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Semester V – Industrial Economics

Unit 5

TECHNICAL PROGRESS AND PERFORMANCE

Part 1

Topics covered: meaning of technical progress, causes of technical progress, factors affecting technical progress, process of technical progress, importance and externalities of Research and development activity

Introduction:

This session deals with the concepts of technical progress that aim at economic growth and development. It is concerned with allocation of resources in an efficient way. Such resource allocation will lead to improving the well-being of the economy as a whole.

Meaning

The term technical progress is used in several different senses to describe a variety of phenomenon; but three, especially, can be singled out. First it is a term used by economists to refer to the effects of changes in technology or more specifically to the role of technical change in the growth process. It is an umbrella head to cover

all those factors which contribute to the growth of total productivity. Second technical progress is used by economists in narrow specialist sense to describe the character of technical improvements, and is often prefaced for this purpose by the adjectives labor saving or capital saving or neutral. Third technical progress is used more literally to refer to changes in technology itself, defining technology as useful knowledge pertaining to the art of production. Used in this sense, the emphasis is on describing improvements in the design, sophistication and performance of plant and machinery, and the economic activities through which improvements come about-research, invention, development and innovation.

Since it is well known that research is the base activity for technical progress now let's understand the causes of technical progress, the factors affecting technical progress and economic angle of research.

Causes

(1) Research and development (R&D) spending decisions made by firms

- With the increase of R&D spending, it is more likely for a firm to discover and develop a new product.
- If the new product is successful, the firm's future profits will increase. If the expected present value of profits exceeds the expected cost of research, the firm will start on a new R&D project.

(2) Patent laws

- Weaker protection of new products, smaller expected profits can be gained from new products. Thus, lesser incentives for firms to engage in R&D.
- Even in the presence of patent laws, protection is incomplete. Other firms may learn ways of making another product not covered by the patent. They

may learn how to make a better product, thus eliminating the market for the original product.

(3) The fertility of research

- If research is very fertile, it means R&D spending leads to many new products. Firms will have more incentives to do R&D, and R&D and technological progress will be higher.

(4) The appropriateness of research results

- If firms cannot fully capture the profits from the development of new products, they will not engage in R&D and technological progress will be slow.
- Determinants of the appropriateness of research results:

a. If it is widely believed that the discovery of a new product will lead to a subsequent quicker pace in the discovery of other better products, there may be little payoff to bring first. Thus, a highly fertile field of research may not generate high levels of R&D.

b. Too little protection will lead to little R&D. Too much protection will make it difficult for new R&D. Hence, R&D will be lowered.

(5) Innovations may occur in response to pressures on the commodity markets.

- With the rise of population and the increase of the scarcity of land, greater pressure on the demand for agricultural commodities. This may induce innovations in agriculture to takes advantage of increasing profit opportunities.

(6) Innovations are most likely to occur in rapidly growing sectors of the economy.

- Market expansion increases profitability and makes firms to reap the benefits of scale – economies, which are characteristic of modern industrial innovations.
- Greater demand makes available investible funds that are required for new net investment. Firms in the industry will put in a better position to absorb any potential risks associated with new technology.

(7) Continuous competition in oligopolistic markets may lead firms to invest resources in a systematic search for new technology.

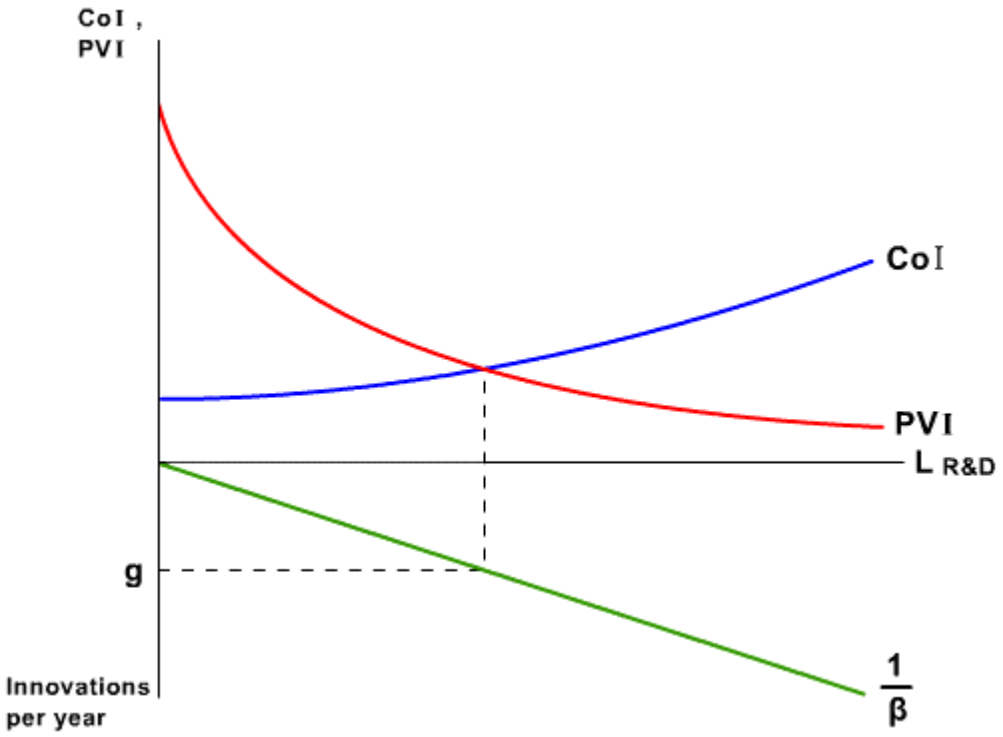
Technological progress as an externality to investment

- Indeed, new ideas and technologies are in some ways linked to the specific equipment, buildings, and tools used in production.
- Some statistical studies suggest that the effect of equipment investment on economic growth is stronger in development investment on economic growth is stronger in developing economies in the early stages of industrialization than it is in the more developed economies.
- New technologies often seemed to be embodied in new machines, and the introduction of a new technology usually coincided with the introduction of new machines or equipment.
- Structures also enable new ideas and methods to be implemented. New ideas cannot be put into practice unless people are trained to apply and use them. Without an investment in education and training, much new technology would not be used.

Therefore, technological progress is not an independent process, completely separate from investment in equipment, structures, and human capital.

- R&D activities are carried out by profit – seeking entrepreneurs. R&D is regarded as a costly activity that is carried out with the intent to produce new products and earn temporary profits.
- Since the cost of R&D activities must be covered, the assumption of imperfect competition is introduced. The greater the potential profit earned by the monopolistic producer, the greater will be the amount of innovative activity.
- Endogenous technological progress is a function of the supply of labor **L**, future profit **π**, the amount of resources needed to create an innovation **β** and the interest rate with which future profit is discounted **r**.

  i.e. **g = f (L, π, β, r)**
- Where **g** = the number of innovations per year.
- The cost of innovation and the present value of innovation determine the equilibrium amount of resources that competitive entrepreneurs devote to innovative activity.



- The number of innovations per year remains constant if nothing else in the model changes. But that implies slower growth as the total number of accumulated innovations grows.
- The number of innovations per year must grow in line with the accumulated level of technology if the growth of technology is to remain constant.

Classification of technical progress

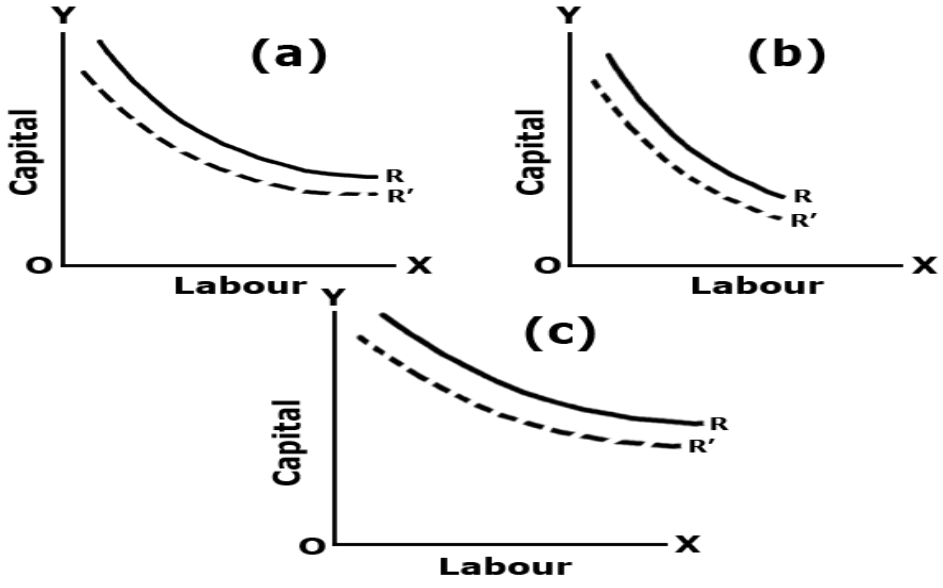
Basically the classification of technical progress as to whether it is capital saving, labor saving or neutral owes its origins primarily to the work of Harrod (1948) and professor Hicks (1932).

Harrods's classification of technical progress employs the concept of capital output ratio. Given the rate of profit, technical change is said to be capital saving if it lowers the capital output ratio, labor saving if it raises the capital output ratio and neutral if it leaves the capital output ratio unchanged.

Hick's classification of technical progress takes the concept of the marginal rate of substitution between factors, which is the rate at which one factor must be substituted for another leaving output unchanged. The marginal rate of substitution is given by the ratio of the marginal products of factors. Holding constant the ratio of labor to capital, technical progress is said to be capital saving if it raises the marginal product of labor in greater proportion than the marginal product of capital, labor saving if it raises the marginal product of capital in greater proportion than the marginal product of labor; and neutral if it leaves the ratio of marginal products unchanged.

Technical progress in economic development

Thus level of technological advancement is an important determinant of economic growth. It is the technical progress that keeps the economy moving. The impact of technological change on production functions can be illustrated with the help of following diagrams.



In the above figure a, b and c is an isoquant of production function before technological change and R represents the same quantities of output after the innovation in the first figure. The innovation is neutral with respect to the two inputs of labor and capital. The new production R' shows that the same output can bed produced with less labor and less capital after technological advancement. The second figure shows that innovation is labor saving and R' shows that the same output can be produced with lesser inputs but the saving of labor is greater than that of capital. The third figure shows that innovation is capital saving and R' shows that the same output can be produced by less inputs after technological change but saving of capital is greater than that of labor.

It is generally assumed that the technological advancement is even more important than capital formation. But the capital formation alone can bring out economic development to a limited extent and the progress stops if there is no technological change. A country cannot remain dependent on the import of technology. A nation that spends more on science and technical research will tend to grow faster than another country accumulating more capital but spending less on technological development.

The technical progress, with reference to substantial contribution to economic growth can be attributed to two factors;

a. Improvisation and b. Innovation.

a. Improvisation

Improvisation of the current procedures can be again referred to a) process development and b) product development.

Process development involves the introduction of new and improved processes, so far technology and production is concerned. Introduction of better machines,

equipment and processes will lead to better quality of output as well as resource efficiency. This will ultimately lead to reduction of real cost of output.

Product development refers to improvisation of features of products, changes in the nature of the product, the use and value of the product. This development is in tandem with the process development and hence society gets improved products finally leading to economic welfare.

b. Innovation

Innovation can be divided into three phases; invention, innovation and diffusion.

Phase 1: Invention

Invention occurs when a completely new idea is developed into a product or a process. It entails the conception of a basic idea. This is the product of laboratory scientists.

Phase 2: Innovation

Innovation provides more efficient and cheaper ways to make existing goods. It can also result in creating new products. Joseph Schumpeter states that technical progress is partly technological and partly economic in nature. Inventions are the emergence of new scientific or technological ideas that may be part of a random, exogenous process.

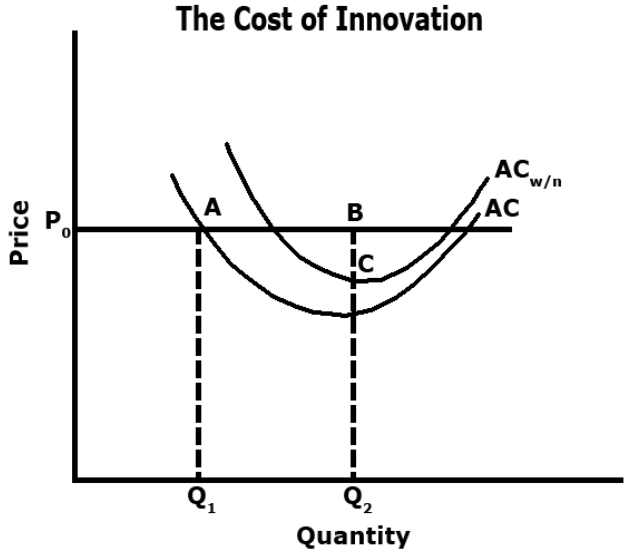
An innovation is an economic process that occurs as a response to perceived profit opportunities, through an act of foresight of the capitalist entrepreneurs, who create or realize these opportunities.

Innovation is referred to as refinement and development of product from viewpoint of commercial viability. The other functions of management are integrated with the production function for ensuring commercial success and ultimately technical

progress. Innovation has not only led to new products and more-efficient production methods, but it has also induced dramatic changes in how businesses are organized and managed, highlighting the connections between new ideas and methods and the organizational structure needed to implement them.

Costs of innovation

Innovations are undertaken to increase the demand for the firm's products. They also involve costs. When the firm seeks to innovate, and whether or not it succeeds, it must commit to a fixed investment. Generally such projects are time taking and the results too are seen only after the commercial viability of the project is established. For e.g. there are two firms with identical production costs (AC) and with and identical price (P_0). Assuming that the firm does nothing to change its product and sells Q_1 units of it, but the second firm spends N dollars of innovation, sells Q_2 units of product, and bears the costs of production and innovation represented by $AC_{w/n}$. one of the two firms, the second is in the obviously preferred position:



It sells larger volume of goods

Its effective average cost-the unit cost for the quantity that is able to sell-is lower than that of the first firm

All other things being equal, this illustrates the case of profitable innovation.

Phase 3: Diffusion

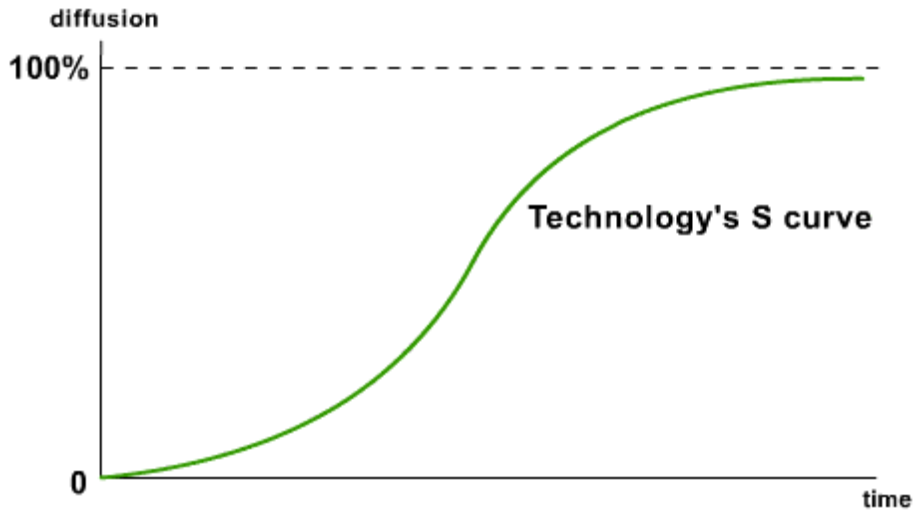
Diffusion occurs when the product or process seems to be feasible for the organization and the organization decides to adopt or imitate the product or the process.

Diffusion of innovation

The third stage of technical progress is diffusion. Generally new processes and techniques are developed by capital goods industries and are adopted initially by a single firm in some other industry in order to reduce production costs. This gives the innovating firm a cost reducing competitive edge. But over a long period it reduces when the competing firm tries to imitate and thus diffusion takes place.

The speed of diffusion as well as the factors affecting diffusion varies across various industries for different processes or techniques.

The micro economics of diffusion of new capital goods incorporating process has been based on the epidemic approach has been elaborated by Griliches (1957) and Mansfield (1961). It assumes a disequilibrium process where profitable innovations are adopted by firms with a delay. This is generally due to consideration of cost of replacement of old machinery as well as thorough assessment of profitability parameters. Hence this process is generally slow-paced in the beginning. It gradually picks the pace as the word spreads around. Eventually the speed reduces as the proportion of non-adopters is reduced and a few laggard firms decide to switch over. Hence the diffusion of a technology generally follows an S-shaped curve as early versions of technology are rather unsuccessful, followed by a period of successful innovation with high levels of adoption, and finally a dropping off in adoption as a technology reaches its maximum potential in a market.



Mansfield considered several variables which may influence the speed of diffusion in different circumstances. Some of them are;

- Fast market growth
- Fast growth and development of communication channels and investment appraisal techniques
- Introduction of innovation during expansion phase

Following Mansfield's work Davies (1979) used a sophisticated theoretical approach. He distinguished between simple and complex innovations first. He assumed that a peaking curve at an early stage would be possible if the innovation was easy to imitate. After fitting diffusion curves to each group of innovations he found five determinants of speed of diffusion. They are;

- Profitability
- Labor intensity
- Industry growth
- Firm numbers
- Variance of logarithms of firm size

His results on market structure and diffusion revealed that, though traditionally believed that industries with many firms will speed the diffusion process with reference to competitive pressures yet the speed was retarded due to poor or slow communication. Secondly firm size inequalities as well as firm's goals may lessen the diffusion speed. Market concentration has a direct relationship with diffusion speed. Industries with fewer firms but firms of less unequal size tend to be associated with faster diffusion.

Thus by providing incentives, technical progress can be fuelled via research and patenting thereby asserting economic growth. Further we need to understand the technical progress with reference to market economy.

Hence technical progress can be attributed to the rigorousness of these three phases. This has led to the growing importance of research and development in all organizations. The expenditure on this front has increased considerably as there are empirical studies showing positive correlation between research and progress. The studies have also reflected that the correlation is statistically significant in concentrated industries. Though they have the capacity to tap greater technological opportunities than the less concentrated yet it does not negate its importance in other industries.

Economics of research

Research is associated with inventions and discoveries of newer products or processes. It is characterized by two elements; one that there is high level of uncertainty associated with it and second the output has characteristics of a public good.

Uncertainty in research arises because when the resources are employed, there is no certainty of output. But this risk is worth being borne as it can be categorically spread over a large number of members of a community. The capital market facilities can be availed as it not only facilitates huge funding but it is socially relevant as it provides a platform for investors with risk appetite. Kenneth Arrow, a renowned economist pointed out that if all the research activity is financed through capital market, then this activity will not bear any risk and hence its effectiveness will reduce. Large organizations undertaking more number of research projects are able to spread the risk by investing in mutually offsetting research projects.

The other element associated with research is the information, which is the output possesses the characteristic of public good. Once the product is out in the market, there are two problems associated with it. One is the non-excludability and the other is non-rivalness.

Non excludability refers to the product's appropriateness or availability to be reproduced at a low cost. Arrow emphasized the difficulties associated with establishing property rights in information, given that once it is available, it cannot remain excluded and hence would be reproduced at a low cost. If the firm may make an attempt to keep it a secret, it will not be able to exploit the opportunities to the fullest.

Non rivalness refers to the fact that the information available to one person may be equally available to another person. Neglecting the costs of disseminating information, it would be socially desirable to make new ideas and inventions freely available to all.

Both the above problems can be tackled by strategy of patenting the idea or product or process. It allows the firm to use its own idea and protect it being disseminated notoriously. In a free enterprise system with property rights in invention, however, an inventor is given an incentive to invent precisely because of its ability to restrict the use of his invention in order to earn a monopoly rent. Hence to strike a compromise, such rights are granted for a fixed term and hence full utilization of the product or idea can be done for social progress.

Externalities of research

Developed countries are on the leading edge of technological innovations. It is imperative for them to keep on innovating in order to sustain their current growth

rates. Without this they will find it difficult to maintain the existing living standards. In accordance to his reality, companies in the developed world are spending huge sums of money on R & D to keep the momentum going.

On the other hand, as suggested by endogenous growth theories, developing countries too will have to spend enormously on R & D if they want of catch up with GDP and per capita GDP growth rates of the rich industrial countries. In absence of this it is impossible to imagine poor countries coming out of the poverty trap.

The problems associated with R & D restrict the small and medium organizations to undertake research activities and hence government has to support such inventive activity.

R & D is more in the nature of public good rather than private good and therefore the role of government becomes paramount in encouraging and enhancing this activity. There are significant externalities and spillover effects associated with any kind of R & D activity. This is also the factor which makes the firms bit reluctant in furthering inventive activity. It would not be possible even through patents and such other mechanisms to fully reap the benefits of inventive efforts. If the society is to benefit through these activities then it is very much expected of the government to support it in all possible ways.

Governments in many countries directly support scientific and technical research, for example, through grant-providing agencies (like the National Science Foundation in the United States) or through tax incentives (like the R&D tax credit). The primary economic rationale for a government role in R&D is that, in absence of such intervention, the private market would not adequately supply certain types of research. However the faith in government‘s ability to anticipate

and reflect the preferences of individuals with respect to the risks of inventive activity, among other things is questionable.

Also the problem, which is apparent to basic or fundamental research, is that the full economic value of a scientific advance is unlikely to accrue to its discoverer, especially if the new knowledge can be replicated or disseminated at low cost.

Societal progress through technical progress

Research and invention are the activities which create knowledge, and development and innovation are the activities which apply new knowledge to the task of production. These are all basic economic activities. But the study of the way in which societies progress technologically, and the speed of the progress, is not only the preserve of the economist. The economist can identify the mainsprings of the progress, but its pervasiveness and acceptance in societies is not purely an economic matter. It depends on the native population's attitude towards invention and innovation. Economic backwardness in many countries may quite legitimately be traced back to a relative shortage of inventors, innovators and risk takers. Schumpeter also stressed on the fact that entrepreneurship and innovation have a great role to play in societal progress. Technical assistance programs in developing countries, organized by developed countries are designed to foster innovation, particularly adoption of new techniques and new goods. Societies' exposure to new goods may be a powerful factor in economic development by acting as an incentive to producers and workers to increase their surplus for exchange.

Summary

In this unit we have understood that technical progress is the key to economic growth. In order to boost its growth, a firm may make inventions and later to reap its benefits to the fullest, it is required to make it commercially feasible. This

would further lead to diffusion of the same innovation and allow other firms in the industry to imitate or adopt the new product or process. Thus it would push the production function up and there would be efficient and effective allocation of resources of an industry. This is an autonomous function which raise the level of output for ach different level of capital labor ratio. Hence innovation not only aims at technological advancement but it is an economic activity which increases social welfare. The only limitation it carries is the enormous expense behind R & D. large firms may find it easy but small firms will have to depend on capital market or government intervention. Government would also be keen to invest in this as it possesses the characteristic of public good. The attitude of the industry towards innovation along with government involvement can help society progress via technical progress.