MODULE 5

Technology Management

Technology

An Introduction

The word ‘technology’ has a wider connotation and refers to the collection of production possibilities, techniques, methods and processes by which resources are actually transformed by humans to meet their wants. Ferré (1988) has defined technology as “practical implementations of intelligence”. However, Gendron (1977) has provided a more comprehensive definition:

“A technology is any systematized practical knowledge, based on experimentation and/or scientific theory, which is embodied in productive skills, organization, or machinery”.

The role of technology in fostering economic growth of nations and enhancing their industrial competitiveness has been widely recognized, through its domineering influence over industrial productivity. Further, technology has emerged as the most important resource that contributes directly to socio-economic development. Hence, technology is viewed from various perspectives: as an ‘engine for economic development’, as a ‘strategic resource’, and as a ‘competitive weapon’. This necessitates effective management of technology - at both national and firm levels. Technology Management (TM), which inter alia aims at planning and developing the technological capabilities of an organization or a nation, has now occupied the centre stage of decision-making.
Gaynor (1989) has provided the following description of TM:

“Managing technology is a method of operation that leverages human resources, technology and other business assets by optimizing the relationships between the technology functions of the business enterprise. It is the process of integrating science, engineering and managing with research, development and manufacturing in order to meet the operational goals of the business unit effectively, efficiently and economically. It includes managing the totality of the technology operations from concept through commercialization”.

TM embraces several interconnected issues such as: technology policy; technological forecasting and assessment; technology strategy; technology transfer; technology-induced as well as market-oriented Research and Development (R&D); process technology and product technology and their continuing improvement; human resource management in terms of innovative capabilities, flexibility and contribution; and technology project management.

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TM was set into motion when man invented the wheel, except that it was never practiced consciously. Now, TM has become what it never was before, an organized and systematic discipline. As TM embraces several interconnected issues ranging from policy planning at the national level to strategic planning at the firm level, it calls for decisions and result-oriented actions at the macro-as well as micro-levels and an effective macro-micro linkage.

Macro technology management commonly refers to technology management at the national level. It includes:

- Planning for the development of technological capabilities at the national level.
- Identification of key sectoral technology and related fields to be developed.
- Determining ‘make’ or ‘buy’ decisions, i.e., whether importation or self-development is to be pursued.
- Establishment of institutional mechanisms for directing and coordinating the development of national technological capabilities.
- Design of policy measures for controls.
Micro technology management concerns technology management at the firm or project level. It includes:

- Responding to competitors who are using technology as a strategic weapon.
- Integrating technology strategy into the overall corporate strategy.
- Identifying and evaluating technological options and innovations and the factors relating to their success and failure.
- Directing research and development itself, including determination and definition of project feasibility.
- Monitoring and planning technological obsolescence and replacement.

Both macro and micro-technology management seek to raise economic efficiency. Micro TM is the basis for macro TM, while the latter provides guidelines and an environment for the former. Consistency among these two levels of management is essential, but institutional mechanisms will largely determine whether they are effectively combined. While macro-support could catalyze changes, the real actions have to take place at the industry level.

Technological Change

Theories And Measurement

Technological change has been broadly defined as:

“the process by which economies change over time in respect of the products and services they produce and the processes used to produce them”.

More specifically, it has been termed as:
“Alteration in physical processes, materials, machinery or equipment, which has impact on the way work is performed or on the efficiency or effectiveness of the enterprise”.

Technological change may involve a change in the output, raw materials, work organization or management techniques - but in all cases it affects the relationship between labor, capital and other factors of production. While the policies to stimulate technological progress and productivity growth - at both national and firm levels - must be formulated in a broad socio-economic context, their focus ought to be on the internal dynamics of technological change. It has been suggested that the knowledge pertaining to technological change in the less developed countries would be a crucial input to the understanding of the phenomenon in industrialized nations. In this light, the following paragraphs provide a selective survey of theories and measurement of technological change (Saren, 1991; Sharif, 1986; Stoneman, 1983; Saviotti, 1985).

**Major Theories Of Technological Change**

**Neo-Classical Theory**

The basic tool for the study of technological change is the notion of a production function which specifies a quantitative relation between inputs and outputs. The most common inputs are capital and labor, which are called factors of production. The production function can be represented as a series of isoquants - curves corresponding to the constant output obtainable by the infinite number of available combinations of the factors of production. At any given time there is a given level of technology which determines the techniques available for production.
According to this theory technological change takes place in the form of shifts of the production function towards the origin.

Some of the major limitations of neo-classical theory are:

- **Only labor and capital are incorporated as factors of production.** The inclusion of more factors, however, makes the application of the production function analytically more complicated.

- **The presence of infinite techniques at a given level of technology is rather unrealistic.** Real life situations often imply a choice between a restricted number of options.

- **Only cost-reducing improvements can be described by the production function.** Improvements in performance or the appearance of new services find no place in this theory.

- **Though an efficient tool for equilibrium analysis of economic life, it is ill at ease when dealing with dynamic problems.**

**Marxist Theory**

Karl Marx perceived technology as not self generating, but as a process directed by willful, conscious, active people and molded by historical forces. He held that technological change - the development of the productive forces - was the prime mover of history. The individual entrepreneur invests and innovates because it is rational for profit maximization or necessary for survival. Marx seemed to be under the spell that innovations simply must be labor-saving.
Major limitations of the Marxist theory are:

- Undermining of capital-saving innovations.
- Underemphasizing the concept of productivity.
- Controversy involved in the theory of the falling rate of profit.

**Schumpeter’s theory**

This theory views innovation as the engine of economic development and as a disequilibrium phenomenon. Innovation is defined as the carrying out of new combinations of means of production, which include a wide variety of cases such as: the introduction of a new good or of a new quality of a good, or of a new method of production, the opening of a new market, the conquest of a new source of supply of raw materials, the carrying out of a new organization of any industry. The emphasis is laid on the notion that technological change is to be understood as a case of innovation more generally and not as another piece of routine economic behavior. Schumpeter’s formulation of production function differed from neoclassical theory in that capital was excluded and only labor and land were included as inputs.

Major limitations of this theory are:

- Psychology of the entrepreneur (the embodied aspect of innovation) is an elusive phenomenon.

- No explicit attention is paid to the process by which innovation is generated.

- Lack of empirical evidence.
Evolutionary Theory

This suggests a biological analogy to explain technological change. The Darwinian two-state process of mutation (invention) and selection (innovation) has been employed to understand the evolution of technology. Biological evolution appears to have a certain correspondence with the interpretation of technological changes in industrial sectors - from a state of flux when product innovation prevails in the search for a successful design, to a maturity phase where incremental process innovation prevails.

Major limitations of the evolutionary theory are:

- *Dearth of quantitative models.*
- *Many propositions need to be validated.*

Market-Pull Theory

Markets govern the innovation process. The market constitutes a communication channel through which political, economic, social and ecological forces influence buyers in their demand for technological products. Continuous changes in these forces have an impact on the response provided by technology with respect to the type, capabilities, performance, safeguards, solutions, etc. These messages are transmitted and communicated through the market where buyer’s requirements (themselves influenced by external forces) are matched with technological changes and where future demands can be detected by the producers of technology.
Major limitations of this theory are:

- *The logical and practical difficulties in interpreting the innovation process.*

- *Difficulties of defining demand functions as determined by utility functions.*

- *The incapability of defining the ‘why’, ‘when’ and ‘where’ of certain technological developments instead of others.*

**Technology-Push theory**

Technology is defined as an autonomous or quasi-autonomous factor. It assumes a one-way causal determination approach, i.e., from science to technology to the economy. It proposes that technological developments occur exogenously through discoveries, theories, ideas and R & D work, which may or may not then create (or be matched with latent) demand for their output.

Major limitations of this theory are:

- *Failure to take into account the intuitive importance of economic factor in shaping the direction of technological change.*

- *Lack of understanding of the complex structure of feedbacks between the economic environment and the directions of technological change.*

**Measurement Of Technological Change**

**Economic Indices**

Arithmetic indices are derived based on price variations in capital and labor in relation to the industrial output. Technological change is measured as the
weighted average of the change in factor prices, holding inputs constant. Solow derived a geometric index based on the premise that technological change is equal to the change in output not accounted for by the changes in labor and capital.

**Patents**

Patent statistics have been used as indicators of technological change. They have also been used to analyze the diffusion of technology across firms or industries or countries. Patent studies are also concerned with the analysis of the innovation process itself in order to assess and evaluate the output of research activity.

**Rate of improvement of technology**

A figure of merit for each functional capability of a technology is to be identified. For a product it could be travel speed per unit time (transport vehicles), or lumens per watt (lighting fixtures), or instruction execution rate per second (computers). For a process, it could be the efficiency of fuel utilization or reduction in waste generation. S-shaped growth curves are formulated to form a system of curves depicting advancement of technologies.

**Rate of Substitution of Technology**

It is determined on the basis of relative changes in the market shares of two technologies or two sets of technologies. Cumulative pattern of gain in market share by a technology exhibits S-shaped growth.
Rate of Diffusion of Technology

It represents the cumulative number of adopters of a new product, material or process. This follows an S-shaped curve. The substitution and diffusion phenomena have been discussed in greater detail in the Chapter 6.

Use Of Technology Forecasts

The purpose of any type of forecasting and the proper role of the forecaster is to assist the contemporary decision-makers in the choosing of policies and making of plans that are most promising.

In the National Context:

- Developing technological competencies so as to meet global competition and international trading imperatives.
- Planning for creation of sustainable comparative advantages in select technological thrust areas.
- Planning for the well-being of citizens with the aid of technological innovations.

In the context of Business Firms:

- Establishing technical parameters and performance standards for new products and processes.
- Augmenting new product development efforts as well as improvement of existing products.
- Enabling better timing for new technology introduction and facilitate ‘take-to-market’ strategy formulation.
- Aiding prioritization of research programmes and identification of techno-
scientific skills required for the same.

- **Identifying major opportunities and challenges in technological environment and offering guidance for technological planning.**
- **One of the main aspects of Technology Forecasting is its communication aspect.**
- **Technology Forecasting (TF) initiates and fosters the communication between various communities such as:**
  - Science and science (inter-disciplinary fields)
  - Science and Technology
  - Industry and politics
  - Technology and public administration
  - Technology and the general public.

Technology forecasts can be a short, medium or a long-term exercise. Short term forecasts are of usually a year or less, might typically deal with a single technology. Medium-term forecasts might cover a 2-10 year period. Long-term forecasts cover 10-20 years - a time horizon long enough for totally new technologies to emerge. Longer the time frame, tougher it is to predict what is in stock for the future pertaining to technology changes. Sometimes, forecasts misfire because of a fascination of ones own technology and also due to the enthusiasm it generates among market analysts and magazine writers. A classic example is the bold forecast that NASA made regarding the huge sun-reflecting satellites to illuminate night-shrouded areas of the earth which they predicted would be possible by the mid-1970s. Such forecasts with faulty timelines can be totally worthless to corporate planners, and worse they can turn into money pits. This brings into focus the need for employing accurate technology forecasting methods.
The most appropriate choice of forecasting method depends on:

- *What is being attempted to forecast*
- *Rate of technological and market change*
- *Availability and accuracy of information*
- *The planning horizon*
- *The resources available for forecasting.*

### Classification Of Technology Forecasting Methods

The technological forecasting methods can be classified as exploratory and normative forecasting methods. Exploratory technological forecasting starts from today’s assured basis of knowledge and is oriented towards the future, while normative technological forecasting first assesses future goals, needs, desires, mission, etc., and works backwards to the present. Exploratory forecasting is more focused on predicting how a new technology will evolve on a predetermined curve, which is S-shaped, while the normative forecasting attempts to be more pro-active. With so many choices available, each having distinct characteristics, a calculated choice has to be made while choosing a forecasting method. Some of the factors that influence the choice of the forecasting methodology can depend on the time frame for the forecast, how much precision is needed in the prediction and the purpose of the forecast.
## TECHNOCLOGICAL FORECASTING METHODS

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**Delphi Method**

The Delphi method, which is subjective in nature, is arguably the most popular forecasting tool in vogue. Though statistical or model-based forecasting techniques are preferred over expert opinion techniques, there are two scenarios where subjective (or intuitive) methods are found to be relevant.

- *When there is no precedent - mostly in the case of new technology forecasting* where expert opinion is the only possible source of forecasting or in situations where the impact of factors which were previously considered to be relevant have lost their strength.
- *Ethical evaluation is required – instances where ethical issues are more important than technical and economical issues.*

The basic idea of a Delphi survey is to interview experts on a topic. But the exercise is not restricted to collection of opinions but also to provide each expert the facility review based on the recommendations of his/her peers. This exercise contains a minimum of 2 stages in which the outcomes of the first round of interviews are provided back through a controlled feedback to the experts during the second round.
The Delphi method has three unique characteristics that differentiate it from other methods such as committee approach and brainstorming.

**Anonymity**: During the Delphi procedure, a member does not know the specific contributions of the other members. In most cases a person would not even know who the members of his/her group are. This methodology has its unique benefits. It avoids any bias of opinion owing to the reputation of other members. The anonymity also provides the experts an opportunity to revisit their articulated opinions, without the fear of embarrassment, when they encounter any evidence contrary to their expectations.

Iteration with controlled feedback: The survey coordinator extracts responses which are deemed relevant to the topic and these are sent back to the group. This sort of mediation throughout the process ensures that biased opinions are not pushed by merely repeating or restating them over and over again.

Statistical group response: In a committee approach only the majority opinion emerges out of the discussion while the minority recommendations are lost. But in the Delphi method, for every item the responses are depicted with statistics that describe both the dominant view as well as the degree of spread.

The Delphi process involves the following steps:

- **Identify the subject in which the Delphi survey is to be conducted.**
- **Recruit a group of experienced people who can prepare the questionnaire for forecasting the technological developments.**
- **During the first round the questionnaire is then distributed among experts to address all possible aspects of the issues. These participants are asked to forecast events or predict trends regarding the issue.**
responses are collected and all opinions including the extreme ones are taken into cognizance.

- In the second round, results of the first round are sent back to the participants and it contains a consolidated list of all the responses. The participants are then asked to forecast the possible occurrences enlisted in each of the responses.

- In the third round, all the responses are sent back to the participants. This time, along with the inclusion of statistical details, they are also asked to reevaluate their responses. After the end of the third round, the moderator processes the response by combining it with similar responses, summarizing lengthy ones, etc.

- The questionnaire for the fourth round contains the responses, the statistical information and the summary of points for modifying the forecasts, if any. Here the participants are required to provide reasons for any change in a given forecast value.

- At the end of the fourth round, the moderator collects and summarises the results and comes out with forecasts, the degree of disagreement and a summary of critical issues for each forecast.

- The Delphi method is mostly used in the following contexts:
  - To determine critical factors that might impact the development of technology.
  - To forecast statistical estimates on the progress of a particular technology over a specified duration.
  - When forecasting cannot be made using other methods.
  - To evaluate the chance of a particular event occurring under given conditions.
Trend Extrapolation

This method uses historical data rate to determine the rate of progress of technology in the past and extends it into the future. This type of forecasting implies that the factors which affected the past trends would continue to impact in the same known manner. But this methodology cannot be applied in every technology context. There are instances where natural limits exist for the governing factors and hence, extrapolation will give skewed results. There are two types of extrapolation based on the rate of progress of past behaviour – linear and exponential methods.

Linear Extrapolation is used where a linear growth function is predicted. The trend is explained using the linear equation:

\[ y_i = A x_i + B \]

- \( y_i \) is the value of the dependant variable in the \( i^{th} \) time period
- \( x_i \) is the value of the independent variable in the \( i^{th} \) time period

\( A \) and \( B \) are estimated by the method of sum of squares and minimizing them from the projected extrapolation.

The second method of trend extrapolation is the exponential method. A exponential growth curve could be assumed to be as follows:

\[ Y_i = A B^{X_i} \]

- \( Y_i \) is the value of the variable to be estimated
- \( X_i \) is the impact variable
- \( A, B \) are constants to be estimated.

There are cases where the trend does not follow either a linear or exponential pattern. In such cases a polynomial trend equation may be applied to identify the trend.
## Technology Monitoring

Major steps involved in technology monitoring are:

- **Scanning**
- **Filtering**
- **Analysis and Development of forecast**

### Scanning

The idea behind scanning is to collect as much information that is available on the particular field of technology. The information could cover the following aspects:

- *Research plans and developments*
- *Environment of the technology*
- *Support of various governments for the technology*
- *Human skills and capabilities*
- *Social and ethical issues*
- *Benefits of the technology*

### Filtering

In most cases, not all the information captured on the technology would be relevant for a particular forecast. Hence, based on the forecast required, the necessary information is identified through filtering of pertinent data.

### Analysis and Development

This methodology is relevant in situations such as developing Research and Development (R&D) plan; and identifying new sources of technology or emerging technologies
# Growth Curves

The evolution of technology as a function of time has been found to follow patterns similar to the growth curves of biological systems. The biological s-curve is used to represent technology evolution with technology adoption on the y-axis and time on the y-axis. It implies that when a technology is newly introduced, it takes some time to gain acceptance in the market, and after this, rapid adoption of the technology takes place. But in reality, no technology continues to grow exponentially for an indefinite period of time and this leads to the curve flattening out in a later stage. This insight can be used by technology forecasters in analyzing maturing technologies, in setting feasible research goals, and in determining the utility of additional development spending. There are basically two types of s-curve formulations, which can be adopted based on the requirements of the forecaster.

## Pearl-Reed Curve

The Pearl-Reed curve is symmetric about the inflection point (at $y = L/2$) and plots a straight line on a semi-log graph.

The Pearl curve is used to track individual technologies. But the overall growth of technologies is tracked by integrating the s-curves of all the individual curves.

<table>
<thead>
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<th>Pearl-Reed Curve Formula</th>
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<tr>
<td>$y = L / (1 + a \times e^{-bt})$</td>
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<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
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<tbody>
<tr>
<td>$y$</td>
<td>Forecast variable</td>
</tr>
<tr>
<td>$L$</td>
<td>Upper limit of $y$</td>
</tr>
<tr>
<td>$a$</td>
<td>Location coefficient</td>
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<tr>
<td>$b$</td>
<td>Shape coefficient</td>
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**Gompertz curve**

The Gompertz curve is not symmetric about the inflection point and does not plot a straight line on a semi log graph. But the log of L/y does plot a straight line on a semi log graph. These curves are used to represent technologies where the growth in the initial stage is faster than in the Pearl curve.

![Gompertz Curve Formula](image)

The choice of which curve to adopt depends on the dynamics of the technology to be modeled. The slope of the pearl curve is a function of both the present level of technology (y) and the difference between the present value and upper limit (L-y). But the slope the Gompertz curve for large values of y is a function only of the difference between the present value and the upper limit (L-y). Generally the Pearl curve is used in the forecasting technology substitution, where initial diffusion of the technology makes further substitution of technology easier while the Gompertz curve is mostly applied to forecast absolute technical performance.

**Relevance Trees**

It is an organised ‘normative’ approach starting with a particular objective and used for forecasting as well as planning. The basic structure looks like an organisational chart and presents information in a hierarchical structure. The
hierarchy begins with the objectives which are further broken down into activities and further into tasks. As one descends down, the details increase at every level. The entries when taken together at each level describe the preceding level completely. Also, all activities and tasks depicted should be mutually exclusive.

The principle behind using the relevance tree is to evaluate systematically all the related technologies that would lead to the success of the intended objective.

From the forecasting perspective, the branches represent alternatives that are traced to a number of points, which represent deficiencies in the existing technology. Thus, the relevance tree provides a framework for identifying the deficiencies that need to be overcome. It is usually relevant in situations where distinct levels of complexity can be identified and the same can be simplified by further breaking them down.

![Relevance Tree](source: Burgelman et al. (1996))

Figure: Relevance Tree [Source: Burgelman et al. (1996)]
Morphological Analysis

It is a normative technique developed by Fritz Zwicky which provides a framework for exploring all possible solutions to a particular problem. The morphological analysis involves the systematic study of the current and future scenarios of a particular problem. Based on this study, possible gaps are identified and the morphological analysis further provides a framework to explore other alternatives to fill these gaps. From the forecasting perspective, the method enables creation of a list of all the possible outcomes of a technology in order to determine different categories of its applications. For example, even though cardboard was developed as a material for packaging, a morphological analysis would assess its performance and utility in other applications - given its strength, density, and other properties, the analysis considers the possibility of using it for sound insulation, heat insulation, and other applications.

<table>
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<tr>
<th>Alternates</th>
<th>1</th>
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<td>Key Parameters</td>
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<td>Energy Source</td>
<td>Manual Winding</td>
<td>Vibration</td>
<td>Battery</td>
<td>Solar</td>
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<td>Energy Store</td>
<td>Weight Store</td>
<td>Spring Store</td>
<td>Bimetallic Coil</td>
<td>No Store</td>
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<tr>
<td>Motor</td>
<td>Spring Motor</td>
<td>Electric Motor</td>
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<tr>
<td>Regulator</td>
<td>Balance Wheel</td>
<td>Pendulum</td>
<td>Tuning Fork</td>
<td>Quartz</td>
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<tr>
<td>Gearing</td>
<td>Pinion Drive</td>
<td>Chain Drive</td>
<td>Worm Drive</td>
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<tr>
<td>Indicator Device</td>
<td>Dial Hands</td>
<td>Slide Marks</td>
<td>Liquid Quartz</td>
<td>Light Indicators</td>
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Mission Flow Diagrams

Mission Flow Diagrams have been originally conceived by Harold Linstone as a means of analyzing military missions. This involves mapping all the alternative routes or sequences by which a given task can be accomplished. The analyst needs to identify significant steps on each route and also determine the challenges/costs associated with each route. The performance requirements can then be derived for each associated technology and the same can be used as normative forecasts.

Technology Life Cycle (TLC)

The nature of a technology and its implications to firms have been observed to undergo perceptible changes over its life span. Although it is correct to view a TLC as a continuum, it is more convenient to consider it as a series of discrete stages for the purpose of better understanding and analysis. A technology typically evolves through the following stages in its life cycle. Figures below broadly portray the various aspects that characterize these stages.

![Figure: Industry and market structures over a TLC](image-url)
1) **Cutting-edge**: This stage refers to the birth of a new technology. The primary focus of entrepreneur(s), here, is on its Research and Development (R&D) to a demonstrable form. Nevertheless, the need for financial support for R&D and for testing prototypes is also a pressing concern at this stage. Although basic research forms a major part of the effort in this stage, firms seldom do it without a specific application in mind. However, the scope of such an application may not be clearly known to the firm and the related knowledge may still be abstract. Hence, the target market, and the feasibility and viability of R&D at this stage are also uncertain.

2) **State-of-the-Art**: This stage in a TLC begins with the deployment of cutting-edge technology to solve customers’ problems. The customer base state-of-the-art technology is usually small, but sophisticated. Hence, technical specialists are, perhaps, ideal for marketing the technology. Some of the functions, such as engineering, manufacturing, finance and administration may have begun formally while others may still be embryonic at this stage. Many other important functions are carried out with the help of hired consultants or agencies. The market
witnesses a high rate of product innovations and as a result a great product diversity can be observed. The production process will be usually nonstandard. Hence, the state-of-the-art technology can respond easily to the varied market requirements, but only ineffectively and inefficiently.

3) **Advanced**: The gradual standardization of technological characteristics leads to rapid market expansion. The market largely consists of less sophisticated customers who seek all the benefits of state-of-the-art technology, but have no desire to develop the technical expertise needed to understand the technology. This market calls for professional marketing. The potential profits attract a large number of competitors and hence, the technology is no longer of the hi-tech variety available with only a few suppliers. A market shakeout, segmentation, and further standardization are bound to occur. A firm’s survival in the market beyond this stage indicates its relatively efficient operations. At this stage, a part of the production system is likely to be automated, and division of labour is more pronounced. However, there is a possibility that the rapidly increasing demand may cause manufacturing and marketing capacity crises which will call for a major transformation in the organization structure. Parallelly, financial and administrative crises are also likely.

4) **Mainstream / Mature**: As technology enters this stage, the scope for further product innovations reduces and process technology becomes the target of innovative effort of firms. However, gradually, even the production process gets so well integrated that the possibility of any major changes in product or process technological elements will be limited and product differentiation becomes difficult. Hence, the strategic thrust shifts to efficient and economic production for
minimizing costs. This may be achieved by huge capital investments or shifting the production base to the Third world. When the production costs also cease to offer comparative advantage, the competition will shift to customer service. This may help the firm to maintain and improve upon growth momentum and market position. In this stage, the firm will be better managed by a professional management team than entrepreneur/owner. The organization will have grown in size and will call for more formal structures, communications, and systems.

5) **Decline:** During this stage, the scope for further improvement of the technology diminishes rapidly. The increasing marginal cost of its improvement, coupled with the functional superiority of the next generation technology, results in the older technology giving way to the new one gradually. However, it may not be easy for the new technology to wipe out the older technology one and pervade the market. The overlap between the above successive stages of a TLC makes it a continuous process rather than a set of discrete stages (Mohan Babu and Ganesh, 1997).

**Long Range Business Planning**

Since the 1990s technology forecasting activities under various names have gained popularity in the corporate world. Both large and small companies today depend on TF to survive. Large companies have been using TF to streamline R&D efforts and plan for new product developments while smaller companies survive on technological innovation through use of proper TF methods.

TF is directly linked to the corporate strategy of the firm. Corporate strategy basically deals with product/service delivery, customer interactions and
also competitive market forces. Long-Range Business Planning can be formulated at various levels:

- **Organisational level** – It deals with the firm’s purpose of existence. It aims to answer questions like ‘What are we providing’, ‘What is our mission, values etc?’
- **Company level** – This level deals with determining product lines or considering business which the company should enter into, develop or divest.
- **Strategic Business Unit level** – This deals with developing strategic business units – its goals and objectives and the means to achieve it.
- **Functional level** – It incorporates decisions like devising R&D and marketing strategies.

With respect to technology, the above strategic perspectives aim to address the issues:

- How can technology provide sustainable competitive advantage?
- How can technology meet the business objectives of the firm?

The following form the basic premise as firms establish linkages between technology and business objectives:

- **Technology provides a base to define the range of business opportunities and options viable for a firm.**
- **It can provide a sustainable competitive advantage to the firm.**
- **Business strategies can be channelised using technology.**

The key aspects covered by Technology Forecasting in this business context are:
• **Environment analysis and monitoring of global trends in order the identity developments that may influence at the firm level or the industry level.**

• **Set time horizons for each of the R&D activities based on the time horizon of the firm’s strategy.**

• **Compilation of information on trends that might provide an opportunity or impose threat on the firm in the future.**

• **Evaluates the direction of the existing R&D strategy and suggests realignment, if necessary.**

Technology strategy formulation has occupied centre-stage of long-range corporate planning owing to the emergence of technology as a competitive weapon and the need to grapple with global market forces through effective deployment of technologies in organizations.

**Formulation Of Technology Strategy**

Burgelman *et al* (1996) conceptualize technology strategy as an evolutionary organizational learning process, which highlights the links between technical competencies and capabilities, technology strategy and experience. The authors opine that technology strategy can be realized through the enactment of several key tasks such as (i) internal and external technology sourcing, (ii) deploying technology in product and process development (iii) using technology in technical support activities. In turn, performing these activities provides valuable experience that serves to augment and change firm’s technical competencies and capabilities.
Maj Saren (1991) proposed a comprehensive framework for technology strategy formulation. In this framework, paradigms, trajectories and frontiers of a given technology forms the basis for the development of a reliable technology forecast.

A ‘technology paradigm’ is a model or pattern of solution of selected technological problems, based on selected principles from natural science and on selected material technologies. ‘Technological trajectories’ are a series of technical developments along the path which have common features either in application of the same principle or by their application to the same technological system. ‘Technology frontier’ can be defined as the highest level reached upon a trajectory in terms of those technological and economic dimensions, which are prescribed by the relevant paradigm.

The following are the key questions/issues addressed in a firm’s technology strategy:

- **Strategic decisions made with reference to technology and/or R&D.**
- **Can technology provide a distinctive competence and competitive edge?**
- **Do technology and R&D decisions augment firm’s business strategy?**

The basic steps for the development of technology strategy have been given in the following figure (Maj Saren 1991).
The ability of a firm to evolve a technology strategy depends on its understanding of the process and dynamics of technological change and diffusion; identifying the objectives of the technology forecast; and selection of the right technological forecasting technique. The objective of technology strategy is to identify technological opportunities (for acquisition and/or exploitation) in the context of its internal resources/competences and availability of market growth avenues.

While firms incorporate technology issues within their overall business strategies, governments formulate technology policies for strengthening institutional mechanisms that infuse technological dynamism in industries (Sharif, 1994).
Intellectual Property Rights

Intellectual property is based on the power of imagination. It is the ability to stand on the existing knowledge, and see beyond, to the next frontier of discovery, that leads to the personal, cultural and economic advancement. Intellectual Property (IP) is a legal concept which deals with creations of human ingenuity. Human expression in the form of inventions, literary, artistic and musical works, symbols, names and images used in commerce etc. IP Right (IPR) is a legal protection given to such manifestation of human mind and effort. Basically IPR is an arrangement between the creator and the State for legal protection of the invention to enable commercial benefits in lieu of the full disclosure of his invention to the humanity adding stock to the existing knowledge for the betterment of society.

In law, intellectual property (IP) is an umbrella term for various legal entitlements which attach to certain types of information, ideas, or other intangibles in their expressed form. The holder of this legal entitlement is generally entitled to exercise various exclusive rights in relation to the subject matter of the IP. The term intellectual property reflects the idea that this subject matter is the product of the mind or the intellect, and that IP rights may be protected at law in the same way as any other form of property.

Intellectual property laws vary from jurisdiction to jurisdiction, such that the acquisition, registration or enforcement of IP rights must be pursued or obtained separately in each territory of interest. However, these laws are becoming increasingly harmonised through the effects of international treaties such as the 1994 World Trade Organization (WTO) Agreement on Trade-Related Aspects of
Intellectual Property Rights (TRIPs), while other treaties may facilitate registration in more than one jurisdiction at a time. Certain forms of IP rights do not require registration in order to be enforced.

Intellectual property laws confer a bundle of exclusive rights in relation to the particular form or manner in which ideas or information are expressed or manifested, and not in relation to the ideas or concepts themselves (see idea-expression divide). It is therefore important to note that the term "intellectual property" denotes the specific legal rights which authors, inventors and other IP holders may hold and exercise, and not the intellectual work itself.

Intellectual property laws are designed to protect different forms of intangible subject matter, although in some cases there is a degree of overlap. **Copyright** may subsist in creative and artistic works (e.g. books, movies, music, paintings, photographs and software), giving a copyright holder the exclusive right to control reproduction or adaptation of such works for a certain period of time.

A **patent** may be granted in relation to an invention that is new, useful and not simply an obvious advancement over what existed when the application was filed. A patent gives the holder an exclusive right to commercially exploit the invention for a certain period of time (typically 20 years from the filing date of a patent application).

A **trademark** is a distinctive sign which is used to distinguish the products or services of one business from those of another business.

An **industrial design** right protects the form of appearance, style or design of an industrial object (e.g. spare parts, furniture or textiles).
A trade secret (also known as "confidential information") is an item of secret, non-public information concerning the commercial practices or proprietary knowledge of a business.

Patents, trademarks and designs fall into a particular subset of intellectual property known as industrial property. (Source: Wikipedia)

**Institutional Mechanisms In India**

Department of Science & Technology (DST) was established in May 1971, with the objective of promoting new areas of Science & Technology and to play the role of a nodal department for organising, coordinating and promoting S&T activities in the country. DST has major responsibilities for specific projects and programmes:

- **Formulation of policy statements and guidelines on science and technology; and coordination of areas of science and technology, in which a number of institutions and departments have interests and capabilities;**

- **Support to basic and applied research in national institutions throughout the country and provision of minimum infrastructural facilities for testing and instrumentation;**

- **Support to autonomous research institutions, whose specialisation range from advanced medical research materials to astronomy;**

- **Support knowledge-based and innovation driven entrepreneurship development to create self-employment opportunities;**
The Technology Information, Forecasting and Assessment Council (TIFAC) is a registered society under Department of Science & Technology. TIFAC was established in 1988 with the following objectives:

- *Undertake technology assessment and forecasting studies in selected areas of national economy.*
- *Watch global trends and formulation of preferred options for India.*
- *Promotion of key technologies, and*
- *Provide information on technologies.*

The goals of TIFAC include generation of Technology Forecasting / Technology Assessment / Techno Market Survey documents, developing on-line nationally accessible information system, promotion of technologies and evolving suitable mechanism for testing of technology and enabling technology transfer as well as commercialization. TIFAC produced more than 200 reports including the 25 document series on Technology Vision up to 2020 and 16 document series on S&T in different sectors. TIFAC has been identified by industry, institutions and administrators as a store house of advanced information on almost all areas of technology – both global and Indian.
REFERENCES


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