# CHAPTER EIGHT: TECHNOLOGICAL PROGRESS

 **Introduction**

***Dear learners, welcome to the eighth unit of this course!*** In this chapter we are going to discuss about the analysis of innovation and research and development (R&D) activities which are quite prevalent in manufacturing and other business circles. Innovation is one of the several strategies through which a firm could change its situation in the market in pursuit of its objectives. It is an instrument, which the firm uses to enhance its competitive power in the market. It provides a basis for greater degree of diversification and hence growth of the firm. The major elements of innovation or technological change, such as,

* New products,
* New methods of production,
* New markets and
* New forms of industrial organization etc,

These make the firms and industries to run efficiently over time. Recognizing such role J.A. Schumpeter took innovation as "the fundamental impulse that sets and ­ keeps the capitalist engine in motion". He found innovation as the out­standing fact in the economic history of capitalistic society. Innovation is not confined to such a society only. It is a common feature in almost every economic system whether capitalistic or socialistic or something else. Science and technology become operative through innovation.

In the modern world,

An individual wants to be ***more creative***,

A firm or corporation strives for the ***progressiveness*** of its business and

A government works for the collective ***security and welfare*** of masses.

Innovation is an important weapon for all these. In fact, survival of mankind depends to a great extent on innovation, particularly in the fields ofmaterial requisites oflife.

## 8.0. The process of innovation: Concepts and Relations

The terminology of innovation consists of a set of interrelated terms. The first and perhaps the most important one is the concept of invention.

 **An invention is the creation of the new technology**. By 'techno­logy' we mean any tool or technique, any product or process, any physical equipment or method of doing or making, by which human capability is extended. It is an intellectual act which involves a perception of a new image, of a new connection between old conditions, or of a new area for action. All inventions, big or little, are made for some practical uses. **The process of adopting an invention in a practical use is called innovation.** It is the implementation of a new or significantly improved idea, good, service, process or practice that is intended to be useful.

 If the existing product line is changed by a firm, i.e. it introduces a new product with or without dis­placement of the old ones, and then it is defined as **product-innovation.** If a new method is initiated to produce existing products then it is **process­ innovation.** Both of these are the elements of **'technological innovation'**. When a firm makes changes in its marketing strategy we define that as **'market-innovation'**.

Similarly, there may have innovation in organizational practices, financing and any other aspect of business conduct. The concept of innovation is, thus, very broad. The entrepreneur or manager when performs the act of innovation is called '**innovator**'. He invests resources for the innovation and takes the risks involved in that. This is a very important role, indeed a pivotal one, for the growth of industries. **Innovation occurs when the entrepreneur believes that it is worthwhile to commercialize the invention**. Schumpeter identifies five types of innovation, viz

1) The **introduction of a new good** —that is one with which consumers are not yet familiar—or of a new quality of a good.

2) The **introduction of a new method of production**, which need a discovery scientifically new, and can also exist in a new way of handling a commodity commercially.

3) The **opening of a** **new market** that is a market into which the particular branch of manufacture of the country in question has not previously entered, whether or not this market has existed before.

 4) The **conquest of a new source of supply of raw materials** or half-manufactured goods, again irrespective of whether this source already exists or whether it has first to be created.

5) The **carrying out of the new organization** (the reorganization of methods of operation) of any industry, like the creation of a monopoly position or the breaking up of a monopoly position.

Another useful concept related to the innovation process is 'imitation'. It is a situation when an innovation is copied by others. That is, the inno­vation spreads across the market. In other words, we call it **'diffusion of the innovation'**. Such diffusion may be rapid or slower depending on the market situation, but it will be easier or safer than the act of innovation.

**Chapter objectives**

**After reading this chapter you will get acquainted with**

* The meaning of Invention, Innovation and Diffusion
* The importance of Invention, Innovation and Diffusion in the performance of a firm.
* The diffusion of innovation.
* The relation between Innovation and employment
* The characteristics of firms and markets in the process of change

## 8.1 Stages of Technological Change

**The first stage: (*Invention*)** is carried on by indivi­duals or corporate bodies like research institutes, universities, government bureaus and companies- the source of invention. It is just like any other corporate activity such as sales or production where certain inputs are used to get some output in a broad sense; we may call invention as output of the research industry. If so, an invention will be a goal-oriented activity. A government or corporation will be making invention for solving some social problem or for the sake of extra profits or money. To achieve the goal of invention a series of steps will be taken beginning from the definition of the problem, the alternative routes to its solution and finally the output in the form of the invention. It is an orderly sequence, a matter of applying conscious intelligence to the solution of the problems. The ‘output’ of the process may not come during the stipulated time. There may be frustration, delay, failures, etc., but the process of invention goes on. In general invention can be taken as an orderly, intellectual, goal oriented process, a fundamental one, for the innovation or technological change in a society. It does not usually move in a straight line according to the plan, but takes unexpected twists and turns to reach the destination.

**The Second stage: *(innovation)*** is a logical extension of invention. When an invention is made, its fruits are made available to the society through innovation. An entrepreneur or corporation comes forward, makes the required investments for the innovation. As mentioned earlier, innova­tion may be in product or process of manufacturing or any other activity of the corporation. It involves risks and uncertainties. An innovator bears them and it is precisely on this ground that economists justify existence of excess profits for him.Process-innovation and product-innovation are two important types of innovation.

***Process innovation*** arises when relative prices of factors of production change. If labor becomes costly, the firm may think of cost saving by adopting capital intensive technique and vice-versa. In the familiar iso-quant framework, it implies a movement along the isoquant when the input prices change. There will not be any R&D expenditure involved in this, as technology will not change. Only the equili­brium situation for the least cost combination of inputs changes. Further, if technology changes this means a new production function causing a shift of the isoquants. In this situation, the need for process innovation is obvious. The input proportions to produce a given level of output will change if there is technological change giving rise to the process innovation.

***Product innovation*** is necessitated because of a variety of reasons. Primarily, a product change may be stimulated either by a new technology or by a change in relative prices of existing products. Changes in consumer preferences and cost of production- are the sources of change in relative prices of the products. If a product is costly for the firm and at the same time its price declines in the market because of unfavorable circumstances, it will be less profitable and, hence, is likely to be replaced by a new one.

The process of innovation has a well defined goal and the adaptation of the new technology or product to achieve the goal is an orderly management function of the firm.

**The third stage: (*Diffusion*)** is the imitation of innovation. The innovation, initiated by an innovator, spreads in the market. The rate of diffusion depends on market structure. If there are rigid patent practices and the government assistance in technological progress is negligible, then we expect a low rate of diffusion of the inno­vation. On the other hand, if technology is freely available, there are no rigid patent practices and investment requirements for the new technology are not alarming, then the rate of diffusion will be fairly high. From social point of view diffusion or spread of the innovation is desirable but from an individual firm & point of view it is not, as the firm would not be able to maintain its gains through innovation when it is imitated by its rivals.

*In short, there are three terms -invention, innovation and diffusion -are the succes­sive stages of the process of innovation or technological change. Diffusion is not possible without innovation which in turn is not possible without invention. The entire process of change, i.e. from invention to imitation, comes under research and development (R&D) activity of the firm.*

8.2 Invention, Innovation and diffusion

 *Define Invention, Innovation and diffusion? Clearly state the difference among invention Innovation and diffusion? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*

Many major technological changes begin with basic research, which is research aimed at gaining knowledge for its own sake. The research scientist in a major university laboratory working on quantum physics is engaged in basic research. Applied research is aimed at obtaining knowledge with the objective of using that knowledge for commercial purposes. The chemist working on AIDS in a pharmaceutical company’s laboratory is doing applied research. The lines between basic and applied research, however, often becomes blurred. The chemist, for example, may in the course of his or her applied research make a basic research discovery of an idea that ‘’should’’ work. In the invention stage the idea passes through its first rough tests, which indicate that it will indeed work. Invention is an important step in the process of technological development, but it is only a preliminary step. The next stage in the process is innovation, which is the first commercial application of the invention. Innovation requires refinement of the inventions ‘’get the bugs out’’ and develop a marketable product. Finally, diffusion is the stage at which the innovation comes into common use.

1. **Patents and Patent protections**

Do you know anything about patent and patent protection?

Patents provide an inventor with exclusive rights to a new and useful product, process, and substance or design. New products include machines (mechanisms with moving parts) or manufactured articles (without moving parts) such as tools. New processes or methods include chemicals process for treating metal or manufacturing drugs, mechanical processes for manufacturing goods, or electrical process. New substances include chemical compounds and mixtures; this concept covers the composition of matter.

Now designs include the shapes of products where the shapes serve of functional purpose. In addition, improvements on products, processes, and substances may be patented.

**Patent** is a legal monopoly grant that is awarded to inventors in exchange for their agreement to disclose their inventions to the public. A valid patent gives an inventor monopoly power to decide on the use of transfer, or withholding of an innovation. The awarding of a patent has an admirable objective, the dissemination of technological knowledge that might otherwise be kept secret, but the patent grant may be abused and come indirect conflict with another economic goal, the reduction of monopoly power.

Patents exist for one economic purpose-to increase the rate of technological advance without question, some major technological breakthrough would never have been developed, or would have been developed much later, in the absence of patent protection. Economic theory suggests, however, that patent protection may not increase the rate of technological advance. In fact, theory suggests that in some cases patent protection decreases the rate of technological advance. To understand the potential dilemma associated with the current system, consider the following three possible scenarios.

**Scenario 1:**

Suppose a weekend garage inventor, hypnotically Named Mr. Tinker, is driven to invent, not by money, but by a fairly common character fruit-curiosity. One day Mr. Tinker discovers a new method for cheaply harnessing solar energy. Although Mr. Thinker never gave any thought to the patent system as he worked on his invention every weekend, on realizing the importance of his discovery, he runs to a patent differently, and a few years latter receives a patent. We then turns the patent over to a large firm., hypothetically called International solar Machines (ISM), and on the basis of Mr. Tinker’s patent ISM develops a solar energy device, which it prices well above marginal and average cost. Over the next decades, other firms spend millions of dollars in an unsuccessful attempt to invent around the ISM patent. Finally, after seventeen Years, the ISM patent is made public, but by then ISM is virtual monopolist in the solar energy business. Furthermore during the period of patent protection, ISM patented a number of minor technological advances based on MR. Tinker’s original patent, so that by the time the original patent expires, ISM is firmly entrenched as the leader in the salary energy field, and few firms will consider attempting to challenge ISM’s stock holders have all made large fortunes, but the solar energy industry has performed in every inefficient manner in terms of static efficiency. Furthermore, to protect its investment in Tinker’s original device, ISM withheld using some of its improvement patens for several years, therefore, ISM slowed the rate of technological advance on improvements to the Tinker patent. Society has benefited from Mr. Ticker’s device but has also paid a price in the form of reduced static efficiency and a slow rate of technological improvement on the basic patent.

**Scenario 2**

Now consider on alternative scenario to the Mr. Tinker story, one without a patent system. Mr. Tinker develops the same solar energy device, and takes the device to ISM. A member of the ISM development department likes the idea, and ISM proceeds with development. Because of a lack of patent protection, ISM decides to introduce the device as quickly as possible before its competitors learn about the existence of the invention (perhaps rumors of the device have already begun to circulate). ISM is first into the market and initially charges a high profit-maximizing price. Within twelve to twenty-four months, ISM and Mr. Tinker have made a large economic profit, and the first imitations of MR. Tinker’s invention appear on the market. After another twenty-four moths many imitations are available, but to keep one step ahead of the competition, ISM and some of its competitors have already marketed more advanced devices based on the original Tinker technology. Within five years, the basic Tinker device is obsolete, and many companies are competing for a share of the salary energy harnessing market. Some firms make a profit, others sustain an economic loss and leave the market, but an average the industry is earning normal economic profits. Prices approximate marginal and average cost, and the industry is performing efficiently from a static stand point. In this scenario, the lack of patent protection has actually increased the rate of technological advance, and the outcome is preferable to that of scenario 1 from both a static and dynamic perspective.

**Scenario 3**

Now consider another possible scenario in the absence of patent protection. Mr. Tinker develops the same solar energy device and approaches the development department at ISM. After careful consideration, the development department concludes that although the device is technologically sound, development would be too expensive, and therefore, without patent protection ISM could not expect to earn a profit, Mr. Tinker then approaches several other large high-technology firms, but each responds in the same negative manner. Finally, completely discourage, Mr. Tinker gives up, and the device never becomes a commercial reality. Because of a lack of patent protection, society has lost all of the potential benefits associated with Mr. Tinker’s device.

Economic uncertainty surrounding the patent system exists because it is impossible to determine how often the first scenario occurs, as opposed to how often the second or third scenarios would occur in the absence of patent protection. Scenario 2, without patent protections, is clearly preferable to scenario1, with patent protection. However, scenario 1, with patent protection, is clearly preferable to scenario 3, without patent protection.

Another way to think about this dilemma is to recognize that some inventions and innovations are patent dependent and others are not patent dependent, that is, some technology would become available only with a patent system, but other technology would become available just as quickly or even more quickly, without a patent system. Like many economic issues, the patent system involves trade-offs. Some inventions and innovations that are not patent dependent are protected to ensure that society receives the benefits of all patent-dependent inventions and innovations. Because the system involves social costs as well as social benefits, patent holders should not be granted unrestricted rights and privileges.

Patents induce inventions and innovations, but also increase monopoly power. The patent system always results in net social benefits for patent-dependent innovations. The patent system, however, always result in net social losses for non patent-dependent innovations because these innovations would be devolved without the casts of granting monopoly power. There are a variety of reasons why many high-technology innovations would be developed without patents. First, many inventions and innovations result from human curiosity and genius. Such inventions are driven primarily by a need to understand. The development of fire and the wheel, for example incentives for invention and innovation often result from first mover advantages or an ability to move rapidly down a earning curve. Third, complementary investments in marketing and service can provide sufficient protection from competition for new inventions or innovations (e.g. IBM). Finally, Secrecy may provide better protection against imitation that patents because with patent protection the new technology is made public. Whereas with secrecy competitors are prevented from gaining insight into the new inventions or innovation

1. **Incentives for Investment**

What do you think is the reason that without patents or other government’s incentives, there would be too little research?

 Most economists and policy makers believe that without patents or other government incentives, there would be too little research. The chief reason is that inventions are fundamentally new information, and information is public good. If someone possesses some information, you can possess and benefit from that some piece of information. Thus, my knowledge of the information does not prevent you from using it. If some consumers of the information can obtain it costless (for example, you can read a book in a library). The producer of the information has less incentive to produce it than, of every one had to pay for it. Why would one be willing to incur the entire expense of developing new information, processes, or products of people could benefit from them for free? Although some people like inventors and firms under take research for the pecuniary rewards. Thus, if they could not benefit from their new developments, this latter group would not engage in research.

Eliminating most such research would harm society because it has social value. New manufacturing methods lower the costs of producing existing products and allow society to produce more output with the same amount of input. New products increased productivity (for example, improve seeds with higher output or better quality) or give pleasure.

1. **Imitation Discourages Research**

Without a patent, any one could use new information, and imitations of new inventions could be sold legally. Suppose you discovered a cure for AIDS. You could sell your new drug for large sums of money if a patent gave you exclusive rights. Without a patent other companies could duplicate your drug, and competition would drive the price to the competitive level. You would incur all the research costs and but not all the private benefit (profits). Every firm wants to copy others inventions, and no firm wants tog to the expense of inventing anything itself. Thus, without patents consumers could buy new inventions at competitive prices, but there would be few new inventions. Indeed, society tries to reduce the number of certain types of new inventions by not offering patent protection. For example, in the United States, you cannot patent a gambling device such as a slot machine.

1. **Patents Encourage Research**

Can you mention how patent rights encourage Research? By imposing costs on potential imitators, patents can give market power to patent holders. The resulting monopoly profits can be strong inducement to be the first to invent a new product.

A rational inventor engages in costly research up to the point where the expected marginal return from more research equals it marginal cost. If the inventor’s return is less than society’s, the inventor tends to under invest in research. Patents may permit inventors to capture a large share of the benefits (internalize the externality) associated with the production of knowledge by insulating them from competition. By granting these exclusive rights through patents, society encourages more inventions in some industries. Patents may also encourage too much innovation. For example, suppose an improved method of weather prediction is developed that allows accurate prediction of crop yields after all planting decisions have been made. The inventor can make a fortune speculating on future farm prices. Despite the profits from speculation, there may be little efficiency gain to society from the new forecasting technique. Without patents or other incentives to engage in research and development there would be too little research, especially, when imitation is easy and rapid.

1. **Patents Encourage Disclosure**

Some countries’ patent laws encourage disclosure of new discoveries sooner than other countries laws. To obtain a patent, an inventor must demonstrate that the invention is novel and no obvious.

By providing patent protection of inventors, society obtains two valuable results: greater incentives for additional research and development and an acceleration of innovation through disclosure of inventions.

Such disclosure can increase the pace of invention as one inventor builds on the work of another. Some firms do not patent discoveries so that their competitors will not learn about them. These firms must protect their secret knowledge from leaking out to others, as can occur when employees take a job with a competitor. It is illegal for employees to reveal trade secrets of their former firms. To the degree that firms use the patent system, there is greater disclosure than would occur with trade secrets.

1. **Value of a Patent**

Patents, which grant exclusive rights to success full inventors, also induce research. Unlike prizes or government research contracts, however, patents lead to distortions due to monopoly pricing. Thus, they are less efficient than optimal prices or research contracts if the government has sufficient information to induce the optimal amount of research. There are reasons to use patents, however, because the government typically has limited information. In any case, patents are an extremely common method of inducing research throughout the world.

Example for value of a patent: suppose that the first successful firm receives patent granting exclusive rights to sell the product. Does this reward of monopoly profits induce the optimal number of firms to conduct research? To determine how many firms engage in a patent race, in which several firms compete to be the first to make the discovery and be granted the patent, one needs to find out how much the patent is worth.

Take the following assumptions in to consideration to calculate the value of the patent

**a**. The demand in each period for the new product is linear i.e

 P=6-5Q

Where p is the price and Q is the number of units sold

**b**. The marginal (and average) cost of production is 1

**c**. If two firms make a discovery simultaneously, they split the patents rights.

**d**. The interest rate r, is 10 percent

A firm that obtains exclusive rights under a patent acts like a monopoly and maximizes its profits by setting marginal revenue equal to marginal cost. In the example, the monopoly charges price Pm = 3.50, sells qm = 0.5 units and makes annual profits of ∏m= 1.25. With monopoly pricing, the annual consumer surplus is 0.65, which is one –fourth of the consumer surplus of a competitive industry. These calculations show how much monopoly rights to sell the new good are worth per year. How much the patent is worth over time depends on how long it costs. We consider two cases: a patent that lasts forever and one that lasts for only a few years.

***Permanent Patent***: If a patent lasts forever, the patent holder earns monopoly profits forever. These large potential rewards may induce many firms to race to win the patent, resulting in excessive research effort.

If the patent lasts forever, and the interest rate r=10 percent, the present value of the patent is  = 12.50. That is, the present value of a stream of monopoly profits of 1.25 every year forever is 12.20. If you put 12.50 in a bank account that paid 10 percent interest, you would receive 1.25 interests each year. The present value of a permanent patent, in our example, is 50 percent (= 12.50/25) of the net social value of the invention if the product were sold at competitive prices.

Each firm has an equal chance of obtaining the patent, so the expected return to a firm undertaking research is 12.50 times the probability that it makes the discovery first, P(n)/n. A firm joins the patent race as long as its research costs, m=1, are less than its expected benefits from winning the race.

***Finite patent length***: By having patents last shorter periods of time, t, the government can reduce the incentive for excessive research. Having exclusive rights for only t years reduces the present value of the flow of monopoly profits, thus the expected private benefit to each firm is lower, so fewer firms engage in research.