional rise in the money price of non-traded goods and in the nominal exchange rate (and thereby in the money price of traded goods). These changes leave all real variables (including the real exchange rate) unchanged.

The currency substitution model postulates that in an economy with a market for non-traded goods that clears at all times, long-run equilibrium is reached when the value of wealth and the real exchange rate clear the market for traded goods, thereby bringing the current account into balance and keeping the stock of foreign assets constant. On the other hand, short-run equilibrium requires only that wealth and the real exchange rate clears the market for non-traded goods as well as the money market. The current account surplus or deficit changes the foreign money stock as the economy adjusts.

9.6.4. *A Diagrammatic Illustration of the Currency Substitution Model*

The working of the currency substitution model can be illustrated with the aid of Figure 9.3. In the left panel, the schedules *TT* and *NT* describe combinations of wealth (W) and real exchange rate (Q) that satisfy equations (9.16) and (9.17), which define the equilibrium conditions in the markets for traded and non-traded goods, respectively. The *TT* schedule is positively sloped, whereas the *NT* schedule is negatively sloped. The market for traded goods is not always in equilibrium, which means that the economy is not always to be found on the *TT* schedule. Points on the *TT* schedule are associated with zero balance on the current account, obtained only in the long run for a given stock of foreign currency.

What happens to the steady-state equilibrium when the economy is not on the *TT* schedule? Suppose that the economy is found at a point (say B) above and to the right of the *TT* schedule. If the real exchange rate is $\bar{Q}_0$, this implies a level of wealth (W_1) that is too high to be consistent with equilibrium in the traded goods sector. This, in turn, implies that the demand for traded goods is in excess of supply (meaning a current account deficit) with a consequent tendency for a fall in the stock of foreign currency.

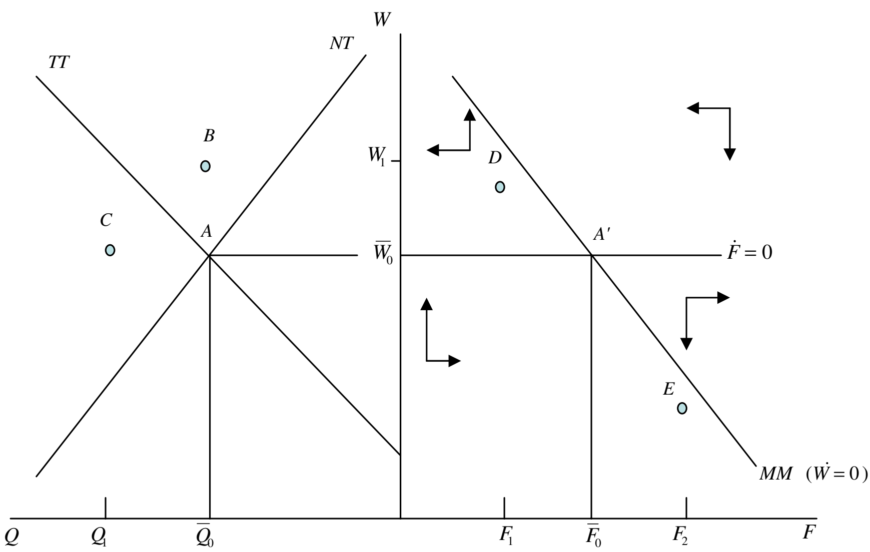

Figure 9.3. Long-run equilibrium in the currency substitution model.

Similarly, if the economy is found at point C below and to the left of the TT schedule, then (for a given level of wealth, $\bar{W}_0$) the real exchange rate (Q_1) is too high to be consistent with equilibrium in the traded goods sector. This in turn implies that the supply of traded goods is in excess of demand, and hence there is a current account surplus with a rising stock of foreign money.

The market for non-traded goods is assumed to clear at all times, which means that the economy must always be somewhere on the NT schedule. Therefore, at any point below and to the right of the NT schedule, the level of wealth is higher than the level that is consistent with equilibrium in the market for non-traded goods. This, in turn, must imply relatively high demand for non-traded goods. Other things being equal, high demand for non-traded goods must be offset by a high relative price in the market for non-traded goods (Q) to restrain demand and stimulate supply. On the other hand, when wealth is low, so is consumption, excess supply can only be prevented by a high relative price in the other sector (that is, a high value of Q).

In the right panel in Figure 9.3, the $\dot{F} = 0$ and $MM(\dot{W} = 0)$ schedules describe combinations of wealth and foreign currency holdings that satisfy equations (9.19) and (9.22), respectively. The $\dot{F} = 0$ schedule divides the space into two halves. At any point above this schedule (say D) a country's wealth is greater than its equilibrium level, hence it experiences a current account deficit and outflow of foreign exchange that is equal to $F_1\bar{F}_0$. Alternatively, at any point below this schedule (say E), wealth is lower than its equilibrium level, hence it experiences a current account surplus and adds to its stock of foreign currency the amount $\bar{F}_0F_2$. Notice that the $\dot{F} = 0$ schedule is flat because the volume of foreign currency balances at any point has no direct bearing on equilibrium in the market for traded goods.

The $MM(\dot{W} = 0)$ schedule has a negative slope. It is drawn on the assumption that (around the steady state) $\partial\dot{W}/\partial W < 0$. As it is evident, the system exhibits a saddle-path stability, where the motion of the variables is described by the arrows implied by the signs of the partial derivatives of equations (9.19) and (9.22) around the steady state. If $\partial\dot{W}/\partial W > 0$, then the $MM(\dot{W} = 0)$ schedule is positively sloped and is steeper than the saddle path. Along the perfect foresight path (which is a unique path that converges on the steady state and satisfies the laws of motion and initial conditions), a higher value of F is associated with a higher value of W.

Initially, the economy is in a steady-state position at points A and A' where $\bar{F}_0$, $\bar{W}_0$, and $\bar{Q}_0$ are the initial equilibrium values of foreign currency holdings, total assets, and the real exchange rate, respectively. The markets for traded and non-traded goods are in equilibrium at point A, where TT and NT cross and the unique combination of wealth and the real exchange rate $(\bar{Q}_0, \bar{W}_0)$ is compatible with equilibrium in both markets. In the right panel in Figure 9.3, the $MM(\dot{W} = 0)$ schedule crosses the horizontal $\dot{F} = 0$ schedule at A', where long-run equilibrium is reached with the static level of wealth $\bar{W}_0$ and a foreign currency money stock of $\bar{F}_0$.

Consider now the effect on the real exchange rate of a monetary expansion in a world of flexible prices and exchange rates under currency substitution. As shown in Figure 9.4, the economy is initially in a steady-state (long-run) equilibrium at point A, with $\bar{F}_0$, $\bar{W}_0$, and $\bar{Q}_0$ as the initial steady-state equilibrium values of foreign currency holdings, wealth, and the real exchange rate, respectively. A rise in the money supply pushes the $MM(\dot{W} = 0)$ curve out from $MM_0(\dot{W} = 0)$ to $MM_1(\dot{W} = 0)$, establishing a new steady-state equilibrium at point C in the panel on the right in Figure 9.4. As μ does not appear in equations (9.16) or (9.17), monetary expansion has no direct effect on either of the product markets, and thus the TT and NT schedules do not move or shift in either direction. At point C, wealth is constant and back to its pre-disturbance level $(\bar{W}_0)$ to ensure that $\dot{F} = 0$. Similarly, the real exchange rate is back to its original steady-state equilibrium level $(\bar{Q}_0)$. Once the dust has settled, the only change is that the proportion

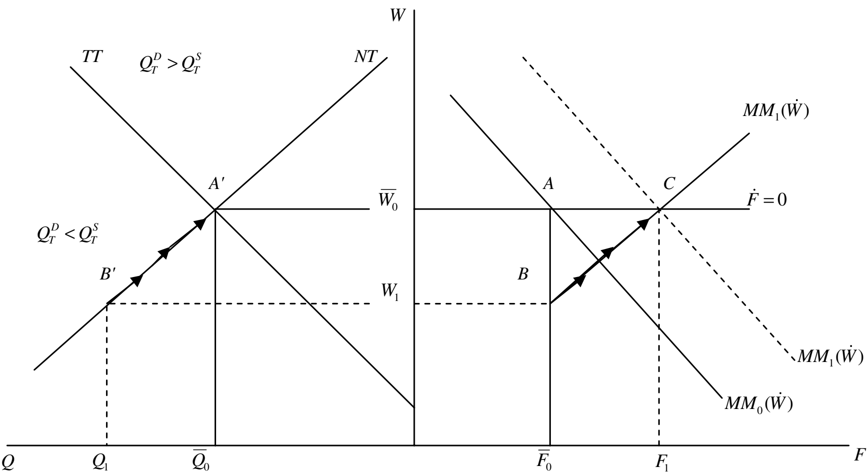

Figure 9.4. Exchange rate dynamics in the currency substitution model.

of wealth held in foreign currency terms rises at the expense of the domestic currency. Hence, the monetary expansion leads in the long run to a higher opportunity cost of holding domestic money, and consequently to a rise in the share of foreign relative to domestic currency in the total asset portfolio.

The mechanism of how the monetary expansion causes only foreign currency holdings to rise is illustrated in Figure 9.4. Under perfect foresight, as soon as a certain percentage expansion in the money supply is announced, economic agents perceive the opportunity cost of holding domestic money to rise proportionally, with a consequent fall in the desired ratio of M'/F. As the stock of domestic holdings of foreign currency cannot change instantaneously, the level of wealth falls from $\bar{W}_0$ to W_1. This decline in wealth is inevitable, as the rise in the expected relative cost of holding domestic currency reduces the desired ratio of domestic to foreign currencies, which (given the initial value of foreign currency holdings, $\bar{F}_0$) can be brought about only by a decline in $M' = M/S$, and thus in W. As the initial nominal stock of domestic money (M, at point A) is given, the decline in $M' = M/S$ is brought about by a rise in the nominal exchange rate, S. As the real exchange rate is the ratio of the nominal exchange rate (S) to the price of non-traded goods (P_N), it follows that $\dot{S} > \dot{P}_N$. If the aggregate price level is a weighted average of S and P_N, it follows that the exchange rate changes by more than the overall price level. This is what is known as the overshooting phenomenon in the Calvo–Rodriguez (1977) model.

In the short run, the economy must move from A to B, with a fall in wealth from $\bar{W}_0$ to W_1 and an increase in the real exchange rate from $\bar{Q}_0$ to Q_1. This is because point B represents the only position of short-run equilibrium that is consistent with the perfect foresight path that converges on the new steady-state equilibrium at point C. As the level of wealth falls from $\bar{W}_0$ to W_1, the real exchange rate must rise from $\bar{Q}_0$ to Q_1, leading to real exchange rate overshooting relative to the value determined by long-run equilibrium (that is, $Q_1 > \bar{Q}_0$).

However, the economy cannot settle at B, because it must move to C in the long run. The transition to long-run equilibrium at C (along a path like the one marked with arrows in Figure 9.4) is characterized by a falling real exchange rate, so that the overshooting pattern is reversed, at a rate of currency depreciation that is less than the rate of inflation in the non-traded goods sector. At B'on the NT schedule in the left panel, the combination of a relatively high price of traded goods (Q_1) and low wealth (W_1) leads to a current account surplus. It follows that, in the aftermath of the monetary expansion (and consequent currency depreciation), the economy gains foreign exchange and the level of wealth begins to recover from its initial fall.

Liviatan (1981) re-examines the relation between monetary expansion and real exchange rate dynamics within the framework of utility-maximizing behavior and long-run perfect foresight, using an approach that is similar to that of Sidrauski (1967). It is shown that a central property of the Calvo–Rodriguez model (namely, long-run constancy of total assets) no longer holds. As a result, the impact effect of μ tends to result (under our assumptions) in real appreciation rather than real depreciation of the domestic currency. In contrast, Calvo (1985) re-examined the currency substitution hypothesis with rational expectations in terms of the Sidrauski-type model (where domestic and foreign money enter the utility function) and derived results that did not contradict Calvo and Rodriguez (1977).

9.7. The Importance of Currency Substitution in a Regional Setting

The phenomenon of currency substitution is more important in a regional setting where there is a relatively high degree of cross-border mobility of resources. For example, the introduction of the euro by the European Monetary System in Western Europe may provide evidence of a high degree of currency substitution among European currencies. Many economists tested the proposition of a high degree of substitution among European currencies and found supportive evidence that was interpreted as indicating pressure on and interest among European countries for the establishment of the European Monetary Union. For example, Girton and Roper (1981) argued that "in the presence of a high degree of currency substitution monetary unification is inevitable." Melvin (1985) could not reject the currency substitution hypothesis for European countries and found evidence indicating that it is consistent with the presence of significant currency substitution in Europe, which would contribute to exchange rate volatility. He concluded that "the evidence presented in the last section suggests that the move toward European Monetary Union may be more a result of currency substitution pressures via volatile foreign exchange markets than a desire to hasten economic and/or political integration." He further argued that the empirical results of his study suggest that "currency substitution cannot be ruled out as having contributed to the volatility of European exchange markets during the period of floating exchange rates." He suggested that the criticism that exchange rates are "too volatile" under floating exchange rates seem to be a relevant critique in a region like Europe.

9.8. Some Policy and Analytical Issues Related to Currency Substitution

There are many policy and analytical issues related to currency substitution in developing countries, but there are no clear-cut answers to most of the underlying questions. The issues that are examined here are the most relevant for currency substitution in developing countries, including the following[7]:

- Whether or not currency substitution should be encouraged.
- How the presence of currency substitution affects the choice of nominal anchors in inflation stabilization programs.
- The effects on the real exchange rate of changes in the rate of monetary expansion in a world of flexible prices and exchange rates under currency substitution.
- Interaction between inflationary finance and currency substitution.
- The empirical verification of the currency substitution hypothesis.

9.8.1. *Should Currency Substitution be Encouraged?*

There is no consensus on the issue of whether or not currency substitution should be encouraged. Some economists argue that every effort should be made to induce the use of the domestic currency (by raising interest rates on domestic assets), while others make a case for a full dollarization of the economy (that is, adopting the U.S. dollar as the only legal tender, as in Panama). The reasons for the desire to discourage the use of foreign currencies are not clear. The case for encouraging the use of foreign currencies is even less clear, mainly due to the inflationary consequences of a higher degree of currency substitution. The extreme measure of a fully dollarized economy may put unnecessary constraints on the economy and render the banking system more vulnerable.

Full dollarization is the type of solution that has often been proposed after the failure of price stabilization programs in several Latin American

[7] For a detailed discussion, see Calvo and Vegh (1992).

countries such as Mexico, Bolivia, Peru, and Panama. It is expected to help stop inflation by withdrawing power from the central bank to produce high-powered money. In fact, a fully dollarized economy should, in principle, inherit the inflation rate of the country whose currency has been adopted (the U.S.). Moreover, supporters of full dollarization point to the cases of Panama and Liberia, where such a system appears to have worked reasonably well. Cukierman *et al.* (1992) argued that the advantage of a fully dollarized economy over a fixed exchange rate is that the former should be more credible because it represents a higher degree of commitment. It is also argued that the use of foreign money should provide the government with more discipline. Thus, a government that cannot resort to inflationary finance will be constrained to "put its house in order" rather than to find alternative sources of finance (like domestic debt).[8]

Full dollarization may be criticized on several grounds. First, there is no guarantee that the system will not be discontinued in the future. As observed in case of Liberia, political instability may lead to a liquidity shortage, which (coupled with increasing fiscal deficits) may induce the government to print massively. Second, Fischer (1982) suggested that a war could also result in a swift return to the use of the domestic currency to free up foreign exchange reserves (circulating as a means of payment) to finance additional government expenditure. Third, as argued by Cukierman *et al.* (1992), a large external shock could force the government to renege on its commitment to restore the use of the exchange rate as a policy instrument. Thus, it would be naïve to expect that full dollarization would result in a quick equalization of prices and interest rates with the rest of the world, as the credibility problem is not likely to go away immediately. A traditional argument against full dollarization is that the government gives up revenues from the inflation tax. For example, Fischer (1982) shows that there are many countries in which seigniorage constitutes over 10% of total revenue. If the government is acting optimally, replacing the revenue from inflation by conventional taxes would lead to welfare losses. Perhaps, a more fundamental criticism of full dollarization is that unless domestic banks are also fully integrated with the Federal Reserve, the system will be forced to operate without a "lender of last resort." Optimists may actually argue that this is all for the better because the lack of a lender of last resort will impose a more strict discipline on the domestic banking system.

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[8]See Frenkel (1982) for a discussion of the "discipline" argument in the context of the fixed versus flexible exchange rates debate.

9.8.2. *Discouraging the Use of Foreign Currencies*

The policy of discouraging the use of foreign currencies is typically supported by governments that rely heavily on the revenues generated by money creation. Tanzi and Blejer (1982) argue that currency substitution is undesirable because it reduces monetary independence and may thus endanger the ability of policymakers to implement stabilization programs. However, Rostowski (1992) points out that discouraging the use of foreign currencies could be counterproductive because it deprives the economy of any attractive means of payment. This, in turn, reduces total liquidity in the system, leading to a negative impact on domestic trade, thereby increasing the inflationary impact of fiscal disequilibria and impoverishing the economy.

One way to boost the demand for domestic money, which has gained popularity in Latin America and several industrialized countries since the mid-1970s, is to offer higher interest rates on bank deposits. But this is an artificial method of discouraging the use of foreign currency because higher domestic interest rates will magnify the eventual inflationary explosion.[9]

Another extreme way of de-dollarizing the economy, which has been observed in several Latin American countries (Bolivia and Mexico in 1982 and Peru in 1985), is the forced conversion of the stock of foreign currency deposits in the domestic financial system into domestic currency. In all three cases, forced conversion was accompanied by a large nominal devaluation and the subsequent adoption of a fixed exchange rate. Forced de-dollarization often has opposite effects to those intended by the authorities. As argued by Melvin and Fenske (1992), the Bolivian 1982 "official de-dollarization" was supposed to reduce the demand for dollar and widen the base for the inflation tax. Instead, it seems to have stimulated capital flight and simply has driven the dollarized economy underground.

9.8.3. *Currency Substitution and Nominal Anchors*

The conventional wisdom on currency substitution and nominal anchors appears to be that if there are substantial holdings of foreign currency in

[9]Dornbusch and Reynoso (1989) were skeptical of high interest rates as a substitute for fiscal correction. Based on the Brazilian case, they argue that the steady accumulation of public debt that pays high interest rates leads to a situation in which the entire debt is matched by interest-bearing, checkable deposits. Eventually the government will be unable to roll over its debt, and a funding crisis will arise.

circulation, fixed exchange rates provide a more effective nominal anchor. If exchange rates are allowed to vary, the monetary authorities would not be able to control the money supply (inclusive of foreign exchange) in terms of the domestic currency. If the exchange rate between two monies is fixed, these two monies become perfect substitutes as their risk characteristics are similar. Girton and Roper (1981) argue that in cases where currency substitutability is imperfect, it is far from obvious that under flexible exchange rates the system is left without a nominal anchor. Calvo and Vegh (1990) argue that currency substitution is important because it plays a key role in determining the magnitude of the recession that results from money-based stabilization. Specifically, a reduction in the growth rate of money causes the nominal interest rate to fall, which induces substitution away from foreign money and toward domestic money. This switch provokes a recession because, under sticky prices, the real domestic money supply cannot increase, which means that output must fall to restore equilibrium in the money market. The higher the elasticity of currency substitution, the larger will be the shift to domestic money, and the more severe will be the recession.

Rostowski (1992) takes the opposite view that currency substitution may actually reduce the severity of the initial recession associated with money-based stabilization. In the presence of the costs of switching from one currency to another, the initial fall in nominal interest rates induces little substitution as the public assesses the cost of switching from the foreign to the domestic currency against the net discounted value of the inflation tax. So, this channel is expected to play a role in the first stage of a stabilization program. Moreover, since the pre-stabilization level of liquidity in the economy is higher than that in the absence of currency substitution, the "liquidity crunch" associated with the implementation of the stabilization plan will be less severe.

In the case of exchange rate-based stabilization programs, the domestic money supply adjusts endogenously (if capital is perfectly mobile), which means that the above considerations that lead to a recession in money-based stabilization are rendered irrelevant. However, it is argued by Calvo and Vegh (1990) that if stabilization is fully credible, the presence of currency substitution will result in a wealth effect as the public gets rid of the foreign currency, reducing seigniorage payments to the foreign government. This wealth effect causes a permanent increase in consumption. If stabilization is not fully credible (in the sense that the public perceives it as being temporary), the presence of currency substitution does not alter qualitatively the result that the fall in nominal interest rates causes an initial consumption boom. As inflation remains high (due to lack of credibility), real currency appreciation causes a recession eventually.

In money-based stabilization programs, expectations play a bigger role in exchange rate determination in the presence of currency substitution. Specifically, the higher the elasticity of substitution, the larger the shift from domestic to foreign currency as a result of the fall in expected inflation, and thus the higher the fall in the nominal exchange rate. Thus, a high degree of substitution (measured by the elasticity of substitution between the two currencies) makes the exchange rate significantly volatile and responsive to credibility issues. Therefore, a high degree of currency substitution strengthens the case for fixed exchange rates, particularly if an early deceleration of inflation contributes significantly to the credibility of the stabilization program.

9.8.4. *Monetary Expansion and the Real Exchange Rate*

The issue of how monetary growth affects the real exchange rate under currency substitution in a world of flexible prices and exchange rates is important from the perspectives of both theory and policy. It is an important policy issue, given price stabilization programs in countries like Brazil and Peru. It is also an important theoretical issue. The early literature on currency substitution (contributed, among others, by Kouri, 1976; Calvo and Rodriguez, 1977; Calvo, 1985) focused on floating exchange rates. Kouri (1976) and Calvo and Rodriguez (1977) combined the monetary approach and the rational expectations hypothesis to examine the effect of monetary expansion on the real exchange rate under currency substitution. What motivated, the Calvo–Rodriguez exchange rate model under currency substitution and rational expectations was the Argentinean experience of 1975 when a significant rise in the monetary growth rate was accompanied by strong real depreciation (measured in terms of the black market exchange rate).

A simple monetary model with perfectly flexible prices and without capital mobility, for example, could not explain the Argentinean episode. This is because the simple model assumes that a once-and-for-all increase in the monetary expansion rate leads to a once-and-for-all adjustment in prices and exchange rates with no change in relative prices (even in the presence of non-traded goods). In the Calvo–Rodriguez model, currency substitution is identified as a natural "missing" ingredient that makes the simple monetary model compatible with the facts. This is because the currency substitution hypothesis is compatible with (i) some degree of capital mobility, a case that started to gain popularity in international finance theory due to the emergence of "petrodollars" and (ii) the fact that, in Argentina as in many other inflation-prone countries, individuals appear to hold substantial amounts of foreign currency for transaction purposes. A key assumption of the Calvo–Rodriguez model is that foreign currency is the only internationally traded asset, which means that the only channel for the economy to alter its stock of foreign currency is through the current account. A higher monetary growth rate boosts the steady-state demand for foreign money relative to domestic money. The accumulation of foreign currency can only be brought about by a current account surplus, which requires real currency depreciation.

Liviatan (1981) employed a utility maximizing framework (including both domestic and foreign money in the utility function) to re-examine the issue and turned the Calvo–Rodriguez (1977) result on its head. He found that a permanent increase in the rate of monetary expansion gave rise to transitory real currency appreciation and deterioration in the balance of payments. Livitian argued that the key difference between his result and that of Calvo and Rodriguez pertains to the response of the steady-state level of total assets to a permanent increase in the monetary growth rate. While steady-state total assets remain constant in the Calvo–Rodriguez model, they decline in Liviatan's model. Calvo (1985) provided a more general analysis, which included Liviatan's model as a special case. He argued that whether or not the Calvo–Rodriguez result is obtained depends critically on the magnitude of the elasticity of substitution between consumption and liquidity services relative to the elasticity of substitution between the two currencies in the production of liquidity services. Depending upon the parameter configuration, the real exchange rate may rise or fall as a result of a rise in the growth rate of the money supply (see, for example, Bufman and Leiderman, 1992, 1993).

9.8.5. *Inflationary Finance under Currency Substitution*

The presence of currency substitution has important implications for inflationary finance. Keynes (1923, p. 41) argues that one of the ways in which the public can protect itself from the inflation tax is by using "foreign money in many transactions where it would have been more natural and convenient to use their own." Even if the government imposes foreign exchange controls to prevent a flight from the currency, the public manages to circumvent these controls and resorts to foreign currency to satisfy most of their needs.

Sargent (1982, p. 82) reports that in the latter stages of hyperinflation, the Germans made every effort to hold large quantities of foreign currencies (instead of marks) for the purpose of conducting transactions. By October 1923 (according to his rough estimates), the real value of foreign currencies circulating in Germany was at least equal to and perhaps several times the real value of Reichsbank (the central bank of Germany from 1876 until 1945) notes in circulation.

There are two main approaches to studying inflationary finance under currency substitution. The first approach considers monetary financing as given and analyzes how currency substitution affects the level and variability of the inflation tax, as well as the level of seigniorage. The second approach follows public finance principles, viewing the inflation tax as resulting from an optimal choice among various distorting taxes. The main issue is thus how currency substitution affects the optimality of resorting to the inflation tax.

The Level and Variability of the Inflation Tax

An important point is that currency substitution affects both the level and variability of the inflation tax. The extent to which currency substitution affects inflation depends on the elasticity of the demand for real domestic money. In the presence of currency substitution, the more elastic the demand for real domestic money, the higher will be the inflation rate that results from any given budget deficit.[10] In the context of Cagan's (1956) model, the higher elasticity of money demand in the presence of currency substitution implies that the revenue-maximizing inflation rate is lower than what materializes in the absence of currency substitution (see Khan and Ramirez-Rojas, 1986). Thus, this model predicts that the government will be able to collect less seigniorage if a foreign currency also provides liquidity services. Assessing the quantitative relation between currency substitution and seigniorage for Israel (using quarterly data over the period 1978–88), Bufman and Leiderman (1992) reached two conclusions. First, at low inflation rates the ratio of seigniorage to GDP increases as inflation rises. Second, small changes in the liquidity properties of the foreign currency relative to the domestic currency have a substantial impact on the ratio of seigniorage to GDP.

McNelis and Asilis (1992) argue that currency substitution may not only lead to higher inflation, for a given budget deficit, but also to more volatile

[10]For an earlier discussion see Nichols (1974).

inflation. Using the simulations of a model in which small increases in currency substitution cause the inflation process to become unstable, they show that even deficits that are not large may lead to increasing inflationary instability. They also show that the inflation variability predicted by the model is consistent with that observed in Argentina, Bolivia, Mexico, and Peru.

Rojas-Suarez (1992) also emphasizes the effects of currency substitution on the dynamics of inflation in the case of Peru. In particular, she examines the role of currency substitution as the mechanism through which fiscal and monetary policies affect inflation. She argues that as the public switches from domestic to foreign currency holdings, the inflationary consequences of a given budget deficit are aggravated. Moreover, this mechanism becomes more important as inflation accelerates, as the public adjusts its money portfolio quickly.

The process of switching from domestic to foreign money may not be without costs when inflation rises. As suggested by Sturzenegger (1992), it may have an important bearing on the income distribution aspects of inflationary finance. Casual evidence suggests that high-income consumers can protect themselves from inflationary taxation in a better way by resorting to a more efficient transactions technology than low-income consumers. To capture this phenomenon, Sturzenegger assumes that there is a fixed cost of switching from the domestic currency to the foreign currency. As a result, only high-income consumers find it optimal to switch to the foreign currency, and hence they bear a lower inflation tax than low-income consumers.

The Public Finance Approach

The public finance approach to studying the effects of currency substitution on inflationary finance was pioneered by Phelps (1973). In this approach, the government is assumed to choose, in an optimal way, commodity (or income) taxes and the inflation tax to finance an exogenously given level of government spending. Hercowitz and Sadka (1987) consider the issue of whether or not it is optimal for policymakers to impose restrictions on the use of foreign exchange that would allow them to resort to the inflation tax. In the absence of restrictions on currency conversion and the presence of a positive inflation rate, consumers would hold foreign exchange only and convert it into the domestic currency just before carrying out their transactions. As it is costless to collect the income tax when the inflation tax generates a waste of resources (associated with having to impose currency conversion costs), Hercowitz and Sadka (1987) conclude that the optimal inflation tax is zero. The key assumption behind this result is that the foreign currency cannot act as a medium of exchange. Once the medium of exchange property of a currency is considered as the defining characteristic of currency substitution, it follows that this analysis fails to capture this phenomenon. Vegh (1989a) models explicitly the medium of exchange property of foreign currency, assuming that its use reduces transaction costs, thereby acting as an (imperfect) substitute for the domestic currency. It is assumed that the government resorts to consumption tax in addition to the inflation tax. In this context, it can be shown that if the foreign nominal interest rate is positive, then it is optimal to impose a positive inflation tax.

A somewhat unappealing feature of Vegh's (1989a) model is that the optimal inflation tax does not depend on government spending. This seems to be inconsistent with the stylized facts. Vegh (1989b) shows that when the government resorts to income tax, rather than a consumption tax (in addition to depending on the foreign nominal interest rate), the optimal inflation tax also depends on government spending. He also shows that the higher the degree of currency substitution, the higher is the optimal inflation tax for a given level of government spending and the foreign nominal interest rate. However, Kimbrough (1991) reaches conclusions that are opposite to those of Vegh (1989a,b). In a model in which foreign money is used to buy imported goods and domestic money is used to buy non-traded goods, he concludes that the optimal inflation tax is zero.

9.9. Recapitulation

Currency substitution is the tendency of individuals and firms to hold diversified currency portfolios under the assumption that domestic and foreign currencies are close substitutes. A foreign currency is held along with, or instead of, the domestic currency when the domestic currency cannot perform one or more of the basic functions of money: medium of exchange, unit of account, and store of value.

There are two important implications of currency substitution. First, it has been demonstrated that if the domestic and foreign currencies are close substitutes from the perspective of money demanders, the ability of countries to conduct monetary policies independently will be weakened or even eliminated, even under flexible exchange rates. Under currency substitution, changes in foreign interest rates or the expected exchange rate make the domestic demand for money function unstable, because resources are shifted in response to changes in prospective relative returns. Thus if a significant number of individuals and businesses hold diversified currency portfolios, this would undermine seriously the independence and effectiveness of monetary policy under flexible exchange rates. The second implication of currency substitution is that exchange rates become more volatile. In the extreme case of perfect currency substitution, the exchange rate becomes indeterminate.

From a practical perspective, the currency substitution model makes more sense than other models that do not allow individuals and firms to hold foreign currency. The tendency to hold foreign currency or diversified currency portfolios is conspicuous, as it is triggered by transaction, precautionary, and speculative motives. It is particularly conspicuous under inflationary conditions when the domestic currency fails to perform the functions of unit of account and store of value.

CHAPTER 10

The Microstructure Approach to Exchange Rates

10.1. Macroeconomic Models: Failure and Alternatives

A wide range of macroeconomic models of exchange rates were developed over the period between the late 1920s and the early 1980s. These models are based on two fundamental postulates. First, the equilibrium exchange rate is primarily a macroeconomic phenomenon, implying that it is uniquely determined by macroeconomic aggregates or fundamentals (prices, money supply, income, interest rates, and so on). Second, the equilibrium exchange rate immediately reacts to shifts in the macroeconomic fundamentals. Based primarily on different postulates and on a two-country framework, macroeconomic models describe the evolution of the equilibrium exchange rate as a function of current and future values of a set of macroeconomic variables.

While an enormous amount of research has been carried out on macroeconomic models, none of them has proven to be satisfactory in explaining and predicting short-run movements in exchange rates.[1] The crisis started in the early 1980s with the landmark papers of Meese and Rogoff (1983a,b) who found evidence showing that the macroeconomic fundamentals that underlie these models cannot explain movements in exchange rates any better than a "no change" model. Meese (1990) suggests that "the proportion of (monthly or quarterly) exchange rate changes that current models can explain is essentially zero." Even with the wisdom of 20 years hindsight, evidence that macroeconomic models can outperform a naïve random walk model is still elusive.[2] In fact, the work of Meese and Rogoff has exerted (and continues to exert) a pessimistic view of exchange rate modeling.[3]

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[1]However, macroeconomic models are somewhat successful in explaining medium to long-term movements in exchange rates (Frankel *et al.*, 1996).

[2]See, for example, Mark and Sul (2001), Rapach and Wohar (2001, 2003), and Faust *et al.* (2001).

[3]For a survey, see Frankel and Rose (1995), Isard (1995), and Taylor (1995).

The problem with the monetary model of exchange rates (and macroeconomic models in general) is that it is based on homogenous beliefs and expectations, which conform to the notion of "speculative efficiency." It is argued that information that is relevant for determining the exchange rate is publicly known and that the process through which new information affects the exchange rate and determines its new equilibrium level is also known by all market participants. In the narrowest sense, however, the exchange rate is regarded as the relative price of two national monies, which is driven by the demand for and supply of money through purchasing power parity. It is, therefore, determined by macroeconomic variables that affect the demand for and supply of money. The fact remains, however, that the underlying macroeconomic variables fail to explain exchange rate volatility. Some economists conclude that the most critical determinants of exchange rate volatility are not macroeconomic in nature, because nominal exchange rates are much more volatile than the macroeconomic fundamentals to which they are linked.[4]

The difficulty of explaining short-run exchange rate dynamics by using macroeconomic models can be attributed to the forward-looking nature of currency values and to the impact on exchange rates of the arrival of news on macro variables. Indeed, when news reaches the foreign exchange market, exchange rates react immediately, anticipating the effect of these fundamental shifts. As it is hard to observe the impact of news on macroeconomic fundamentals, it is not easy to control for the news effects on exchange rate dynamics and hence any meaningful analysis is hard to conduct within the context of macroeconomic models. Moreover, the huge trading volume in the foreign exchange market cannot be explained by the asset market approach (see Chapter 1). Explaining volume is difficult because monetary models assign no role to actual transactions in mapping macroeconomic variables onto exchange rate behavior.

Four main explanations are suggested for why exchange rates seem to be disconnected from macroeconomic fundamentals[5]:

1. Some economists have attempted to use parameter instability to explain why macroeconomic fundamentals have so little forecasting power (for example, Canova, 1993; Rossi, 2005). An important conclusion that

[4]See, for example, Flood and Rose (1995). Some figures supporting this proposition can be found in Chapter 1.
[5]For a detailed discussion, see Bailliu and King (2005, p. 32).

emerges from this line of research is that the forecasting performance of macroeconomic models is poor because the parameters of the estimated equations are unstable over time. Sarno and Taylor (2002, p. 135) argue that this instability could be attributed to policy-regime changes, implicit instability in key relations that underlie the econometric specification (such as the money demand function or the purchasing power parity equation), and agents' heterogeneity that would lead to different responses to macroeconomic developments over time.

2. There is the possibility that forecasting performance based on macroeconomic fundamentals can be improved by allowing for nonlinearity in the relation between the exchange rate and macroeconomic fundamentals. While there is some evidence that is supportive of nonlinearity (for example, Taylor and Peel, 2000), little evidence exists on the proposition that allowing for nonlinearities can boost the forecasting accuracy of macroeconomic models.[6]
3. Many economists argue that the key assumptions underlying standard exchange rate models (for example, purchasing power parity and uncovered interest parity) are invalid.
4. Flood and Rose (1995) note that nominal exchange rates are much more volatile (at low frequencies) than the macroeconomic fundamentals to which they are linked in macroeconomic models. Excess volatility suggests that these models based on macroeconomic fundamentals are unlikely to be very successful either at explaining or forecasting nominal exchange rates.

In sharp contrast to the 1970s, the 1980s witnessed a dramatic appreciation of the U.S. dollar against major currencies. The strong dollar frustrated forecasters, as argued by Levich (1983), and lent credence to the view that exchange rates are governed by more than simple market fundamentals (Meese, 1986). If the exchange rate is not determined by macroeconomic fundamentals, then what determines it? Some explanations have been explored in the literature:

1. Some economists have argued that frequent and large exchange rate fluctuations can be explained by speculative runs that may

[6]Clarida *et al.* (2003) found evidence indicating that the term structure of forward premia contains valuable information for forecasting spot exchange rates and that exchange rate dynamics display nonlinearities. They proposed a term-structure forecasting model based on a regime-switching vector error correction specification.

represent self-fulfilling expectations on the part of market participants (Blanchard, 1981; Blanchard and Watson, 1982; Meese, 1986; Evans, 1986). Blanchard (1981) argues that the rationality of agents' behavior and expectations does not imply that the price of an asset is equal to its fundamental value, and that there can be rational deviations of the price from this value (rational bubbles). The extraneous variables can be included in the set of exchange rate determinants to test the hypothesis that there are rational speculative bubbles in the foreign exchange market. However, Flood and Hodrick (1990) and Evans and Lyons (2002a,b) believe that the bubble hypothesis remains unconvincing.

2. Other economists proposed to incorporate a variable that can explain irrationality on the part of economic agents (Dominguez, 1986; Frankel and Froot, 1987). For example, exchange rates may be determined in part by avoidable expectational errors. On prior grounds, however, some economists have shown that this alternative is unappealing.
3. Lyons (2001a) and Evans and Lyons (2002a) have proposed an alternative exchange rate model based on the microstructure theory of finance. This is a hybrid model that includes a macroeconomic determinant (interest rates) and a microstructure determinant (order flow) to explain exchange rate movements. The model accounted for more than 60% of daily changes in the DEM/USD rate and more than 40% of daily changes in the JPY/USD rate. Evans and Lyons (2005a) found evidence showing that this model provides better out-of-sample forecasts than a random walk over periods ranging between 1 day and 1 month.

10.2. The Microstructure Models of Exchange Rates

The market microstructure (or microstructure) models are used to determine the exchange rate through the process and outcomes of exchanging currencies under explicit trading rules in the foreign exchange market. Microstructure models are derived from the market participants' individual optimization problems in which different micro aspects of the foreign exchange market play an important role in determining the exchange rate.[7] These micro aspects of the foreign exchange market include the transmission of information among market participants, the behavior of market participants, the importance of order flow, the heterogeneity of trading volume, and

[7]Microstructure models of exchange rates have been developed by Kyle (1985), Lyons (1995), and Evans and Lyons (2002a).

exchange rate volatility (Sarno and Taylor, 2001). Microstructure models allow us to explain the evolution of the exchange rate in an intra-daily sense, when foreign exchange dealers adjust their bid and offer exchange rate quotes throughout the business day in the absence of any macroeconomic news.

These models begin with the premise that much of the information pertaining to the (current and future) state of the economy is dispersed across market participants (individuals, firms, and financial institutions). This information is used by market participants to formulate their day-to-day decisions, including decisions on trading in the foreign exchange market at exchange rates quoted by dealers. Dealers quote the bid and offer rates at which they stand ready to buy and sell currencies. The difference between the market value of buy and sell orders, initiated by customers during any trading period, is termed "customer order flow." It is noteworthy that order flow is different from trading volume because it conveys information. Positive (negative) order flow indicates to a dealer that (on balance) customers value the underlying currency more (less) than the quoted offer (bid) rate.

10.2.1. *Assumptions of Microstructure Models*

What distinguishes microstructure from macroeconomic models is that the former begin from a very different set of assumptions from those of the latter. Macroeconomic models assume that agents are identical, information is perfect, trading is costless, and that the trading process itself is irrelevant. Microstructure models relax all of these assumptions. In particular, as Lyons (2001a) argues, microstructure models relax the three most restrictive assumptions of the asset market (macroeconomic) models.

First, microstructure models postulate that the information structure in the foreign exchange market is not perfect, but rather asymmetric, implying that some customers have private information.[8] When the market is not fully efficient, informed customers can exploit their informational advantage by issuing their buy and sell orders to market makers. By observing the order flow, a market maker makes inference about private information and adjusts the exchange rate quotes accordingly. For example, if there is an incoming

[8]Private information is not necessarily about macroeconomic fundamentals. In the microstructure approach, private information is defined as any information that is not public and that helps produce a better exchange rate forecast than public information alone (Lyons, 2001a, p. 26).

buy order, the market maker might raise the probability that the customer may have received "good" news, whereas this probability is reduced if there is an incoming sell order. In this way, dealers incorporate private information into their buy and sell quotes. In fact, dealers in the foreign exchange market claim that trading with their customers is one of the most important sources of information (Goodhart, 1988; Yao, 1998; Cheung and Wong, 2000).

Second, macroeconomic models assume that market participants are identical and unable to affect the equilibrium exchange rate. In microstructure models, on the other hand, market participants differ in ways that affect exchange rates. Market participants with common information regularly interpret exchange rates differently from those with asymmetric information. Differences among market participants may arise because of differences in the motives for trade: some traders are primarily hedgers, whereas others are primarily speculators (and even among the latter, speculative horizons can differ dramatically).

Third, microstructure models embody the proposition that the trading mechanisms (institutional settings) in the foreign exchange market differ in ways that affect exchange rates. To understand the trading mechanisms and how they affect the exchange rate, one has to be aware of the structure of the foreign exchange market, the characteristics of currency trading, and the types of currency traders. The foreign exchange market is a two-tier market. In the first tier, which constitutes a slightly less than half the total, customers trade with dealers privately. In the second tier, dealers trade with each other. Interdealer trade is largely carried out through electronic brokers, though it may be arranged privately. Although most market structures are hybrid in practice, there are three basic forms of market structures: (i) auction markets, (ii) single-dealer markets, and (iii) multiple-dealer markets.

10.2.2. *Exchange Rate Determination in Microstructure Models*

Evans (2008a,b) argues that although the pattern of foreign exchange trading is too complex to provide any useful insight into exchange rate behavior, a closer examination reveals two key features pertaining to exchange rate determination. First, the equilibrium exchange rate does not evolve out of a "black box." Instead, it is solely a function of the bid and offer rates quoted by dealers at a point in time. Second, information about the current and future state of the economy affect the exchange rate only when (and if) it affects dealers' quotes. Dealers may revise their quotes when new public information about any macroeconomic fundamental is released via announcement and when they receive order from customers and other dealers. This order flow channel is the mechanism through which dispersed information pertaining to the economy affects dealer quotes and hence the exchange rate.

Based on these two features, Lyons (1995) and Evans and Lyons (2002a) developed a canonical multidealer model in which the exchange rate is assumed to be a simple sequence of quoting and trading. At the start of each period, dealers quote to their customers bid and offer exchange rates, which are assumed to be good for any amount and are publicly observed. Subsequently, they receive orders from customers against these quotes. In the next period, dealers quote exchange rates to other dealers in the interdealer market, where they have the opportunity to trade among themselves. The exchange rate quotes that dealers make to other dealers in the interdealer market are also good for any quantity and are publicly observed. In the final period, they can trade with the public.

Dealers quote exchange rates simultaneously and independently, and these quotes are available to all dealers. Consequently, the same exchange rate is quoted by dealers to both customers and other dealers at a particular point in time. The quote made at time t is

$$s_t = (1 - b) \sum_{i=0}^{\infty} b^i E[z_{t+i} \mid \Omega_t^D] \tag{10.1}$$

where s_t is the log of the exchange rate quoted by all dealers, z_t is the value of exchange rate fundamentals, and $0 < b < 1$. The form of fundamentals underlying equation (10.7) differs according to the macroeconomic structure of the model. For example, z_t may include domestic and foreign money supplies and household consumption. In models where central banks conduct monetary policy via the control of short-term interest rates (following Taylor's rule), z_t includes variables used to set the policy. More generally, z_t includes a term that identifies the foreign exchange risk premium. The term $E[z_{t+i} \mid \Omega_t^D]$ represents all dealers' expectations regarding macroeconomic fundamentals conditioned on the information set Ω_t^D, which is common to all dealers at t. This does not imply that all dealers have the same information. On the contrary, order flows received by individual dealers represent important private information, implying that there may be a good deal of information heterogeneity across dealers at any point in time. An important point is that due to the "fear of arbitrage," individual dealers choose not to quote prices based on their own private information. In this trading environment, dealers use private information to initiate trade with other dealers, thereby contributing to the process through which all dealers acquire information.

To examine the role of fundamentals as a driver of exchange rate dynamics, let us iterate equation (10.1) forward one period and rearrange the resulting expression to obtain

$$\Delta s_{t+1} = \frac{1-b}{b}(s_t - E[z_t \mid \Omega_t^D]) + u_{t+1} \tag{10.2}$$

and

$$u_{t+1} = \frac{1-b}{b}\sum_{i=1}^{\infty} b^i (E[z_{t+i} \mid \Omega_{t+1}^D] - E[z_{t+i} \mid \Omega_t^D]). \tag{10.3}$$

Equation (10.2) decomposes the change in the logarithm of the exchange rate into two components: expected change, $(E[\Delta s_{t+1} \mid \Omega_t^D])$ and unexpected change, $(u_{t+1} = s_{t+1} - E[s_{t+1} \mid \Omega_t^D])$. The expected rate of change in the exchange rate is proportional to the difference between the current rate and dealers' expectations of the levels of fundamentals. From equation (10.1), we know that this difference is equal to the present value of future changes in fundamentals:

$$s_t - E[z_t \mid \Omega_t^D] = \sum_{i=1}^{\infty} b^i E[\Delta z_{t+1} \mid \Omega_t^D]. \tag{10.4}$$

Which means that if fundamentals are expected to change in the future, dealers are likely to quote different exchange rates, thereby contributing to the realized rate of change (Δs_{t+1}).

The second term in equation (10.2), $u_{t+1} = s_{t+1} - E[s_{t+1}|\Omega_t^D]$, represents the impact of the new information received by all dealers between t and $t+1$. Equation (10.3) shows that new information affects the exchange rate quoted at $t+1$ to the extent that it revives forecasts of the present value of fundamentals based on dealers' common information.

Evans (2002) argues that the arrival of new information pertaining to macroeconomic fundamentals has important implications, not only for the dynamics of exchange rates but also for the pattern of trading. It is argued that news on macroeconomic fundamentals can take two forms: common knowledge (CK) news and non-common knowledge (NCK) news. CK news contains unambiguous information about current and/or future macroeconomic fundamentals that is observed simultaneously by all traders and immediately incorporated into the exchange rate quotes they make. CK news thus affects dealers' exchange rate quotes directly. News and non-common knowledge news can come from a private or public source, operating via order flow and conveying dispersed information about fundamentals to dealers. Dispersed information comprises micro-level information on economic activity that is correlated with fundamentals, reaching the foreign exchange market via the order flows initiated by individual dealers. These order flows have no immediate effect on dealers' quotes because they represent private information to the recipient dealer. This information affects exchange rate quotes once it is known to all dealers, which makes interdealer order flow central to this process. Individual dealers use their private information to trade in the interdealer market. By doing that, information on customer orders is aggregated and spread across the market. This dispersed information is incorporated into dealer quotes once the information aggregation process is complete.

Evans (2008b) argues that microstructure models have a big advantage over macroeconomic models because their trade-based foundations provide details on how news about fundamentals affects exchange rates. In particular (as equation (10.9) indicates), microstructure models focus on how new information about fundamentals reaches dealers and induces them to revise their exchange rate quotes. In fact, microstructure models open up new conceptual space for understanding the link between fundamentals and the exchange rate because they provide the analytical framework for studying how new information about fundamentals becomes embedded in dealers' quotes via trading.

Microstructure models are used to determine the exchange rate in the actual, complex, and realistic settings of the foreign exchange market, where information is dispersed, market participants are heterogeneous with different information sets, the trading process is not transparent, and where bid–offer spreads reflect the costs (to market makers) of processing orders and managing inventories. The microstructure model can be represented in terms of a general stochastic form as follows:

$$\Delta s_t = g(\Delta x_t, \Delta I_t, \ldots) + v_t. \tag{10.5}$$

Δs_t, which is the logarithmic return on a foreign currency trading over two transaction periods (rather than over a month as in macroeconomic models), is driven by the variables included in the function $g(\Delta x_t, \Delta I_t, \ldots)$ such as the order flow (Δx_t) and the net dealer positions or inventory (ΔI_t).

Order flow can take both positive and negative values because the counterparty either buys (+) a currency at the dealer's offer rate or sells (−) a currency at the dealer's bid rate. Microstructure models predict a positive relation between the rate of change in the exchange rate (Δs_t) and order flow information (Δx_t), which is not available publicly. For example, if a market participant has superior information about the exchange rate of a particular currency, and if the information advantage induces this participant to trade, then a dealer can learn from those trades (purchases indicate good news for the underlying currency, and vice versa). The relation between Δs_t and ΔI_t is referred to as the inventory-control effect on the exchange rate. Other variables that affect the exchange rate in microstructure models include the volume of trading and the bid–offer spread.

10.2.3. *Information Models versus Inventory Models*

Microstructure models are derived from the market participants' individual optimization problems. These models are classified into information and inventory models, depending on how they explain the effect of order flow on the exchange rate. In information models, the order flow affects the exchange rate permanently because participants have heterogeneous information. In these models, the market maker (quoting dealer) usually knows that some of his customers possess some private information and consequently they will buy when the underlying currency is underpriced and sell when it is overpriced. Informed customers may even decide not to trade if the exchange rate quoted by the market maker is not suitable. The market maker often makes losses when making trades with informed customers, but compensation comes from the profit on transactions with uninformed customers.

In inventory models, the key question is how risk-averse market makers adjust their exchange rate quotes in such a way as to close unwanted, foreign exchange positions. In these models, there is no information asymmetry, which means that order flow affects the exchange rate only temporarily. Market makers do not take speculative positions, but they encounter uncertainty that stems from random differences in the arrival of buying and selling orders. If the market maker's open currency position moves from the desirable level due to a transaction, quotes will be adjusted in such a way as to induce deals that help square the position.

Although order flow is the key explanatory variable in both information and inventory microstructure models of exchange rates, it is only a proximate determinant of exchange rate dynamics. Order flows transmit pieces of information about the fundamental determinants of the exchange rate that are aggregated by the market. Microstructure models do not deny the role played by macroeconomic fundamentals in determining the exchange rate. The main difference between macroeconomic and microstructure models lies in the mechanisms through which fundamentals affect the exchange rate. Therefore, microstructure models represent a complement to, rather than a competitor of, macroeconomic models.

10.3. Factors Affecting Exchange Rates in Microstructure Models

When we move from macroeconomic to microstructure models, two variables that play no role in macroeconomic models take center stage: order flow and spreads. The other variables affecting exchange rate determination in microstructure models include the volume of trade and heterogeneity of market participants.

10.3.1. *Order Flow*

Before we investigate how order flow affects the exchange rate, it is essential to understand order flow itself. It must be noted that transaction volume and order flow are not the same. Order flow is defined as the cumulative flow of signed transactions, where each transaction is signed positively or negatively, depending on whether the initiator of the transaction is buying or selling, respectively.[9] In other words, it is the transaction volume that is classified based on the direction of trading. A positive sum over any period indicates net buying pressure, while a negative sum indicates net selling pressure.

Orders that require execution as soon they arrive (called market orders) generate the signed order flow. Order flow, as used in microstructure finance, is a variant of "excess demand," a key term used in economics. However, there are two differences between the two concepts. First, excess demand is equal to zero in equilibrium (by definition), implying that there are two sides to every transaction. This is not true of order flow, because orders are initiated against a market maker who, if properly compensated, stands ready to absorb imbalances between buyers and sellers. Second, order flow

[9]This definition of order flow needs to be adjusted slightly for markets that involve a "limit order book" rather than dealers (Lyons, 2001a). Limit orders are collected together in an electronic "book." The most competitive orders in the book represent the best available bid and offer quotes, which are analogous to the bid and offer quotes in markets that involve dealers. The limit orders are the passive side of any transaction, just as the quoting dealer is always on the passive side.

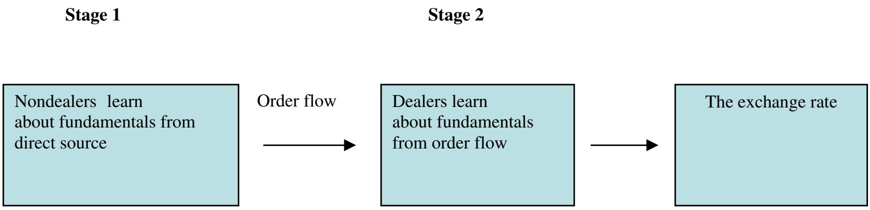

Figure 10.1. Stages of information processing in microstructure models.

is different from excess demand in the sense that the former measures actual transactions, whereas shifts in the latter need not induce transactions. For example, the demand shifts caused by the flow of public information in macroeconomic models move the exchange rate without the need for transactions to occur.

Order flow is one of the key explanatory variables in all microstructure models. Evans and Lyons (1999, 2002a) claim that net order flow has substantial explanatory power for exchange rate changes on a daily basis and can explain 60% and 40% of the return variation for the mark/dollar and yen/dollar rates, respectively. The explanatory power of order flow depends on the factor that causes it. It may convey information about macroeconomic fundamentals that is dispersed among market participants. This information-aggregation role of order flow provides a link between economic fundamentals and the behavior of the exchange rate. It can also convey information about how foreign exchange dealers manage their inventories. Lyons (2001a) found that order flow is less informative in this respect.

Figure 10.1 illustrates an important feature of microstructure models that relates directly to order flow. Information about macroeconomic fundamentals is processed in two stages. The first stage relates to observations of fundamentals by non-dealer market participants (mutual funds, hedge funds, individual with special information, etc.). The second stage relates to dealers' observation of macroeconomic fundamentals that comes from order flow.[10] Dealers set exchange rate quotes on the basis of their interpretation of news about fundamentals.

[10]That dealers learn only from order flow is an extreme assumption that underlies all standard microstructure models because these models assume that all information is private. In contrast, macroeconomic models make the other extreme assumption that all information is publicly available.

Microstructure models of exchange rates emphasize the information role of order flow in a trading setting with heterogeneous agents. In this setting of information asymmetry, order flow is a proxy variable that captures the market's reaction to macroeconomic announcements and other news that anticipate future shifts in economic conditions. As the macroeconomic fundamentals underlying exchange rates change, traders adjust their expectations and rebalance their portfolios accordingly, leading to a change in the exchange rate. In other words, order flow is a transmission mechanism for public information about fundamentals and private information that affect exchange rates.

Research in market microstructure focuses on order flow because it carries more news than volume, the bid–offer spread and other variables. The information associated with the order flow is of two types. First, order flows are a signal of the future expected value of the cash flows generated by the underlying financial asset. In the case of the foreign exchange market (where the asset is foreign exchange), these cash flows are associated with the interest differential between the two currencies. Second, order flows provide information about the equilibrium market discount rate. It is defined as the net balance of orders initiated by buyers and sellers in the foreign exchange market, which means that it measures the net pressure of demand for a currency.

The inventory control effect arises when a foreign exchange dealer adjusts the bid–offer quotes throughout the business day in the absence of any news about macroeconomic fundamentals. For example, if the dealer has a larger long position than is desired, the bid and offer quotes may be adjusted to encourage fewer purchases and more sales to balance the position. The inventory control effect on the exchange rate can explain why traders may alter their quotes in the absence of any news about the fundamentals. Lyons (1995) studied the DEM/USD market and estimated that (on average) foreign exchange dealers alter their quotes by 0.00008 for each $10 million of undesired inventory.

In addition to the inventory control effect, there may also be an asymmetric information effect, which causes exchange rates to change due to traders fear that they are making quotes to someone who knows more about current market conditions. Even though there is no news about macroeconomic fundamentals, information is transmitted from one trader to another through the act of trading. When a dealer posting a quote of JPY110.45-95 is called by another dealer offering to buy 10 million dollars at 110.95 (the offer price), the first dealer must wonder whether the second dealer knows something she does not.

10.3.2. *The Bid–Offer Spread*

The bid–offer spread is the second variable that has attracted considerable interest in the literature on market microstructure. This variable can play an important role in exchange rate determination in microstructure models for three reasons (Lyons, 2001a). The first reason pertains to data on bid–offer spreads, which provide a means for finding out whether or not order flow is informative. This implies that the behavior of the spread may tell us something important about the market's information structure.

The second reason why the spread receives considerable attention is practical. Practitioners are intensely concerned with managing trading costs. Spreads exist because of three costs faced by dealers. One of these costs (typically referred to as an adverse selection cost) results from asymmetric information. Dealers know that they can lose money on trades, particularly with those customers who are better informed. If one could identify better informed customers before trading, then this would not be a problem because dealers can choose not to trade, or they could adjust their quotes appropriately. Because dealers are unable to identify better informed customers, they must protect themselves against losses by increasing the width of the quoted spread to all potential counterparties (informed and uninformed alike). Lyons (2001a) argues that dealers in fact include an adverse selection effect in their spreads when they attempt to protect themselves by increasing the width of their spreads. Empirical findings are supportive of an adverse selection effect in the spread. Dealers raise spreads to protect themselves against informative incoming orders (Lyons, 1995; Yao, 1998; Naranjo and Nimalendran, 2000). For example, Lyons (1995) found that the foreign exchange dealer he tracked protected himself from adverse selection by increasing the width of his spread by about one pip (or 0.0001 DEM/USD) for every $5 million increase in the size of the incoming order.

The third reason why the spread receives so much attention is historical. Since its inception, the literature on market microstructure has sought to separate itself from the literature on trading under rational expectations. Rational expectations models have been developed in complete abstraction from the actual trading mechanisms in the foreign exchange market, using the underlying assumption that trading mechanisms have little effect on the relation between the underlying fundamentals and the exchange rate. On the other hand, microstructure models can be used to demonstrate how changes in the trading mechanisms affect exchange rates. This orientation has led to a focus on the determination of real-world transaction prices (spreads).

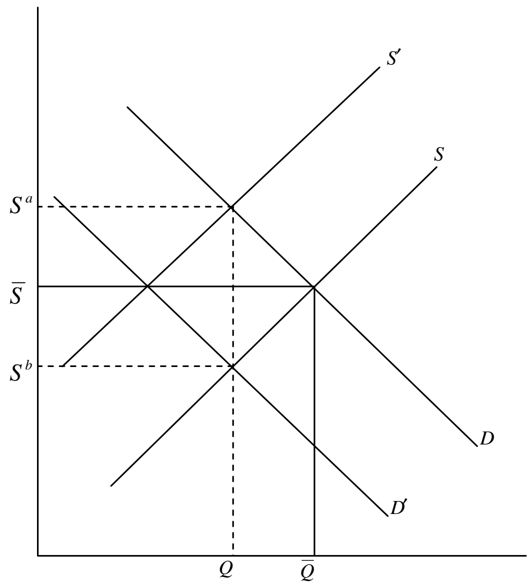

Figure 10.2. Effect of the bid–offer spread on the equilibrium exchange rate.

In the foreign exchange market, bid–offer spreads are compensations to market makers (dealers) for providing liquidity services to investors.[11] Dealers, in fact, allow trading to occur by standing ready to buy and sell currencies at the bid and offer rates they quote to customers. Demsetz (1968) defines this service as "predictable immediacy," and uses the typical demand and supply model represented by Figure 10.2 to formalize the rationale for the spread.

Consider a continuous foreign exchange market with aggregate supply (sell) and demand (buy) schedules (S) and (D). In an ideal world, investors would come together simultaneously and the market would clear at the exchange rate ($\bar{S}$) and the quantity of foreign exchange ($\bar{Q}$). In the actual market, however, such coordination of trading is impossible. By assumption, the foreign exchange market is continuous, and there is no mechanism for holding orders (for example, a limit order book) over time.[12] In fact, the

[11] See, for example, Keynes (1936, p. 158) and Stigler (1964, p. 129).

[12] A limit order is an offer by a bank to buy or sell, but not both, a certain amount of currency against another currency at a specified exchange rate. A limit order, specifying the quantity and the price of an offer to buy or sell, remains with the broker until it is withdrawn by the bank. Unlike the direct market, which is an open-order-book market, the brokered market is called a closed-order-book market.

actual foreign exchange market is largely dominated by market makers, who quote two-way bid and offer exchange rates at which they stand ready to buy and sell currencies. The market maker knows the market (aggregate) demand and supply propensities, which are represented by the D and S schedules.

Clearly, the market maker will not be willing to stand ready to buy and sell foreign currencies at $\bar{S}$, which is determined by demand and supply because this exchange rate guarantees the market maker no compensation for the kind of services he or she provides to investors. To be compensated for the service provided, the demand and supply curves that the market maker presents to the public are represented by D' and S', respectively. Consequently, the market maker's demand and supply curves shift leftward. Cutomer purchases clear at S^a, which is determined by the intersection of the market demand schedule (D) with the market maker's supply schedule (S'). Similarly, investor sales clear at S_b, which is determined by the intersection of the market supply schedule (S) and the market maker's demand schedule (D'). The differences $(S^a - \bar{S})$ and $(\bar{S} - S^b)$ represent liquidity premia or compensation to the dealer for the provision of services. The quantities of foreign exchange (Q) purchased and sold by the market maker happen to be equal, so that no market maker's inventory is accumulated. The market maker's profit is thus equal to $Q(S^a - S^b)$.

10.4. The Microstructure Solution to the Determination Puzzle

The exchange rate determination puzzle implies that, in the short run, there seems to be no reliable determinants of exchange rates. Economists putting forward the proposition that macroeconomic fundamentals do not explain exchange rate behavior are eventually faced with the (hard) task of providing alternative explanations for exchange rate determination. Lyons (2001a) resolves the determination puzzle by using the dispersed information approach based on the microstructure model, drawing heavily on the work of Evans and Lyons (1999). He argues that one advantage of the microstructure approach is that it helps identify the variables that have escaped the attention of macroeconomists, most importantly order flow. He developed the hybrid model

$$\Delta s_t = f(\Delta i, \Delta m, \ldots)_t + g(\Delta x, \Delta I, \ldots) \tag{10.6}$$

where the function $f(\Delta i, \Delta m, \ldots)$ is the macroeconomic component of the model and $g(\Delta x, \Delta I, \ldots)$ is the microstructure component. The hybrid model represented by equation (10.6) is split into two parts that are not necessarily independent. Whether or not the two parts are independent depends on the microstructure determinant (order flow) and the type of information it conveys. There are two basic types of information that order flow can convey: (i) information about the stream of future cash flows or payoff and (ii) information about the market-clearing discount rate. One way order flow can convey information about $f(\Delta i, \Delta m, \ldots)$ is by aggregating the information in individuals' expectations of $f(\Delta i, \Delta m, \ldots)$. If order flow conveys payoff information only, then the two sets of determinants $f(\Delta i, \Delta m, \ldots)$ and $g(\Delta x, \Delta I, \ldots)$ are interdependent, whereas if it conveys discount rate information, then the two sets of determinants are not interdependent. This is explained in Figure 10.3, where the top panel shows that in macroeconomic models, information about macroeconomic fundamentals is publicly known, and so is the mapping of fundamentals to the exchange rate. This means that there is a direct connection between fundamentals and the exchange rate. In contrast, as the middle panel illustrates, information about

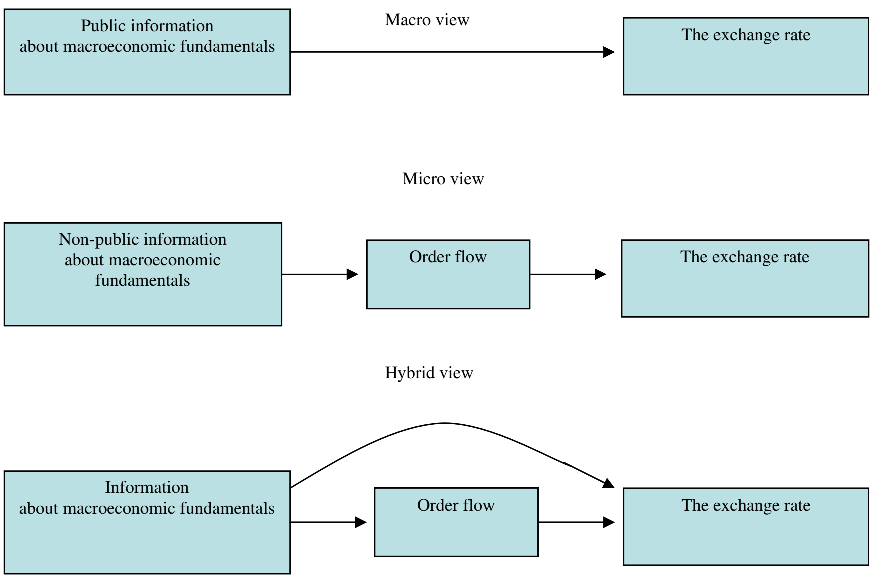

Figure 10.3. The micro, macro, and hybrid views of exchange rate determination.

fundamentals is not publicly known in microstructure models. It is first transformed into order flow, which becomes a signal to exchange rate setters that exchange rate quotes need to be adjusted. The bottom panel illustrates what actually happens in the foreign exchange market: information about macroeconomic fundamentals affects the exchange rate directly and indirectly through order flow. This represents the hybrid view of exchange rate determination.

The Evans–Lyons (1999, 2002a) hybrid model is based on a simultaneous-trade approach. The economic intuition behind this model is very simple. Public demand for foreign exchange is uncertain and realized at the start of each day. Demand realizations produce orders that are not publicly observed, and therefore any information conveyed by them needs to be aggregated in the trading process. For simplification, demand realizations are assumed to be correlated with the future interest rate differential, so that any price impact operates through the discount rate. Demand of this type includes liquidity demand, hedging demand, and speculative demand, which affect exchange rate quotes because the rest of the market requires concession to absorb them.

Consider a pure exchange economy in which there are N dealers, a continuum of non-dealer customers (the public), an infinite number of trading days and two assets: one risk-free (with gross return equal to one) and one risky. Moreover, dealers and customers all share an identical negative exponential utility function, and within each day there are three rounds of trading, as shown in Figure 10.4: (i) dealers trade with the public, (ii) dealers trade among themselves to share risk, and (iii) dealers trade with the public to share risk more broadly. Dealers quote exchange rates simultaneously and independently, and these quotes are available to all dealers.

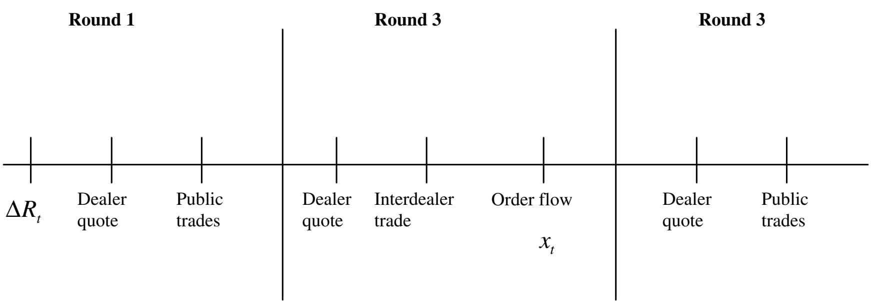

Figure 10.4. Daily trading.

At the beginning of each day, the payoff from holding foreign exchange is R_t (composed of a series of increments (ΔR_τ)), which is given by

$$R_t = \sum_{\tau=1}^{t} \Delta R_\tau. \tag{10.7}$$

The payoff increments (ΔR_τ) are normally distributed with zero mean and constant variance. These realized increments, which are observed publicly at the beginning of each day, represent the flow of publicly known macroeconomic information (the components of the model $f(\Delta i, \Delta m, \ldots)$). This increment may be considered as changes in interest rates.

Figure 10.4 shows that after observing the payoff (R_τ) on foreign exchange holding, each dealer sets a quote for his public customers. As in the simultaneous-trade model, exchange rate quotes made by dealers represent two-way (bid and offer) rates set simultaneously and independently. Suppose that the quote of i in round one of day t is S_{it}^1. Evans and Lyons (1999, 2002a) show that, in equilibrium, all dealers choose to quote the same exchange rate (S_{it}^1). Each dealer then receives a customer-order realization (C_{it}^1) that is executed at the quoted exchange rate (S_t^1), where $C_{it}^1 < 0$ denotes a customer sale (dealer i purchase) order. Each of these N customer-order realizations is distributed normally with zero mean and constant variance (that is, $C_{it}^1 \approx \text{Normal}(0, \sigma_C^2)$). These realizations are not publicly observable and they can be aggregated to obtain public demand for foreign exchange in round one:

$$C_t^1 = \sum_{i=1}^{N} C_{it}^1. \tag{10.8}$$

Round two is the interdealer trading round. Each dealer simultaneously and independently makes two-way quotes to other dealers (that is, S_{it}^2). These interdealer quotes are observable and available to all dealers. Evans and Lyons (1999, 2002a) show that (like in round one) all dealers choose to quote the same price (S_t^2). Each dealer then simultaneously and independently trades on other dealers' quotes. Let T_{it} be the net interdealer trade initiated by dealer i in round two of day t. At the close of round two, all dealers observe the net interdealer order flow on that day:

$$x_t = \sum_{i=1}^{N} T_{it}. \tag{10.9}$$

This order flow information is important because it conveys the size and sign of the public order flow in round one. To understand why, consider the interdealer trading rule derived by Evans and Lyons (1999, 2002a):

$$T_{it} = \alpha C_{it}^1 \tag{10.10}$$

where α is a constant (positive) coefficient. Each dealer's trade in round two is proportional to the customer order he received in round one. This implies that when dealers observe the interdealer order flow ($x_{it} = \sum T_{it} = \alpha C_{it}^1$) they can infer the aggregate public order flow (C_t^1) in round one.

In round three, dealers share overnight risk with the non-dealer public. A crucial assumption made in Evans and Lyons (1999, 2002a) is that dealers set exchange rates in round three, such that the public willingly absorb all dealer inventory imbalances, so that each dealer ends the day with no net position. This assumption rules out inventory effects on exchange rates at the daily frequency (because dealers do not hold overnight positions that require compensation). In round three, exchange rates that dealers quote to induce public absorption of these imbalances depend on the round two interdealer order flow, which informs dealers of the size of the total position that the public needs to absorb (as given by $x_t = \alpha C_t^1$). To determine the round 3 exchange rates, dealers need to know two things: (i) the total position that the public needs to absorb (which they learn from x_t) and (ii) the public's risk-bearing capacity, which is assumed to be less than infinite.

Under the assumption of negative exponential utility, the public's total demand for foreign exchange in round three (C_t^3) is a linear function of its expected return, conditional on public information:

$$C_t^3 = \gamma E[\Delta S_{t+1}^3 + R_{t+1} \mid \Omega_t^3] \tag{10.11}$$

where γ captures the aggregate risk-bearing capacity of the public, implying that the public is willing to absorb a larger (smaller) foreign exchange position for a given expected return if the value of γ is larger (smaller). Ω_t^3 is the public information available at the trading time in round three (which includes all past R_t and x_t).

Evans and Lyons (1999, 2002a) show that the exchange rate at the end of day t is

$$S_t = \beta_1 \sum_{\tau=1}^{t} \Delta R_\tau + \beta_2 \sum_{\tau}^{t} x_\tau. \tag{10.12}$$

Therefore, the change in the exchange rate from the end of day $t-1$ to the end of day t can be written as

$$\Delta S_t = \beta_1 \Delta R_t + \beta_2 \Delta x_t \tag{10.13}$$

where β_1 is a positive constant (that depends on γ and α).

Equation (10.13) represents the hybrid model of Evans and Lyons (1999, 2002a) in which the exchange rate is determined by macroeconomic and microstructure factors. They introduce two changes to equation (10.13) for estimation purposes. First, the public information payoff (ΔR_t) represents the macroeconomic component ($f(\Delta i, \Delta m, \ldots)$). They use changes in the interest differential ($\Delta(i - i^*)$) as a proxy for the macroeconomic component. Second, they replace the rate of change of the exchange rate with the rate of change in the logarithm of the exchange rate. Therefore, equation (10.13) can be rewritten in a stochastic form as follows[13]:

$$\Delta s_t = \beta_1 \Delta(i - i^*)_t + \beta_2 \Delta x_t + \upsilon_t \tag{10.14}$$

where Δs_t is the change in the logarithm of the exchange rate from the end of day $t-1$ to the end of day t, $\Delta(i - i^*)$ is the change in the overnight interest differential from $t-1$ to t, and x_t is the interdealer order flow during the same period. In equation (10.14), $\Delta(i - i^*)$ is a measure of variation in macroeconomic fundamentals, whereas Δx_t is a measure of microstructure component of exchange rate determination.

The hybrid model represented by equation (10.14) differs from the one represented by equation (10.6) in two respects. First, equation (10.14) cannot be viewed as fully accommodating both the micro and macro views of exchange rates represented by equation (10.6). This is because equation (10.14) includes the interest rate differential only, which is obviously an incomplete measure of macroeconomic fundamentals. The reason Evans and Lyons (1999, 2002a) do not specify a full-blown macroeconomic model is that other macroeconomic variables (for example, money,

[13]Lyons (2001a) describes three important considerations regarding the modeling strategy. First, although the determination puzzle concerns exchange rate behavior over months and years (and not over minutes), the hybrid model must make sense at lower frequencies. Second, because interdealer flow is more transparent, it is more immediately relevant to exchange rate determination than customer–dealer order flow. The hybrid model should also reflect this institutional feature. Third, the model should provide a vehicle for understanding the actual behavior of order flow.

Table 10.1. Estimates of the Evans–Lyons model (equation (10.14)).

	β_1	β_2	R^2
DEM	0.52	2.10	0.64
(t-statistic)	(1.5)	(10.5)	
JPY	2.48	2.90	0.45
(t-statistic)	(2.7)	(6.3)	

Source: Evans and Lyons (1999, p. 34).

output, and inflation) are not available at the daily frequency. Second, equation (10.14) uses the change, rather than the level of the interest differential.[14]

Table 10.1 presents estimates of equation (10.14), using daily data on the DEM/USD and JPY/USD exchange rates. As shown in Table 10.1, the coefficient on order flow is correctly signed and significant. The coefficient on the interest differential is not significant in the case of the DEM/USD exchange rate. The overall fit of the model is striking relative to traditional macroeconomic models, as the R^2 turned out to be 0.64 and 0.45 for the DEM and JPY equations, respectively. Moreover, the explanatory power of these regressions is almost completely due to order flow.

10.5. The Microstructure Solution to the Excess Volatility Puzzle

The excess volatility puzzle implies that exchange rates are much more volatile than the macroeconomic fundamentals that supposedly determine them. While other asset prices (such as stock prices) share the same property, the volatility puzzle in the foreign exchange rate is distinctive in many respects (Lyons, 2001a). First, contrary to popular belief, exchange rates are less volatile than stock prices in an absolute sense. The annual standard deviation of exchange rate returns range between 10% and 12% for major currencies against the dollar, whereas the annual standard deviation of

[14]Using the interest differential in levels, Evans and Lyons (1999, 2002a) found similar results to those based on the change in the interest differential. One must feel uneasy about the arbitrary use of the interest differential in level and first difference because it sounds like data mining.

equity returns ranges between 15% and 20% for individual stocks.[15] Second, exchange rates are generally more volatile when floated than when managed. Given this stylized fact, comparison can be made between regimes with different management intensities to find out why volatility differs, thereby shedding light on the causes of exchange rate volatility.[16] Then why is it that exchange rates are more volatile than the determining fundamentals?

Two main approaches can be used to answer this question, one theoretical and the other empirical. The theoretical approach was pioneered by Dornbusch (1976c) in his overshooting model, as he demonstrated that when goods prices are sticky but the exchange rate is free to jump, economic shocks have a disproportionately larger effect on the exchange rate. This theoretical explanation has not been very successful empirically. A good example of the empirical approach is the work of Flood and Rose (1995, p. 5), who argue that if exchange rate stability arises across regimes without corresponding reduction in macroeconomic volatility, then macroeconomic fundamentals cannot be used to explain exchange rate volatility. Thus, if the volatility reduction emanating from managing exchange rates does not follow from a corresponding reduction in the volatility of macroeconomic fundamentals, it is unlikely that the most critical determinants of exchange rate volatility are macroeconomic in nature.

Following the work of Evans and Lyons (1999), Killeen *et al.* (2006) demonstrate that exchange rates are more volatile under flexible exchange because order flow conveys more information than under fixed exchange rates. Under flexible rates, the elasticity of public demand for foreign exchange is (endogenously) low because of higher exchange rate volatility, which means that the holding of foreign currency is not without risk. In contrast, the elasticity of demand is infinite under fixed rates as exchange rate volatility pales into insignificance, making the holding of currency effectively risk-free.[17] This eliminates portfolio balance effects and precludes order flow from conveying any information about exchange rate volatility.

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[15]These figures, however, are not universal across markets and time. There is no fundamental reason why exchange rates should be more or less volatile than stock prices. In general, volatility is a shared property of all financial prices.

[16]This approach has been commonly applied, among others, by Flood and Rose (1995) and Killeen *et al.* (2006).

[17]This is not strictly true unless we are talking about strictly fixed exchange rates. In practice, it is invariably the case that "fixed" exchange rates are adjustable via devaluation and revaluation. If the standard deviation is used as a measure of volatility, then one big realignment of an exchange rate may make "fixed" exchange rates more volatile than flexible rates.

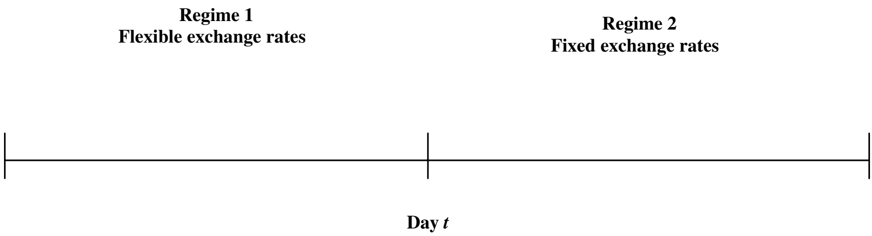

Figure 10.5. Trading under flexible and fixed exchange rate regimes.

Killeen *et al.* (2006) applied a variant of the Evans and Lyons (1999) model to what they called a "natural experiment" of switching from the European Monetary System (EMS) to the European Monetary Union (EMU), which (in terms of regimes) is a switch from a target zone to rigidly fixed rates. In this model, trading days relate to two regimes: a flexible rate regime followed by a fixed rate regime. The shift from flexible to fixed rates is random with constant probability (ρ) at the end of each trading day. The shift from flexible exchange rates is a random event, the arrival of which is shown in Figure 10.5 at the end of day T. Once the regime has shifted to fixed rates, it remains there indefinitely.

Under the flexible exchange rate regime, payoff increments (ΔR_i) are distributed normally, with zero mean and constant variance. On the first morning of the fixed-rate regime, the central bank (credibly) commits to pegging at the previous day's closing rate and maintains $\Delta R_i = 0$ thereafter. Thus, the exchange rate equations at the end of day t (derived for both fixed and flexible exchange regimes) can be written as follows. Under flexible exchange rates ($t \leq T$), we have

$$S_t = \alpha_1 \sum_{\tau=1}^{t} \Delta R_\tau + \alpha_2 \sum_{\tau}^{t} x_\tau \tag{10.15}$$

while under fixed exchange rates ($t > T$), the equation is

$$S_t = \alpha_1 \sum_{\tau=1}^{T} \Delta R_\tau + \alpha_2 \sum_{\tau}^{T} X_\tau + \alpha_3 \sum_{\tau=T+1} x_\tau \tag{10.16}$$

where T denotes the day on which the regime shifts from flexible to fixed exchange rates. Equations (10.15) and (10.16) describe a cointegrating relation between the level of the exchange rate, cumulative macroeconomic fundamentals, and cumulative order flow. The cointegrating relation is regime dependent.

Under flexible exchange rates, the change in the exchange rate from the end of day $t-1$ to the end of day t can be written as

$$\Delta S_t = \alpha_1 \Delta R_t + \alpha_2 x_t. \tag{10.17}$$

It remains to be the case, however, that exchange rate volatility can be explained in terms of the heterogeneity of market participants. This line of reasoning has been suggested by Moosa (2002c), Moosa and Shamsuddin (2003), and by Moosa and Al-Muraikhi (2007). For example, Moosa (2002c) suggests a microeconomic view of exchange rate determination to explain exchange rate volatility, by assuming that traders are either fundamentalists (using rules or discretion to generate buy and sell signals) or technicians (using filter and moving average rules). As these traders generate different buy and sell signals, shifts in the excess demand function are erratic, causing the observed exchange rate volatility. Likewise, Moosa and Shamsuddin (2003) argue, on the basis of a descriptive model, that exchange rate volatility can be explained in terms of the heterogeneity of traders with respect to their trading strategies, which are based on expectation formation mechanisms, technical trading rules, and fundamentals. Within these broad categories, they classified traders into 19 different types, such that each type is assigned a market weight that reflects the profitability of the underlying trading strategy. By using these weights to simulate an exchange rate series, they found that the actual and simulated series exhibit the same volatility patterns and that they belong to the same statistical distribution. They conclude that trader heterogeneity can generate exchange rate volatility. Further discussion of these ideas can be found in Section 10.7.

10.6. The Microstructure Solution to the Forward Bias Puzzle

The forward bias puzzle arises when the forward spread fails as an unbiased predictor of the expected change in the exchange rate, even though the foreign exchange market is informationally efficient. In an empirically testable form, the forward bias model may be expressed as

$$\Delta s_{t+1} = \beta_0 + \beta_1 (f_t - s_t) + u_{t+1} \tag{10.18}$$

where Δs_{t+1} is the expected change in the exchange rate realized at time $t+1$, $f_t - s_t$ is the forward spread, and u_{t+1} is a forecasting error

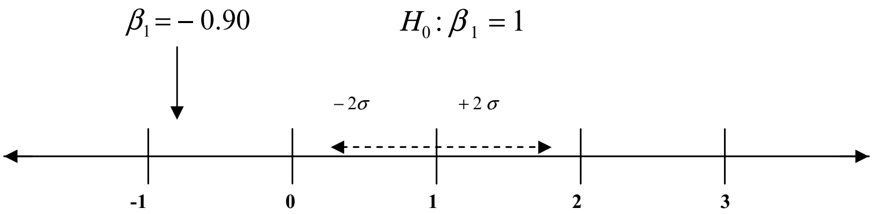

Figure 10.6. The statistician's perspective on the forward bias puzzle.

realized at time $t + 1$ (assumed to be random). For the forward rate to be an unbiased predictor of the expected spot rate, the estimates of β_0 and β_1 should be equal to (insignificantly different from) zero and one, respectively.

Lyons (2001a) argues that the forward bias puzzle can be looked at in three perspectives: (i) the statistician's perspective, (ii) the economist's perspective, and (iii) the practitioner's perspective. These perspectives are described in the following three subsections.

10.6.1. *The Statistician's Perspective on Forward Bias*

The statistician's perspective on the forward bias puzzle involves testing the null hypothesis that the regression estimate of the coefficient on the forward premium is equal to one (that is, $\beta_1 = 1$). Some researchers also test the null hypothesis $\beta_0 = 0$.

A huge number of studies have tested the unbiasedness hypothesis and found the coefficient $\beta_1 < 1$. In fact, β_1 is frequently estimated to be less than zero.[18] The average coefficient across some 75% published estimates is -0.88.[19] Only a few published estimates of β_1 are positive, but in no study is it equal to or greater than one. Consider Figure 10.6, which represents testing the statistical significance of the null hypothesis that $\beta_1 = 1$ in equation (10.18). The two-standard band ($\pm 2\sigma$) around the null hypothesis is not even close to one, including the typical estimate of -0.88.

[18]For a comprehensive survey on the forward rate bias see Moosa and Bhatti (1997a, pp. 79–93, 257–279).
[19]See Froot and Thaler (1990).

10.6.2. *The Economist's Perspective on Forward Bias*

To rationalize the failure of the unbiasedness hypothesis, economists have suggested several explanations.[20] Many economists applied filter rules to find out if the market's expectations of exchange rates are rational (for example, Dooley and Shafer, 1983; Levich and Thomas, 1993). The studies conducted, *inter alia*, by Fama (1984), Wolff (1987b), and Miles (1993) used alternative models to find out if the failure of unbiasedness could be attributed to the presence of risk premia. A number of economists used survey data on expectations to find out if the failure of the hypothesis can be attributed to irrationality, to the risk premium, or to some combination thereof (for example, Cavaglia *et al.*, 1994). Other economists (including MacDonald (1985), Korajczyk (1985), and Pittis (1992)) focused on exploring the factors accounting for the forward bias. The results emerging from these studies have not resolved the puzzle.

10.6.3. *The Practitioner's Perspective: Limits to Speculation*

The practitioner's perspective on the forward bias puzzle is based on what Lyons (2001a) calls limits to speculation and falls within the broader microstructure approach in two ways. First, the explanation is based on the central link between exchange rate adjustment and order flow. Second, the explanation makes use of institutional realities that are often neglected in macroeconomic models.

To understand the practitioner's perspective on the forward bias puzzle, consider the size of the forward spread that is needed before a currency trading strategy yields the same Sharpe ratio resulting from a buy-and-hold equity strategy. The Sharpe ratio, which is commonly used by financial institutions to measure the performance of their trading strategies, is calculated as

$$\text{Sharpe ratio} = \frac{E(R_S) - R_f}{\sigma_S} \tag{10.19}$$

where $E(R_S)$ is the expected return, R_f is the risk-free interest rate, and σ_S is the standard deviation of the return. The underlying currency strategy requires selling the foreign currency forward when $F_t > S_t$ and buying it

[20]For a comprehensive survey see Moosa and Bhatti (1997a, pp. 82–93, 270–278).

forward when $F_t < S_t$ (or equivalently borrowing in the low interest currency and investing in the high interest rate currency).[21] The logic underlying this strategy is very simple. If $F_t > S_t$, then S_{t+1} will on average end up below F_t. One can expect to make profit from locking in a sale of foreign currency at F_t when the expected spot rate at $t + 1$ is below F_t. Similarly, if $F_t < S_t$ then one can expect to make profit from having locked in a purchase of foreign currency at F_t when the expected spot rate at $t + 1$ is above F_t. Alternatively, the buy-and-hold equity strategy would involve buying and holding an equity index fund (for example, a fund that tracks the S&P 500 index).

Under the null hypothesis of no bias in the forward rate (that is, $\beta_1 = 1$ in equation 10.18), the Sharpe ratio of the currency strategy is zero. The forward bias affects the expected return, which means that the larger the bias, the larger will be the numerator in equation (10.19). The bias does not affect the denominator in equation (10.19) because the return standard deviation on currency holding is determined by exchange rate variances and covariances. Lyons (2001a) calculated (annual) Sharpe ratios for various currency strategies as applied to the six most liquid currency pairs (DEM/USD, GBP/USD, JPY/USD, SFR/USD, FFR/USD, and CAD/USD) over the period from January 1980 to December 1998. The results are presented in Table 10.2.

Figure 10.7 shows that if the estimated β_1 falls anywhere in the interval $(-1, 3)$, then a currency strategy designed to exploit the bias has a lower return per unit risk than a simple equity strategy, which means that the currency strategy will not be useful. From the practitioner's perspective, the two standard-error band that the statistician draws around the null $\beta_1 = 1$

Table 10.2. The Sharpe ratio of a simple currency strategy.

	Strategy 1: Equal weighted	**Strategy 2: >Median discount**	**Strategy 3: <Median discount**
Sharpe ratio: with no costs	0.48	0.46	0.49
Sharpe ratio: with costs	0.37	0.39	0.41

Source: Lyons (2001a, p. 214).

[21] This is the so-called "carry trade" (see, for example, Moosa, 2008c).

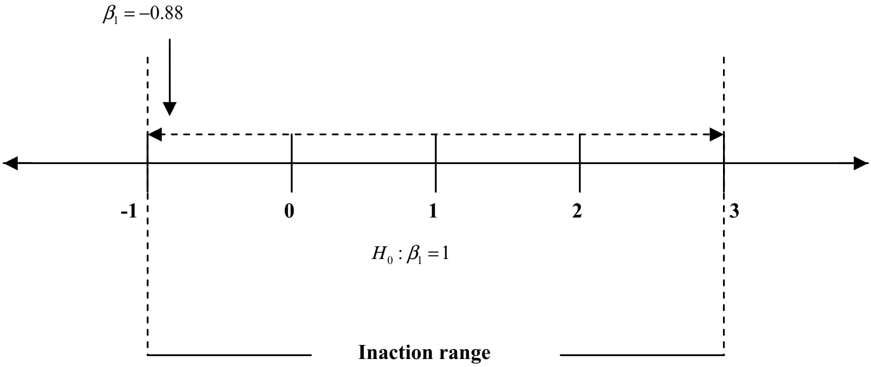

Figure 10.7. The practitioner's perspective on the forward bias puzzle.

misses the point. Instead, practitioners draw a band around the null $\beta_1 = 1$ that corresponds to speculative significance as opposed to statistical significance. If the Sharpe ratio of 0.40 is the practitioner's threshold for determining the tradable opportunities, then the interval from $\beta_1 = -1$ to $\beta_1 = 3$ would not be attractive.[22] These values of β_1 define an inaction range, a range within which the forward rate bias does not attract speculative capital. Viewed this way, the forward bias puzzle is not a glaring profit opportunity.

Forward bias can persist without violating speculative efficiency. In addition to the Sharpe ratio of currency strategies, there are three other parts of the explanation as to why bias can persist without violating speculative efficiency. These include the following:

1. *Anomaly persistence*: if speculative capital is not allocated to exploit the forward bias, the bias will persist.
2. *Institutional allocation of speculation capital*: institutions with a comparative advantage in exploiting the forward bias allocate their speculative capital base, in large part, based on Sharpe ratios.
3. *Underallocation of speculative capital*: because a Sharpe ratio of 0.4 is well below most institution's minimum threshold, the anomaly persists.

Lyons (2001a) argues that several empirical findings are consistent with his inaction band explanation based on the Sharpe ratio. One testable implication is the following. If this explanation is true, the coefficient β_1 should

[22] 0.4 is the estimated Sharpe ratio for a buy and hold strategy in U.S. stocks.

be closer to unity when the forward spread is further from zero (other things remaining the same). This is because the numerator of the Sharpe ratio depends on two variables: the size of the forward spread and the value of β_1. If the standard deviation of the return on currency holding strategy and the value of β_1 are held fixed, a forward spread that is further away from zero implies a high Sharpe ratio. A high Sharpe ratio in turn attracts more speculative capital, which induces adjustment in the exchange rate toward consistency with unbiasedness. Huisman *et al.* (1998), for example, found evidence indicating that unbiasedness holds much more tightly in periods when the forward spread is further away from zero. Flood and Taylor (1996) obtained a similar result.

10.6.4. *A Simple Explanation: Model Misspecification*

Economists tend to explain the forward rate bias in terms of the irrationality of expectations and the presence of risk premium. But there is a rather simple explanation, which is model specification, as pointed out by Moosa (2004a). The unbiasedness hypothesis stipulates that there is a lagged relation between the spot and forward rates, which gives $s_t = \delta + \phi f_{t-1} + \varepsilon_t$ (in logarithmic form). However, covered interest parity tells us that the forward rate is calculated by adjusting the spot rate for the interest rate differential, which gives the contemporaneous relation $s_t = \delta + \phi f_t + \varepsilon_t$. As CIP must hold as an arbitrage or a hedging condition, this means that the lagged model is misspecified, unless the forward rate follows an AR(1) process with a drift factor.[23] In this case $f_t = a + bf_{t-1} + \xi_t$, hence $s_t = (\delta+\phi a)+\phi b f_{t-1}+(\phi\xi_t+\varepsilon_t)$, which is a reduced form equation relating the spot rate to the lagged forward rate. But even if the assumption that the forward rate follows an autoregressive process was valid, the reduced form equation is still derived from the contemporaneous relation implied by CIP. The reasoning for the lagged relation that is based on the proposition that the forward rate forecasting error is equivalent to speculative profit is simply not sound.

Moosa (2004a) estimated the CIP equation (in a TVP framework) and found that the coefficient restriction $\phi = 1$ cannot be rejected in any case, whereas the restriction $\delta = 0$ is rejected in one case only because

[23] Moosa (2004b) demonstrates that CIP holds as an arbitrage or a hedging condition in the absence of bid–offer spreads. However, it only holds as a hedging condition once we allow for bid–offer spreads.

there is a significant interest differential between the yen and the pound. To show that the contemporaneous relation between the spot and forward rates dominates the lagged relation, Moosa also estimated the equation $s_t = \delta + \phi f_t + \lambda f_{t-1} + \varepsilon_t$ and found that the restriction $\lambda = 0$ cannot be rejected in any case. This, he argues, is a solid evidence indicating that the relation between the spot and forward rates is contemporaneous, not lagged.

10.7. Recapitulation

In response to the failure of the standard macroeconomic models, some economists sought to explore the puzzles raised by these models by capturing the effect of the structure of the foreign exchange market on the exchange rate, leading to the development of the microstructure models of exchange rates. These models are used to determine the exchange rate through the process and outcomes of exchanging currencies under explicit trading rules in the foreign exchange market. Microstructure models are derived from the market participants' individual optimization problems in which different micro aspects of the foreign exchange market play an important role in determining the exchange rate. These microstructure aspects of the foreign exchange market include the transmission of information among market participants and their behavior, the importance of order flow, the heterogeneity of trading volume, and exchange rate volatility. This approach makes it possible to explain the evolution of the exchange rate in an intra-daily sense, when foreign exchange dealers adjust their quotes throughout the business day in the absence of any macroeconomic news.

While macroeconomic models assume that market participants are identical, information is perfect, trading is costless, and that the trading process itself is irrelevant, microstructure models relax all of these assumptions. More specifically, these models postulate that the information structure is asymmetric, implying that some market participants have private information. They are based on the assumption that market participants differ in ways that affect exchange rates. Market participants with common information regularly interpret exchange rates differently from those with asymmetric information. They also embody the proposition that the trading mechanisms (institutional settings) in the foreign exchange market differ in ways that affect exchange rates.

All in all, the microstructure approach is a refreshing departure from the conventional macroeconomic approach. The beauty of this approach is that it is more realistic in the sense that it takes into account the actual process of trading in the foreign exchange market and departs from the dogmatic assumption that market participants think and act alike, which makes no sense at all. Furthermore, microstructure models do not imply the claim that fundamentals do not matter for exchange rate determination. It seems that this approach has put the last nail in the coffin of the neoclassical approach to exchange rate.

CHAPTER 11
The News Model of Exchange Rates

11.1. Introduction

One of the fundamental insights of the asset market models of exchange rates is that, in efficient markets under rational expectations, the exchange rate is determined in a similar manner to the determination of other asset prices to reflect all publicly available information about macroeconomic fundamentals. These models also postulate that the exchange rate reacts immediately to shifts in the market's expectations about the future course of these fundamentals. An important implication of these postulations is that new information that induces changes in the market's expectations is reflected swiftly in the exchange rate, thus precluding any unexploited profit opportunities from arbitrage. One implication of these postulations pertains to the estimation and evaluation of exchange rate models, suggesting that these models should be evaluated on the basis of how well unanticipated shocks or news (about the macroeconomic fundamentals underlying these models) explain changes in exchange rates.

The proposition that the exchange rate depends on expectations implies that periods dominated by uncertainty, new information, rumors, announcements, and news (which induce frequent changes in expectations) are likely to be periods in which changes in expectations are the prime cause of fluctuations in the exchange rate.[1] Furthermore, as the information inducing changes in expectations must be new, the resulting fluctuations in the spot exchange rate cannot be predicted by the lagged forward rate that is based on past information. When new information becomes the prime cause of variation in the spot exchange rate, these variations are likely to be larger than variations in the forward spread. Frenkel (1981b) argues that changes in expectations between the time that the forward prediction is made and the

[1] See Frenkel (1981b).

spot rate is observed explain the forward forecasting error. These changes in expectations, which he calls news, are based on information revealed after the forward contract has been made, but before the spot rate is realized. Consequently, the role of news is most aptly captured by changes in expectations, not by the forward forecasting errors. These changes in expectations must be incorporated in the forward market efficiency model to capture the impact of the news on the exchange rate.[2]

News about macroeconomic fundamentals affects the exchange rate, not only in the macroeconomic models, but also in the microstructure models of exchange rates. The importance of news, or unanticipated shocks, in explaining the erratic behavior of exchange rates in the context of the macroeconomic models of exchange rates has been examined, *inter alia*, by Dornbusch (1980b), Frenkel (1981b), Edwards (1983), Hoffman and Schlagenhauf (1985), Hardouvelis (1988), Hogan *et al.* (1991), Bajo-Rubio and Montavez-Graces (2000), and by Napolitano (2000). The role of news in the context of microstructure models has been examined, among others, by Evans and Lyons (2003), Love and Payne (2003), and Andersen *et al.* (2003).

It is worth noting that only common-knowledge information about macroeconomic fundamentals matters in macroeconomic models. In microstructure models, on the other hand, non-common knowledge is also important in determining the exchange rate. And while the announcement of public information about macroeconomic fundamentals is transmitted directly to the exchange rate in macroeconomic models, the transmission takes place via order flow in microstructure models.

11.2. The Role of News in Macroeconomic Models of Exchange Rates

A widely accepted view is that macroeconomic exchange rate models do not provide an adequate account of exchange rate determination. Nonetheless, it is possible that news about the fundamentals affects the exchange rate even if the fundamentals themselves do not affect the exchange rate in the manner suggested by these models.

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[2]This sounds rather elegant. However, and as argued in Chapter 10, the failure of the forward rate to predict the spot rate is that the underlying model is misspecified. And it is not misspecified because of the exclusion of the news term. Thus, the addition of a news term cannot salvage the model.

News about fundamentals can be defined as the difference between the values of the fundamentals predicted by market participants and the actual values released after announcements have been made. For example, market participants form expectations about the value of the money supply before the central bank announces the money supply figures, and these expectations are translated into decisions to buy or sell a currency. These decisions ultimately help determine the current level of the exchange rate. For example, once the central bank announces the money supply figure, market participants buy or sell currencies as long as what is announced is different from what they expected (which gives rise to news). Thus, news about fundamentals is an important determinant of the exchange rate.

Dornbusch (1980b) was the first economist to rationalize the role of news in exchange rate determination in the context of the asset market models. He argued that by introducing rational expectations, asset market models focus on “news” as the determinant of unanticipated changes in the exchange rate. According to him, the exchange rate follows a time path delineated by interest differentials (or the forward premium), whereas news about monetary developments or the state of demand bring about immediate changes in the level and time path of the exchange rate. To quantify the effect of news on the exchange rate, Dornbusch assumed that with perfect substitutability the actual rate of change of the exchange rate $\left(\Delta s_{t+1}\right)$, which is realized at time $t+1$, is equal to the sum of the anticipated change $\left(\Delta s^{\mathrm{e}}_{t+1}\right)$ (which is measured by the nominal interest differential) and the unanticipated change (news). The unanticipated change is measured as the difference between actual and anticipated changes $(\Delta s_{t+1} - \Delta s^{\mathrm{e}}_{t+1})$:

$$\Delta s_{t+1} = (i - i^*)_t + (\Delta s_{t+1} - \Delta s^{\mathrm{e}}_{t+1}). \tag{11.1}$$

By rearranging equation (11.1), we obtain

$$(\Delta s_{t+1} - \Delta s^{\mathrm{e}}_{t+1}) = \Delta s_{t+1} - (i - i^*)_t. \tag{11.2}$$

Assuming that the forward spread is equal to the interest differential, $(f - s)_t = (i - i^*)_t$, equation (11.1) can be rewritten as follows:

$$\Delta s_{t+1} = (f - s)_t + (\Delta s_{t+1} - \Delta s^{\mathrm{e}}_{t+1}) \tag{11.3}$$

or

$$\Delta s_{t+1} = (f - s)_t + (\text{news})_t. \tag{11.4}$$

Equation (11.4) suggests that in an efficient foreign exchange market characterized by rational expectations, only surprises (or news) should result in exchange rate movements, implying that fluctuations in the exchange rate cannot be predicted by the forward spread. By adding s_t to both sides of equation (11.4), the news model can be represented by the equation

$$s_{t+1} = f_t + (\text{news})_t. \tag{11.5}$$

As evident from equation (11.5), for the foreign exchange market to be efficient, excess return on any speculative investment must be uncorrelated with any linear combination of costless information available at the time when the decision to buy or sell a currency is made. This implies that only news or unanticipated changes in information should be correlated with excess returns.

Thus, equations (11.4) and (11.5) can be used to examine the impact of news on the exchange rate. However, it must be noted that these equations cannot be tested empirically unless the news variable is quantified. For the empirical testing of equations (11.4) and (11.5), therefore, one has to identify the factors that determine the impact of news on the spot exchange rate. To identify these factors, we start by making the following assumptions: (i) the spot and forward foreign exchange markets are characterized by the presence of a large number of arbitragers with ample funds; (ii) the absence of exchange controls; (iii) negligible transaction costs; and (iv) rational expectations. Given these assumptions, the no-arbitrage condition can be written as

$$f_t = E_t s_{t+1} + \rho_t \tag{11.6}$$

where f_t is the logarithm of the forward rate observed at time t (for delivery at time $t+1$), s_{t+1} is the logarithm of the spot exchange rate prevailing at $t+1$ and ρ_t is the risk premium. E_t is the rational expectations operator, such that

$$E_t s_{t+1} = E(s_{t+1} \mid \Omega_t) \tag{11.7}$$

where Ω_t is the information set available at time t, on the basis of which expectations are formed. By manipulating equation (11.6), relaxing the restriction that the coefficient on the forward rate is unity, and assuming (for the time being) that the risk premium is time-invariant, we obtain

$$E_{t-1} s_t = \mu + \delta f_{t-1} \tag{11.8}$$

where $\mu = -\rho_{t-1}$. The coefficient restriction implying unbiased efficiency is $(\mu, \delta) = (0, 1)$.

Now, suppose that the spot exchange rate is determined by the linear relation

$$s_t = \sum_{i=1}^{n} \alpha_i z_{it} \tag{11.9}$$

where z is a vector of explanatory variables. By applying the rational expectations operator, we obtain

$$E_{t-1} s_t = \sum_{i=1}^{n} \alpha_i E_{t-1} z_{it}. \tag{11.10}$$

By subtracting equation (11.10) from equation (11.9), we obtain

$$s_t - E_{t-1} s_t = \sum_{i=1}^{n} \alpha_i (z_{it} - E_{t-1} z_{it}) \tag{11.11}$$

or

$$s_t = E_{t-1} s_t + \sum_{i=1}^{n} \alpha_i (z_{it} - E_{t-1} z_{it}). \tag{11.12}$$

Substituting equation (11.8) into equation (11.12) gives

$$s_t = \mu + \delta f_{t-1} + \sum_{t=1}^{n} \alpha_i (z_{it} - E_{t-1} z_{it}). \tag{11.13}$$

Equation (11.13) implies that if the restrictions $\mu = 0$ and $\delta = 1$ hold, then excess return to speculation should be correlated with unanticipated changes in the vector of z variables that are relevant to the determination of the spot exchange rate. An important issue underlying equation (11.13) is the identification of these variables because several specifications of the news model can be suggested, depending upon the variables appearing in the underlying macroeconomic models.

11.2.1. *The News Framework of the Flow Model*

The Mundell–Fleming flow model of exchange rates is based upon the notion that the exchange rate adjusts to balance the demand for foreign exchange and the supply of foreign exchange that arises out of current account as well as capital account transactions. In this model, the exchange rate moves to equilibrate the international demand for goods and assets. The demand for goods by domestic and foreign residents is determined by relative domestic and foreign prices and incomes. On the other hand, the international demand for assets depends on the difference between domestic and foreign interest rates. Consequently, the flow model suggests that excess returns to speculation should be correlated with unanticipated changes in the price differentials, income differentials, and interest differentials. Thus, the news model as implied by equation (11.13) can be rewritten to obtain a specification that is based on the flow model:

$$\begin{aligned} s_t = \mu + \delta f_{t-1} &+ \alpha_1[(p_t - p_t^*) - E_{t-1}(p_t - p_t^*)] \\ &+ \alpha_2[(y_t - y_t^*) - E_{t-1}(y_t - y_t^*)] \\ &- \alpha_1[(i_t - i_t^*) - E_{t-1}(i_t - i_t^*)]. \end{aligned} \tag{11.14}$$

Equation (11.14) shows that an unanticipated increase in domestic prices and real income relative to foreign prices and real income gives rise to domestic currency depreciation, and vice versa.

11.2.2. *The News Framework of the Monetary Models*

In the late 1970s and early 1980s, a wide variety of monetary models emerged as alternatives to the flow model. These models include (i) flexible-price monetary model, (ii) sticky-price monetary model, (iii) real interest differential sticky-price model, and (iv) equilibrium real exchange rate sticky-price model. They postulate that the exchange rate adjusts to balance the international demand for domestic and foreign money stocks. Some of these models imply that goods prices adjust instantaneously, while others are based on the assumption that goods prices adjust only in the long run. However, all these models share the common postulate that asset prices adjust rapidly, and that domestic and foreign monetary conditions at home and abroad are stable. The flexible-price monetary model is derived by combining the money demand functions with purchasing power parity and uncovered interest parity, producing an equation whereby the spot exchange rate can be expressed as a function of relative money supply, relative income, and the expected inflation differential. Therefore, the news framework of this model suggests that excess returns to speculators should be correlated with unanticipated changes in the relative money supply, relative income, and the expected inflation rate differential:

$$\begin{aligned} s_t = \mu_t + \delta_t f_{t-1} &+ \alpha_1[(m_t - m_t^*) - E_{t-1}(m_t - m_t^*)] \\ &- \alpha_2[(y_t - y_t^*) - E_{t-1}(y_t - y_t^*)] \\ &+ \alpha_3[(\pi_t^{\mathrm{e}} - \pi_t^{*\mathrm{e}}) - E_{t-1}(\pi_t^{\mathrm{e}} - \pi_t^{\mathrm{e}*})]. \end{aligned} \tag{11.15}$$

Equation (11.15) shows that an unanticipated increase in the domestic money supply relative to the foreign money supply results in an unanticipated increase in domestic prices relative to foreign prices, which in turn causes depreciation of the domestic currency. Likewise, an unexpected rise in either domestic income or domestic expected inflation relative to the corresponding foreign variable alters the domestic demand for money relative to the foreign demand for money, leading to currency appreciation in the first case (unexpected rise in income) and depreciation in the second case (unexpected rise in inflation).

The sticky-price model of Dornbusch (1976c) postulates that goods prices fail to adjust in the short run, which means that purchasing power parity holds in the long run only. An interesting property of this model is that, as a short-run reaction to monetary expansion, the exchange rate overshoots the long-run value determined by purchasing power parity. With sticky prices, an expansion in the domestic money supply relative to the foreign money supply results in a decline in domestic interest rates, which in turn causes the domestic currency to depreciate as a result of capital outflow. This depreciation exceeds the depreciation associated with purchasing power parity as it must be adequate so that the rationally expected rate of future appreciation cancels out the interest differential, so that uncovered interest parity is maintained. Thus, the news form of the sticky-price model can be written as

$$\begin{aligned} s_t = \mu_t + \delta_t f_{t-1} &+ \alpha_1[(m_t - m_t^*) - E_{t-1}(m_t - m_t^*)] \\ &- \alpha_2[(y_t - y_t^*) - E_{t-1}(y_t - y_t^*)] - \alpha_3[(i_t - i_t^*) - E_{t-1}(i_t - i_t^*)]. \end{aligned} \tag{11.16}$$

Frankel (1979b) developed a variant of the Dornbusch (1976c) sticky-price model, in which the real interest differential appears as an additional explanatory variable. In a news form, this model suggests that unanticipated changes in the exchange rate are a function of relative money supply, relative income, relative expected inflation, and the expected real interest rate differential

$$
\begin{aligned}
s_t = \mu_t + \delta_t f_{t-1} &+ \alpha_1[(m_t - m_t^*) - E_{t-1}(m_t - m_t^*)] \\
&- \alpha_2[(y_t - y_t^*) - E_{t-1}(y_t - y_t^*)] \\
&+ \alpha_3[(\pi_t^{\mathrm{e}} - \pi_t^{\mathrm{e}*}) - E_{t-1}(\pi_t^{\mathrm{e}} - \pi_t^{\mathrm{e}*})] \\
&- \alpha_5[(i_t - \pi_t^{\mathrm{e}}) - (i_t^* - \pi_t^{\mathrm{e}*}) - E_{t-1}((i_t - \pi_t^{\mathrm{e}}) - (i_t^* - \pi_t^{\mathrm{e}*}))].
\end{aligned} \tag{11.17}
$$

Equation (11.17) represents a general news model that incorporates features of both the flexible-price and the sticky-price models. Like the flexible-price model, it suggests that an unanticipated rise in the domestic money supply and inflation rate relative to the corresponding foreign variables lead to depreciation of domestic currency, whereas an unanticipated rise in domestic income relative to foreign income results in currency appreciation. On the other hand (like the sticky-price model), an unanticipated rise in domestic interest rates relative to foreign interest rates results in domestic currency appreciation.

Hooper and Morton (1982) developed a more general variant of both the sticky-price model and the real interest differential version of Frankel (1979b). In this model, cumulative current account differences appear as an additional determinant of the exchange rate. The news version of this model is

$$
\begin{aligned}
s_t = \mu_t + \delta_t f_{t-1} &+ \alpha_1[(m_t - m_t^*) - E_{t-1}(m_t - m_t^*)] \\
&- \alpha_2[(y_t - y_t^*) - E_{t-1}(y_t - y_t^*)] \\
&+ \alpha_3[(\pi_t^{\mathrm{e}} - \pi_t^{\mathrm{e}*}) - E_{t-1}(\pi_t^{\mathrm{e}} - \pi_t^{\mathrm{e}*})] \\
&- \alpha_5[(i_t - \pi_t^{\mathrm{e}}) - (i_t^* - \pi_t^{\mathrm{e}*}) - E_{t-1}((i_t - \pi_t^{\mathrm{e}}) - (i_t^* - \pi_t^{\mathrm{e}*}))] \\
&- \alpha_6[(ca_t - ca_t^*) - E_{t-1}(ca - ca_t^*)].
\end{aligned} \tag{11.18}
$$

The same interpretation as before is valid for this model.

11.2.3. *The News Framework of the Portfolio Balance Models*

Portfolio balance models can be classified into three main categories, depending upon assumptions pertaining to the portfolio preferences of residents in different countries. In Chapter 8, we derived the specifications of portfolio balance models embodying various assumptions on asset preferences where the exchange rate is determined by a variety of factors. We have also derived various specifications representing syntheses of the portfolio balance model with different variants of the monetary model along the lines suggested by Frankel (1983b), where the exchange rate is determined not only by monetary fundamentals but also by relative bond supplies.[3] These different model specifications suggest that unanticipated changes in the exchange rate are due to unanticipated changes in the set of variables postulated by the underlying portfolio balance model as exchange rate determinants.

However, Hoffman and Schlagenhauf (1985) point out that as announcements on bond holdings are not made, it may be argued that market participants respond to announcements that result in changes in bond holdings. Frankel (1983b) argues that the supply of bonds issued by a country to its private sector is made up of that country's government debt, the cumulative sales of its foreign assets in foreign exchange intervention, its assets held by other central banks, and its monetary base. On the other hand, the supply of foreign bonds held by the private sector is represented by the cumulative current account position plus sales by other central banks of foreign assets for its currency less its central bank purchase of foreign assets in foreign exchange intervention. These definitions suggest that a fiscal deficit in a country could be an important factor indicating changes in that country's supply of domestic bonds, whereas current account developments in that country could convey information about possible changes in the supply of foreign bonds held by its private sector. The news model in this case shows that the spot exchange rate depends on unanticipated changes in a country's current account, fiscal deficit, and the interest rate differential:

$$
\begin{aligned}
s_t = \mu_t + \delta_t f_{t-1} &- \alpha_1[(i_t - i_t^*) - E_{t-1}(i_t - i_t^*)] \\
&- \alpha_2[(ca_t - ca_t^*) - E_{t-1}(ca_t - ca_t^*)] \\
&+ \alpha_3[(def_t - def_t^*) - E_{t-1}(def_t - def_t^*)]. \qquad (11.19)
\end{aligned}
$$

Equation (11.19) shows that an unanticipated surplus in the current account of a country is expected to result in currency appreciation, whereas an unanticipated domestic budget deficit results in depreciation.

[3]For example, equations (8.43), (8.47), and (8.48).

The news form of the synthesis of Dornbusch's (1976c) sticky-price and simple portfolio balance equations as well as the synthesis of Frankel's (1979b) real interest differential and simple portfolio balance equations are given respectively as follows:

$$\begin{aligned} s_t = \mu_t + \delta_t f_{t-1} + \alpha_1[(m_t - m_t^*) - E_{t-1}(m_t - m_t^*)] \\ - \alpha_2[(y_t - y_t^*) - E_{t-1}(y_t - y_t^*)] - \alpha_3[(i_t - i_t^*) - E_{t-1}(i_t - i_t^*)] \\ - \alpha_4[(ca_t - ca_t^*) - (ca_t - ca_t^*)] \\ + \alpha_5[(def_t - def_t^*) - (def_t - def_t^*)] \end{aligned} \tag{11.20}$$

$$\begin{aligned} s_t = \mu_t + \delta_t f_{t-1} + \alpha_1[(m_t - m_t^*) - E_{t-1}(m_t - m_t^*)] \\ - \alpha_2[(y_t - y_t^*) - E_{t-1}(y_t - y_t^*)] \\ + \alpha_3[(\pi_t^{\mathrm{e}} - \pi_t^{\mathrm{e}*}) - E_{t-1}(\pi_t^{\mathrm{e}} - \pi_t^{\mathrm{e}*})] \\ - \alpha_5[(i_t - \pi_t^{\mathrm{e}}) - (i_t^* - \pi_t^{\mathrm{e}*}) - E_{t-1}((i_t - \pi_t^{\mathrm{e}}) - (i_t^* - \pi_t^{\mathrm{e}*}))] \\ - \alpha_6[(ca_t - ca_t^*) - E_{t-1}(ca_t - ca_t^*)] \\ + \alpha_7[(def_t - def_t^*) - E_{t-1}(def_t - def_t^*)]. \end{aligned} \tag{11.21}$$

Again, the same description as before is valid.

11.3. The Role of News in the Microstructure Models of Exchange Rates

The microstructure approach is useful for understanding the effect of news on the exchange rate. In the microstructure models, order flow is identified as an important determinant of exchange rate dynamics at short horizons. Liquidity and information are the two key channels through which order flow can affect the exchange rate. The liquidity effect materializes only when foreign exchange dealers need to be compensated for the risk they bear when they hold foreign currencies, whereas the information effect arises only when order flow contains information about macroeconomic fundamentals. This linkage of order flow with macroeconomic fundamentals relates the former news or announcements that are continuously released to foreign exchange traders by various official and unofficial sources.

The microstructure models of exchange rates emphasize the information role of order flow in a trading setting with heterogeneous market participants. In the presence of information asymmetry, order flow is a proxy that captures the market's reaction to macroeconomic announcements and other news that anticipate future shifts in economic conditions. Order flow helps aggregate the heterogeneous nature of the information available to various market participants and traders' expectations of fundamentals. Information asymmetry may arise from the fact that news and information are not equally accessible to everyone, or from the fact that various participants interpret news in different ways. As macroeconomic fundamentals change, traders adjust their expectations and rebalance their portfolios accordingly, leading to changes in exchange rates. This implies that order flow is a transmission mechanism for public information (about macroeconomic fundamentals) and private information that affect exchange rates. Evans and Lyons (2003) believe that at least half of the response of the exchange rate to macroeconomic news announcements is transmitted to exchange rates via order flow.

In efficient asset markets, where market participants hold rational expectations, the equilibrium exchange rate is assumed to change immediately in response to the arrival of new information within the framework of not only the standard macroeconomic models, but also the microstructure models. In macroeconomic models, what matters for the exchange rate determination process is common knowledge (CK) news to all market participants. In microstructure models, on the other hand, heterogeneous beliefs (or non-common knowledge news) are essential for exchange rate determination (Evans, 2002). Evans (2008a,b) argues that, in the microstructure models, the equilibrium exchange rate is solely a function of the bid and offer rates quoted by dealers at a point in time, and that it reacts immediately to the new information that arrives to dealers via macroeconomic announcements or from customers and other dealers.

Evans (2002) points out that common knowledge news (public announcements of information about fundamentals) arrives simultaneously to all market participants and that the implications of news for the equilibrium exchange rate are interpreted homogenously. On the other hand, non-common knowledge news can come to market participants from a private or a public source, which means that there is no consensus among market participants about its implications for the equilibrium exchange rate. Thus, a macroeconomic announcement may be a source of public non-common knowledge news when there is no consensus among market participants about its implications for the exchange rate. The key difference between common knowledge and non-common knowledge news lies in the fact that the former immediately shifts the whole distribution of the equilibrium exchange rate (with no effect on the pattern of foreign exchange trading) whereas the latter affects both the equilibrium exchange rate and the trading pattern, as measured by interdealer order flow.

However, given the fact that there is no widely accepted microstructure model of exchange rates, neither of these extreme perspectives is likely to be correct. Evans and Lyons (2002a) have developed a hybrid view within the microstructure model, postulating that public macroeconomic information affects the equilibrium exchange rate not only directly (as in a standard macroeconomic model) but also indirectly via order flow. The Evans–Lyons model integrates public macroeconomic information and heterogenous agents' private information, where order flow serves as a mapping mechanism from dispersed information to exchange rates. Empirically, they found that the R^2 of a model designed to explain daily exchange rate changes increases from 0.01–0.05 for a regression of exchange rate changes on interest rate differentials (a proxy for public macroeconomic information) to 0.4–0.6 for a regression that incorporates order flow.

In fact, order flow is an important transmission mechanism that facilitates the aggregation of dispersed exchange rate relevant information such as heterogenous interpretations of news, changes in expectations, and shocks to hedging and liquidity demands (Rime *et al.*, 2007). Theoretically, order flow can aggregate macroeconomic information for two reasons: (i) different interpretation of news and (ii) heterogeneous expectations of fundamentals. Order flow explains contemporaneous exchange rate movements because it contains information (either about macroeconomic fundamentals or long-run risk premia) that was previously dispersed among market participants. A distinguishing feature of microstructure analysis is that (unlike macroeconomic analysis) the same information is not shared by all market participants and/or is interpreted differently by participants.

The fact that order flow helps explain exchange rate behavior does not necessarily imply that it drives exchange rates. Indeed, it may well be that macroeconomic fundamentals are the main force driving the exchange rate, yet the conventional measures of news about future values of fundamentals are so imprecise that order flow performs better empirically. In fact, order flow is most informative when it conveys information (about macroeconomic fundamentals) that is dispersed among market participants. However, it is less informative when it arises from the management of inventories by foreign exchange dealers in response liquidity shocks (Lyons, 2001a).

11.3.1. *The Link Between Macroeconomic Fundamentals and Exchange Rates*

In the microstructure models of exchange rates, order flow may be seen as a mechanism for aggregating differences in the interpretation of news in real time and changes in heterogeneous expectations about the future state of the economy. Therefore, the exchange rate can be written as the discounted value of current and expected fundamentals[4]:

$$s_t = (1-b)\sum_{\tau=0}^{\infty} b^{\tau} E_t^m z_{t+\tau}. \tag{11.22}$$

By iterating equation (11.22) forward and rearranging terms, we obtain

$$\Delta s_{t+1} = \frac{(1-b)}{b}(s_t - E_t^m z_t) + \varepsilon_{t+1}^m \tag{11.23}$$

where

$$\varepsilon_{t+1} = (1-b)\sum_{\tau=0}^{\infty} b^{\tau}[E_{t+1}^m z_{t+\tau+1} - E_t^m z_{t+\tau+1}]. \tag{11.24}$$

Thus, innovation in the spot rate (ε_{t+1}^m) comes from the present value of revisions in the market maker's forecasts of future fundamentals. This implies that the percentage change in the exchange rate realized at time $t+1$ is a function of (i) the gap between the current exchange rate and expected fundamentals and (ii) a term that captures changes in expectations. Thus, there is scope for order flow to coordinate agents' expectations about current fundamentals and to capture changes in expectations of future fundamentals that agents base their trades on.

Unexpected changes in fundamentals may trigger different interpretations regarding the implications of news for the equilibrium exchange rate. Suppose that a scheduled announcement on GDP growth in the U.S. relative to Japan is x percent greater than what was expected by market participants. Furthermore, let us assume that every market participant agrees that this represents good news for the value of the U.S. dollar in terms of the Japanese yen. As a result of the announcement, the dollar will become y percent more valuable in terms of Japanese yen, inducing dealers to quote a JPY/USD rate that is y percent higher. This is the standard mechanism through which news affects exchange rates.

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[4]See Evans and Lyons (2005a).

Now suppose that everyone believes that the GDP announcement represents good news for the dollar, but there are diverse assessments as to how large the resulting appreciation of the U.S. dollar should be. As a result, the initial rise in the JPY/USD exchange rate may be viewed as too large by some market participants and too small by others. Thus, traders who believe that the rise is too small will place orders to purchase the dollar, while those who believe the rise to be too large will place orders to sell the dollar. In aggregate, the balance of these trades represents the order flow that dealers use to revise their exchange rate quotes.

11.3.2. *The Link Between Order Flow and Macroeconomic News*

From microstructure models we know that market makers obtain information about macroeconomic fundamentals from the flow of transactions. Order flow and consequently transaction flows arising at time t are likely to be correlated with the arrival of any information to market makers. But to determine whether or not order flow contains information about fundamentals, we must realize whether or not transaction flows generated before time t could be correlated with the arrival of information between t and $t+1$. If all transaction flows are observed contemporaneously by every market maker, the exchange rate innovation (ε^m_{t+1}) is expected to be correlated with the unanticipated portion of transaction flows at time t. As a consequence, ε^m_{t+1} is likely to be correlated with order flows at time $t-1$ and earlier.

If market participants trade on the basis of heterogeneous interpretations of unexpected changes in fundamental values, then unexpected changes in fundamentals (or news about fundamentals) can play an important role in explaining fluctuations in order flow. Unexpected changes in fundamentals can be calculated as follows[5]:

$$n_{i,t} = \frac{z^a_{i,t-k} - E_{t-1} z^a_{i,t-k}}{\hat{\sigma}_i} \tag{11.25}$$

where $z^a_{i,t-k}$ is the value announced for fundamental variable i at time $t-k$; k is a week, month, or quarter; E_{t-1} is the expected value of, or the survey expectation of, $z^a_{i,t-k}$, and $\hat{\sigma}_i$ is the sample standard deviation of $z^a_{i,t-k} - z_{t-l} F^a_{i,t-k}$ over announcement days $t-k$. If announcements on macro variables are made on fixed days, the daily timing of each announcement will be known in advance. These macroeconomic announcements are called

[5] See Balduzzi *et al.* (2001).

"scheduled announcements." Let us set $n_{i,t} = 0$ on days for which no announcement is scheduled. To find out whether or not macroeconomic news affects order flow, we can estimate the regression equation:

$$\Delta x_t^j = \alpha_0 + \sum \alpha_i n_{i,t} + \eta_t \tag{11.26}$$

where j may represent different currencies. Positive news on the domestic economy is associated with a decrease in order flow, whereas positive news on foreign economies is associated with an increase in order flow.

The microstructure model predicts that news affects the exchange rate both directly and indirectly via order flow (Lyons, 2001a; Evans and Lyons, 2003). The common knowledge part of news affects the equilibrium exchange rate directly, while the non-common knowledge part of news reflects heterogeneous interpretations of the news for the equilibrium exchange rate. By regressing changes in the exchange rate on macroeconomic news, we can find out if macroeconomic announcements affect the exchange rate directly. The regression equation is written as

$$\Delta s_t^j = \beta_0 + \sum \beta_i n_{i,t} + \upsilon_t. \tag{11.27}$$

It must be noted that if macroeconomic news explains changes in the exchange rate significantly, this will not imply that order flow information is redundant. Controlling for the direct news effect, order flow could still transmit the heterogeneous interpretations of this news to the exchange rate. To find out if macroeconomic news affects the exchange directly or indirectly (via order flow), we regress changes in the exchange rate on macroeconomic news and order flow:

$$\Delta s_t^j = \gamma_0 + \sum \gamma_i n_{i,t} + \phi \Delta x_t^j + w_t. \tag{11.28}$$

Equation (11.28) can help demonstrate whether using order flow boosts the explanatory power of the model, as compared to news alone. The regression equation can also be used to show if order flow alone explains exchange rate fluctuations.

11.4. Recapitulation

Macroeconomic models of exchange rates have identified a wide variety of variables as relevant to the determination of the spot exchange rate. These models can be divided into two broad categories: flow models and asset market models. Asset market models have been put forth as an alternative to the traditional flow models. There is a wide array of asset market models that differ from each other, depending upon the degree of substitutability between domestic and foreign assets and the degree of adjustment of prices in the goods markets. Based on the degree of asset substitution and adjustment of goods prices, asset market models in each case can be classified into two broad categories: (i) monetary models and portfolio balance models and (ii) flexible-price monetary models and sticky-price monetary models. In all of these models, the exchange rate is determined by a set of macroeconomic variables such that total changes in exchange rates are related to total changes in macroeconomic variables, where the word "total" implies both anticipated and unanticipated changes.

The news approach postulates that it is possible that news about fundamentals affects the exchange rate even if the fundamentals themselves do not affect the exchange rate in the manner suggested by these models. News about fundamentals can be defined as the difference between the values of the fundamentals predicted by market participants and the actual values released after announcements have been made. This proposition makes a lot of sense intuitively, but the news model does not fare better than conventional models empirically because of misrepresentation of news when the unanticipated components are derived econometrically.

CHAPTER 12

Empirical Evidence on the Macroeconomic Models of Exchange Rates

12.1. Evidence on the Mundell–Fleming Model

Notwithstanding the enormous amount of theoretical work carried out on the Mundell–Fleming model, not much work has been conducted to test its empirical validity.[1] Pearce (1983) was the first economist to examine the empirical validity of the Mundell–Fleming model for the Canadian dollar exchange rate *vis-à-vis* the U.S. dollar using quarterly data over the period 1971:Q1–1982:Q1. To test the validity of the Mundell–Fleming model, Pearce (1983) employed regression analysis to estimate equation (2.11) and produced results that were not supportive of the model. The results showed that the model performs extremely poorly, not only because its explanatory power is very low (the value of R^2 is 0.14), but also because it suffers from serial correlation. The OLS estimates of the coefficients turned out to be statistically insignificant.

Bhatti (2001) examined the empirical relevance of the Mundell–Fleming model for the Pakistani rupee exchange rates *vis-à-vis* the currencies of the U.S., U.K., Switzerland, Germany, France, and Japan using quarterly data on exchange rates, industrial production, short-term interest rates (market rates), and long-term interest rates (bond yields) over the period 1982:Q1–2000:Q4. By employing the Johansen and Juselius (1990) test for cointegration, he obtained results showing a strong long-run relation between exchange rates and their underlying determinants (relative prices, incomes,

[1] However, a significant amount of work has been carried out, among others, by Rhomberg (1964), Krueger (1965), Sohmen (1967), Sohmen and Schneeweiss (1969), Turnovsky and Kingston (1977), Prachowny (1977), and Makin (2007) on the theoretical and empirical relevance of the model with respect to its predictions regarding the effectiveness of fiscal and monetary policies under fixed and flexible exchange rates.

and interest rates) in all cases. The estimates of the coefficients of the model are correctly signed and significant when long-term interest rates are used and not so with short-term interest rates. The results lend strong support to the Mundell–Fleming model in all cases, except for the exchange rates *vis-à-vis* the French franc and the U.S. dollar when long-term interest rates are used.

Following Harvey (2006b), Moosa (2007) specified and estimated a post-Keynesian flow model in which the exchange rate depends on relative income, relative prices, and the interest rate differential, as well as a moving average of the exchange rate, which is justified by Harvey in terms of the behavioral finance phenomena of availability, representativeness, anchoring, conventional wisdom, and overconfidence. The model specified by Moosa is different from the (flow) model used by Harvey in that the dependent variable in the model used by Harvey is the first difference rather than the level (or the log level) of the exchange rate. Moosa argues that the flow model is typically written in such a way as to make the dependent variable the level of the exchange rate because the explanatory variables are written in levels. Furthermore, the diagrammatic representation of the flow model has the level of the exchange rate on the vertical axis (the dependent variable), whereas the explanatory variables cause shifts in the supply and demand curves.

The empirical work of Moosa (2007) was designed to find out if the results of Harvey (2006b), which demonstrate the superiority of the post-Keynesian approach over the neoclassical approach, hold after taking care of what may appear as loopholes that cast doubt on the validity of the results and conclusions. The loopholes in Harvey's work, as identified by Moosa (2007), are (i) an overly simplistic version of the monetary model; (ii) deriving inference on the basis of invalid t statistics; (iii) comparing two models with different dependent variables; and (iv) possible data mining. These points were dealt by Moosa in the following manner:

1. The monetary model used by Harvey is simplistic because it is based on a simple demand for money function that does not include the interest rate as an explanatory variable. This can be perceived as misspecification because the interest rate affects not only the speculative motive for holding money, but also the precautionary and transactions motives (for example, Baumol, 1952). The monetary model used by Moosa encompasses a semi-log demand for money function in which the interest rate is an explanatory variable.

2. The t statistics cannot be used to derive inference on the sign and significance of the estimated coefficients (and hence the importance of individual explanatory variables) when the regressors are integrated variables. Although this problem can be avoided by correcting the t statistics, Moosa chose to avoid it by using alternative model evaluation criteria that can be used to assess the validity of the overall model specification.
3. The problem of comparing two models with different dependent variables was simply avoided by specifying both models with the dependent variable being the log exchange rate (as suggested by economic theory). This made it possible to carry out non-nested model selection tests, which would be impossible otherwise.
4. The problem of data mining was avoided by estimating the flow model exactly as specified by economic theory without experimenting with the explanatory variables.

The results presented by Moosa corroborate Harvey's (2006b) results, which show a rejection of the neoclassical approach to exchange rate determination (as represented by the flexible-price monetary model) in favor of the post-Keynesian approach (as represented by a version of the flow model that takes into account market psychology). The significance of these results for the underlying debate is that Harvey's conclusions are valid even after dealing with the points that may be raised by the supporters of the neoclassical approach. What is also significant is that Harvey's results are corroborated despite the use of a different data frequency, four exchange rates (as opposed to one) and different model evaluation criteria.

12.2. Evidence on the Monetary Model of Exchange Rates

There is a vast amount of empirical work on various versions of the monetary model of exchange rates. A selective survey is presented in the following four subsections.

12.2.1. *Evidence Based on Conventional Econometric Methods*

A selective summary of the studies employing conventional econometric methods is presented in Table 12.1. The earliest studies investigating the validity of the flexible-price monetary model were conducted, *inter alia*, by Bilson (1978a–c), Hodrick (1978), Humphrey and Lawler (1977), and

Table 12.1. **Summary of the studies based on conventional econometric methods.**

Study	Sample	Currencies	Findings
Frenkel (1976)	1920–23, monthly	German mark *vis-à-vis* the U.S. dollar	The forward premium is used as a proxy for the expected change in the exchange rate. The results are supportive of the flexible-price model.
Fry (1976)	1955–72, annual	Afghanis *vis-à-vis* the U.S. dollar	A quite remarkable explanatory power of the monetary model.
Bilson (1978a)	1972–76, monthly	German mark *vis-à-vis* the British pound	The results are supportive of the flexible-price monetary model.
Bilson (1978b)	1970–77, monthly	German mark *vis-à-vis* the British pound	The rational expectations monetary model is consistent with the data.
Bilson (1978c)	1970:06–77:08, monthly	German mark *vis-à-vis* the British pound	The results offer strong support for the monetary model in general.
Humphrey and Lawler (1977)	1973–77, quarterly	U.S. dollar *vis-à-vis* the British pound and Italian lira	The results for the British pound are supportive of the monetary model.
Putnam and Woodbury (1979)	1972–77, monthly	British pound *vis-à-vis* the U.S. dollar	The use of the Hildreth–Lu technique provides results that are supportive of the flexible-price model.
Frankel (1979b)	1974–78, monthly	German mark *vis-à-vis* the U.S. dollar	The results are highly supportive of the real interest differential model.
Dornbusch (1980b)	1973–79, quarterly	U.S. dollar *vis-à-vis* the German mark	Unfavorable results.
Rasulo and Wilford (1980)	1973–78, quarterly	U.S. dollar *vis-à-vis* the British pound and Italian lira	The equality of income elasticities is a reasonable assumption for Italy, but not for the U.K.
Haynes and Stone (1981)	1974–78, monthly	German mark *vis-à-vis* the U.S. dollar	The results reject the hypothesis of identical demand for money coefficients.

(*Continued*)

Table 12.1. (*Continued*)

Study	Sample	Currencies	Findings
Driskell (1981)	1973–77, quarterly	Swiss franc *vis-à-vis* the U.S. dollar	Favorable for the sticky-price monetary model.
Hooper and Morton (1982)	1973–78, monthly and quarterly	U.S. dollar trade-weighted index	A hybrid monetary model that includes cumulative current account balances among the regressors. The results are favorable.
Frankel (1983a)	Jan. 1974–Oct. 1978, monthly	German mark *vis-à-vis* the U.S. dollar	The results are consistent with the sticky-price monetary model. Only the coefficient on the relative money supply is incorrectly signed.
Frankel (1983b)	1974–81, monthly	German mark, British pound, French franc, Japanese yen, and Canadian dollar *vis-à-vis* the U.S. dollar	An attempt to revive the monetary model by adding a relative velocity term. The results are favorable.
Boughton (1984)	1973–83, quarterly	German mark, British pound, French franc, Japanese yen *vis-à-vis* the U.S. dollar, and U.S. dollar SDR-weighted effective exchange rate	Hatanaka's residual-adjusted Aitken estimator is used to negate the endogeneity of interest rates.
Lafrance and Racette (1985)	1971–80, monthly	Canadian dollar *vis-à-vis* the U.S. dollar	The Cochrane–Orcutt procedure is used to eliminate the presence of severe autocorrelation. The results are poor.
Leventakis (1987)	1974–84, quarterly	German mark *vis-à-vis* the U.S. dollar	Unfavorable results.

Putnam and Woodbury (1979). They relied mainly on conventional econometric procedures (OLS, 2SLS, and instrumental variables). The results obtained from these studies showed that the simple model, which is represented by equation (3.7), performed fairly well during the first 5 years or so of the flexible exchange rates period. These results were also interpreted as indicating support for the implications of the monetary model that there is a one-to-one correspondence between the exchange rate and relative money supply and that there is a negative relation between the exchange rate and relative income. Bilson (1978b) and Hodrick (1978) tested the monetary model for two currencies (British pound and German mark) *vis-à-vis* the U.S. dollar, producing results that were supportive of the implications of the flexible-price monetary model, except for the German mark for which the coefficient on the interest differential turned out to be significantly negative. On the other hand, Frankel (1979b) tested a more general monetary model, incorporating the inflation differential as an additional explanatory variable, and found results that were supportive of the model for the German mark over the period 1974:07–1978:02.

However, the empirical studies that were conducted in the 1980s and 1990s were not that supportive of the monetary model (for example, Frankel, 1983a). While the evidence presented in earlier studies was supportive of the monetary model, more recent evidence has rejected the model as a way of explaining the determination of exchange rates. Studies refuting the monetary model are consistent in producing the wrong sign of the coefficient on relative money supply, which is hypothesized to be positive and equal to one (for example, Dornbusch, 1980b; Haynes and Stone, 1981; Frankel, 1981). The probable origin of this problem is the potential endogeneity of the interest rate differential and the expected inflation differential. Having these endogenous variables among the explanatory variables in a regression equation means that direct estimation by OLS is inappropriate because the endogenous variables are likely to be correlated with the residuals, thus making the OLS estimates biased and inconsistent. With the relative money supply and nominal interest rate differential among the regressors, it is certain that an endogenous variable will be among the explanatory variables because the monetary authorities cannot target the money supply and interest rates simultaneously. The perverse sign of the coefficient on the money supply term may therefore reflect the fact that the authorities choose to determine interest rates while allowing the domestic money supply to adjust endogenously. This means that depreciation of the domestic currency is associated with a rise in the interest rate and a decline in the money supply.

A second problem that is evident in the studies using OLS is that of serial correlation. The values of the first-order serial correlation coefficients reported by Backus (1984), Lafrance and Racette (1985), and Leventakis (1987) are not statistically different from unity. This suggests that the monetary model is misspecified in the sense that some variables that are important determinants of the exchange rate have been excluded. It could also mean that certain dynamic specifications have been ignored (misspecification of the dynamics).

A third explanation for the failure of the monetary model when estimated by OLS is that the demand for money function and its assumptions are unreliable. The first assumption (restriction) is that of identical demand for money coefficients across countries, which has been examined by Rasulo and Wilford (1980), Haynes and Stone (1981), and by Boothe and Glassman (1987). The second assumption is that the log-linear specification is appropriate for the money demand function. It has been claimed by Poloz (1984) and by Judd and Scadding (1982) that the log-linear specification is inappropriate, and that the demand for money function should be nonlinear. Meese and Rose (1991) argued that nonlinearities may be present in the money demand functions, implying that equations (3.3) and (3.4) are misspecified. The third assumption is that of stable or static demand for money functions. This assumption has been explicitly tested in a number of studies, but in particular by Frankel (1982a,b), Poloz (1984), Lafrance and Racette (1985), Boothe and Poloz (1988), and by Smith and Wickens (1986).

12.2.2. *Out-of-Sample Forecasting*

A further criterion used to examine the empirical validity of exchange rate models is out-of-sample forecasting performance. However, the diversity of the methods used to generate out-of-sample forecasts does not result decisively in the general conclusion that the exchange rate follows a random walk. A summary of these studies is presented in Table 12.2.

Meese and Rogoff (1983a) compared the forecasting ability of the (Frenkel–Bilson) flexible-price monetary model, the (Dornbusch–Frankel) sticky-price monetary model, and the (Hooper–Morton) equilibrium real exchange rate monetary model (as represented by equations (3.7), (6.6), and (6.34), respectively) with that of the simple random walk, various univariate time series models, the forward rate, and an unconstrained vector autoregressive (VAR) model. The conclusion that emerged from their study is that

Table 12.2. **Summary of the studies based on the out-of-sample forecasting power.**

Study	Sample and frequency	Currencies used	Findings
Meese and Rogoff (1983a)	1973–81, monthly	U.S. dollar *vis-à-vis* the British pound, German mark, and Japanese yen; U.S. dollar trade-weighted index	Monetary models fail to outperform simple random walk over all horizons.
Meese and Rogoff (1983b)	1973–81, monthly	U.S. dollar *vis-à-vis* the British pound, German mark, and Japanese yen; U.S. dollar trade-weighted index	Monetary models outperform the random walk model for horizons beyond 12 months.
Somanath (1986)	1973–81, monthly	German mark *vis-à-vis* the U.S. dollar	The monetary model outperforms the random walk over all horizons.
Boothe and Glassman (1987)	1974–83, monthly	German mark and Canadian dollar *vis-à-vis* the U.S. dollar	The simple random walk ranks highest in forecasting accuracy.
Boughton (1987)	1973–83, quarterly	German mark and Canadian dollar *vis-à-vis* the U.S. dollar	A preferred habitat portfolio balance model is developed that outperforms the simple random walk for all exchange rates except for the British pound.
Wolff (1987a)	1973–81, monthly	German mark, Japanese yen, and British pound *vis-à-vis* the U.S. dollar	The random walk model outperforms all other structural models, except for the German mark.
Wolff (1987b)	1973–81, monthly	U.S. dollar *vis-à-vis* the British pound, German mark, and Japanese yen	Despite the use of the Kalman filter, the simple random walk outperforms all other structural models, except for the German mark.

(*Continued*)

Table 12.2. (*Continued*)

Study	Sample and frequency	Currencies used	Findings
Mark (1995)	1973–91, quarterly	Canadian dollar, German mark, Japanese yen, and Swiss franc	The monetary model outperforms the random walk model.
Kilian (1999)	1973:2–97:4, quarterly	Canadian dollar, German mark, Japanese yen, and Swiss franc	Results based on a bootstrap method show very limited support for the monetary model and no evidence of increased long-horizon predictability.
Groen (2000)	1973:01–94:04, quarterly	14 exchange rates against the U.S. dollar and the Deutsche mark	Results based on panel procedure reject the null of no cointegration jointly for all the exchange rates, using either USD or DEM as a numeraire for the 14-country panel.
Tawardros (2001)	1984:01–96:01, monthly	Australian dollar	An unrestricted dynamic monetary model outperforms the random walk model at all forecasting horizons.
Mark and Sul (2001)	1973:01–97:01, quarterly	18 currencies *vis-à-vis* the U.S. dollar	Two important findings emerge: (i) exchange rates are cointegrated with the long-run determinants postulated by the monetary model and (ii) panel-based forecasts show that the forecasting power of the model is significant.

(*Continued*)

Table 12.2. (*Continued*)

Study	Sample and frequency	Currencies used	Findings
Chung (2003)	1980–2002, monthly	Won, yen, and dollar	By using five economic models and three time series (univariate) models, the results reveal that the predictability of time series models is relatively superior to that of the random walk and economic models.
Rapach and Wohar (2003)	1973:1–97:1, quarterly	19 currencies *vis-à-vis* the U.S. dollar	Panel procedure lends considerable support to the monetary model as in Groen (2000) and in Mark and Sul (2001).
Wright (2003)	1973–2002, monthly and quarterly	The currencies of Canada, Germany, Japan, U.K. versus U.S.	Using regression model averaging, forecasts are a “bit” better than the random walk model in terms of mean square error (MSE).
Qi and Wu (2003)	1973–97, monthly	USD, JPY, DEM, GBP, and CAD	A neural network model with market fundamentals cannot beat the random walk in out-of-sample forecasting. Without fundamentals, the forecasts are slightly better. Overall results are on the negative sides: neither nonlinearity nor market fundamentals are important in improving exchange rate forecasts.

(*Continued*)

Table 12.2. (*Continued*)

Study	Sample and frequency	Currencies used	Findings
Sarno (2003)	1979–2000, weekly	USD, JPY, and GBP	The Markov-switching model is superior to the linear model in terms of out-of-sample forecasting, suggesting that nonlinearities play some role in forecasting exchange rates.
Sarno and Valente (2004)	1985–2003, weekly	The currencies of U.K., Switzerland, Japan, Canada, New Zealand, Sweden, Norway, and Denmark versus U.S. dollar	A Markov-switching VECM outperformed linear models and random walk.
Sarno and Valente (2007)	1977–2003, quarterly	The currencies of the U.S., Japan, U.K., Canada, Switzerland, and Germany	Weak out-of-sample predictive power may be caused by poor performance of model selection criteria rather than lack of information content in fundamentals.
Moura and Lima (2007)	1999–2005, monthly	Brazil versus U.S.	Some specifications forecast exchange rates better than the random walk. The best specifications include variables that capture monetary policy, country risk, and terms of trade.
Lam *et al.* (2008)	1973–2007, quarterly	Euro, pound, and yen versus the U.S. dollar	Depending on the currencies and forecast horizon, some of the models outperform the random walk.

no model achieved a significantly lower root mean square error (RMSE) than the simple random walk at any forecasting horizon. The poor performance of the monetary models led Meese and Rogoff (1983a, pp. 15–17) to conclude that "… given our finding that the random walk model almost invariably has the lowest root mean square error over all horizons and across all exchange rates, we can unambiguously assert that the other models do not perform significantly better than the random walk model."[2] As a result of the work of Meese and Rogoff (1983a,b), "… it became difficult to present another set of weak regression results without embarrassment" and that "the theory of exchange rate determination has never recovered from the empirical debacle of the early 1980s" (Krugman, 1993, p. 7).

Many economists have enhanced the performance of the static monetary model by using estimation techniques that properly capture the dynamic data generating process of the variables in question. For example, MacDonald and Taylor (1993) estimated the rational expectations model using monthly data on the German mark *vis-à-vis* the U.S. dollar over the period 1976–90. Based on various cointegration techniques, they generated dynamic exchange rate forecasts that outperformed the forecasts of the simple random walk model at every forecasting horizon. Similar results were obtained by MacDonald and Taylor (1994) and Tawadros (2001) who show that the forecasts of the monetary model generated from their chosen error correction model outperform the simple random walk model.[3] MacDonald and Taylor (1994) show that the monetary model can be a valid representation of exchange rate behavior in the long run by using monthly data for the British pound *vis-à-vis* the U.S. dollar over the period 1976–90. They also show that the forecasts of the British pound produced using a chosen error correction model outperform those generated from a number of alternative models, including the random walk model.

[2]A common malpractice in studies of this kind is deriving inference on the basis of the numerical values of measures of forecasting accuracy such as the root mean square error. These measures are estimated with standard errors, which means that their numerical values mean nothing if looked upon without the standard error of the estimation. Inference can only be derived by testing the statistical significance of the difference between two root mean square errors (and other measures of forecasting accuracy). This can be done by using the AGS test of Ashley *et al.* (1980) and the Diebold and Mariano (1995) test. See also, Harvey *et al.* (1997).

[3]Again, no test was conducted to find out if the "outperformance" was statistically significant.

Employing the Johansen (1988) test, Tawadros (2001) estimated a parsimonious dynamic error correction model for the Australian dollar *vis-à-vis* the U.S. dollar using the estimated cointegrating vector. The error correction model is then used to forecast the exchange rate for six forecasting horizons: 1, 3, 6, 12, 18, and 24 months ahead, over the period 1994:2–96:1. The calculated root mean square errors are used to demonstrate that an unrestricted dynamic monetary model outperforms the random walk model at all forecasting horizons.

Other economists have tried to improve the forecasting performance of structural exchange rate models by allowing for nonlinearities and by estimating the equations in a time-varying parametric framework. For example, Wolff (1987b, 1988), Schinasi and Swamy (1989), and Canova (1993) estimated models with time-varying parameters. By allowing the coefficients to vary over time, this method overcomes the problem of instability in the money demand functions. Like Meese and Rose (1991), Mizrach (1992) and Diebold and Nason (1990) allow for nonlinearities in the exchange rate equations. Subsequent studies, however, proved such efforts to be unsuccessful, fragile, or sensitive to minor changes in the techniques or data.

Studies conducted by Mark (1995) and by Chinn and Meese (1995) made some progress by focusing on neglected aspects of the problem, such as the possibility of better long-run predictability, the finite sample properties of the test statistics, and the estimation procedure implied by the theoretical model. Mark (1995) and Chinn and Meese (1995) found that monetary fundamentals outperform the random walk model over longer horizons for a similar set of currencies against the U.S. dollar. Using quarterly data on the Canadian dollar, German mark, Japanese yen, and Swiss franc over the period 1973:2–91:4, Mark (1995) generated in-sample and out-of-sample forecasts over horizons of 1, 4, 8, 12, and 16 quarters from a restricted version of the simple monetary model. This version of the model relates changes in the exchange rate to the difference between the current fundamentals and the current exchange rate, relying on non-parametric bootstrapping to account for small-sample bias and size distortion in asymptotic tests. The results show that monetary fundamentals outperform the random walk model over 3–4-year long horizons. Chinn and Meese (1995) examined the forecasting performance of four structural models, using both parametric and non-parametric techniques. The results that emerge from their study show that fundamental-based error correction models outperform the random walk model for long-term horizons, whereas for short-term horizons these models perform no better than the random walk model, particularly for a subset of the models and currencies investigated. Bacchetta and von Wincoop (2006, p. 552) suggest that "the poor explanatory power of existing theories of the nominal exchange rate is most likely the major weakness of international macroeconomics."

Research subsequently conducted by Kilian (1999), Berkowitz and Giogianni (2001), and Faust *et al.* (2001) criticized Mark's (1995) methodology and the resultant conclusions on the stationarity of the data, robustness to the sample period, appropriate benchmark for comparison, and the vintage of the data. Attempts to forecast with panel data (Groen, 2000; Mark and Sul, 2001; Rapach and Wohar, 2003) or very long sample periods (Rapach and Wohar, 2001) have not been successful in establishing the existence of predictability beyond reasonable doubt.[4]

Most economists seem to agree that the Meese–Roggof results cannot be overturned. For example, Sarno and Taylor (2002, pp. 136 and 137) conclude that "although empirical exchange rate models occasionally generate apparently satisfactory explanatory power in-sample, they generally fail badly in out-of-sample forecasting tests in the sense that they fail to outperform a random walk." Engel *et al.* (2007) suggest that outperforming the random walk in forecasting is "too strong a criterion for accepting an exchange rate model." They show that standard models imply near random walk behavior in exchange rates, so that their power to beat the random walk in out-of-sample forecasting is low.[5] They follow Engel and West (2005) who demonstrated that, under plausible assumptions, exchange rate models imply that the exchange rate nearly follows a random walk, which means that it is not surprising that exchange rate models cannot provide better forecasts than the random walk model. They also argue that the Meese–Rogoff exercise, in which the forecasts were actual *ex-post* (rather than forecasted) values of the fundamentals is particularly flawed, because the out-of-sample fit of the models can be made arbitrarily worse or better by algebraic transformations of the model. They even argue that the out-of-sample fit of the standard models can be made much better (under the Meese–Rogoff methodology) if the models are written in a way that emphasizes the importance of expectations in determining exchange rates.

[4]For a detailed critical discussion on these studies, see Neely and Sarno (2002).

[5]The problem with this argument is that, at least as far as forecasting is concerned, failure to beat the random walk means that these models are useless. Why spend time and effort to construct an exchange rate forecasting model when better forecasts are given by the current rates? This issue pertains to market-based forecasting (see Moosa, 2000b, 2004a).

12.2.3. *Cointegration-Based Dynamic Models*

One of the striking features in many of the studies using OLS is that serial correlation is clearly present. As Pentecost (1991), MacDonald and Taylor (1992), and Taylor (1995) assert, it is indicative of dynamic misspecification. As such, it has been suggested that the monetary model should be tested by using cointegration because the estimated coefficients are still consistent, even with the presence of serial correlation. As Engle and Granger (1987) and Stock (1987) demonstrate, the use of cointegration also gives consistent estimates of the parameters even in the presence of simultaneity bias.

Boothe and Glassman (1987), Baillie and McMahon (1987), and Baillie and Selover (1987) used the Engle and Granger (1987) methodology to test the monetary model. These studies, which are summarized in Table 12.3, identify a number of empirical regularities (Lane, 1991): (i) exchange rates are $I(1)$; (ii) relative prices are $I(1)$; (iii) relative money supplies are $I(1)$; (iv) real output differentials are $I(0)$; (v) interest rate differentials are $I(0)$; (vi) exchange rates are not cointegrated with relative prices, implying that purchasing power parity does not hold in the long run; and (vii) exchange rates are not cointegrated with relative money supplies, implying that the neutrality of money postulate does not hold in the long run.

More recently, panel cointegration has been used to test exchange rate models. Groen (2002) tests for cointegration in a number of countries using a panel-data version of the Engle–Granger (1987) two-step procedure. To test the monetary model, he used two four-country data sets consisting of exchange rate data and monetary fundamentals relative to the U.S. and U.K. Likewise, Basher and Westerlund (2008) examine the validity of the monetary model during the post-Bretton Woods era for 19 OECD countries. Their analysis considers simultaneously the presence of cross-sectional dependence and multiple structural breaks. Their results show that the monetary model is valid only when the presence of structural breaks and cross-country dependence has been taken into account. They also demonstrate that breaks in the model can be derived from purchasing power parity.

Groen (2000) argues that the failure of cointegration tests on the time series of individual countries can be related to the availability of a short time span for the post-Bretton Woods period of flexible exchange rates. The importance of the data span has been highlighted by Shiller and Perron (1985) and by Hakkio and Rush (1991) who have shown that the power of unit root tests and the Engle–Granger (1987) cointegration test to reject the null of nonstationarity depends on the data span. Groen suggests the use of panel cointegration to circumvent this problem. Based on a panel version

Table 12.3. Summary of the studies based on the Engle–Granger cointegration test.

Study	Sample	Currencies	Findings
Boothe and Glassman (1987)	1974–83, monthly	German mark *vis-à-vis* the U.S. dollar	The results show that all variables are $I(1)$, although a long-run relation could not be found.
Baillie and McMahon (1987)	1973–84, monthly	Canadian dollar, French franc, Italian lira, Japanese yen, German mark, and British pound *vis-à-vis* the U.S. dollar	The results of integration tests are mixed and a valid cointegrating regression could not be found.
Baillie and Selover (1987)	1973–84, monthly	Canadian dollar, French franc, Italian lira, Japanese yen, German mark, and British pound *vis-à-vis* the U.S. dollar	Unfavorable results, as a valid cointegrating regression could not be found.
Groen (2000)	1973–94, quarterly	The currencies of Germany, Australia, Austria, Canada, Finland, France, Italy, Japan, the Netherlands, Norway, Spain, U.K., Switzerland, and Sweden versus U.S. dollar	On a pooled time series level, there is cointegration between exchange rates and macroeconomic fundamentals.
Groen (2002)	1973–94, quarterly	The currencies of Germany, Japan, Switzerland, and U.K. versus the U.S. dollar	Panel error correction modeling provides evidence for the validity of cointegration restrictions and long-run parameter restrictions of the monetary model.

of the Engle–Granger two-step procedure, he found that the residuals of the panel-based estimated monetary model to be stationary.

The monetary model typically involves several macroeconomic variables. These variables have different orders of integration, and are possibly related by more than one cointegrating vector. If the variables have an order of integration that is different from unity, they cannot be included in the cointegrating regression. Moreover, the Engle–Granger (1987) methodology is not capable of estimating more than one cointegrating vector. For these reasons, economists started to employ the Johansen (1988) procedure to test the model. A summary of the studies that are based on the Johansen procedure is presented in Table 12.4.

The technique developed by Johansen (1988), and set out fully by Johansen and Juselius (1990), is suitably equipped to estimate several cointegrating vectors. MacDonald and Taylor (1991a, p. 179) argue that "… the most startling indictment against the [monetary] model is the finding by a number of researchers that it does not even give a long-run explanation for the nominal exchange rate." MacDonald and Taylor concluded that the rejection of the monetary model as a long-run representation of exchange rate behavior was attributable to the use of an inappropriate econometric technique, and that the tests of the restrictions have been inappropriately implemented because of the problems of nonstationarity.

However, there are several problems with the Johansen procedure. Moosa (1994) argues that cointegrating vectors cannot be interpreted as behavioral or reduced form equations because the Johansen procedure does not categorize variables either as endogenous or exogenous. Similarly, Alogoskoufis and Smith (1991) assert that the coefficients of a long-run equation can be a combination of adjustment, expectational, and structural parameters. Consequently, the coefficients contained within each cointegrating vector cannot be given a structural interpretation. Wickens (1996, pp. 267 and 268) demonstrated that it is "… difficult to give a satisfactory economic interpretation to estimated cointegrating vectors … because, without introducing *a priori* information, they are not identified." Hence, Wickens concluded by stating that the use of cointegration analysis, and in particular the Johansen technique, may be of less use in econometric modeling than what was first thought. Furthermore, the Johansen test tends to over-reject the null of no cointegration and produces implausible point estimates of the cointegrating vectors. It also produces results that are not robust with respect to model specification, which makes it convenient for those who want to prove a preconceived idea and produce "good" results.

Table 12.4. Summary of the studies based on the Johansen test.

Study	Sample	Currencies	Findings
MacDonald and Taylor (1991a)	1976–90, monthly	Japanese yen, German mark, and British pound *vis-à-vis* the U.S. dollar	The results are highly supportive of the monetary model as a long-run equilibrium relation. At least one cointegrating vector for all three exchange rates.
Baillie and Pecchenino (1991)	1973–90, monthly	U.S. dollar *vis-à-vis* the British pound	No evidence is found to support the hypothesis that the nominal exchange rate is cointegrated with relative money supply and real output.
MacDonald and Taylor (1993)	1976–90, monthly	German mark *vis-à-vis* the U.S. dollar	By employing the Campbell–Shiller (1987) technique, the results show that the rational expectations version of the monetary model is a valid representation of long-run equilibrium.
MacDonald and Taylor (1994)	1976–90, monthly	British pound *vis-à-vis* the U.S. dollar	The chosen parsimonious specification easily outperforms the simple random walk model over all horizons.
Moosa (1994)	1975–86, monthly	British pound, German mark, and Japanese yen *vis-à-vis* the U.S. dollar	Significant cointegrating vectors are found.
Chrystal and MacDonald (1995)	1972–90, quarterly	British pound and German mark *vis-à-vis* the U.S. dollar	The use of divisia monetary indices provides theoretically consistent coefficient estimates.

(*Continued*)

Table 12.4. (*Continued*)

Study	Sample	Currencies	Findings
Kanas (1997)	1980–94, quarterly	German mark, the Netherlands guilder, Italian lira, French franc, and Danish kroner (cross rates)	Results support the hypothesis of cointegration in all currency pairs.
Johnston and Sun (1997)	1973–96, quarterly	Canadian dollar, German mark, Japanese yen, and British pound *vis-à-vis* the U.S. dollar	The monetary model provides good explanation for exchange rates in the long run.
Kouretas (1997)	1970:06–94:05, monthly	Canadian dollar *vis-à-vis* the U.S. dollar	The results support the unrestricted version of the monetary model.
Cushman (2000)	1970:06–98:12, monthly	Canadian dollar *vis-à-vis* the U.S. dollar	Evidence is unsupportive of the monetary model in the long run.
Tawadros (2001)	1984–96, monthly	Australian dollar *vis-à-vis* the U.S. dollar	The forecasts generated based on a parsimonious error correction model outperform the random walk model.

12.2.4. *Simultaneous Equation Models*

The poor empirical performance of the reduced form single-equation monetary model has led some economists to suggest that simultaneous equation models would be ideal for capturing the co-movements of exchange rates and other variables in response to various exogenous shocks. The rationale for this contention stems from two sources. First, the reduced-form monetary model may contain some endogenous variables among the regressors. Radaelli (1988), for instance, performed Granger exogeneity tests on the U.S., German, and Japanese monetary model variables and concluded that interest rates and price levels should be treated as endogenous variables. These results suggest that the authorities in the countries under consideration target the money supply and allow interest rates to adjust endogenously. As a result, the appearance of the real interest rate differential in the monetary model requires the use of an instrumental variables technique or a simultaneous equation method. Second, the treatment of exchange rate expectations in the monetary model results in a major problem. If exchange rate expectations are formed rationally, the reduced form equation would include current and all future expected values of the explanatory variables as regressors, thus requiring additional equations to produce these forecast values. It appears that these equations would be appropriately estimated simultaneously with the exchange rate equation by a systems estimation technique.

Other economists, however, have been extremely skeptical of this view, arguing that the use of a systems estimation technique has both advantages and disadvantages. Meese (1990), for instance, notes that while multi-equation estimation offers the potential for increased precision of parameter estimates, it also carries the risk that misspecification of any single equation can infect the estimated parameters in every equation. Table 12.5 provides a summary of the studies based on simultaneous equation models.

12.3. Evidence on the Monetary Model Under Rational Expectations

Because tests of the monetary model based on the reduced form equations have generally produced little empirical support in favor of the model, some economists wonder whether these equations are flawed or whether Meese and Rogoff's procedure is faulty (for example, Hoffman and Schlagenhauf, 1983; Woo, 1985; Finn, 1986). Hoffman and Schlagenhauf (1983) estimated the monetary model under rational expectations and tested the

Table 12.5. Summary of the studies based on simultaneous equation models.

Study	Sample frequency	Currencies used	Findings
Papell (1986)	1973–83, quarterly	Japanese yen trade-weighted index	Constrained maximum likelihood techniques are used to estimate a portfolio balance model. Importance of the current account is confirmed.
Hall (1987)	1973–84, monthly	British pound effective exchange rate	The results show that the current account has a significant role in determining the exchange rate.
Papell (1988)	1973–84, quarterly	German mark, Japanese yen, British pound, and U.S. dollar effective exchange rates	Constrained maximum likelihood techniques are used, providing results favorable to Dornbusch's overshooting model.
Lewis (1988)	1975–81, monthly	British pound, Canadian dollar, German mark, and Japanese yen *vis-à-vis* the U.S. dollar	Poor results precluding judgment about the efficacy of intervention policies on the exchange rate.
Gandolfo *et al.* (1990)	1960–84, quarterly	Italian lira *vis-à-vis* the U.S. dollar	The balance of payments identity is used as a specific equation in a continuous time model of the exchange rate. Results confirm the superiority of simultaneous equation models.
Homaifer and Zietz (1995)	1974–91, quarterly	Eight major currencies *vis-à-vis* the U.S. dollar	The results show that official intervention in the foreign exchange market eliminates the random walk property of exchange rates.

implied restrictions. The findings that emerged from this study indicate that the parameter constraints associated with the monetary model and those implied by the rational expectations hypothesis are consistent with actual exchange rate behavior.

In addition to estimating the rational expectations version of the monetary model and testing the parameter restrictions associated with the rational expectations hypothesis, Woo (1985) and Finn (1986) employed the Meese–Rogoff procedure to compare the forecasting ability of the underlying model with that of the random walk model. Woo (1985) reformulated the monetary model using a money demand function with a partial adjustment mechanism, which had in previous studies received more empirical support than a money demand function with instantaneous stock adjustment. Testing this rational expectations form of the monetary model for the DEM/USD exchange rate, Woo obtained results indicating that the parameter estimates are reasonable and robust with respect to the estimation technique, to different specifications of the driving processes, and to changes in the estimation period. The results also show that Woo's formulation outperforms the random walk model as well as its own unconstrained equivalent in out-of-sample forecasting. Similar results were obtained by Finn (1986), who evaluated the forecasting accuracy of the simple monetary model, its rational expectations version, and the random walk model. The full information maximum likelihood estimates of the rational expectations version of the model turned out to be favorable, whereas the instrumental variable estimates of the "simple" monetary model were not.

de Jong and Husted (1993) attempted to reconcile the findings of cross-equation restriction tests based on non-structural representation with the empirical drawbacks of the structural forms of the monetary model. This is done by investigating the possibility that the nonrejections obtained by these studies (using non-structural versions of the monetary model) may be due to problems with the small-sample performance of the cross-equation restrictions test. To explore this possibility, they conducted Monte Carlo experiments designed to find out if the asymptotic critical values deliver appropriate sizes in this application and to evaluate the power of the tests against departures from the restrictions. Following Woo (1985), they examined monthly, seasonally adjusted data on the currencies of Canada, France, Japan, the Netherlands, and the U.K. relative to the U.S. dollar over the period 1974:01–88:12. The results showed that the tests had surprisingly low power in detecting non-trivial departures from the model. These results were interpreted as indicating that something was missing from the standard versions of the monetary model.

However, MacDonald and Taylor (1993) are skeptical about tests of the monetary model under rational expectations, arguing that these tests may have been implemented incorrectly. They re-examined the forward-looking rational expectations monetary model for the DEM/USD exchange rate and produced results rejecting the restrictions implied by the model. These results, however, validated the monetary model as a long-run condition. The results also showed that the forecasts generated by a dynamic error correction model (by imposing the restrictions implied by the long-run monetary model) are superior to those of the random walk model.

12.4. Evidence on the Monetary Model Allowing for Currency Substitution

A summary of the studies of currency substitution is presented in Table 12.6. One of the initial approaches to the investigation of currency substitution was to embody the process within a money demand function. Chrystal (1977) attempted to explain the composition of certain foreign currency balances as if each individual currency was competing for the role of being a vehicle currency. The results are broadly supportive of the currency substitution hypothesis, showing that the effect of interest rates is dominant and robust for all four currencies.

A second approach is based on the impact of external factors on the velocity of domestic money (that is, the relation between domestic monetary growth and the growth of nominal income). Miles (1978) investigated this issue using a CES production function in which monetary services are produced by both domestic and foreign currency real balances. The degree of currency substitution was measured by the elasticity of substitution between these two balances. These results have been criticized by Bordo and Choudhri (1982).

A third approach that is used to test the currency substitution hypothesis is to examine the significance of external factors in determining the rate of domestic inflation. McKinnon (1982) argues that because currency substitution potentially destabilizes the demand for individual national currencies, it is inappropriate to use purely national monetary aggregates in explaining the cycles of national inflation rates. He overcomes this problem by constructing a crude index of the world money supply based on each country's

Table 12.6. **Summary of the studies allowing for currency substitution.**

Study	Sample	Currencies	Findings
Chrystal (1977)	1961–70, quarterly	British pound, French franc, German mark, U.S. dollar effective exchange rate	The use of the two-stage restricted least squares estimation provides results that are broadly supportive of the currency substitution hypothesis.
Bordo and Choudhri (1982)	1966–79, quarterly	Canadian dollar, French franc, German mark, and British pound *vis-à-vis* the U.S. dollar	The results offer very little support for the currency substitution hypothesis.
McKinnon (1982)	1972–83, annual	A crude index of the world's money supply is constructed using the domestic money supplies of 10 major industrial countries	A reduced form model of domestic income growth is used to show that external factors have a substantial impact on U.S. economic activity.
Ortiz (1983)	1933:01–80:04, quarterly	USD/peso	There is no evidence for currency substitution.
Cuddington (1983)	1966–79, quarterly	Canadian dollar, French franc, German mark, and British pound *vis-à-vis* the U.S. dollar	The results offer very little support for the phenomenon of currency substitution.
Batten and Hafer (1984)	1966–83, quarterly	Canadian dollar, French franc, British pound, Dutch guilder, and U.S. dollar effective exchange rates	The results offer very little support for the phenomenon of currency substitution.
Radcliffe *et al.* (1984)	1972–83, annual	Canadian dollar, French franc, German mark, and British pound *vis-à-vis* the U.S. dollar	Very little evidence in support of the currency substitution hypothesis.

(*Continued*)

Table 12.6. (*Continued*)

Study	Sample	Currencies	Findings
Batten and Hafer (1985)	1972–84, quarterly	Japanese yen, German mark, and the U.S. dollar effective exchange rates	A distributed lag model is used to measure the effect of currency substitution on economic activity. The results show a significant effect for the rate of change of the exchange rate.
Moosa (1999)	1919–23, monthly	German mark *vis-à-vis* the U.S. dollar	A significant degree of currency substitution. Dominance of extrapolative and adaptive expectations.
Moosa (2000a)	1919–23, monthly	German mark *vis-à-vis* the U.S. dollar and two mark effective exchange rates	The results are supportive of the monetary model allowing for currency substitution. No evidence for proportionality.
Tsang and Ma (2002)	1983:01–98:06, monthly	Hong Kong dollar	Evidence to support currency substitution in the long run and in the short run.
Gazos (2008)	Various episodes of hyperinflation	The currencies of Germany 1923, Austria 1923, Poland 1924, Hungary 1924, and Bolivia 1985.	The results confirm the importance of currency substitution under hyperinflation.

share of world GNP relative to some base year. By using this fixed-weight approach, complications arising from continuously fluctuating exchange rates are avoided.

One conclusion of the empirical studies of currency substitution is that exchange rate changes are constantly caused by factors other than currency substitution. Another conclusion is that changes in the exchange rate arise from changes in the demand for domestic money, but it is impossible to distinguish between the changes induced by currency substitution and those arising from other factors.

12.5. Evidence on the Portfolio Balance Model

A selective summary of the studies examining the empirical validity of the portfolio balance model is presented in Table 12.7. Branson *et al.* (1977) were the first to develop the portfolio balance model and test it empirically to explain the behavior of the DEM/USD exchange rate. This rate was excessively volatile because (unlike the other major currencies that have generally been managed to maintain a particular relation either to the U.S. dollar or the German mark) the two currencies were floating freely relative to each other. Branson *et al.* (1977) attempted to find out if the portfolio balance model could explain movements of the DEM/USD rate over the period 1971:08–76:12 by estimating equation (8.27) in a log-linear form, dropping the variables representing the supply of domestic bonds. The results obtained by using the OLS estimation procedure show that although all of the coefficients on the underlying explanatory variables (such as the stock of domestic and foreign money and the stocks of domestic and foreign bonds denominated in foreign currencies) have the expected signs, they are not statistically reliable because of the presence of high autocorrelation in the residuals. The coefficients of the model were estimated again by applying the Cochrane–Orcutt method to correct for autocorrelation in the residuals. Only the coefficient on the U.S. money supply remained statistically significant.[6]

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[6]Correcting for serial correlation, which was a very popular procedure in the 1970s, is used to make the results more credible. It is also a "magical" procedure that takes the value of the coefficient of determination and DW statistic close to their perfect values of 1.0 and 2.0, respectively. However, it has been established that this practice is faulty because serial correlation implies model misspecification. The solution would be to respecify the model, not to correct for serial correlation (see Mizon, 1995).

Table 12.7. Summary of the studies on the portfolio balance model.

Study	Sample	Currencies	Findings
Branson *et al.* (1977)	1971:08–76:12, monthly	USD/DEM	Supportive results.
Branson *et al.* (1979)	1971:08–78:12, monthly	USD/DEM	Supportive results.
Bisignano and Hoover (1982)	1973:03–78:12, monthly	CAD/USD	Supportive results.
Dooley and Isard (1982)	1973:05–77:06, monthly	USD/DEM	Rational expectations forecasts generated by the model perform better than forward rates in predicting the monthly changes in the spot rate.
Kearney and MacDonald (1986)	1973:03–82:12, monthly	GBP/USD	Results are mixed.
Min and MacDonald (1993)	1981:10–89:12, monthly	KOW/USD	Results are supportive of the portfolio balance model when it is well specified. Forecasts generated by the well specified model are better than the random walk model.

To find out how the actions of the fiscal and monetary authorities influence the exchange rate, Branson *et al.* (1977) derived simple reaction functions for the authorities' foreign (*FG*) and domestic (*HG*) components of the monetary base, with the objective of capturing the simultaneity between the exchange rate and the money supply. Employing the 2SLS procedure, consistent estimates were produced of the reaction functions (where the German monetary base is regressed on its target value and changes in the DEM/USD rate) jointly with the exchange rate equation over the period under consideration. The results show that the significance of the consistent estimates of the exchange rate equation is higher than the significance of the OLS estimates.

Branson *et al.* (1979) extended the estimation of the model for the DEM/USD exchange rate to the period 1977–78, producing results that did not differ significantly from the earlier ones in the sense that the estimated model still suffered from autocorrelation. To study the performance of the original equation (estimated over the period 1971–76), they generated *ex-post* forecasts beyond the sample period and found evidence indicating that the original equation overpredicts the U.S. dollar value of the German mark during most of 1978. In another paper, Branson *et al.* (1979) tested the portfolio balance model for five currencies (Japanese yen, French franc, Italian lira, Swiss franc, and British pound) against the mark for a variety of periods over the 1970s. They produced statistically significant and correctly signed coefficients, but the model again suffered from autocorrelation, most likely indicating misspecification.

Bisignano and Hoover (1982) argue that the portfolio balance model should be tested in a bilateral framework in which the demand and supply functions of the underlying three assets (money and bonds denominated in domestic and foreign currencies) are explicitly specified. They examined the validity of the portfolio balance model by testing equation (8.30) in a log-linear form for the Canadian dollar *vis-à-vis* the U.S. dollar over the period 1973:03–78:12 and produced results that were supportive of the model.

Dooley and Isard (1982) are critical of the key assumption of the portfolio balance model developed by Kouri (1976) and Branson (1976) that international transfers of wealth through current imbalances can influence the exchange rate only if assets denominated in different currencies are imperfect substitutes. In models based on this assumption, changes in the currency composition of asset portfolios can only occur through current account imbalances. Dooley and Isard argue that this assumption is inconsistent with the functioning of international credit markets in which governments and private borrowers routinely issue foreign currency denominated debt. They developed a portfolio balance model in which current account imbalances can be "financed" through transfers of bonds denominated in either currency. The reduced form equation representing the model links the expected rate of change in the exchange rate with the interest rate differential, a set of asset stocks, and wealth.

Dooley and Isard (1982) were the first to construct data on domestic and foreign bond holdings without assuming that the current account deficit is financed entirely in one of the two currencies under consideration. For example, in applying the model to the DEM/USD rate, they viewed the U.S. demand for the U.S. bonds as one of the components of total demand, while attributing other demand components to private German wealth holders, private and official OPEC residents, and private and official residents of the rest of the world. By using an iterative estimation procedure, they generated rational expectations forecasts of the DEM/USD exchange rate over the period 1973:05–77:06, which were better than forward rates in predicting monthly changes in the spot rate.

The results produced by Leventakis (1987) are not supportive of the portfolio balance model. He tested a simple version of the portfolio balance model (with static expectations on the exchange rate) for the DEM/USD exchange rates over the period 1974:01–84:04, in which individuals hold three assets: domestic money, domestic bonds, and foreign bonds. On the other hand, Kearney and MacDonald (1986) developed an extended version of Branson's (1977) small country portfolio balance model of exchange rates that allows for bank lending. Employing OLS and the Theil–Goldberger mixed estimation techniques, they tested the validity of their model based on equation (8.74) for the GBP/USD exchange rate over the period 1973:03–82:12. The results were mixed.

Frankel (1983a) examined the validity of four alternative specifications of the portfolio balance model for the DEM/USD exchange rate over the period 1974:01–78:10. The first three specifications are represented by equations (8.35), (8.37), and (8.38), whereas the fourth one is a general specification that includes each of the first three equations as a special case.[7] The general specification of the portfolio balance model incorporates all four stock variables: supplies of domestic and foreign bonds and the cumulated current accounts of both countries. The results produced by estimating all of the model specifications are very poor (significant but incorrectly signed coefficients).

Min and MacDonald (1993) investigated the relevance of the portfolio balance model for the Korean won against the U.S. dollar and compared the forecasting accuracy of the model with that of the random walk.

[7] Equation (8.35) represents a portfolio balance model postulating that residents of all countries have uniform asset preferences. Equation (8.37) involves the "small home country" model, in which the relevant stock variables are the supply of domestic government bonds and the supply of foreign bonds to domestic residents. Equation (8.38) represents the "small foreign country" version of the model, in which the relevant stock variables are the supply of foreign bonds and the supply of domestic bonds to foreign residents.

They estimated the portfolio balance model over the period 1981:10–88:12 and compared its forecasting ability with that of the random walk model over the period 1989:01–89:12. Using the 2SLS procedure, they estimated reaction functions together with an exchange rate equation, which is similar to that developed by Branson *et al.* (1977), producing results that did not support the model. Therefore, they built an alternative observationally equivalent version of the portfolio balance model based on the proposition that there is no feedback effect from changes in the exchange rate to the money supply. They then applied 2SLS to both reaction functions and the exchange rate equation associated with the observationally equivalent model and produced consistent estimates that were supportive of the model. They also calculated the root mean square error (RMSE) and the mean absolute error (MAE)Mean absolute error (MAE)) of the structural model and the random walk model, showing that the portfolio balance model produces better forecasts than the random walk model when it is well specified.[8]

12.6. Evidence on the Role of News

Table 12.8 provides a summary of some of the studies using the news approach to exchange rate determination. Dornbusch (1980b) suggested that in an efficient foreign exchange market characterized by rational expectations, only surprises (or news) should move the exchange rate. Frenkel (1981a) illustrated this proposition by showing that the variance of monthly percentage changes in exchange rates is greater than the variances of the monthly forward spread by over 20%. This suggests that much of the variability of exchange rates is due to news that could not have been anticipated, nor reflected in the forward premium prevailing in the previous period. In general, the evidence on the role of news is mixed.

Edwards (1983) showed that news "partially" accounts for the poor performance of the forward rate as a predictor of the future spot rate. On the other hand, Hoffman and Schlagenhauf (1985) obtained very poor results by analyzing the effect of news on several monetary and portfolio balance

[8]It is the same story all over again: deriving inference on the superiority of one model over another in terms of forecasting accuracy by comparing the numerical values of root mean square error, MAE,)Mean absolute error (MAE)) etc. What is needed here is a proper statistical test to find out whether or not the difference between the root mean square error's of two models is statistically significant. For example, Moura and Lima (2007) use the Diebold–Mariano (1995) test for this purpose.

Table 12.8. Summary of the studies of the effect of news.

Study	Sample	Currencies	Findings
Dornbusch (1980a)	1973–79, quarterly	U.S. dollar *vis-à-vis* the German mark	Fluctuations in the exchange rate cannot be predicted by the lagged forward rate.
Frenkel (1981a)	1973–79, monthly	U.S. dollar *vis-à-vis* the French franc, German mark, and British pound	Much of the variability in exchange rates is due to news that could not have been anticipated and reflected in the forward premium.
Edwards (1983)	1973–79, monthly	French franc, German mark, British pound, and Italian lira *vis-à-vis* the U.S. dollar	News accounts partially for the poor performance of the forward rate as a predictor of the future spot rate.
Hoffman and Schlagenhauf (1985)	1973–81, monthly and quarterly	French franc, Italian lira, Japanese yen, and German mark *vis-à-vis* the U.S. dollar	News is incorporated in several monetary and portfolio balance models. The results are very poor.
Goodhart and Smith (1985a)	1977–83, monthly	U.S. dollar *vis-à-vis* the British pound	The impact of money supply announcements in the U.S. and U.K. are rather similar in magnitude.
Goodhart and Smith (1985b)	1977–83, monthly	U.S. dollar *vis-à-vis* the British pound	The market reacts in anticipation of a policy action by the authorities to an unanticipated change in the British money supply.
Hardouvelis (1988)	1979–84, monthly	German mark, Japanese yen, Swiss franc, British pound, French franc, Canadian dollar, and Italian lira *vis-à-vis* the U.S. dollar	The results are inconsistent with the predictions of the monetary model, but they are consistent with models that stress price rigidity.

(*Continued*)

Table 12.8. (*Continued*)

Study	Sample	Currencies	Findings
Hogan *et al.* (1991)	1980–89, intra-day	U.S. dollar *vis-à-vis* the British pound, Japanese yen, and German mark	Large unanticipated U.S. trade deficits have an impact on all three exchange rates.
Hasan and Moussa (1991)	1976–82, weekly	Canadian dollar *vis-à-vis* the U.S. dollar	In the face of an unstable monetary policy, old information plays a part in the movement of exchange rates.
Karfakis and Kim (1995)	1985–92, monthly	U.S. dollar, German mark, Japanese yen, British pound, and Swiss franc *vis-à-vis* the Australian dollar	The results are consistent with the view that market participants use the portfolio balance model when responding to news.
Moosa (2002b)	1975–2000, quarterly	U.S. dollar, Japanese yen, British pound, and Canadian dollar (dollar rates and cross rates)	Unbiased efficiency does not hold and there are time-varying risk premia. The news variables, proxied by the residuals of VAR models, do not have a significant effect on the exchange rate.
Ehrmann and Fratzcher (2005)	1993–2003, quarterly	U.S. dollar, German mark/euro	News about fundamentals is a relevant driving force for exchange rates.
Watts (2007)	1975–2001, monthly	The currencies of Australia, Canada, the U.K., Japan, and New Zealand (various combinations)	Little support for the effect of news. Econometric extraction of news is the problem.

models. Hardouvelis's (1988) results were inconsistent with the predictions of the monetary model, but they were consistent with those models stressing price rigidity. And Hogan *et al.* (1991) showed that large unanticipated U.S. trade deficits have an impact on all of the exchange rates they examined.

More recently, Bajo-Rubio and Montavez-Graces (2000) tested the news model for the peseta-mark and peseta-dollar exchange rates using monthly data over the period 1986:1–96:6. They extracted news variables from the money supply, interest rate, inflation rate, trade balance, and the fiscal balance by using ARIMA modeling, the Kalman filter, the HP filter, and the Bean surprise model. They managed to show some "partial" effect of news on the exchange rate. Napolitano (2000) examined the market efficiency and news hypotheses for the euro/pound rate over different time horizons. By extracting the news variables from a VAR model, he rejected the unbiasedness hypothesis, showing the importance of news in determining the short-run movements in exchange rates.

Moosa (2002b) tested the news model using quarterly data on six exchange rates involving four currencies over a period extending back to 1975. The results show that unbiased efficiency does not hold and that there are time-varying risk premia. The results also show that the news variables, proxied by the residuals of VAR models, do not have a significant effect on the exchange rate. It is argued that while news is a theoretically plausible explanation for erratic changes in the exchange rate, generated regressors cannot represent news adequately. This conclusion is shared by Watts (2007), who carried extensive empirical work using a larger number of currency combinations. He also carried out a newspaper search for news items (announcements) that affect exchange rates and compared that with the actual behavior of exchange rates subsequently. Another conclusion that can be derived from these studies is that announcements are not news unless they have been unanticipated in full or in part.

So, the available empirical evidence is mixed, to say the least. Copeland (1994, p. 359) concludes that "no combination of news variables has yet come anywhere near explaining the volatility of exchange rates." Some economists view this conclusion as disappointing, because the news model was originally advocated as an explanation (and rationalization) of turbulence in the foreign exchange market. He also refers to "unsatisfactory results," particularly the residual serial correlation reported in the empirical studies of the news model. Copeland further argues that "new information cannot be the whole story," which is evident by comparing exchange rate volatility during the opening and closing hours of the market.[9] He suggested rational bubbles as an alternative explanation for exchange rate volatility.

12.7. Evidence on the Exchange Market Pressure Model

A summary of the studies investigating the validity of the exchange market pressure monetary model and its various forms is reported in Table 12.9. Girton and Roper (1977) developed the exchange market pressure monetary model and applied it to the experience of Canada over the period 1952–74. Using conventional regression analysis, they obtained results that were supportive of the role of exchange market pressure in the simultaneous determination of exchange rates and international reserves as well as the dependence of monetary policy in Canada during the period under consideration. They tested the validity of their model on the basis of equation (7.9), regressing exchange market pressure (measured by the combined change in exchange rates and international reserves) on changes in domestic credit, foreign money supply, and relative income (using three alternative measures for the U.S. money supply: broad money (M2), narrow money (M1), and the monetary base (H)). The results are strongly consistent with the predictions underlying the model. For example, all of the coefficients of the model are correctly signed and significant at the 5% level. The coefficients on the domestic component of the Canadian money supply range between -0.96 and -0.97, supporting the view that the Canadian monetary authorities had little scope for conducting the monetary policy independently.

To find out whether or not the results are sensitive with respect to the composition of market pressure (whether the authorities absorb pressure in international reserves or in the exchange rate), Girton and Roper estimated equation (7.9) without changes in the interest rate differential, including the ratio of changes in the exchange rate to changes in international reserves ($Q = \Delta s/\Delta r$) as an additional explanatory variable. The results turned out to be similar to those obtained earlier: the coefficient on Q appears to be insignificant, implying that the explained value of the exchange market pressure is not sensitive to its composition.

Connolly and da Silveira (1979) argue that there are two reasons why Brazil provides a particularly good example for the application of the

[9]If news arrives evenly over 24 h and the market is open for 12 h, one would expect the variance of the overnight change to be equal to that of the opening-to-closing change.

Table 12.9. Summary of the studies of the exchange market pressure model.

Study	Sample	Currencies	Findings
Girton and Roper (1977)	1952–74, annual	Canadian dollar *vis-à-vis* the U.S. dollar	Evidence is supportive of exchange market pressure and monetary dependence.
Connolly and da Silveira (1979)	1955–76, 1962–75, annual	Brazilian real *vis-à-vis* the U.S. dollar	The simple exchange market pressure model performs fairly well in the first period and very well in the second period.
Modeste (1981)	1972:02–78:03, monthly	Argentina peso *vis-à-vis* the U.S. dollar	The results are supportive of the simple model.
Kim (1985)	1980:03–83:07, monthly	Korean won *vis-à-vis* the U.S. dollar	Evidence strongly supportive of the simple model.
Burdekin and Burkett (1990)	1963:01–88:01, quarterly	Canadian dollar *vis-à-vis* the U.S. dollar	The results are supportive of the market pressure model.
Wohar and Lee (1992)	1959–86, annual	Japanese yen *vis-à-vis* the U.S. dollar	The unrestricted version of the model performs better than the restricted models used in earlier work.
Thornton (1995)	1986:01–92:12, monthly	Cost Rica colon *vis-à-vis* the U.S. dollar	The results are strongly consistent with the simple monetary model of exchange market pressure.

Girton–Roper (1977) model. First, it is in many respects a unique example of a post-war managed floating system. Second, it is a small open economy in the sense that world prices and the monetary conditions encountered by Brazil are taken as given. However, instead of testing the Girton–Roper model developed in a two-country context, they tested a simple version of the model developed in a single-country context, as represented by equations (7.14) and (7.15), over two post-war periods: 1955–75 and 1962–75. The results show that while there is evidence for the role of domestic credit in both periods, the price and income coefficients are significant over the second, but not over the first period. In all cases, however, the estimated coefficients are consistent with their hypothesized theoretical values of -1 for domestic credit expansion and $+1$ for foreign prices and domestic income. Connolly and da Silveira also tested sensitivity to the composition of exchange market pressure by incorporating an additional explanatory variable, $Q = (\Delta s - 1)/(\Delta r - 1)$, on the right-hand side of the equations for both periods. The results show no sensitivity to the composition, which is consistent with the finding of Girton and Roper (1977) for Canada.

Similar results were obtained by Modeste (1981), Kim (1985), Wohar and Lee (1992), and Thornton (1995). Modeste (1981) tested the simple version of the exchange market pressure model for Argentina over the period 1972–78 by estimating equations (7.14)–(7.16). The OLS estimates of equation (7.14) show that all of the estimated coefficients are correctly signed and close to their hypothesized values. While the estimated coefficients on domestic credit expansion and domestic income are significantly different from zero at the 5% level, the estimated coefficient on foreign prices is not. However, the F-statistic indicates that the variables jointly explain significantly the combined variation in the balance of paymets and the exchange rate. Tests are also performed to determine the effect of the composition. The results are strongly consistent with those reported by Girton and Roper (1977) for Canada and by Connolly and da Silveira (1979) for Brazil.

Kim (1985) tested the simple version of the Girton–Roper model for the Korean won over the period February 1980 to July 1983 and found results providing strong support for the model. Although the estimated coefficients on all of the underlying variables are correctly signed, the coefficients on domestic credit expansion, domestic income, and foreign prices are not consistent with their hypothesized values. In particular, the estimated coefficients on the domestic credit expansion are equal to -0.69 (-0.78), while those on domestic income and foreign prices are 0.95 (0.31) and 0.06 (0.06), respectively. Kim included the percentage changes of the money multiplier as another explanatory variable whose estimated coefficients turned out to be significant and correctly signed.

Wohar and Lee (1992) developed and tested an expanded and less restrictive version of the Girton–Roper model, as represented by equation (7.26), for the Japanese yen over the period 1959–86. The results obtained by using the percentage change in three alternative measures of the U.S. money supply (high-powered money, M1 and M2) are consistent with the model. The coefficients on all of the variables are correctly signed. Although the estimated value of the money multiplier is consistent with its hypothesized value, it is statistically insignificant in all cases. Similarly, the coefficient on foreign income growth is correctly signed with a negative value but it is insignificant in equations using both high-powered money and M2.[10] The coefficients on changes in the real exchange rate are significant in all cases, indicating the presence of large deviations from purchasing power parity. The interest rate differential appears to have the hypothesized negative coefficient and it is significantly different from zero in all but the high-powered money equation. The coefficient on domestic income was insignificantly different from one in all but the M2 equation, whereas the coefficient on the foreign money supply appears to be significant with unitary value in all of the three cases. These results, combined with highly significant negative "offset" coefficients associated with domestic credit expansion, lend strong support to the model. The results of estimating the expanded and less restrictive version of the model were generally similar to those of Girton and Roper. However, when the Davidson–MacKinnon (1981) model selection tests were applied, the results lent strong support to the expanded and unrestricted version of the exchange market pressure monetary model.

Thornton (1995) applied the Girton–Roper model to the Costa Rica colon over the period 1986–92. He examined the validity of the model by (i) testing it directly based on equation (7.18), (ii) testing the hypothesis of sensitivity to the composition of exchange market pressure, and (iii) regressing changes in international reserves alone on the underlying variables. The results from the first regression test provide strong evidence in support of the model.

[10]The statement "consistent with its hypothesized value but statistically insignificant," like the statement "correctly signed but insignificant," is tautology. When an estimated coefficient is insignificant, its sign does not matter, because it is statistically (though not numerically) equal to zero. Unfortunately, statements like these appear in the literature too often.

The estimated coefficients on all of the explanatory variables are correctly signed and significantly different from zero. Furthermore, the coefficient on domestic credit expansion is close to the hypothesized value of -1. The results obtained from the second regression test do not differ significantly from those obtained from the first test. The coefficient on $Q(Q = (\Delta s - 1)/(\Delta r - 1))$ is insignificant, while the other coefficients remain essentially of the same size and statistical significance. With the third regression test, the results are slightly better.

12.8. Recapitulation

While the earlier empirical evidence on macroeconomic models, based on conventional econometric methods and data from the 1920s and the early part of the 1970s, was rather supportive. However, this strand of work suffered from various econometric problems, and it turned out to be specific to the 1920s and the 1970s. The results based on longer sample periods are not supportive, leading to very pessimistic conclusions about the validity of macro models as an explanatory and predictive tool. The problems arising in these studies are the endogeneity of the explanatory variables (such as interest rates), serial correlation (indicating model misspecification), and the underlying assumptions about the demand for money function. This led to some economists to admit explicitly the failure of macroeconomic models and attempt to uncover the reasons for this failure (for example, Smith and Wickens, 1986; Lane, 1991). What added to skepticism about the validity of the monetary model was the results of studies examining their predictive power, which proved to be inferior to that of the random walk model (for example, Meese and Rogoff, 1983a,b).

As a result, some attempts have been made to boost the predictive power of the model by allowing for nonlinearities, by estimating the model in a TVP (time-varying parametric) framework and by adding a lagged dependent variable. Ironically, the very act of adding a lagged dependent variable amounts to converting the model into random walk. Other approaches have also been used to boost the credibility of exchange rate models. For example, Cheung *et al.* (2002) re-assess exchange rate prediction using a wide set of models, including productivity-based models and behavioral equilibrium exchange rate models. Korinek and Rashid (2006) argue that the problem with conventional exchange rate models is that the exchange rate is postulated to be a function of the realized values of macroeconomic variables, when they should be a function of the expected values. The same idea is put forward by Engel and West (2004, 2005). It remains true, however, that none of these alternative approaches could have predicted the 9-sigma fall of the Australian dollar in October 2008. But it is not only about extraordinary events. Even under normal circumstances, Rogoff (2003) still insists that "one of the most remarkable facts about G3 exchange rates is that they are so seemingly immune to systematic empirical explanation." The *status quo*, therefore, is rather unsatisfactory.

CHAPTER 13

Empirical Evidence on the Microstructure Models of Exchange Rates

13.1. Introduction

It is well established empirically that standard macroeconomic models of exchange rates cannot explain and predict movements in exchange rates adequately, particularly at short horizons. This empirical finding has led to endeavors to explore whether or not the problems of these models could be resolved if the microstructure of the foreign exchange market is taken into consideration. For example, trading activity in the foreign exchange market (as well as private information that is dispersed among market participants) may play an important role in determining exchange rates.

Evans and Lyons (1999, 2002a) were the first to provide a microstructure perspective of exchange rate determination by focusing on the information structure of trading between foreign exchange dealers in the foreign exchange market. Instead of relying on macroeconomic fundamentals exclusively, they emphasize the role played by a determinant from the field of microstructure. They developed and estimated a hybrid model in which both macroeconomic fundamentals (for example, interest rates) and microstructure factors (for example, order flow) are combined to determine the exchange rate at high frequencies. They argue that order flow is most informative when it conveys private information (about macroeconomic fundamentals) that is dispersed among market participants. It is this information-aggregation role of order flow that provides a link between economic fundamentals and the exchange rate. Order flow may, however, turn out to be to less informative when it arises as a consequence of the management of inventories by foreign exchange dealers in response to a liquidity shock (Lyons, 2001a).

While it is the information-aggregation role of order flow that has been emphasized in Lyons's (2001a) microstructure model of exchange rates, some critics argue that order flow reflects a variety of liquidity effects that are temporary and unrelated to macroeconomic fundamentals, such as momentum trading, trend-chasing behavior, and other types of feedback trading (for example, Dominguez, 2003; Froot and Ramadorai, 2005). Breedon and Vitale (2004) developed and tested a structural model in which agents' heterogeneity and asymmetric information allowed for the presence of both of these characteristics to have effects on exchange rates. Their research proposes very little support for the information-based interpretation of order flow in terms of fundamentals. Instead, they argue that the relation between order flow and exchange rates is almost totally the result of liquidity effects and not of any information contained in order flow.

Numerous studies have been conducted on microstructure models, not only to establish empirically the ability of order flow to explain movements in exchange rates at short horizons, but also to test numerous other hypotheses on order flow and exchange rate behavior. Work on microstructure models of the foreign exchange market can be divided into four strands. The first strand is concerned with testing the explanatory power of order flow in determining different exchange rates (for example, Evans and Lyons, 1999, 2002a; Lyons, 2001a; Payne, 2003; Breedon and Vitale, 2004). The second strand deals with the issue of whether or not order flow is linked to other exchange rate characteristics, such as bid–offer spreads (Payne, 2003), liquidity (Moulton, 2005; Breedon and Vitale, 2004), and volatility (Killeen *et al.*, 2006). The third strand deals with the hypothesis that if information is publicly and simultaneously released to all market participants, then it is largely impounded into exchange rates directly or indirectly via order flow (for example, Ito and Roley, 1987; Goodhart *et al.*, 1993; Almeida *et al.*, 1998; Fornari *et al.*, 2002; Andersen *et al.*, 2003; Evans, 2002; Evans and Lyons, 2003; Love and Payne, 2003; Andersen *et al.*, 2003). The fourth strand pertains to using the microstructure model as a new test of international financial integration (Evans and Lyons, 2002b). A selective summary of these studies is presented in Tables 13.1–13.3.

13.2. The Explanatory Power of Order Flow

Order flow explains most of the variation in exchange rates over short horizons, whereas macroeconomic exchange rate models produce virtually

Table 13.1. Evidence on the microstructure model of exchange rates.

Study	Data and Source	Currencies	Findings
Evans and Lyons (1999, 2002a)	Reuters D2000–01, 01/05/96–31/08/96, daily data on 79 trading days (4 months)	DEM/USD, JPY/USD	Order flow explains about 60% of daily changes in DEM/USD and 40% in JPY/USD. For DEM/USD market, \$1billion of net dollar purchases raises the DEM price of a dollar by about 0.5%.
Danielsson *et al.* (2002)	Reuters D2000–02, 28/09/99–24/07/00, 5-min observations	EUR/USD, JPY/USD, GBP/USD, EUR/GBP	Order follow explains 10–50% of daily changes in four exchange rates. In-sample forecasts of exchange rates based on order flow outperform those of the random walk.
Hau *et al.* (2002)	EBS, 01/01/98–31/12/99, daily observations	DEM/USD, EUR/USD, JPY/USD, CHF/USD, JPY/DEM, JPY/EUR, CHF/DEM, CHF/EUR	Pooled order flow explains 36% of variation in pooled monthly return. Impact of order flow on exchange rates is larger in the post-euro period.
Payne (2003)	Reuters D2000–02, 06/10/97–10/10/97, tick-by-tick weekly observations	DEM/USD	60% of spread is explained by private information. 40% of exchange rate variability is due to trade imbalance.

(*Continued*)

Table 13.1. (*Continued*)

Study	Data and Source	Currencies	Findings
Carpenter and Wang (2003)	Australian dealers' trades 01/05/02–03/07/00 1- and 5-min observations	EUR/USD, USD/AUD	Order flow explains 10–40% of daily changes in tick-by-tick rates.
Breedon and Vitale (2004)	EBS and Reuters data, August 2000–January 2001	EUR/USD	Strong contemporaneous correlation between order flow and exchange rates is mostly due to liquidity effects.
Marsh and O'Rouke (2005)	RBS customer trades, 01/08/02–29/06/04	EUR/USD, JPY/USD, GBP/USD, JPY/EUR, GBP/EUR, JPY/GBP	Customer order flow generates R^2 of 0.05–0.27 on daily rates.
Berger *et al.* (2005)	Reuters D2000–02, 01/01/99–29/02/04, 1-min observations	EUR/USD, JPY/USD	Order flow generates R^2 of 0.30–0.50 for intra-daily and daily returns. Order flow Granger causes returns at 1-min frequency.
Biønnes and Rime (2005)	Four Scandinavian dealers' trades, 02/03/98–06/03/98, tick-by-tick observations	DEM/USD, CHF/DEM, NOK/USD, NOK/DEM, SEK/DEM, DKK/DEM	Order flow and exchange rates are cointegrated. 50–80% of spread explained by private information.
Evans and Lyons (2005a)	Citibank dealers' customer trades, 01/01/93–30/06/99, daily observations	EUR/USD	Microstructure models outperform traditional macroeconomic models and the random walk in out-of-sample forecasting. Microstructure forecasts explain 16% of monthly exchange rate volatility.

(*Continued*)

Table 13.1. (*Continued*)

Study	Data and Source	Currencies	Findings
Froot and Ramadorai (2005)	State Street Co. Int. portfolio flows 01/01/94–09/02/99, daily observations.	111 rates from 19 countries	International portfolio flows are positively correlated with contemporaneous returns. No long-run co-movement between flows and spot rates.
Killeen *et al.* (2006)	EBS, 01/01/98–31/12/99	FFR/DEM	Cumulative order flow and spot rate are cointegrated over the flexible regime period. DEM1 billion trade imbalance raises DEM/FFR by 3 pips.
Evans and Lyons (2007)	Citibank dealers' customer trades, 01/01/93–30/06/99, daily observations	EUR/USD	Customer order flow forecasts future macroeconomic variables over horizons ranging from 1 month to 2 quarters. Different explanatory power of different end-user order flows from daily to monthly returns.

Table 13.2. Evidence on the direct effect of macroeconomic news on exchange rates.

Study	Data and Source	Currencies and Macroeconomic News	Findings
Goodhart *et al.* (1993)	Reuters data, 9 April–3 July 1989, 130,000 observations over 8 weeks	GBP/USD Macroeconomic news reported on Reuters (pages FXNB and AAMM): US trade figures, UK interest rate	Exchange rate level appears to be a stable process when it is allowed to be affected by news. This result is strengthened dramatically when the news effect enters the conditional variance process.
Almeida *et al.* (1998)	Reuters data, 1/1/92–31/12/94, 5-min observations for 3 years	DEM/USD US and German Macroeconomic announcements plus market expectations data of MMSI.	Most news announcements have significant effect on the exchange rate change in the 15-min post-announcements, although the significance of these effects decreases rapidly.
Evans and Lyons (2001)	Reuters D2000–01, 01/05/96–1/08/96	DEM/USD US and German news from Reuters News service (Olsen Associates)	Direct effect on exchange rate of macroeconomic announcement is 10%.
Evans and Lyons (2003)	Reuters D2000–01, 01/05/96–31/08/96, 5-min observations	DEM/USD US and German news data from Reuters Money Market Headlines News screens.	News releases increase order and exchange rate volatility at daily and intra-daily frequency. The direct impact of news releases on exchange rates is 1/3 of the total news effect.

(*Continued*)

Table 13.2. (*Continued*)

Study	Data and Source	Currencies and Macroeconomic News	Findings
Andersen *et al.* (2003)	Olsen and Associates data, 3 January 1992–30 December 1998, 5-min observations for 6 years.	CHF/USD, DEM/USD, EUR/USD, GBP/USD, JPY/USD IMMS real-time data on 32 expected and announced macroeconomic fundamentals	Announcement surprises produce conditional mean jumps. Exchange rates react to news in an asymmetric fashion. Bad news has greater impact than good news.
Ehrmann and Fratzscher (2005)	January 1993–14 February 2003, 120 monthly observations	EUR/USD, DEM/USD 12 US and 11 German news announcements MMS International.	News about fundamentals has a significant effect on exchange rates. US news has a bigger role than German news in explaining the exchange rate movements.
Dominguez and Panthaki (2006)	Reuters D2000–02, 06/10/1999–24/07/00, 20-min observations	EUR/USD, GBP/USD, UK, US, and Euro scheduled macroeconomic news, non-scheduled fundamentals-driven news and non-scheduled non-fundamentals-driven news	A broader set of news does not provide a vast improvement over macroeconomic news. However, non-scheduled non-fundamentals-related news has a statistically significant impact on both intra-day exchange rate returns and volatility.
Evans and Lyons (2005b)	Citibank exchange rates and transactions data on end-user customers, 11/3/93–30/6/99	USD/EUR Real-time data on expectations and scheduled announcements on 30 US and 13 German macroeconomic variables.	News affects order flow in all cases, and induced changes in trading in all cases remain significant for days. Induced trades also have persistent effects on exchange rates. Currency markets do not respond to news instantaneously.

(*Continued*)

Table 13.3. Evidence on the indirect effect of macroeconomic news on exchange rates.

Study	Data and Source	Currencies and News	Findings
Evans (2002)	D2000–01, 1/05/96–31/08/96, daily observations on 79 full trading days	DEM/USD	Two striking results emerge: (i) much of short-term exchange rate volatility is due to dealers' heterogeneous trading decisions and (ii) public news is rarely the predominant source of exchange rate movements.
Love and Payne (2003)	Reuters D2000–02, 28/09/99–24/07/00, 1-min observation	EUR/USD, GBP/USD, GBP/EUR, UK, US, and Euro scheduled news and expectations data from S&P	Impact of order flow on exchange rates doubles around news releases. Over half of the impact on spot rates of news releases is via order flow.
Evans and Lyons (2003)	Reuters D2000–01, 01/05/96–31/08/96 5-min observations	DEM/USD	News releases increase order flow and exchange rate volatility at daily and intra-daily frequency. The impact of news releases on spot rates via order flow is 2/3 of the total, with direct news effects of 1/3.
Anderson *et al.* (2003)	Reuters FXFX, 03/01/92–30/12/98, 5-min observations	EUR/USD, DEM/USD, JPY/USD, GBP/USD, CHF/USD, IMMS real-time data on 32 expected and announced macroeconomic fundamentals	News announcements have a large immediate effect on spot rates. News explains 5–40% of the daily changes in returns.

(*Continued*)

Table 13.3. (*Continued*)

Study	Data and Source	Currencies and News	Findings
Ehrmann and Fratzscher (2005)	January 1993–14 February 2003, 120 monthly observations	EUR/USD, DEM/USD, 12 US and 11 German news announcements, MMS International	News releases cause about 75% of the monthly directional changes of the EUR/USD exchange rate, although the magnitude of these changes is not well explained.
Dominguez and Panthaki (2006)	Reuters D2000–02, 06/10/1999–24/07/00, 20-min observations	EUR/USD, GBP/USD, UK, US, and Euro scheduled macroeconomic news, non-scheduled fundamentals-driven news and non-scheduled non-fundamentals-driven news	The results indicate that along with the standard fundamentals, both non-fundamental news and order flow matter in predicting exchange rate behavior.
Killeen *et al.* (2006)	EBS daily data, January–December 1998	DEM/FFR	Order flow induces more volatility under flexible exchange rates because the elasticity of speculative demand is (endogenously) low. It had persistent effect on DEM/FFR before EMU parities were announced, but after announcement, it was decoupled from DEM/FFR.

(*Continued*)

Table 13.3. (*Continued*)

Study	Data and Source	Currencies and News	Findings
Carlson and Lo (2006)	Reuters D2000–02, 6–10 October 1997	DEM/USD	An announcement of a rise in German interest rates (an unexpected public news) leads to an initial reaction by traders to increase speculative activity, thereby destabilizing the markets for the next 2 h.
Rime *et al.* (2007)	Reuters D2000–02, 13/02/2004–14/02/2005, daily observations	EUR/USD, GBP/USD, JPY/USD	Order flow is intimately related to a broad set of current and expected macroeconomic fundamentals and is a powerful out-of-sample predictor of daily movements in exchange rates. Sharpe ratio generated by order flow forecast is generally above unity and substantially higher than its counterpart from alternative models, including the random walk model.

no correlation between the exchange rate and macroeconomic fundamentals over periods as short as 4 months (Evans and Lyons, 1999). Evans and Lyons (1999, 2002a) obtained real-time data on all bilateral transactions completed among foreign exchange dealers via the Reuters Dealing 2000-1 electronic trading system in the spot DEM/USD and JPY/USD markets during the period 31 May–31 August, 1996. They used the data to test a hybrid model that includes both a macroeconomic determinant (interest rates) and a microstructure determinant (order flow). They estimated a regression equation relating logarithmic changes in the spot exchange rate (Δs_t) to changes in the interest differential ($\Delta(i - i^*)_t$) and order flow (Δx_t) measured as the difference between the number of buyer- and seller-initiated trades in day t. The regression equation can be written as

$$\Delta s_t = \beta_0 + \beta_1 \Delta(i - i^*)_t + \beta_2 \Delta x_t + u_t \tag{13.1}$$

where $\beta_1 > 0$ and $\beta_2 > 0$. This simple linear specification can be described as follows. A positive value of β_2 implies that within day t, the number of buy-orders exceeds that of sell-orders. This in turn implies that a majority of traders have purchased the foreign currency during the day, indicating that they consider it to be undervalued. For the DEM/USD and JPY/USD regressions, Evans and Lyons found that a positive value for order flow induces an increase in the exchange rate. In the case of the DEM/USD regression, they found that in a day where DEM buy-orders exceeded sell-orders by 1000, the German mark appreciated by 2.1%. Similarly, a positive value of β_1 indicates appreciation of the German mark.

Using OLS, Evans and Lyons (1999, 2002a) obtained results that were supportive of strong correlation between exchange rates and order flow. The results showed that coefficients on the macroeconomic determinant (interest differential) and the microstructure determinant (order flow) were correctly signed and significant for both currency pairs. They also found that the explanatory power of these regressions was due to order flow. Regressing changes in the spot exchange rate on the interest differential only produced low R^2 and insignificant coefficients on the interest differential for both currency pairs. The results do not change when the level of the interest differential rather than the change is used in regressions for both currency pairs.[1] The model accounts for more than 60% of daily changes in the

[1] Once again, trying regressions with the level and first difference of the interest rate differential sounds like data mining. The choice of the variable should be based on theoretical justification or econometric testing (for example, non-nested model selection tests).

DEM/USD rate and more than 40% of daily changes in the JPY/USD rate. These results were found to be fairly robust by the subsequent studies conducted, among others, by Rime (2000), Payne (2003), Breedon and Vitale (2004), and Bacchetta and von Wincoop (2006). All of these studies show that the interdealer order flow is positively related to exchange rates, which in turn implies that a currency appreciates (depreciates) when buy-order-initiated (sell-order-initiated) trades dominate.

Rime (2000) argues that macroeconomic models of exchange rates have low explanatory power at short horizons because they utilize public information and neglect private information in exchange rate determination. He tested a microstructure trading model of exchange rates, incorporating both private and public information for four exchange rates (NOK/USD, NOK/DEM, NOK/SEK, and NOK/GBP) using 3 years of weekly data on currency trading in the Norwegian currency market collected by Norges Bank (the Central Bank of Norway) over the period 1996–99.[2] The results show that order flow is an important variable for explaining weekly changes in exchange rates, thereby indicating an important role for private information. The explanatory power of the model was observed most clearly in the case of the NOK/DEM rate, which was the most heavily traded currency pair in the Norwegian market.

Danielsson *et al.* (2002) extended the work conducted earlier by Evans and Lyons (2002a) by considering the daily sampling frequency and one currency pair at a time. Using 10 months of Reuters D2000-2 electronic brokerage data over the period 1999–2000, they investigated the relation between order flow and exchange rates across frequencies ranging from 5 min to 1 week for four currency pairs (EUR/USD, EUR/GBP, GBP/USD, and JPY/USD). Their results indicate that the contemporaneous order flow explains exchange rates significantly across different frequencies. The results, however, show considerable differences in the explanatory power of the various regressions. For the EUR/USD rate, R^2 stays around 0.40 for the 5 min to 1 week frequencies, while for the JPY/USD rate, the R^2 rises with aggregation from 0.06 at 5 min to 0.67 at 1 week. By contrast, the value

[2]Rime's (2000) model is slightly different from, but closest in spirit to, that developed and estimated by Evans and Lyons (1999). They used 3-month interest differential and oil spot prices to capture the public information effect and order flow relating to spot and forward trading in currencies to capture the private information effect on the underlying exchange rates.

of R^2 for both GBP exchange rates declines with aggregation from 0.26 at 5 min to 0.01 at 1 week. This is a puzzling result when it is interpreted in isolation.

Berger *et al.* (2005) used the electronic brokerage service (EBS) data with various frequencies ranging from 1 min to 1 month over the period January 1999 to February 2004. They explored the relation between the contemporaneous order flow and exchange rate return for two currency pairs: JPY/USD and EUR/USD.[3] Berger *et al.* claim that their data set has several advantages relative to the set used by Evans and Lyons (2002a). First, it represents the majority of trading in the interdealer spot market for the two most traded currency pairs under the current market structure. Second, it makes it possible to examine the impact of order flow across various frequencies, ranging from 1 min to 1 month. Third, the actual signed trading volume, rather than merely the signed deal count (as in Evans and Lyons, 2002a), is used as a measure of order flow, allowing for transaction size. Fourth, minute-by-minute data are used to examine the relation between order flow and exchange rate movements. Fifth, exchange rate returns are based on true executable quotes, and not on indicative quotes, which may or may not represent the rates truly available to traders. Notwithstanding the potential for differences with the previous work, the results obtained by Berger *et al.* are broadly consistent with those reported earlier by Evans and Lyons (2002a). A regression of daily exchange rate returns on contemporaneous order flow results in a significant positive coefficient with an R^2 of 0.45 for the EUR/USD rate and 0.50 for the JPY/USD rate. The results are supportive of a significant positive relation between 1-min contemporaneous order flow and 1-min exchange rate returns with an R^2 of about 0.30 for both currency pairs.

Gradojevic (2007) examined the role of order flow in determining the CAD/USD exchange rate using data obtained from the Bank of Canada for the period from October 1994 to December 2004, consisting of 1-, 5-, and

[3]Berger *et al.* (2005) argue that the share of interdealer dealing conducted through brokered transactions has risen sharply relative to that conducted through direct dealing. Based on a survey conducted in April 2004, the Bank of England found that 66% of the interdealer spot business in the U.K. market was conducted through electronic broking platforms. Today, both EBS and Reuters systems, which offer effective electronic limit order books, play a leading role in interdealer spot trading. EUR/USD and JPY/USD (the two most traded currency pairs) are traded primarily on EBS, whereas GBP/USD (which is the third most traded currency pair) is traded on Reuters Dealing 2000-2.

20-day frequencies. For robustness testing purposes, Gradogevic (2007) divided the data into three subsamples: November 1994–August 1998, September 1998–June 2002, and July 2002–December 2004. Net trading flows (order flows in Canadian dollar) for six Canadian commercial banks are categorized with respect to trading partner as follows[4]:

1. Commercial client transactions (CC) include all transactions with resident and non-resident financial customers.
2. Canadian-domiciled investment transactions (CD) include all transactions with non-dealer financial institutions located in Canada.
3. Foreign institution transactions (FD) include all transactions with foreign financial institutions, such as foreign dealers, pension funds, mutual funds, and hedge funds.
4. Interbank transactions (IB) include transactions with other Canadian-domiciled financial institutions, such as chartered banks, credit unions, investment dealers, and trust companies.

Gradojevic (2007) employed regression analysis to test two variants of equation (13.1) that links exchange rate returns to the contemporaneous and lagged values of the disaggregated order flows of the four transaction types. The regression equations are written as

$$\Delta s_t = \beta_0 + \beta_1 CC_t + \beta_2 FD_t + \beta_3 IB_t + \beta_4 CD_t + \varepsilon_t \tag{13.2}$$

$$\Delta s_t = \beta_0 + \beta_1 CC_{t-1} + \beta_2 FD_{t-1} + \beta_3 IB_{t-1} + \beta_4 CD_{t-1} + \varepsilon_t. \tag{13.3}$$

Equation (13.2) relates contemporaneous exchange rate returns to contemporaneous cumulative order flows aggregated from $t-1$ to t, whereas equation (13.3) relates contemporaneous exchange rate returns to lagged values of cumulative order flows, aggregated from $t-2$ to $t-1$. It is argued that equation (13.3) is a forecasting model, as it can be used to explain the relation between the exchange rate change (from $t-1$ to t) and order flow (aggregated from $t-2$ to $t-1$). The regression results based on equation (13.2) (using the data set involving three different short-term horizons, 1-, 5-, and 20-days) show that the net order flow explains changes in the CAD/USD exchange rate significantly, with $\bar{R}^2$ ranging from 0.21 (1-day) to 0.49 (20-day).

[4] The order flow data account for approximately 83% of all CAD/USD transactions, whereas the remaining part represents other foreign exchange transactions involving the Canadian dollar.

13.3. Order Flow and Other Characteristics of Exchange Rates

Some economists have attempted to relate order flow to some other characteristics of the exchange rate, such as the bid–offer spread (Payne, 2003), liquidity (Moulton, 2005; Breedon and Vitale, 2004), and volatility (Cai *et al.*, 2001; Killeen *et al.*, 2006). The following is a description of some of these studies:

Using a new data set on the DEM/USD rate obtained from the electronic foreign exchange brokerage Reuters D2000-2 system covering one trading week (6–10 October 1997), Payne (2003) examined the effects of private information on exchange rates. The results confirm the existence of private information on the foreign exchange market, indicating that asymmetric information costs account for 60% of the spread. The results also show that the order flow explains about 40% of the variation in the DEM/USD exchange rate. Payne (2003) claims that his work has two advantages over earlier work in this area. First, while earlier studies employed data on the activity of a single dealer, the data set he used reflects the activity of multiple dealers, thereby providing a wider coverage of activity on the interdealer market and yielding more broad-based results. Second, whilst earlier studies have demonstrated that at least some foreign exchange traders possess information, none has computed the aggregate impact of this information. Payne (2003) applied the VAR methodology associated with Hasbrouck (1991a,b), which allowed him to compute the proportion of all information entering the quotation prices via order flow. The VAR formulation used by Payne (2003) is

$$\Delta s_t = \sum_{i=1}^{m} \alpha_i \Delta s_{t-i} + \sum_{i=0}^{m} \beta_i x_{t-i} + \varepsilon_{1t} \tag{13.4}$$

$$x_t = \sum_{i=1}^{m} \gamma_i \Delta s_{t-i} + \sum_{i=1}^{m} \delta_i x_{t-i} + \varepsilon_{2t} \tag{13.5}$$

where the innovations from equations (13.4) and (13.5) must satisfy the following restrictions

$$E(\varepsilon_{1t}) = E(\varepsilon_{2t}) = E(\varepsilon_{1t}, \varepsilon_{2t}) = 0 \tag{13.6}$$

$$E\left(\varepsilon_{1t}^2\right) = \sigma^2, \quad E\left(\varepsilon_{2t}^2\right) = \Omega \tag{13.7}$$

$$E(\varepsilon_{1t}, \varepsilon_{2S}) = E(\varepsilon_{1t}, \varepsilon_{1S}) = E(\varepsilon_{2t}, \varepsilon_{2S}) = 0, \quad \forall\, t \neq s. \tag{13.8}$$

Equations (13.4) and (13.5) form a general model of the dynamics of trades and quotes and interactions between these variables. It must be noted that the VAR is not entirely standard, because the contemporaneous realizations of order flow enter the exchange-rate return equation. The opposite is not true, in the sense that only lagged values of the exchange rate return are considered in the regression for order flow. Payne (2003) argues that this is because trades precede quote revisions, but reverse causality is not allowed.

The innovation term ε_{1t} in equation (13.4) corresponds to the quote revisions induced by the arrival of public information, associated with macroeconomic announcements and the like, whereas the innovation term ε_{2t} in equation (13.5) pertains to unpredictable trading activity, possibly associated with private information. From the vector moving-average (VMA) representation of the VAR model, Payne (2003) derived the impulse response functions associated with news releases and trade innovations. He then managed to separate the components of exchange rate volatility that pertains to public information from the component that is due to trade innovation.

The results of estimating equation (13.4) show that the sum of the coefficients β_i is positive and significantly different from zero, while R^2 is 0.25, suggesting that order flow has a positive impact on exchange rates. From the VMA representation, Payne (2003) found that the total impact of the U.S. dollar buy-order on the DEM/USD rate is equal to zero, whereas variance decomposition reveals that more than 40% of exchange rate variability must be attributed to unpredictable trading activity.

Breedon and Vitale (2004) argue that "theoretical underpinnings of this empirical result associate the explanatory power of order flow to two different channels of transmission, due respectively to liquidity and information effects." However, empirical studies of the microstructure approach fail to indicate clearly which of the two channels of transmission is at work when trade innovations affect exchange rates. Breedon and Vitale point out that the empirical studies conducted, for example, by Evans and Lyons (1999, 2002a) and Payne (2003), suggest that order flow conveys information on shifts in fundamentals and hence affects the spot rate via an information effect. They also argue that other studies (for example, Froot and Ramadorai, 2002) claim instead that order flow is not related to shifts in fundamental variables and hence impinge on the spot rate only via the liquidity effect. Unlike the studies based on simple reduced-form models of the link between order flow and exchange rates, Breedon and Vitale developed a simple structural model of exchange rate determination that draws from the analytical framework proposed by Bacchetta and von Wincoop (2006), which makes it possible to separate the liquidity effect of the order flow on exchange rates from its information effect. They employed an innovative transaction data set (which covers all direct foreign exchange transactions completed in the EUR/USD market via EBS and Reuters between August 2000 and January 2001). The results indicate that the strong contemporaneous correlation between order flow and exchange rates is mostly due to liquidity effects.

13.4. The Forecasting Power of Order Flow

While the microstructure model of Evans and Lyons (1999) produced outstanding in-sample fit over short horizons, its out-of-sample forecasts (particularly for 1- and 2-week horizons) were not better than a random walk. They follow the Meese and Rogoff (1983a) methodology to examine the out-of-sample forecasting power of the microstructure model represented by equation (13.1). Like the Meese–Rogoff forecasts, their forecasts are based on realized values of order flow and changes in the interest differential. They split the entire sample into two subsamples: the first 39 observations were devoted to generate in-sample forecasts, while the last 50 observations were used to generate out-of-sample forecasts. The root mean square error was calculated for the time interval between day 40 and day 89 and compared with those obtained with a simple random walk model. For both currency pairs (DEM/USD and JPY/USD), the root mean square error was 30–40% smaller than that for a simple random walk at the daily, weekly, and bi-weekly horizons. However, as suggested by Evans and Lyons (1999), the 89-day sample shows very low power at the 1- and 2-week horizons. Although the RMSE estimates generated by Evans and Lyons are roughly 35% lower at these horizons, their out-of-sample performance is not statistically significant. For more powerful tests to generate forecasts at longer horizons, longer spans of transactions data are required.

Vitale (2007) argues that given the standard errors of the estimated RMSEs, such difference is significantly unique at the 1-day horizon. At first sight, however, this result might not look impressive on two grounds: (i) the predictive power of the model dies away pretty quickly and (ii) the forecasts are not proper as they are generated based on the actual values of the explanatory variables. Furthermore, Vitale points out that the out-of-sample forecasts generated by Evans and Lyons (1999) suffer from simultaneity bias, which emerges if exchange rate movements cause order flow. Thus if the exchange rate leads to a feedback effect on order flow, the OLS estimates of β_2 in equation (13.1) will be biased. Vitale demonstrates that in the presence of positive-feedback trading rules, the results reported by Evans and Lyons (1999) are spurious and hence misleading.

Using a different data set on aggregated and disaggregated order flows, and employing two different statistics (the mean square error (MSE) ratio and the projection statistic), Evans and Lyons (2005a) were also able to generate out-of-sample forecasts from their model that outperform the random walk model at all horizons. In contrast to examining the forecasting ability of various models over longer horizons, they examined the forecasting power over shorter horizons and produced results indicating that their model was robust across various forecasting horizons (from 1–20 days).

To assess the forecasting power of the microstructure model of exchange rates, Evans and Lyons (2005a) generated the mean square error ratio and the projection statistic, using two different model specifications labeled Micro I and Micro II models, which are specified as follows:

$$\Delta s_{t+1} = \beta_0 + \beta_1(\Delta x)_t^{AGG} + u_{t+1} \tag{13.9}$$

$$\Delta s_{t+1} = \beta_0 + \sum_{j=1}^{6} \beta_j(\Delta x)_{j,t}^{DIS} + u_{t+1} \tag{13.10}$$

where $\Delta x_t^{AGG}\left(\Delta x_{j,t}^{DIS}\right)$ is the order flow from six end-user segments (segment j).

To assess the significance of the forecast of the microstructure model, Evans and Lyons (2005a) employed the "projection statistic" (β), which is estimated as follows:

$$\Delta\hat{s}_{t+h\,|\,t} = \alpha + \beta\Delta s_{t+h} + \varepsilon_{t+h} \tag{13.11}$$

where Δs_{t+h} is the actual rate of change in the exchange rate, $\Delta\hat{s}_{t+h\,|\,t}$ is the forecast of Δs_{t+h} based on the information available at time t, and h is the forecasting horizon. For the microstructure model to outperform the random walk model, the estimate of β must be significantly different from zero. It is argued that the only fact that might complicate inference pertains to the possible presence of serial correlation in the residuals of equation (13.11). To correct for serial correlation (13.11), the variance of β is estimated via the Newey and West (1987) estimator. By definition, the estimated value of β is calculated as

$$\hat{\beta} = \frac{\mathrm{Cov}(\Delta s_{t+h}, \Delta \hat{s}_{t+h|t})}{\mathrm{Var}(\Delta s_{t+1})}. \tag{13.12}$$

Evans and Lyons (2005a) compared the forecasting power of two microstructure models (Micro I and Micro II) with those of the random walk and macroeconomic models (UIP). The models were compared across five forecasting horizons (h): 1, 5, 10, 15, and 20 days. They used Citibank's data on end-user trades in the largest EUR/USD spot market over the period January 1993 to June 1999. These data comprise end-user transaction flows of six main segments: (i) non-financial corporations, (ii) investors (such as mutual funds and pension funds), and (iii) leveraged traders (hedge funds and proprietary traders). They produced mean square error ratios and projection statistics showing that the microstructure model consistently outperformed both the macroeconomic and random walk models. The microstructure forecasts account for 16% of the variance in the monthly (20 days) exchange rate changes.

The findings of Evans and Lyons (2005a) were supported by Gradojevic (2007), who employed the same methodology to conduct an extensive in-sample and out-of-sample forecasting exercise of the microstructure model at different forecasting horizons. He produced results showing that order flow could be very useful for forecasting at longer horizons. Gradojevic compared the forecasting power of the microstructure model with that of the random walk model using data for three subperiods: November 1994–August 1998 (1000 observations), September 1998–June 2002 (1000 observations), and July 2002–December 2004 (roughly 550–650 observations, depending on the forecasting horizon). To generate out-of-sample forecasts, the last 300 observations were not used in estimating the model for the first and the second sample periods, whereas the last 200 observations were left out for the third sample period. In-sample and out-of-sample forecasts of the microstructure model were then generated using equations (13.2) and (13.3).

The results obtained by using equation (13.2) show that the in-sample fit of the microstructure model was remarkable at all horizons, with $\bar{R}^2$ ranging from 0.21 ($h = 1$) to 0.49 ($h = 20$). Clearly, the in-sample fit is better at long forecasting horizons. At short horizons ($h = 1$ and $h = 5$), however, the regression fit based on equation (13.3) is poor and (if present) the forecast improvements are insignificant. The out-of-sample forecasts of the microstructure model generated using equation (13.2) are better and robust at all short horizons relative to those of the random walk model. According to the projection statistic, 24–46% of the variance of exchange rate returns can be explained by the microstructure model. Like in-sample forecasts, out-of-sample forecasts based on equation (13.3) are relatively poor. However, the tendency of the microstructure model to perform better at long horizons is maintained. The long forecasting horizon used in Evans and Lyons (2005a) is 20 days, for which the mean square error improvement is about 20% compared to the random walk model. For the same horizon, the forecast improvements obtained by Gradojevic (2007) are of similar magnitudes.

13.5. The Micro Impact of Macroeconomic News on Exchange Rates

In this section, we discuss the empirical studies on the process whereby macroeconomic news has a micro impact on the exchange rate. Several issues are examined in the following subsections, including (i) the macro fundamental-related news and exchange rate changes and (ii) macroeconomic news and exchange rate mean and variance.

13.5.1. *Macroeconomic Fundamentals-Related News and Exchange Rate Changes*

Empirical work on the effect of news arrival on exchange rates dates back to the seminal work of Dornbusch (1980b), who was the first economist to rationalize the impact of news on exchange rate movements in the context of the asset market model. In their follow-up work, many economists (including, among others, Frankel, 1981; Edwards, 1982a,b, 1983; MacDonald, 1985; MacDonald and Ta, 1987) produced some mixed evidence on the news hypothesis. However, a comprehensive piece of work conducted by Hoffman and Schlagenhauf (1985) (within a framework built on several monetary and portfolio balance models) produced very poor results.[5] One important common feature of these studies is that they focus on the low frequency reaction of exchange rates to macroeconomic news in the context of specifically different macroeconomic models. In other words,

[5]For a detailed discussion of the theoretical and empirical work on this strand of research and the impact of news on exchange rates, see Chapters 10 and 11, respectively.

these studies examine the reaction of exchange rates to news related only to some specific macroeconomic fundamentals drawn from the underlying models.

13.5.2. *Macroeconomic Announcements and Exchange Rates*

Several studies conducted, *inter alia*, by Ito and Roley (1987), Hardouvelis (1988), Goodhart *et al.* (1993), and Almeida *et al.* (1998) focus on the high-frequency reaction of exchange rates to real-time news of either some specific-theory-related macroeconomic fundamentals or some broad categories of these fundamentals (which are not typically considered fundamentals in the context of the standard models). These studies start with the premise that while exchange rate changes at short horizons are not well connected with the corresponding changes in macroeconomic fundamentals, news releases about these fundamentals do appear to have significant impact on exchange rates.

Earlier work examining the high-frequency reaction of exchange rates to real-time news about macroeconomic fundamentals has concentrated solely on several U.S. dollar exchange rates sampled at a daily frequency (for example, Hardouvelis, 1988; Aggarwal and Schirm, 1992; Harris and Zabka, 1995). The results produced by these studies show that there is a significant positive relation between dollar appreciation and the U.S. M1 and non-farm employment (and, in some cases, also the merchandise trade balance) news, but no impact of any other macroeconomic news. Similar results have been produced by work exploiting data on spot quotations from the opening and closing of the main regional foreign exchange markets (for example, North America, the Pacific, Tokyo, and Europe). Studies have been conducted by Hakkio and Pearce (1985), Ito and Roley (1987), Hogan *et al.* (1991), and Hogan and Melvin (1994) to examine the effects of macroeconomic news on intra-day exchange rates. These studies produced results showing that the dollar exchange rates respond fairly quickly to the U.S. money supply and trade balance surprises, but not to other types of U.S. news.

Ito and Roley (1987) also found that the JPY/USD exchange rate did not respond to macroeconomic news from Japan. Examining intra-daily movements in the yen/dollar rate in four non-overlapping segments within each business day from January 1980 to September 1985, they produced results indicating that the U.S. dollar tends to appreciate in the New York segment and depreciate in the European segment. In three of the four subsamples considered, the Tokyo segment made virtually no contribution to annual yen/dollar rate movements. Exchange rate volatility also differs across markets. Finally, U.S. money announcement surprises have the most consistent effects on the exchange rate.

Examining the post-October 1979 response of exchange rates and interest rates to the new information contained in the first announcement of 15 U.S. macroeconomic series, Hardouvelis (1988) produced evidence indicating that markets respond not only to monetary news, but also to news about the trade deficit, domestic inflation, and variables that reflect the state of the business cycle. It is demonstrated that, for all 15 macroeconomic variables, a rise (fall) in interest rates is accompanied by appreciation (depreciation) of the U.S. dollar, which is consistent with models that stress price rigidity and the absence of purchasing power parity. In general, an important conclusion that emerges from these studies is that only a few economic announcements have a systematic impact on exchange rates when the latter are sampled at relatively higher frequencies.

Almeida *et al.* (1998) conjecture that other announcements may have noticeable impacts on the exchange rate when examined in a higher frequency setting. They examined the impact of a larger set of (U.S. and German) news announcements on exchange rate changes measured over different time horizons (from 5 min to 12 h post-announcement) over the period 1/1/92–31/12/94. By doing that, they managed to identify significant impact of most announcements in the 15 min immediately following the announcement. Although the main features of the news impact are similar to German and U.S. announcements, there are some peculiarities and interesting features in the German news. First, the news from German announcements tends to be incorporated in the exchange rate more slowly than the news originating from the U.S. due to differences in timing arrangements. Second, the impact on the exchange rate is, on average, quantitatively smaller for German announcements. Finally, the effect of German announcements depends on the proximity to the next Bundesbank council meeting.

Goodhart *et al.* (1993) used an extremely high-frequency data set on the GBP/USD exchange rate to investigate the impact of news on the very short-term movements in exchange rates, producing results that were also supportive of the impact of news. They constructed the data set from a continuous record of the exchange rates quoted on the Reuters screen (some 130,000 observations over an 8-week period). They examined the effect of two specific news events (a U.S. trade balance announcement and a U.K. interest rate change) and concluded in each case that the news caused an exchange rate jump. In their initial estimates (without news effects), they found the GBP/USD rate to be a near-integrated conditional variance process with a unit a root. The result changed dramatically when they incorporated the news variable. In the case where news is allowed to affect the level of the exchange rate, the results suggest that the level of the exchange rate is not a random walk. These results are strengthened dramatically when the news effect is allowed to enter the conditional variance process. In this case, the parametrization of the GARCH process changes from being very close to an integrated process to one that is clearly stable.

Following Ederington and Lee (1996), many studies examined the impact of scheduled and non-scheduled news on exchange rates, focusing attention on the effect on the exchange rate conditional mean, conditional volatility, or both (Fornari *et al.*, 2002; Andersen *et al.*, 2003; Faust *et al.*, 2003; Galati and Ho, 2003; Ehrmann and Fratzscher, 2005; Dominguez and Panthaki, 2006; Pearce and Solakglu, 2007). One of the important distinctions that can be made between macroeconomic news and other news is that the announcements about macroeconomic fundamentals are typically made on schedule, so that market participants can plan their reaction in advance (depending on realizations) about scheduled news. For example, as the repo operations (conducted by the central bank to fine tune liquidity conditions) are scheduled with a fair degree of precision, their announcements provide a clear signal of the central bank's short-term monetary intensions, which means that its impact can be predicted by markets with certainty. As opposed to scheduled news, non-scheduled[6] (fundamentals-related or non-fundamentals-related)[7] news by its nature is less likely to be anticipated by

[6]Non-scheduled news may be defined as an economic or institutional event, declaration, or disclosure that is either totally unlikely or (if likely) occurring at an unknown point in time. Therefore, it is unlikely to be embodied fully in observed prices (Fornari *et al.*, 2002). For example, news releases in the form of headlines appearing in *Financial Times*, *Wall Street Journal*, and the Reuters terminal are unscheduled.

[7]According to Dominguez and Panthaki (2006), news characterized as nonscheduled and nonfundamental largely falls into six main categories. The first four categories (options market, technical analysis, market characteristics, and market sentiment) are all related specifically to the foreign exchange market. These are often based on interviews with, or quotes from, market participants who trade based on technical rather than fundamental information. Other non-fundamental news includes news related to the private sector (often focused on restructuring, mergers and acquisitions, and politics).

market participants, which makes them less able to interpret quickly the implications of this news for exchange rates, potentially leading to more heterogeneity in their responses to news.[8]

Whether news is scheduled or nonscheduled, its impact on the exchange rate may depend on the state of the market at the time the news is released.[9] News releases during periods of high uncertainty may have different effects on the exchange rate from news releases during calmer periods. For example, Andersen *et al.* (2003) note that bad news in good times (economic expansion) has greater impact than good news in good times, suggesting that good news in good times confirms beliefs whereas bad news in good times is received with more surprise.

13.5.3. *Macroeconomic News and Exchange Rate Mean and Variance*

While some studies analyze the effects of real-time news about fundamentals on the foreign exchange market, most studies focus on explaining changes in the conditional variance process of the market (for example, Ito and Roley, 1987; Ederington and Lee, 1994; Andersen and Bollerslev, 1998). Only few studies have so far examined the effect of real-time macroeconomic news on the conditional mean process of the foreign exchange market (Almeida *et al.*, 1998; Andersen *et al.*, 2003; Faust *et al.*, 2003; Galati and Ho, 2003; Ehrmann and Fratzscher, 2005). Almeida *et al.* (1998) investigated the high-frequency reaction of the DEM/USD exchange rate to the macroeconomic information emanating from Germany and the U.S. and found significant intra-day effects of macroeconomic announcements.

Andersen *et al.* (2003) demonstrated that conditional mean adjustments of exchange rates to news occurred more quickly (effectively amounting to "jumps") than conditional variance adjustments. It is argued that conditional variance adjustments of exchange rates to news occur more gradually, an announcement's impact depends on its timing relative to other

[8] Heterogeneity may also increase in reaction to scheduled news. Kondor (2004) shows that if traders display confirmatory bias, the release of public information may increase divergence in opinion. The main insight is that sometimes (public) information implies something different when it is coupled with different (private) pieces of existing information.

[9] Dominguez (2003) shows that the influence of the central bank on exchange rate returns depends on the intra-day timing of intervention (whether they occur during heavy trading volume, or are closely timed to scheduled macroeconomic announcements) as well as on whether or not the operations are coordinated with another central bank.

announcements, and on whether or not the announcement is known in advance. Andersen *et al.* focus primarily on exchange rate conditional means as opposed to variances, both because the conditional mean is of intrinsic interest and because high-frequency discrete-time volatility cannot be extracted unless the conditional mean is modeled adequately. They specified and estimated a model of high-frequency exchange rate dynamics that allows for the possibility of news affecting both the conditional mean and variance. They modeled the 5-min exchange rate (s_t) as a linear function of I (=5) lagged values of itself, and J (=2) lags of news ($n_{t,k}$) on each of K (=41) fundamentals[10]:

$$s_t = \beta_0 + \sum_{i=1}^{I} \beta_i s_{t-i} + \sum_{k=1}^{K} \sum_{j=1}^{J} \beta_{kj} n_{k,t-j} + \varepsilon_t, \quad t = 1, \ldots, T. \tag{13.13}$$

Because the units of measurements differ across economic variables, Andersen *et al.* divided the unexpected component of the announcement ($A_{k,t} - E_{k,t}$) by its sample standard deviation (σ_k) to standardize news[11]:

$$n_{k,t} = \frac{A_{k,t} - E_{k,t}}{\sigma_k} \tag{13.14}$$

where $A_{k,t}$ represents the value of a macroeconomic variable or indicator, k, such as the U.S. money supply or German interest rate, announced between t and $t+1$ by a central bank, $E_{k,t}$ is the corresponding value of the underlying macroeconomic variable expected by market participants (for example, the MMS survey data on money managers' expectation of the 41 variables, at time t).[12]

Andersen *et al.* (2003) consider the disturbance term in the 5-min return model (13.13) to be heteroskedastic and use the two-step weighted least-squares (WLS) procedure to overcome it. First they estimate equation (13.13) by OLS and then they estimate the time-varying volatility of $\hat{\varepsilon}_t$ from the residual of the regression, which is then corrected by fitting the

[10] They chose $I = 5$ and $J = 2$, based on the Schwarz and Akaike information criteria. They also allowed for negative J to account for announcement leakage before the official time, and more generally to account for the fact that MMS forecasts might capture all information available immediately before the announcement.

[11] See Balduzzi *et al.* (2001).

[12] In the efficient market paradigm, prices must reflect all available information, so that it is only the unexpected component of the macroeconomic announcements ($A_{k,t} - E_{k,t}$) that is expected to affect the exchange rate.

following equation:

$$|\hat{\varepsilon}_t| = c + \psi \frac{\sigma_{d(t)}}{\sqrt{288}} + \sum_{k=1}^{K} \sum_{j'=1}^{J'} \beta_{kj'} |n_{k,t-j'}| + \left(\sum_{q=1}^{Q} \left(\delta_q \cos\left(\frac{q2\pi t}{288} \right) \right) + \phi_q \sin\left(\frac{q2\pi t}{288} \right) + \sum_{r=1}^{R} \sum_{j''=0}^{J''} \gamma_{rj''} D_{r,t-j} \right) + u_t \tag{13.15}$$

where $|\hat{\varepsilon}_t|$ is the absolute value of the residual from equation (13.13), which is used as a proxy for volatility in the 5-min interval, t. It is driven partly by the volatility over the day containing the 5-min interval in question ($\hat{\sigma}_{d(t)}$) partly by news ($n_{k,t}$) and partly by calendar effects consisting largely of intra-day effects that capture the high-frequency rhythm of deviations of intra-day volatility from the daily average. The calendar effect is split into two parts. The first part represents a Fourier flexible form, whereas the second part is a set of dummy variables ($D_{r,t}$) capturing Japanese lunch, Japanese open, and the U.S. late afternoon. Because $\hat{\sigma}_{d(t)}$ is intended to capture the average level of volatility on day $d(t)$, it makes sense to construct it using a GARCH (1,1) model, which is routinely found to provide accurate approximations to daily asset return volatility.

Andersen *et al.* (2003) used a data set consisting of 6 years of real-time exchange rate quotations of 5- and 20-min intervals for six exchange rates (CHF/USD, DEM/USD, EUR/USD, GBP/USD, and JPY/USD) over the period 3 January 1992 through 30 December 1998 (2,189 days for a total of $2,189 \times 288 = 630{,}432$ observations). They found results indicating that announcement surprises produce conditional means jumps and that high-frequency exchange rate dynamics are linked to fundamentals. An interesting feature of their results is that they provide some indication of the presence of asymmetries in exchange rate responses to news about macroeconomic fundamentals, in which case exchange rates tend to react more strongly to large and negative news items. They also found that currency prices adjust fully to news immediately (within 5 min), whereas volatilities adjust gradually with complete adjustment within about an hour.

Faust *et al.* (2003) considered the effects on 5-min DEM/USD, EUR/USD, and GBP/USD exchange rate returns of 10 macroeconomic announcements covering the period 1987–2002 (obtained from Olsen and Associates). They found evidence showing that for several real-time announcements, stronger than expected news releases lead to U.S. dollar appreciation, which is consistent with existing evidence. From responses of U.S. and foreign interest rate term structures, they infer that these news releases either reduce the risk premium for holding a foreign currency or imply a considerable future expected dollar depreciation.

Galati and Ho (2003) investigate the extent to which daily movements in the euro/dollar rate are driven by news about the macroeconomic situation in the U.S. and the euro area during the first 2 years of the EMU. They attempt to find out if market participants react to news in different ways, depending on whether news comes from the U.S. or from the euro area, and whether it is good or bad. Furthermore, they also investigate whether or not traders' reaction to news has changed over time. Using data sampled at a daily frequency over the period 1999–2000, they obtained results showing that macroeconomic news has statistically significant correlation with daily movements of the euro against the dollar. The results reveal indications of asymmetric response, but to different extents at different times. There is also evidence indicating that the market responds predominantly to bad news from the euro area, while ignoring good news. The evidence further shows that the impact of macroeconomic news on the euro/dollar rate is stronger when news switches from good to bad, and vice versa.

Like Andersen *et al.* (2003), Faust *et al.* (2003), Galati and Ho (2003), and Ehrmann and Fratzscher (2005) employed real-time data on the announcements of monetary policy decisions and important macroeconomic variables (in the U.S., Germany and the euro area) as measures of fundamentals. They attempted to find out if announcements about these fundamentals explain the behavior of daily exchange rate movements over the period 1993–2003. Using an econometric methodology similar to that used by Andersen *et al.* (2003), they regressed exchange rate changes on their own lagged values, the news variables from the U.S. and the euro area and dummies to account for potential day-of-the-week effects[13]:

$$\Delta s_t = \alpha + \sum_{i=1}^{I} \beta_i \Delta s_{t-i} + \sum_{i=1}^{I} \beta_i^{EA} n_{i,t}^{EA} + \sum_{j=1}^{J} \beta_i^{US} n_{j,t}^{US} + \gamma^M \,\mathrm{Mon}_t + \gamma^F \,\mathrm{Fri}_t + v_t. \tag{13.16}$$

[13]Lags of the exchange rate change are also included to correct for possible autocorrelation, although in most cases a single lag was sufficient. This is not correction for autocorrelation in the conventional sense (for example, by using the Cochrane–Orcutt method) but rather an attempt to capture the correct dynamic structure. Improper dynamic specification produces autocorrelation.

As the error terms in equation (13.16) is nonnormal and heteroskedastic, Ehrmann and Fratzscher (2005) relied on the WLS method. The first step is to estimate equation (13.16) via OLS, while the second step involves the estimation of an equation for the residuals that is specified as

$$\ln(\hat{v}_t^2) = \alpha_0 + \sum_{i=1}^{I} \alpha_i \ln(\hat{v}_{t-i}^2) + \sum_{i=1}^{I} \alpha_i^{EA} |n_{i,t}^{EA}| + \sum_{j=1}^{J} \alpha_i^{US} |n_{j,t}^{US}|$$
$$+ \theta^M \,\mathrm{Mon}_t + \theta^F \,\mathrm{Fri} + u_t. \tag{13.17}$$

In the third step, the estimated volatility, $\exp(\ln|\hat{v}_t^2| - \hat{u}_t)$, is used as an instrument in the WLS estimation of equation (13.16). It is argued that although estimating this model in a GARCH framework would be superior (due to the direct estimation of the conditional second moments in GARCH models), a GARCH specification could not be used here because of the large number of parameters (25 different news announcements). This is because there is a problem in the convergence of the maximum likelihood estimation. Moreover, the results are robust with respect to the estimation of the model via OLS with heteroskedasticity and serial correlation consistent standard errors.

The results obtained by Ehrmann and Fratzscher (2005) show that news about fundamentals in the U.S., Germany and the euro area have been a relevant driving force behind daily DEM/USD and EUR/USD exchange rate movements in the period 1993–2003. The relative importance of U.S. macroeconomic news is explained at least partly by their earlier release time compared to the corresponding German and euro area news. The exchange rate is also shown to respond more strongly to news in periods of large market uncertainty and when negative or large shocks occur. Moreover, the econometric analysis leads to the conclusion that there are strong asymmetries in the relation between the exchange rate and fundamentals. Overall, the model based on real-time data explains about 75% of the monthly directional changes of the EUR/USD exchange rate, although it does not explain well the magnitude of exchange rate changes.

Dominguez and Panthaki (2006) take the results of Andersen *et al.* (2003) as a benchmark, and raise three follow-on issues:

1. Whether or not a broader set of macroeconomic surprises, which are not typically considered "fundamentals" in the context of standard exchange rate models, is the only sort of news that can explain exchange rate movements.

2. Whether or not a significant portion of exchange rate variation can be explained by using a broader definition of news.
3. If news about macroeconomic fundamentals not only impinges on exchange rates directly, but also exerts influence via order flow.

Dominguez and Panthaki (2006) used the Reuters 2000-2 electronic trading system intra-day data on transaction prices and quote spreads of the EUR/USD and GBP/USD exchange rates sampled over 20-min frequencies, and a broader set of scheduled and non-scheduled news over the period 15 November 1999 to 18 January 2002. They produced results that do not support the proposition that a broader definition of news provides a vast improvement over macroeconomic surprises in exchange rate behavior, giving yet more credence to the importance of macroeconomic variables in standard models. However, the results do indicate that non-scheduled news and (intriguingly) non-scheduled, non-fundamentals-related news have a statistically significant influence on intra-day exchange rate returns and volatility. To examine the impact of news on the conditional mean of exchange rate returns, Dominguez and Panthaki regress the conditional mean of exchange rate returns (Δs_{ti}) on j leads and lags of each of the k news announcements and g lags of past returns (to capture the correct dynamic structure that overcomes autocorrelation). They end up with the following equation:

$$\Delta s_{ti} = \alpha_0 + \sum_{k=1}^{K}\sum_{j=1}^{J} \alpha_{1,j}^{k} n_{ti-j}^{k} + \sum_{g=1}^{G} \alpha_2 \Delta s_{ti-g} + \varepsilon_{ti}. \tag{13.18}$$

As discussed above, most of the studies conducted to examine the impact on exchange rates of real-time news about fundamentals focus primarily on the conditional variance of exchange rates (for example, Ito and Roley, 1987; Ednerington and Lee, 1994; Andersen and Bollerslev, 1998; Kim, 1998; Fornari *et al.*, 2002; Dominguez and Panthaki, 2006; Pearce and Solakglu, 2007).

Examining intra-daily movements in the yen/dollar exchange rate in four non-overlapping segments within each business day from January1980 to September 1985, Ito and Roley (1987) produced results leading to three conclusions. First, the yen (dollar) tended to depreciate (appreciate) in the New York segment and in the European segment, but the direction was mostly neutral in the Tokyo market. Second, exchange rate volatility declined considerably in the Tokyo market, but not in the New York market. Finally, the relative effects of news from the U.S. and Japan were examined explicitly, both with respect to possible major events behind large jumps and the response of the yen/dollar rate to particular economic announcements in both countries. Over the entire sample period, news on the U.S. money stock had the only significant effect.

Ederington and Lee (1994) examined the impact of major U.S. macroeconomic announcements on the yen/dollar exchange rate. They found that these announcements were responsible for most intra-day and day-of-the-week volatility patterns in this market. The initial reaction to a major 8:30 announcement begins around 8:30:10 and lasts until about 8:30:50. A partial price correction is normally observed between 8:31 and 8:32. Price movements after 8:32 are basically independent of those observed earlier although volatility continues to be higher than normal until about 8:55. Similar results were found by Andersen and Bollerslev (1998) for the DEM/USD rate. They provide a detailed characterization of the volatility in the DEM/USD market using a 1-year sample of 5-min returns extracted from quotes on the Reuters interbank network. The data set they used consists of 5-min returns for the DEM/USD rate from 1 October 1992 through 30 September 1993 as well as a longer daily time series of 3,649 observations from 14 March 1979 to 29 September 1993. Examining calendar (intra-day and intra-weekly patterns) and news effects in high-frequency exchange rate return volatility, Andersen and Bollerslev (1998) produced results showing that the largest returns appeared to be linked to the release of public information (in particular, certain macroeconomic announcements). Nevertheless, these results are interpreted as secondary when explaining overall volatility.

Kim (1998) examined the effects of scheduled Australian and U.S. macroeconomic announcements on daily AUD/USD exchange rate changes. Employing EGARCH(1,1) to investigate news effects on the conditional mean and volatility of the changes over various horizons encompassing the announcements, he found evidence indicating that a higher than expected Australian current account deficit announcement led to AUD depreciation, while an unexpectedly higher Australian GDP growth rate led to its appreciation. The results obtained by Kim (1998) show that the conditional volatility of the AUD increases in response to the Australian current account deficit and inflation news, while it goes down in response to news on retail sales. The results also show that the U.S. announcements, in general, had little effect during U.S. market trading. However, the news effects measured over wider time horizons (encompassing the next calendar day's Australian trading) turned out to be more significant.

Fornari *et al.* (2002) analyze the impact of scheduled and non-scheduled news on several Italian financial variables, focusing on the effect of these variables on conditional volatility. By employing a trivariate GARCH model, they assess the impact of political and economic news items on financial variables. Important findings that emerge from this study are the following. First, news affects both the first and the second moments of daily changes in the underlying variables. Second, there is a significant regime shift of the unconditional variance of the underlying variables across the three countries under consideration. Third, the conditional variances display a significant (albeit rather small) seasonal daily pattern. Fourth, contrary to the conventional view, the impact of news on the conditional variance is more pronounced for exchange rates than for Italian long-term interest rates.

Employing high-frequency data for a 10-year period, Pearce and Solakglu (2007) investigated the relation between macroeconomic news and the mark/dollar and yen/dollar exchange rates. They attempted to find out if exchange rate observations need to be sampled at high frequency to detect significant effects of news announcements on mean returns and volatility. They examined the linearity and symmetry of responses to news, allowing the effects of the news announcements to vary across states of the economy. They produced results showing that news reflecting a stronger U.S. economy caused appreciation of the U.S. dollar, that the responses were essentially complete within 5 min, and that measuring the responses over 6 h intervals eliminated the statistical significance of the news. The effects of news appeared linear and symmetric, but no evidence was found to indicate that the effects depend on the state of the economy.

13.5.4. *Macroeconomic Announcements, Order Flow, and Exchange Rates*

In their hybrid microstructure model of exchange rates, Evans and Lyons (1999) show that public macroeconomic information affects the equilibrium exchange rate, not only directly (as in the standard macroeconomic model) but also indirectly via the order flow. They argue that the exchange rate is driven to a significant extent by order flow at short horizons. Using daily data obtained from the Reuters D2000-1 system over the period 1/05/96–31/08/96, they found that order flow accounts for about two-thirds of the variation in the DEM/USD exchange rate. Although no proper tests were conducted, portfolio shifts unrelated to macroeconomic information (for example, shifts in risk preferences, or shifts in hedging demands) were interpreted as the underlying cause of order flow.

Evans and Lyons (2001) developed a microstructure model similar to that of Evans and Lyons (1999), identifying three basic channels through which information affects exchange rates. The first channel mirrors what they describe as traditional models, in which public announcement information or the common-knowledge part of macroeconomic news is impounded into exchange rates immediately and directly (that is, with no role for order flow). The second channel of exchange rate variation mirrors the indirect news effect of public announcement information (or the part of news that is not common-knowledge) impounded in exchange rates via order flow. The third channel of exchange rate variation mirrors Evans and Lyons (1999), in which case exchange rate variations are explained by order flow that is not related to public announcement information. Evans and Lyons (2001) find all of the three sources of exchange rate dynamics to be significant. However, the indirect impact on exchange rates of macroeconomic announcements (via order flow) accounts for twice as much as the direct impact on exchange rates of macroeconomic announcements (not involving order flow). Unlike the finding of previous studies that macroeconomic announcements account for less than 10% of total exchange rate volatility, they found that roughly 30% of exchange rate volatility came from the direct and indirect effects of announcements.

Evans and Lyons (2001) employed a two-equation system (one for exchange rate changes and another for order flow) to demonstrate that the direct effect of macroeconomic information affects exchange rates (as in the standard macroeconomic models) and indirectly via order flow:

$$\Delta s_t = \alpha \Delta x_t + \xi_t + K_t \tag{13.19}$$

$$\Delta x_t = e_t + \eta_t \tag{13.20}$$

where Δs_t is the change in the exchange rate (DEM/USD) from end day $t-1$ to end day t, Δx_t is the order flow between market makers (realized over the same period), α is the coefficient capturing the effect on exchange rate return of order flow (reflecting the information content of order flow), ξ_t is the information that is impounded into exchange returns or the common-knowledge effect of macroeconomic news arrival on exchange rate returns directly, K_t is the effect of other factors (unrelated to both order flow and macroeconomic news and possibly noise) impounded into exchange rate returns, e_t is the order flow effects from macroeconomic news arrival (the non-common knowledge effect of news), and η_t is the effect on order flow of factors unrelated to macroeconomic news (for example, portfolio shifts arising from other sources, such as changing risk tolerance or hedging). Exchange rate returns and order flow are subject to four shocks, which are assumed to be zero mean, mutually uncorrelated and serially uncorrelated.

It is assumed that the variances of the common-knowledge shocks to both exchange rate returns and orders flows (that is, ξ_t and e_t) increase with the number of news arrivals, while the variances of the shocks of other factors to exchange rate returns and order flow (that is, K_t and η_t) are constant. Therefore, we have

$$\mathrm{Var}(\xi_t) = \omega(A_t) \quad \text{and} \quad \mathrm{Var}(e_t) = \sigma(A_t) \tag{13.21}$$

$$\mathrm{Var}(K_t) = s_k \quad \text{and} \quad \mathrm{Var}(\eta_t) = s_\eta. \tag{13.22}$$

To estimate the model represented by equations (13.19)–(13.22), Evans and Lyons (2001) specified linear forms for the variance functions $\mathrm{Var}(\xi_t) = \omega A_t$ and $\mathrm{Var}(e_t) = \sigma A_t$.

Employing the generalized method of moments (GMM) to estimate these functions, along with s_k and s_η, they found evidence indicating that news arrival boosts the volume of trading and that it augments the volatility of exchange rates via both a direct public information channel and an indirect order flow one. Using high-frequency daily data on actual transactions in the DEM/USD market (obtained from the Reuters D2000-1 system) and announcements data from the Reuters News Service over the period 1 May to 31 August 1996, they found evidence indicating that one-third of the variation in order flow is due to macroeconomic announcements. For exchange rates, this evidence is interpreted as implying that 20% of exchange rate variation is due to announcement-induced order flow, while 10% of the variation is due to the direct effect of announcements on exchange rates (that is, not involving order flow).

In their thorough empirical work on the effects of macroeconomic announcements on exchange rates at higher frequencies, Andersen *et al.* (2003, p. 59) suggest that "it will be of interest, for example, to determine whether news affects exchange rates via order flow or instantaneously." Many economists have conducted studies to find out if scheduled and non-scheduled announcements about macroeconomic fundamentals affect exchange rates at higher frequencies directly, or indirectly via order flow (for example, Cai *et al.*, 2001; Love and Payne, 2003; Evans and Lyons, 2003; Dominguez and Panthaki, 2006).

The Japanese yen was highly volatile against the U.S. dollar in 1998: it had never experienced such a dramatic volatility since the breakdown of the

Bretton Woods system in the early 1970s. Cai *et al.* (2001) point out that the three possible causes of yen/dollar volatility, which have been the most frequently mentioned in the literature, include (i) announcements pertaining to macroeconomic fundamentals; (ii) intervention by the Bank of Japan, the U.S. Treasury, and the Federal Reserve; and (iii) portfolio shifts by large institutions. Earlier work (for example, Ederington and Lee, 1994; Leng, 1996; Chatrath and Song, 1998) investigating high-frequency news effects on the Japanese yen emphasizes one of the following three components: time-of-day patterns (intra-day calendar effect), macroeconomic announcements (public information effects), and intra- and inter-day volatility persistence (ARCH effects). Built on a methodology similar to that of Andersen and Bollerslev (1998), Cai *et al.* (2001) explored the role of the three factors simultaneously in producing exchange rate volatility by employing a 1-year sample of 5-min returns in 1998. Examining the impact on the yen/dollar exchange rate of intervention, macroeconomic announcements, and order flow (proxied by yen positions held by major market participants such as commercial and investment banks), Cai *et al.* (2001) produced evidence showing that news has significant effect on volatility, but order flow may play a more important role.

Love and Payne (2003) are critical of the efficient market hypothesis, postulating that under rational expectations there should be no role for order flow in the assimilation of public information into prices. They show that announcements of macroeconomic information not only cause exchange rates to move, but also generate one-sided order flows. The key result that emerges from their research is that even macroeconomic information that is publicly and simultaneously released to all market participants is largely impounded into exchange rates via the key micro-level price determinant (order flow). This result is at odds with the rational expectations-efficient market hypothesis of price determination. Notwithstanding the role of order flow in the assimilation of public information into exchange rates, it is not suggested that foreign exchange markets are inefficient. Love and Payne (2003) used 10 months of transaction level exchange rate data from the Reuters D2002 system for the EUR/USD, GBP/EUR, and GBP/USD rates (at 1-min frequency and a sample of scheduled U.S., U.K., and euro area macroeconomic announcements over the period 28 September 1999 to 24 July 2000). They investigated the effects of news arrival on exchange rates and order flow separately, the impact of order flow on exchange rates around announcement dates, and the effect of news arrival and order flow on exchange rates simultaneously. They estimated the following models of returns for exchange rate k and order flows:

$$\Delta s_t^k = \alpha + \sum_{i=-m}^{m} \beta_i^k n_{t-i} + \varepsilon_t^k \tag{13.23}$$

$$x_t^k = \gamma + \sum_{i=-m}^{m} \delta_i^k n_{t-i} + \varepsilon_t^k. \tag{13.24}$$

To find out whether order flow has a greater or smaller role to play in exchange rate determination when macroeconomic news is publicly released, Love and Payne (2003) estimated the following specification for the three exchange rates under investigation:

$$\Delta s_t^k = \alpha + \beta x_t^k + \sum_{r=1}^{n} \sum_{i=-m}^{m} \gamma_{i,r} x_t^k \cdot I^r(i)_t + \varepsilon_t^k \tag{13.25}$$

where $I^r(i)_t$ is an indicator variable taking the value of one if and only if there is an announcement surprise for region r in period $t - i$. Thus the terms forming the summation in equation (13.25) pick out intervals around news releases, which makes it plausible to find out whether or not the coefficient on order flow changes relative to its normal level. For example, the coefficient on the product of order flow and $I^{UK}(0)_t$ tells us whether, in a minute that has begun with a U.K. announcement, order flow matters more or less than usual. Finally, to find out whether or not exchange rate response to news arrival is intermediated by order flow, Love and Payne (2003) estimated a simple bivariate VAR model for three exchange rate returns and order flows by imposing the $[1, -1, -1]'$ restriction on a cointegrating vector for the three exchange rates. This model is given as follows:

$$\begin{bmatrix} \Delta s_t^k \\ x_t^k \end{bmatrix} = \alpha + \delta(z_{t-1}) + \begin{bmatrix} \beta \\ 0 \end{bmatrix} x_t^k + \sum_{i=1}^{m} \Gamma_{(i)} \begin{bmatrix} \Delta s_{t-i}^k \\ x_{t-i}^k \end{bmatrix}$$
$$+ \sum_{j=0}^{n} \Theta_{(j)} n_{t-j} + \varepsilon_t \tag{13.26}$$

where Δs_t^k is the 3×1 vector of EUR/USD, GBP/EUR, and GBP/USD exchange rate (k) returns, x_t^k is the corresponding 3×1 vector of order flows and n_t is a 3×1 vector of standardized euro area, U.K. and U.S. news, δ is a 6×1 vector of speed of adjustment and the term

$z_{t-1} = \ln(EUR/USD_{t-1}) - \ln(GBP/EUR_{t-1}) - \ln(GBP/USD_{t-1})$ is an equilibrium cointegrating error.

The results obtained by Love and Payne (2003) show that publicly announced macroeconomic information not only causes exchange rates to move, but also causes order flow to change significantly in directions that are consistent with exchange rate movements. The results show that order flow is the main driver of exchange rate movements, which is more informative around macroeconomic data releases. Employing a multivariate VAR analysis of returns and order flows with exogenous news variables, Love and Payne tested the hypothesis that public information is impounded into exchange rates with the need for order flow. They produced evidence rejecting these claims, and by using impulse response analysis, they also found that up to two-thirds of the information is impounded in exchange rates via order flow. This implies that the efficient markets paradigm (according to which public information should be transferred into prices immediately, with no role for trading) is violated.

Vitale (2007) is skeptical of the findings of Love and Payne (2003). He argues that their methodology is prone to a circularity issue, because they define the direction of news on the basis of the effect of macroeconomic announcements on exchange rates. Thus $n_{k,t}$ in equation (13.14) has positive (negative) sign if an unexpected positive macroeconomic announcement ($A_{k,t} > 0$) leads to an increase (decrease) in the value of currency k. Then the effect on the first moment of order flow of news arrival is investigated. As the same sample of observations is used to sign the variables $n_{k,t}$ and to study the effects on exchange rates, their results are biased in favor of a positive effect of news arrival on exchange rate returns. It is argued that it is not easy to pick a sign for news, given the contradictory empirical results of traditional models of exchange rates. For example, an unexpected rise in monetary growth in one country can lead either to depreciation of the domestic currency (if the process generates expectations about inflation and devaluation) or to its appreciation (if nominal interest rates are set to rise in the presence of a central reaction function). In other words, testing the effect of news on exchange rates and order flow is not without trouble, due to the issue of the indeterminacy of the direction of news.

To overcome these problems, one could just concentrate on the effects of news on the second moments of exchange rates and order flow. Following this procedure, Evans and Lyons (2003) produced results that are consistent with those of Love and Payne (2003) by examining the effects of news arrival on exchange rate volatility. They attempted to find out if macroeconomic news is transmitted to exchange rates via induced transactions, and (if so) what proportion of macroeconomic news is transmitted to exchange rates directly and indirectly (via order flow). They employed GMM to identify the relative importance of direct and indirect effects of news by allowing the variances of shocks to order flow and exchange rates to depend separately on the rate of news arrival. It is argued that this approach does not require measurement of the unanticipated component of an announcement. Rather, it is based on a weaker assumption that one can distinguish between periods in which the variance of macroeconomic news flow is relatively high.

Evans and Lyons (2003) used order flow and exchange rate data obtained from the Reuters D2000-1 system for the largest spot market (DEM/USD) sampled over a 5-min frequency and over a 4-month period from 1 May to 31 August 1996, as well as data on a broader set of macroeconomic news (obtained from the Reuters Money Market Headlines News screen). They examined jointly the propositions that macroeconomic news flow leads to higher order flow volatility and that the induced order flow has a signed (first moment) effect on the exchange rate. The results obtained from both daily and intra-daily analysis of the data showed that order flow is considerably more volatile when macroeconomic news is flowing and that these signed orders have the theoretically predicted effects on the exchange rate's direction. Of total news effect on exchange rates, induced order flow accounts for two-thirds, while direct news effects account for one-third.

In their 2005b paper, Evans and Lyons addressed the issue as to whether macroeconomic news arrival affects exchange rates over time or instantaneously. Using Citibank's transaction data covering all of the end-user customers' trades executed by Citibank in the EUR/USD spot market (from 11 April 1993 to 30 June 1999) and real-time data on both expected and announced variables from International Money Market Services.[14] Evans and Lyons (2005b) tested this hypothesis by constructing (for each announcement) a time series of standardized news[15] and then examining the effect of news on currency trades by end-user participants and exchange rates. To examine the impact of news announcements on exchange rates and orders in the days following the announcement, they modeled the dynamics

[14]The sample includes 30 U.S. and 13 German scheduled announcements.

[15]Evans and Lyons (2005b) follow Balduzzi *et al.* (2001) to calculate the unanticipated component of standardized news.

of exchange rates and order flows as a seven-variable, kth-order VAR:

$$\begin{bmatrix} \Delta s_t \\ \Delta x_t^1 \\ \vdots \\ \Delta x_t^6 \end{bmatrix} = A_1 \begin{bmatrix} \Delta s_{t-1} \\ \Delta x_{t-1}^1 \\ \vdots \\ \Delta x_{t-1}^6 \end{bmatrix} + A_2 \begin{bmatrix} \Delta s_{t-2} \\ \Delta x_{t-2}^1 \\ \vdots \\ \Delta x_{t-2}^6 \end{bmatrix} + \cdots + A_k \begin{bmatrix} \Delta s_{t-k} \\ \Delta x_{t-k}^1 \\ \vdots \\ \Delta x_{t-k}^6 \end{bmatrix} + \begin{bmatrix} u_t \\ u_t^1 \\ \vdots \\ u_t^6 \end{bmatrix} \tag{13.27}$$

where Δs_t is the difference between the log exchange rate (EUR/USD) at the end of days t and $t-1$, and Δx_t^j is the order flow for euros from segment j in day t. Daily innovations to the exchange rate and the six order flows, which are represented by u_t and u_t^j respectively, are driven in part by macroeconomic news:

$$u_t = \sum_{i=1}^{M} \beta_i n_{i,t} + \xi_t \tag{13.28}$$

$$u_t^j = \sum_{i=1}^{M} \beta_i^j n_{i,t} + \zeta_t^j, \quad j = 1, 2, \ldots, 6, \tag{13.29}$$

where M is the number of announcement types (43 in this case) and $n_{i,t}$ is the standardized signed news as defined in equation (13.14), $\beta_i (\beta_i^j)$ is the coefficient identifying the average effect of signed news announcement i on the log exchange rate (signed news on the jth order flow segment), and $\xi_t \left(\zeta_t^j\right)$ is the shock representing sources of exchange rate (order flow) innovations that are uncorrelated with news announcements. Unlike in Evans and Lyons (2003) (where distinction is made between direct and indirect effects of news on exchange rates), β_i in this model identifies the total daily effect of the ith news item, while β_i^j is a measure of the total daily effect of news on order flow. This model is designed to answer three questions. First, if news affects order flow, do the effects persist beyond the day of the announcement? Second, if news affects exchange rates, are all of the effects confined to the day of the announcement? Third, do news-induced order flows cause exchange rate movements after the announcement day? By computing the impulse response functions, the results lead to the following important findings: (i) news arrival induces subsequent changes in trading in all of the major end-user segments; (ii) these induced changes remain significant for days; (iii) the changes affect exchange rates significantly; and (iv) currency markets do not respond to news instantaneously.

Dominguez and Panthaki (2006) argue that one reason why exchange rates might not react immediately (or fully) is that news is either not common-knowledge or that different market participants interpret the news item differently. In this case, order flow might convey what is not the common-knowledge news to market makers, which means that this news affects the exchange rate indirectly via order flow. To find out if a broader set of scheduled and non-scheduled news affects exchange rates directly or via order flow, Dominguez and Panthaki employ VAR analysis to estimate the following two-equation system:

$$\Delta s_{ti} = \alpha_0 + \sum_{k=1}^{K}\sum_{j=1}^{J}\alpha_{1,j}^{k} n_{ti-j}^{k} + \sum_{g=1}^{G}\alpha_{2,g}\Delta s_{ti-g} + \sum_{g=1}^{G}\alpha_{3,k}x_{ti-k} + \varepsilon_{1ti} \tag{13.30}$$

$$x_{ti} = \beta_0 + \sum_{k=1}^{K}\sum_{j=1}^{J}\beta_{1,j}^{k} n_{ti-j}^{k} + \sum_{g=1}^{G}\beta_{2,g}\Delta s_{ti-g} + \sum_{g=1}^{G}\beta_{3,k}x_{ti-k} + \varepsilon_{2ti} \tag{13.31}$$

such that $\beta_{2,0} = 0$, implying that order flow does not depend on contemporaneous returns. The results show that order flow explains significantly a larger fraction of the variation in both EUR/USD and GBP/USD exchange rate returns, suggesting that exchange rates (at the very least) are slow to adjust. At the same time, the measure of news explains a relatively small fraction of total variation in order flow. Overall, the results indicate that, along with the standard fundamentals, both non-fundamentals-related news and order flow matter, implying that future models of exchange rate determination ought to include all three types of explanatory variables.

13.6. A Microstructure Test of International Financial Integration

Evans and Lyons (2002b) have proposed a new test of international financial market integration or what they term "informational integration," which is built on currency market microstructure. They divide existing work on international financial market integration into two distinct categories: (i) speculative integration and (ii) geographic integration.[16] Work on speculative integration focuses mainly on whether or not returns on identical financial assets are consistent with speculative efficiency, as described by international parity conditions. By focusing on the parity conditions, these studies relate the degree of financial market integration to relative returns across money market instruments (for example, Martson, 1976; Moosa and Bhatti, 1995, 1996a,b, 1997b; Lothian, 2000). In contrast, research on geographical integration is more focused on national boundaries and on the absolute pricing of broad classes of securities (for example, Solnik, 1974; Grauer *et al.*, 1976; Harvey, 1991; Stulz, 1995; Chan *et al.*, 1992). A survey conducted by Karolyi and Stulz (2001) is representative of the work on geographical integration, which opens with the following definition: "markets where assets have the same price regardless of where they are traded are said to be integrated while markets where the price of an asset depends on where it is traded are said to be segmented." Another example of this line of research is provided by Bekaert and Harvey (1995) who address the issue of whether or not national equity market indexes are priced according to the covariance with the world market (as an integrated-market CAPM would predict) or according to own variance (as a closed-economy CAPM would predict).

Evans and Lyons (2002b) focus specifically on determining if, and to what extent, the information revealed via trades in a given currency market impounded in other currency markets. Important in their definition of financial integration is the phrase "revealed in a given currency market," which refers to information that is not otherwise publicly available. The information revealed and aggregated in the trading process is described as "dispersed bits of information" pertaining to time-varying risk preferences, hedging demands, or interpretations of macroeconomic announcements. This suggests a clear-cut departure on the part of Evans and Lyons (2002b) from the traditional macroeconomic approach to exchange rates, in which all private agents share common information, focusing instead on the macroeconomics of information aggregation.

Evans and Lyons (2002b) demonstrate that in an informationally integrated currency market (in which public demand for a particular currency

[16]Another line of research on this issue includes the work of Feldstein (1982) and Feldstein and Horioka (1980) who based their tests on saving-investment correlation to test for international market integration. For a detailed discussion on this work, see Moosa and Bhatti (1997a) and Moosa (1997).

depends not only on its own rate of return but also on the return on other currencies), order flows in a given currency should be relevant not just for the pricing of that currency, but also for the pricing of other currencies. This means that the exchange rate responds not only to changes in the order flow in that currency, but also to changes in order flows in other currencies. On the other hand, if public demand for a particular currency depends only on its own rate of return, the exchange rate will respond to changes in order flow in that currency alone, and not to the order flows associated with other currency trades. In a reduced form, this model is written as[17]

$$\Delta s_t^i = \alpha_i x_t^i + \sum_{j \neq i}^{m} \beta_{ij} x_t^j + v_t^i \tag{13.32}$$

where Δs_t^i is the daily change in the log value of currency i in terms of a common currency (say, the dollar), x_t^i is the daily order flow associated with currency i, x_t^j is the daily order flow in currency j, and α_i and β_{ij} are the coefficients of own order flow and order flow of other currencies. The effects of the public information increment are captured by the residual v_t^i, which must be serially uncorrelated and uncorrelated with order flows.

Evans and Lyons (2002b) employed a GLS system[18] to estimate equation (13.32) to examine international financial integration for nine currencies *vis-à-vis* the U.S. dollar (German mark, Japanese yen, British pound, Belgian franc, Swiss franc, Swedish krona, French franc, Italian lira, and Dutch guilder) using daily data over the period 1 May–31 August, 1996.[19] They tested two versions of equation (13.32): one including the own order flow only and the other including the order flows of all currencies. In six out of the nine cases, the coefficient on own order flow is positive and statistically significant when the equation incorporates own order flow only. It

[17]This model is an extension of the portfolio shifts model developed by Evans and Lyons (2002a) to a multicurrency setting. It is designed to show how trading in a particular foreign exchange market reveals information that underlies public currency demands, which maintains a link between order flow in that market and order flows in the markets for other currencies.

[18]Because public news affects the international value of the dollar directly, it is likely to affect all of the exchange rates and hence cause serial correlation across the residuals in equation (13.32) for all currencies. This is why Evans and Lyons (2002b) rely on GLS to account for this possibility.

[19]The data were collected from the Reuters Dealing 2000-1 system. According to Reuters, over 90% of the world's direct interdealer transactions are conducted through this system.

is important to note that the coefficients of own order flow are much larger in the cases of the less heavily traded currencies (such as the Italian lira, French franc, Swiss franc, and British pound) than for the heavily traded currencies (the German mark and Japanese yen). This evidence is consistent with the view that the price impact of order flow should be large in less liquid markets (for example, Kyle, 1985). It is also worth noting that order flow accounts for a substantial fraction of the variance in daily exchange rates in the cases where the price impact of own order flow is statistically significant. This is evident from the value of R^2 that ranges between 0.33 (in the case of the pound) and 0.68 (in the case of the mark).

In contrast, two striking results emerge from the estimation of equation (13.32), which incorporates the order flows pertaining to all other currencies. First, order flows account for a substantial fraction of daily changes in exchange rates in all cases, confirming the proposition that order flows are an important (proximate) determinant of daily exchange rates. The value of R^2 in the majority of cases is over 0.65 (ranging between 0.45 and 0.78). Second, at least two order flows have a statistically significant impact on the exchange rate in every case. For every currency but the yen, order flows associated with the German mark have a positive and statistically significant impact on the daily changes in every exchange rate. For some exchange rates (for example, the krona), the cross-currency effects of the German mark and Swiss franc are highly significant. The exchange rates of the Belgian franc, Swedish krona, and Dutch guilder appear to be weakly affected by their own order flows, whereas they are affected strongly by order flows of the two dominant regional currencies, (German mark and Swiss franc). This evidence is consistent with a recent finding of "information geographies" in financial markets (for example, Hau, 2001).

13.7. Recapitulation

This chapter provided a comprehensive survey of the empirical studies of the microstructure models, including some related studies of the effect of news. The empirical evidence surveyed pertained to the microstructure model in general as well as more specific issues such as the direct and indirect effects of macroeconomic news on exchange rates. Further issues include the explanatory power of order flow, order flow, and other characteristics of exchange rates, the forecasting power of the order flow, and the impact of macroeconomic news on exchange rates. One by-product of work on the microstructure approach to exchange rate is the extension of this work to test international financial integration. This is an alternative approach to the conventional approaches to speculative integration (based on international parity conditions) and geographic integration (for example, the international CAPM).

In general, there is evidence that the so-called hybrid model, which includes both macroeconomic and microstructure variables (mainly order flow), performs better than macroeconomic models, thanks mainly to the effect of order flow. This microstructure variable seems to be more correlated with changes in exchange rates than any macroeconomic variable. This does not imply that macroeconomic variables do not matter but rather that order flow is a reflection of the expectation of market participant with respect to the effect of macroeconomic variables on exchange rates.

CHAPTER 14
Concluding Thoughts and Remarks

14.1. Where Do We Stand?

Exchange rate economics remained dormant for a long time after Gustav Cassel made PPP an operational theory that relates exchange rates to prices, describing how the exchange rate moves from one level to another as relative prices change (particularly when changes in relative prices dominate other factors as a result of hyperinflation).[1] Further developments came in the early 1960s with the advent of the Mundell–Fleming model, although this model was more of an open economy macroeconomic model than a model of exchange rate determination.

Renewed interest in exchange rate economics appeared in the 1970s with the worldwide shift to flexible exchange rates following the collapse of the Bretton Woods system in the early 1970s. Although the monetary model of exchange rates has deep roots in the history of economic thought, it was only in the 1970s that the model was proposed in its modern form as an alternative to the Mundell–Fleming flow model. The first version of the model assumed flexible prices and continuous PPP, but this version proved to be empirically inadequate. As a result, several modifications have been suggested, which produced a wide range of models (including the Dornbusch overshooting model, Frankel's real interest differential model, the Buiter–Miller model, the Driskell model, and the Hooper–Morton model). Other modifications to the basic version of the monetary model are derived by allowing for currency substitution, the presence of bonds as another financial asset besides money, exchange market pressure, and the role of news.

Empirical testing of all of these models, no matter how elegant theoretically they are, revealed results that are highly unsupportive. This led

[1] See, for example, Cassel (1916).

some economists to admit explicitly the failure of these models in terms of their explanatory and predictive power. Hence, attempts have been made to uncover the reasons for this failure (for example, Smith and Wickens, 1986; Lane, 1991). Attempts have been made to boost the predictive power of the model by allowing for nonlinearities, by estimating the model in a time-varying parametric framework, and by adding a lagged dependent variable. Ironically, the very act of adding a lagged dependent variable amounts to converting the model into random walk, which is the benchmark that has rarely been outperformed, or so claim the majority of economists.

The results derived from studies based on the Engle–Granger two-step methodology were again unfavorable. These findings cast doubt on the validity of exchange rate models even as a representation of the behavior of exchange rates in the long run. Some economists then argued that this finding is based on the inappropriate residual-based cointegration tests that cannot adequately handle the multivariate case where more than one cointegrating vector may be present. As an alternative they suggested the use of the Johansen (1988) test, which typically produced favorable results. However, one has to recognize the shortcomings of the Johansen test, particularly the tendency to over-reject the null of no cointegration and the lack of robustness with respect to model specification and lag length. This test has proved to be rather convenient for proving any pre-conceived idea, hence we feel that it is no exaggeration for this test to be dubbed "the biggest scandal in modern econometrics."

Some economists argue that exchange rate models may have low power in outperforming the random walk, but there are ways for boosting the predictive power of the models. For example, Mark and Sul (2001) and Groen (2005) use panel error correction models to forecast exchange rates at long horizons (16 quarters or so). Engel *et al.* (2007) point out that "with the increased efficiency of panel estimation, and with the focus on longer horizons, the macroeconomic models consistently provided forecasts of exchange rates that are superior to the "no change" forecasts from the random walk model."

Recently, a group of economists came up with the proposition that "exchange rate models are not as bad as you think" (for example, Engel, 2006; Engle *et al.*, 2007). They further suggest the so-called "present value models of exchange rates," which emphasize the role of expectations in determining the exchange rate movements. Hence, the idea is that exchange rates are not affected by the current values, but rather by the expected values, of the fundamentals. These models can be solved forward to express the exchange rate as the expected present value of current and future fundamentals. These economists question the standard criterion for judging exchange rate models, arguing that if fundamentals are integrated of order one and the discount factor is close to one, the exchange rate will approximately follow a random walk. Hence, they argue against the criterion of whether or not a model can outperform the random walk in out-of-sample forecasting.

The big issue, however, is not the empirical results that do not support conventional exchange rate determination models, but rather the theoretical foundations of these (neoclassical) models. As a matter of fact, it is the faulty theoretical foundations of these models that explain their empirical failure. Apart from the hardcore, ideologically driven supporters of neoclassical models, an increasing number of mainstream economists agree with Post-Keynesian economists on the theoretical pitfalls of these models.[2] To be more specific, the problem of these models lies in the rational representative agent postulate, which has dominated neoclassical economics since the start of the so-called "rational expectations revolution." This so-called revolution has fallen out of favor because it could not survive its encounter with reality in financial markets.

de Grauwe and Grimaldi (2006b) identify the main ingredient of the rational-expectations-efficient-market (REEM) paradigm, which is the basis of conventional exchange rate determination models, as follows:

1. The representative agent is assumed to maximize utility continuously in an intertemporal framework.
2. The forecasts made by this agent are rational, in the sense that they are based on the collection and processing of all available information, including information embedded in the structure of the model. Hence, no systematic forecasting errors are made.
3. The market is efficient, in the sense that exchange rates reflect all available information about the determining fundamental variables.

The underlying idea is that rational agents calculate the exchange rate and when they obtain new information they re-do the recalculation. Failure to indulge in arbitrage on the basis of new information means that they miss out on profitable opportunities. This is the essence of the REEM paradigm, which is the core of neoclassical models of exchange rates.

[2]On Post-Keynesian exchange rate economics, see Harvey (1993a,b, 1996, 2006a,b).

The Post-Keynesian view on this issue is spelled out by Harvey (2006a), who lists the pillars of neoclassical macroeconomics as follows: (i) agents are rational and efficient; (ii) their forecasts are unbiased, and all available information is taken into account; (iii) social and cultural factors are unimportant as economic behavior is natural; (iv) *Homo sapiens* all over the world and across time are driven by the same desire for short-term profit and (v) market participants collect and process all available information. As a result, exchange rates adjust as quickly as the determinants change, hence they move smoothly to the new level.

The problem with conventional exchange rate determination models is that they are inconsistent with the observed behavior of exchange rates, specifically the aspects of behavior that were described by the stylized facts presented in Chapter 1. Harvey (2006a), for example, identifies some aspects of exchange rate behavior that are inconsistent with the predictions of conventional models. These aspects of behavior are (i) volatility is the rule rather than the exception and (ii) technical trading (which is presumably irrational if exchange rates already reflect their own history) is dominant according to survey evidence.

de Grauwe and Grimaldi (2006b) argue on similar lines, postulating that a major shock to conventional exchange rate models has been provided by market crashes and bubbles, as we saw in Chapter 1. They point out that "since the start of flexible exchange rates in 1973 the dollar has been involved in two major bubbles and crashes, each of which lasted 8–9 years (1980–87 and 1996–2004)." This behavior occurred despite the fact that there was not enough positive news to account for the sustained upward and downward movements. Ehrmann and Fratzscher (2005) examined a wide series of fundamental variables and constructed an index of news in these fundamentals. While there was very little movement in the news variables, the exchange rate was moving wildly around the news variable. These results have been confirmed by Goodhart (1989), Goodhart and Figliuoli (1991), and Faust *et al.* (2002).

One possible explanation for this behavior can be found in the Dornbusch overshooting model, but the problem here, as de Grauwe and Grimaldi put it, "the dynamics of the Dornbusch model do not conform with the dynamics observed in the foreign exchange market." This is because the Dornbusch model predicts that a shock leads to an instantaneous jump in the exchange rate and a slow movement back to its fundamental value afterwards, but in reality the bubble phase is typically longer than the crash phase (recall Figures 1.4 and 1.5). There is no way that any of the conventional models could explain (let alone predict) what happened to the Australian dollar in October 2008.

Another observation that is not consistent with the predictions of conventional exchange rate models is volatility clustering, in which case periods of tranquility and turbulence alternate in an unpredictable manner (recall Figure 1.6). This kind of behavior requires volatility clustering of economic fundamentals, which is not observed. Likewise, conventional models are not capable of explaining why percentage changes in exchange rates are not normally distributed and why they could exhibit nine-sigma events (recall Figure 1.6 and Table 1.2).

What is needed, therefore, is a new approach to exchange rates, an approach that produces a more realistic representation of the behavior of exchange rates. There is no doubt that the microstructure has been a refreshing change from conventional macroeconomic models, but there are other promising approaches. Before considering these approaches, it may be useful to explain why the rational expectations hypothesis, once a revolution, has gone the way of the dinosaurs.

14.2. Rational Expectations in the Foreign Exchange Market

It has been by now established that the idea of rational expectations in the foreign exchange market is bizarre, to say the least. To start with, the rational expectations hypothesis precludes heterogeneity in favor of some "representative agent." But there is vast literature disputing the validity of the representative agent hypothesis, rejecting it in favor of heterogeneity on the grounds that the former is inconsistent with observed trading behavior and the existence of speculative markets. Indeed, it is arguable that there is no incentive to trade if all market participants are identical with respect to information, endowments, and trading strategies (Frechette and Weaver, 2001).[3] Brock and Hommes (1997), Cartapanis (1996), and Dufey and Kazemi (1991) have demonstrated that persistence of heterogeneity can result in boom and bust behavior under incomplete information. Furthermore, Harrison and Kreps (1978), Varian (1985), de Long *et al.* (1990),

[3]How is it possible to rationalize the proposition that market participants who think alike would trade $3.2 trillion in foreign exchange on any one day? This volume of trading (and any volume of trading) indicates that there are buyers and sellers who do not think alike. If they think alike at any point in time, they are all either potential buyers or potential sellers, producing a zero trading volume.

Harris and Raviv (1993), and Wang (1998) have shown that heterogeneity can lead to market behavior that is similar to what is observed empirically.

In response to concerns about the representative agent hypothesis, financial economists started to model the behavior of traders in speculative markets in terms of heterogeneity. Chavas (1999) views market participants to fall in three categories in terms of how they form expectations: naïve, quasi-rational, and rational. Weaver and Zhang (1999) allowed for a continuum of heterogeneity in expectations and explained the implications of the extent of heterogeneity for price level and volatility in speculative markets. Frechette and Weaver (2001) classify market participants by the direction of bias in their expectations (their bullish or bearish sentiment), rather than by how they form expectations. The message that comes out of this research is loud and clear: homogeneity is conducive to the emergence of one-sided markets, whereas heterogeneity is more consistent with behavior in speculative markets characterized by active trading and volatility.

There is indeed little evidence for rational expectations in the foreign exchange market, which is a conclusion that is derived from studies based on both survey data and the demand for money approach. For example, Ito (1990) argues that to the extent that individuals are not likely to possess private information, the presence of individual effects may reflect the failure of the hypothesis. Davidson (1982) argues against the rational expectations hypothesis by saying that it is a poor guide to real world economic behavior because it assumes that market participants passively forecast events rather than cause them. Both Harvey (1999) and Moosa (1999) find no evidence for rational expectations in the foreign exchange market based on survey data and estimates of the demand for money function respectively. Moosa (2002a) finds strong empirical support for the Post-Keynesian hypothesis on expectation formation in the foreign exchange market, which rejects rational expectations.

14.3. Exchange Rate Peculiarities

In this section, we describe other aspects of exchange rates behavior that are difficult to explain in terms of conventional models, as well as peculiarities that often make life difficult for those who, for one reason or another, follow exchange rate movements.

The first of these aspects is the behavior of exchange rates in relation to other financial variables such as stock prices and interest rates. We often hear that domestic currency appreciation is bad for the stock market because it hurts exports. But then we often hear that domestic currency appreciation is good for the stock market because it would induce capital inflows, which would boost the domestic stock market. A rise in the domestic interest rate relative to the foreign rate may be good or bad for the domestic currency, depending on whether we believe the flexible-price or sticky-price monetary model.

In relation to the real economy, faster domestic growth can be good or bad for the domestic currency, depending on whether we believe in the flow model or the monetary model. This is why there is no clear-cut view on the cyclical behavior if exchange rates, whether they are pro- or counter-cyclical. Again, different models give us different conclusions on this issue as concluded and presented elegantly by Lenten (2006), who shows that exchange rate models, and macroeconomic models in general, do not agree on whether exchange rates are procyclical or countercyclical. Table 14.1 (reproduced from Lenten, 2006) shows what various models tell us about the cyclical behavior of exchange rates. Which one are we supposed to believe?

Let us take further examples on the peculiar behavior of exchange rates that makes the lives of financial journalists and foreign exchange dealers rather difficult. It is quite common for a financial journalist to write a story attributing the appreciation of the dollar to the rise in oil prices, and a few months later the same journalist would write a story telling us why the dollar depreciated because of higher oil prices. Economic theory can be used to show that a change in a certain fundamental variable can be good or bad for a particular currency. A rise in income may be interpreted to be a bullish signal as growth means profitability and a thriving stock market, but it can be interpreted to be a bearish signal as it leads to the growth of imports and hence deterioration in the current account. Likewise, a rise in interest rate may be taken to be a bullish signal as it implies that domestic assets have become more attractive, or as a bearish signal as a higher interest rate depresses the economy. Other examples are as follows:

- Monetary expansion leads to inflation, which is bad for the domestic currency. Monetary expansion leads to inflation, in which case the central bank reacts by raising interest rates, which is good for the domestic currency.

Table 14.1. Cyclical properties Of output and exchange rates under alternative models.

Relevant model with various types of shocks	**Output**	**Exchange rate**	**Counter-(C), Non-(N) or Pro-(P) cyclical**
IS-LM-BP model			
Monetary expansion	+	+	P
Fiscal expansion			
Perfect capital immobility	+	+	P
High capital mobility			
Short run	+	0	N
Transition	−	−	P
Overall	+	−	C
Perfect capital mobility			
Short run	+	0	N
Transition	−	−	P
Overall	0	−	NA
Dynamic model			
One-period fiscal expansion	+	+	P
Permanent fiscal expansion			
Short run	+	+	P
Transition	−	−	P
One-period monetary expansion	+	+	P
Permanent monetary expansion			
Short run	+	+	P
Transition	−	−	P
Monetary model			
Flexible-price	+	−	C
Sticky-price	+	−	C
Hooper–Morton model	+	−	C
Portfolio balance model	+	−	C
Currency substitution model	+	−	C
Mundell–Fleming model	+	+	P
Flow model	+	+	P
PPP model	+	?	?

Source: Lenten (2006), reproduced with permission.

- Higher interest rates imply higher inflationary expectations, thus it is bad for the domestic currency. Higher interest rate attracts capital flows, in which case this is good for the domestic currency.
- Strong growth leads to higher level of imports and deterioration in the current account, hence currency depreciation. Strong growth leads to higher interest rates and booming financial markets, thus attracting capital flows, which is good for the currency.
- A smaller budget deficit in the absence of a change in saving-investment balance leads to improvement in the current account, which is good for the domestic currency. Lower borrowing requirements by the government eases pressure on interest rates, and lower interest rates are bad for the domestic currency.
- When oil prices are expected to rise, buy the domestic currency against the dollar because it is a petrocurrency. Higher oil prices lead to an increase in the demand for U.S. dollar, so sell the domestic currency.

The reason why financial journalists and foreign exchange dealers have difficult jobs is that exchange rates are difficult to judge. But they could make life less difficult by avoiding some pitfalls that they often fall in

- They tend to look at one variable in isolation, whichever happens to be popular at that time. Exchange rates do not behave in response to one factor or a small number of factors except in one case: hyperinflation. Explaining the behavior of exchange rates or forecasting them on the basis of inflation, interest rates, commodity prices, current accounts, or oil prices in isolation of other factors is hazardous. This is actually the reason why a large number of foreign exchange dealers lost their jobs in the 1980s when they kept on predicting the depreciation of the dollar, which did not materialize until March 1985.
- Failure to distinguish between short- and long-term effects of fundamental variables on the exchange rate. A single factor may have a positive effect on the exchange rate in the short run and a negative effect in the long run.
- Failure to identify reverse causation. For example, is it that improvement in the current account leads to currency appreciation, or that currency depreciation leads to current account improvement? Both of these propositions are correct, but these effects occur over the short and long run, as mentioned above.

- Failure to identify the effect of news. What matters is the unanticipated changes in the variables affecting the exchange rate. What matters is not what is announced, but what is announced relative to what had been anticipated. Announcements are not news in an economic sense. An announcement has a news component if the announced value is different from prevailing expectations prior to the announcement. An announcement of a 5% inflation rate or a $5 billion deficit in the trade balance may be good or bad for the underlying currency, depending on whether the anticipated figure prior to the announcements was higher or lower than the announced figure.

One thing that always follows when exchange rates defy expectations and move in a way that is contrary to what had been anticipated: fundamentals do not matter. Fundamentals do matter, but not to the extent that makes the relation between exchange rates and fundamentals a physical law that is obeyed by all market participants. We will come back to this point later in this chapter.

14.4. Pitfalls in Exchange Rate Economics

Progress in exchange rate economics may have been slow because of some pitfalls that economists do not seem to recognize. For example, an enormous amount of work has been done (and still being done) on the so-called the "forward premium puzzle." In fact, there is no puzzle at all. The failure of the forward rate to forecast the spot rate is due to the fact that they are determined jointly. The forward rate is simply the spot rate adjusted for a factor that reflects the interest rate differential. Thus, the relation between the spot and forward rates is a contemporaneous definitional equation that represents covered interest parity which is an arbitrage or a hedging condition that must hold by definition and by necessity.

Another pitfall is that the foreign exchange market is often viewed a physical system that is expected to work in a mechanical way. Thus, pushing the "button" of inflation should move the market in a particular direction and predictable manner. When this does not happen, a conclusion is reached that inflation does not matter. The same applies to all other fundamentals, just because a model that incorporates these fundamentals cannot outperform the random walk in out-of-sample forecasting. This is not the way to judge the importance and relevance of fundamentals. This issue will be discussed further in the Section 14.6.

Pitfalls are quite conspicuous in the theory and empirical testing of purchasing power parity. To start with, the literature is full of writings that clearly exhibits misinterpretation of the modern originator of the theory, Gustav Cassel, which was initiated by his contemporaries and accepted by subsequent economists. This misinterpretation has led to the emergence of theoretically dubious propositions on PPP. By the 1980s, the empirical testing of PPP has become a "thriving industry," but the misinterpretation of Cassel, upon which the empirical testing is based, has also resulted in the emergence of inappropriate and invalid empirical testing practices. Specifically, Cassel has been misinterpreted with respect to (i) PPP as an operational theory; (ii) the distinction between absolute and relative PPP; and (iii) the role of commodity arbitrage.

Ever since Cassel formulated it as an operational theory early this century, the PPP hypothesis has taken various shapes and forms. The PPP theory has been portrayed as a theory of exchange rate determination, a theory of the transmission of world inflation, a short-run equilibrium condition, a long-run equilibrium condition, an arbitrage condition, a truism, etc. Notwithstanding the possibility that some of these representations may be valid, it is appalling that all of these shapes and forms have been incorrectly attributed to Cassel. The fact remains, however, that Cassel put forward the theory in one operational form only, although he allowed for an approximate but pragmatic representation that he used for the purpose of calculating post-war parities.

Hence, Cassel did not portray his theory as a condition of equality between the exchange rate and the price ratio (what he called the dogma), neither did he say that only the price ratio affects the exchange rate. However, he did come up with a formula as a pragmatic approximation to what happens under conditions of high inflation, or in the long run. Specifically, the literature shows the following:

- While Cassel presented an operational theory, in which the exchange rate is affected by monetary and non-monetary factors, his theory is portrayed as a mechanistic equality between the price level and the price ratio.
- It is claimed that Cassel suggested the (elusive) distinction between absolute and relative PPP. However, no such distinction is evident in his writings.
- It is also claimed that Cassel viewed PPP as an arbitrage relation, when Cassel's theory is actually an extension of the quantity theory of money to the case of an open economy.

The misinterpretations of Cassel has led to several pitfalls:

- The distinction between absolute and relative PPP is redundant for the purpose of empirical testing because price indices are invariably used for this purpose. However, the underlying specifications can still be useful for differentiating between static and dynamic representations of PPP.
- Testing PPP in first differences is faulty because if PPP is valid, then the first difference model is misspecified, and because favorable results would then imply the failure of PPP.
- The distinction between absolute and relative PPP as a theoretical proposition is useless.
- Economists have used faulty procedures to test the coefficient restrictions implied by the properties of proportionality and symmetry.

14.5. Alternative Approaches to Exchange Rates

As stated earlier, disenchantment with conventional models of exchange rates has encouraged the search for alternative approaches. Some economists are contemplating the possibility that exchange rates are affected by factors that economists are ignorant of. Williams *et al.* (1998), for example, use two measures of exchange rate fundamentals: virtual fundamentals derived from asset market variables and traditional fundamentals derived from macroeconomic variables. They found that virtual fundamentals exhibit similar volatility to exchange rates, while traditional fundamentals were stable, exerting no significant effect on exchange rates. And some economists (such as Harvey, 1993, 1996) are calling for the abandonment of mainstream exchange rate models in favor of some more "realistic" alternatives. The microstructure approach is one such alternative that is attracting a lot of interest from mainstream financial economists. As we have already dealt with the microstructure approach, the rest of this section is devoted to three alternative approaches: the Post-Keynesian approach, behavioral finance, and chaos theory.

14.5.1. *The Post-Keynesian Approach*

One of the most prominent Post-Keynesian economists who has been developing the Post-Keynesian approach to exchange rates is John Harvey, who repeatedly argues that neoclassical economists have had no luck in developing a model of exchange rate determination that has had anything but very limited empirical success (Harvey, 1999). Harvey points out that "an explanation of exchange rate movements based on Post-Keynesian principles would be superior to those offered by the mainstream." He uses the Post-Keynesian approach to explain exchange rate volatility. The argument is that exchange rates are determined by international investors' demand for currency as they act to adjust their portfolios with due emphasis on psychological and institutional factors. In fact, Harvey (2006a) argues that "neoclassicists' failure can be traced in large part to their assumption that economic behavior is independent of social, psychological, and cultural influences and is instead driven by rational and presumably natural free market impulses." He adds that "understanding behavior within our system requires that we understand the behavioral norms imposed on agents, norms that are specific and evolving." He attempts to demonstrate that "an explanation of exchange rate determination that places the activity in its psychological context yields results superior to those of one based on traditional neoclassical principles."

In the Post-Keynesian model, exchange rates are determined by the international supply of and demand for each currency. Demand comes from imports, foreign direct investment, portfolio investment, and official reserve management. As it comes from many sources, it follows that the demand for a currency is rooted in several disparate sources, which makes the operationalization the supply–demand model something of a problem. It is also argued that portfolio investment is the most important source of demand for foreign exchange. In fact Harvey (1999) goes as far as saying that "for all intents and purposes it [portfolio investment] determines exchange rates." Portfolio re-adjustment depends on expectations, and as expectations are volatile, exchange rates are volatile too.

The importance of portfolio investment is not denied by neoclassical economists, but Harvey argues that there are crucial differences between Post-Keynesian and neoclassical views about what determines theses flows and how they affect the economy. Neoclassical economists hold the view that financial flows arise to accommodate demand originating in the real side of the economy, and this is why they do not distinguish between portfolio and direct investment. Post-Keynesians believe that the following difference is in place. When foreign direct investment is the source of demand, expectations are stable. However, expectations are not stable when the source is portfolio investment. Hence, exchange rates are driven by the shifting of sentiments of international portfolio managers. According to the Post-Keynesian view, therefore, exchange rate volatility can be attributed to the fact that exchange rates are driven by portfolio investment in search of short-term capital gains. Harvey (2006a) attributes the rapid changes in expectations to the following factors: (i) the speculative nature of the foreign exchange market, (ii) the lack of a true anchor to currency values, (iii) the subculture of foreign exchange dealers, (iv) the particular manner in which decisions are made, (v) the environment of uncertainty in which decisions are made, and (vi) the bandwagon effects.[4] Each of these factors combines to create the volatility that has characterized floating exchange rates. He concludes that "all indications are that it [volatility] is simply a byproduct of the casino into which the international financial system has evolved."

14.5.2. *The Behavioral Finance Approach to Exchange Rates*

The foundation of behavioral finance is that individuals do not behave in the way described by the rational agent paradigm. Some aspects of the behavior of market participants are the following:

- Framing preferences are affected by the way choices are presented.
- According to prospect theory, agents attach different utility value to gains and losses (Kahneman and Tversky, 1973).
- The anchoring effect explains why agents often extrapolate recent price movements. Anchoring means that people base their decisions on the information they understand or the information that is fresh in their minds.

de Grauwe and Grimaldi (2006b) list the principles of behavioral finance as follows:

- Agents experience a cognitive problem when they try to understand the world. They find it difficult to collect and process the complex information with which they are confronted. As a result, they use simple rules to guide their behavior. They do that not because they are stupid but because the world is too complex.
- Agents regularly evaluate the behavioral rules they use and switch from one rule to another if it gives them more satisfaction.
- In the behavioral finance approach, rationality is a selection mechanism based on trial and error, in which imperfectly informed agents decide about the best behavior based on recent experience.

[4]The bandwagon effects create destabilizing expectations. This is a situation when market participants believe that a depreciating currency will depreciate further and an appreciating currency will appreciate further.

The process consists of two stages. In stage one, market participants use small parts of the full information set only because of the complexity of the real world. On the basis of the chosen subset of information, they apply simple forecasting rules. In stage two, market participants want to find out whether the rule they use is good or bad. They do this by checking, *ex post*, how profitable the rule is compared to other available rules. They may then consider switching to better rules.

de Grauwe and Grimaldi, (2006b) present a simple behavioral finance exchange rate determination model, which they show to be sensitive to initial conditions. This property of non-linear models means that very small changes in the initial conditions lead to very different future paths of the exchange rate. The dynamic implications of the model is that it generates persistent movements toward a non-fundamental (bubble) equilibrium. Once in a bubble equilibrium, the exchange rate returns to a fundamental equilibrium (crash) at some point in time. When the exchange rate is in a bubble equilibrium, there is an absence of mean-reverting (fundamentalist) forecasting, and as a result the exchange rate wanders aimlessly, unmoved by fundamental forces. This situation does not last because, at some point, movements in the fundamentals will start attracting the exchange rate, leading to a crash. The crash phase is typically shorter than the bubble phase due to the fact that during the crash, both chartists and fundamentalists forecast a decline in the exchange rate. This model is more consistent with reality than conventional models.

14.5.3. *Chaos Theory*

Chaos theory provides an analysis of phenomena or processes that are too irregular to be predictable. A chaotic process is a deterministic process that looks random. Like many other techniques, the study of chaos or chaotic behavior originated in mathematics and pure science, then imported to economics and finance.

The study of chaos has been motivated by the desire to find out whether or not some natural phenomena are governed by as yet undiscovered laws. Scientists have noticed that some phenomena, like planetary motion, are governed by stable laws but others, such as weather patterns, are not. Hence, the question is whether or not weather phenomena are random. This question has motivated a "search for the truth" because it has become apparent that what was once thought to be random is in fact chaotic. A variable or a process is said to show chaotic behavior when its evolution or time path seems to be random when in fact it is deterministic. This time path is generated by a deterministic non-linear equation.

Economists joined the bandwagon of those utilizing chaos theory when they found out that it could explain some economic and financial phenomena that conventional models have not been able to handle. The motivation for resorting to chaos theory to salvage exchange rate economics is the belief that conventional models have failed because of the underlying assumption of linearity. The implication of this assumption is that exchange rates respond in a linear manner to changes in the determining variables, or that they are generated by univariate linear processes. The tendency to use linear relations is reinforced by the importance of linear regression techniques in this methodology, and the unavailability (until recently) of the tools required to explore non-linear specifications. There is, however, no reason why we should believe that this is the case. If exchange rates are generated by non-linear processes then, given certain conditions, the behavior would look completely random, as it is in reality. This is a non-linear chaotic behavior: it is deterministic and not stochastic. Clyde and Osler (1997) suggest that "the concentration on linearity to the exclusion of all other functional specifications is like taking the bet that the unidentified animal in the next room is an elephant instead of one of any of other species of animals."

The chaos literature has provided an alternative explanation for the behavior of exchange rates. It can be shown that the random behavior produced by the introduction of the stochastic error term in linear equations can also be produced by a simple deterministic non-linear model. The simplest non-linear model that can produce chaotic behavior is represented by the logistic function $s_t = ks_{t-1}(1-s_{t-1})$. Copeland (1994, pp. 392 and 393) shows that this representation can be derived from the regressive expectations representation, which is a component of the exchange rate overshooting model. It can be shown that this equation can generate a variety of time paths for the exchange rate, depending on the value of the tuning parameter, k, and on the initial value, s_0.

Chaos theory seems to provide an alternative approach to exchange rates. But, unlike the microstructure approach and the behavioral finance approach, this approach has not been pursued vigorously by economists. This is probably because financial economists in general, and not only those interested in the behavior of exchange rates, are interested in the microstructure and behavioral finance approaches. As a matter of fact, both of these approaches were initially used to study the behavior of stock prices.

There is much more literature on the application of these approaches to stock prices than what is available on exchange rates.

14.6. Do Macroeconomic Fundamentals Matter?

Empirical macroeconomic models of exchange rates (particularly the standard asset market models) have failed in two respects: out-of-sample forecasting (for example, Meese and Rogoff, 1983a,b) and the ability to explain exchange rate volatility (for example, Flood and Rose, 1999). The failure of fundamental models to explain exchange rate volatility is verified by the casual observation that the volatility of exchange rates far exceeds the volatility of macroeconomic fundamentals. Based on a similar line of reasoning, some economists wonder whether exchange rates are determined by fundamentals or by speculation, implying that the two are mutually exclusive (for example, Dixon, 1999). Hence, what these economists really mean is that speculation cannot be based on fundamentals but rather on some sort of extrapolation of past values of the exchange rate.

These observations have been wrongly interpreted to imply the irrelevance of macroeconomic fundamentals envisaged by asset market models of exchange rate determination (see Moosa, 2002c). It can be demonstrated that the empirical failure of fundamental models and exchange rate volatility are not inconsistent with the relevance of fundamentals. In fact, the conclusion that there is no systematic relation between exchange rates and macroeconomic fundamentals is based on the empirical observation that there is disparity between the actual behavior of exchange rates and what is implied by fundamental models. Hence, the argument goes, these models do not work, and this conclusion is taken as far as saying that fundamentals do not matter.

Some economists disagree with the view that fundamentals do not matter (for example, MacDonald, 1999; MacDonald and Marsh, 1997; Wolff, 1987b). They argue that the results of Meese and Rogoff (1983a,b) can be overturned, even in simple PPP-based models of exchange rates. However, these results cannot do anything to change the (justified) perception of the appalling empirical performance of these models. While there is no doubt that macroeconomic models of exchange rates are inadequate, this inadequacy cannot be interpreted to imply the irrelevance of fundamentals. This interpretation is far-fetched because it implies that the foreign exchange market is governed by the iron law embedded in the underlying fundamental model, and that this iron law is observed and obeyed by all market participants.

These arguments overlook the fact that the foreign exchange market is not a mechanical system that moves according to a pre-determined formula that is yet to be discovered, given the empirical failure of the exchange rate models that have been developed so far. This flawed line of reasoning results from the wrong perception, which Harvey (1993, p. 679) describes by saying that "markets are perceived as quasi-physical phenomena composed of a system of deterministic laws leading to predictable outcomes." The problem with this line of reasoning is that when these predictable outcomes do not materialize, the conclusion that jumps to the forefront is that fundamentals do not drive the foreign exchange market. Rather, it is some other force that is yet to be discovered: this is a very convenient excuse if one rejects a proposition and cannot provide an alternative one. The same arguments also overlook the heterogeneity of participants in the foreign exchange market that can be used to explain volatility, the relevance of fundamentals, and the empirical failure of fundamental models.

A question that is frequently asked is the following (for example, Dixon, 1999): "Are exchange rates ultimately tied down by economic fundamentals, or are they free to drift at random on a sea of speculation?" What follows from this question is the belief that speculation in the foreign exchange market cannot be based on fundamentals. This belief is at odds with the available survey and econometric evidence indicating that foreign exchange dealers base their speculative decisions (related to exchange rate forecasting) on fundamentals, technical analysis or a combination of both.[5] Moosa (2000b, Chapter 2) presents a comprehensive description of decision-making situations involving speculation in the foreign exchange market. The relevant decision rules involve the expected exchange rate as a decision variable. Forecasting the unknown decision variable may be based on fundamental models, technical models, or even market-based models. Hence, speculation does not necessarily preclude the use, and hence the relevance, of fundamentals.[6] The most successful currency speculator, George Soros, has made his billions by speculating on the basis of fundamental factors. This observation alone is a testimony in favor of the proposition

[5] See, for example, Allen and Taylor (1989, 1990), Taylor and Allen (1992), Lui and Mole (1998), Frankel and Froot (1990a–c), and Moosa and Korczak (2000).

[6] There is apparently some confusion in the literature between speculation and bubbles.

that fundamentals are important. Moreover, "drifting at random" does not necessarily mean that fundamentals do not matter.

Fundamentals are important as long as market participants act upon them. When they do, they change the forces of supply and demand and hence affect the exchange rate. A back-to-basics explanation of exchange rate volatility can be presented by considering what happens on the foreign exchange market as a result of the combined effect of various market participants who are quite heterogeneous in their characteristics and actions. Because of this heterogeneity, it is not possible to present a model of exchange rate determination that is represented by a set of equations, let alone a single equation. It is the heterogeneity of the characteristics and actions of market participants that creates exchange rate volatility and leads to the empirical failure of fundamental models despite the relevance of fundamentals.

The importance of fundamentals cannot be judged on the basis of the empirical validity or otherwise of a fundamental model. Unfortunately, however, some economists use the out-of-sample forecasting power of fundamental models as a measure of the relevance of fundamentals (for example, MacDonald, 1999; Rogoff, 1999).[7] In commenting on Mark's (1995) finding of the superiority of fundamental models at long horizons, Rogoff (1999) describes these results as implying "modest empirical connection between exchange rates and macroeconomic fundamentals." Fundamentals are important and relevant if dealers act upon them and take them into consideration when they decide to buy and sell currencies. By doing so, they cause shifts in the excess demand function, leading to changes in the exchange rate. It is in this sense that fundamentals are relevant to exchange rate determination.

Is there any evidence that fundamentalists exist? The answer is a definite "yes": there is ample survey and econometric evidence indicating the existence of fundamentalists. Allen and Taylor (1989, 1990) and Taylor and Allen (1992) provide evidence, based on a survey of some 240 foreign exchange dealers in London, indicating that both technical and fundamental analysis are used. Lui and Mole (1998) conducted a similar survey involving 153 foreign exchange dealers in Hong Kong and found that these dealers placed some weight on both technical and fundamental analysis. The econometric evidence is also supportive. Goodhart (1988) puts forward the view

[7]It may be ironic that while MacDonald and Rogoff disagree on the relevance of fundamentals, they use the same faulty criterion to arrive at their conclusions.

that exchange rate misalignment is determined by the balance of the predictions of technical analysts and fundamental analysts. Likewise, Frankel and Froot (1990b) use an econometric model to demonstrate that both technicians and fundamentalists play a role in the foreign exchange market. On the basis of a similar model, Moosa and Korczak (2000) find that both fundamentalists and technicians play a role in exchange rate determination and that fundamentalists play a bigger role.

From the foregoing discussion regarding macroeconomic fundamentals, Moosa (2002c) derives the following conclusions:

1. Fundamentals are important for exchange rate determination in the sense that dealers act upon them, leading to shifts in the aggregate excess demand for foreign exchange function, and hence to changes in the exchange rate.
2. Exchange rate volatility can be attributed to the heterogeneity of foreign exchange dealers with respect to their actions and trading strategies.
3. The empirical failure of fundamental models is not inconsistent with the relevance of fundamentals. These models do not describe exchange rate behavior adequately because fundamentalists do not react to the same announcement in a similar manner, and because not all market participants are fundamentalists.
4. Exchange rate volatility is not inconsistent with the relevance of fundamentals. For one thing, foreign exchange dealers who create volatility by their actions are heterogenous with respect to their reactions to changes in fundamentals.
5. Speculation does not mean that fundamentals are irrelevant because speculative decisions can be based on fundamental considerations.
6. Fundamentals are relevant to the exchange rate determination process even if the foreign exchange market is experiencing a bubble (and even for short-term decisions).

Fundamentals, therefore, do matter. As we have said before, it is wrong to view the foreign exchange market as a mechanical system with buttons assigned to various fundamentals. It is hazardous to believe that fundamentals do not matter just because pushing a particular button does not move the foreign exchange market in a particular direction. The process is too complex to be viewed in this way. And fundamentals do matter because they are taken into account when decisions are made to buy and sell currencies. Even as we go through the credit crunch in October 2008, fundamentals do play a role, albeit not an exclusive role. Indicators of the health of the

U.S. economy provide incentives to buy or sell the U.S. currency even in the midst of the worst financial crisis since the 1929 crisis.[8]

14.7. Concluding Remarks

The state of exchange rate economics is unsatisfactory, in the sense that mainstream neoclassical models of exchange rate determination have proved to be inadequate for explaining or predicting exchange rate movements. This will, hopefully, keep economists motivated rather than frustrated while pursuing their endeavors to explain such complex phenomena as fluctuations in exchange rates. However, the direction of research should be changed, with less emphasis given to testing the same specifications using different techniques. It is only by thinking more broadly than what is implied by conventional models that we can hope to achieve a better understanding of the exchange rate determination process. It is refreshing to realize that an increasing number of mainstream economists are joining the "counter-revolution," be it under the umbrella of the microstructure approach, behavioral finance or Post-Keynesian economics. It is refreshing to know that economists are beginning to think "outside the box."

[8]The renewed strength of the U.S. currency in the midst of the financial crisis of 2008 can be explained in terms of fundamentals. One such factor is the narrowing interest differentials between other currencies and the dollar. When countries worldwide started to reduce their interest rates in response to the crisis, interest rates on the dollar were already low, thus the interest rate differentials dwindled very quickly, putting pressure on high-interest currencies such as the Australian dollar. The Australian currency collapsed against the U.S. dollar in September and October 2008, *inter alia*, because of the rapid narrowing of the interest rate differential and the decline in commodity prices, both of which happened to be the fundamental factors.

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