An article on
Technology Forecasting methodologies

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DEFINITION

Technology forecasting is the prediction with a stated level of confidences, of the anticipated occurrence of a technological advancement within a given time frame with a specified level of support based on data and / or knowledge of experts in the field.

METHODOLOGIES

There are a large number of methodologies known and many more new methods can be made. Some of forecasting methods are

1. Intuitive Methods
2. Trend Extrapolation
3. Normative Forecasting
4. Growth Curves
5. Cross-Impact Analysis Method

1. INTUITIVE METHODS

Intuitive Methods are based on intuitive power of individuals include methods of obtaining forecasts from experts in their respective areas of specialization and then combining various individual's forecasts or forecast from group of forecasters to get better forecast. Research & Development activities for most discoveries and innovations are deliberately engineered and manipulated by sustained inputs of funds, manpower and strength to achieve a new technology or upgradation in the existing technology to improve their performance and efficiency to meet the requirement of market forces and to survive in the fast moving competitive market. It is also possible to get an idea of likely future events by probing the minds and thought of the people involved in these R & D activities. It is reasonable to think and hope that a reasonably rough picture of the near future is already formed in these experts in their respective fields.

Methodologies of Intuitive Methods are

a. Individual Forecasting,
b. Opinion Polls,
c. Panel,
d. Brainstorming,
e. Delphi Technique,

a. Individual Forecasting,

It is forecasting done by individuals. In this method an expert in a specific field predicts the probable new technological events and / or advancement in an existing technology that are expected to occur in the near future in the area of his expertise. Because of individuals having limited knowledge and can have individual biases this method is of limited applicability because many of the current technological innovations are products of multidisciplinary interactions

of experts in different fields and a specialist in one field alone may not be able to forecast correctly in some instances. In this method the probability of their being wrong is greater.

b. Opinion Polls
In this method more than two individual forecasters' opinions are taken for a particular technological events that is likely to happen in near future and forecasting is done combining opinion of several individual forecasters. In opinion polls methodologies, the errors and bias of individual predictions are likely to be minimized. It is conducted using a large number of sample and care should be taken to involve respondents from various fields. The disadvantage in this method is that any minority forecast, even if it is of significance, will be drowned by the opinion of majority experts.

c. Panel
Here experts from various fields sit together and discusses issues for longer time. A group of experts from multidisciplinary fields interact across a table and derive a number of forecasts of significance. Some countries Navy and Air Force have used this methodology for defense forecasting. The advantage of being multidisciplinary leads to better forecasting even on complex technological events. Some of disadvantages are sometimes extreme and seems to be impractical views get eliminated due to the desire to arrive at a compromise, the forecast of the most vociferous speaker and / or the person with the highest bureaucratic status get importance although their forecast may not be very correct, in corporate environment and government sectors where subordinates will not express views contrary to those of senior personnel and this method may not give useful results.

d. Brainstorming
In this method, individuals under well-trained leader hold meetings in an environment that allows uninhibited and imaginative speculations. It is conducted very informal and free from any obstruction, only one objective clearly worded is chosen at each brain storming session, no criticism or cross questioning is allowed during the brain storming session, absurd ideas appearing at first sights are also considered, sessions are of small informational sessions and the higher and second order ideas are not considered. It is considered better than panel approach.

e. Delphi Technique
This technique is a modification of the panel approach. Here a method of obtaining expert opinion from large groups or people in a systematic way is done by asking well-designed questionnaire from a group of experts not interacting directly. Anonymity of individual forecasters is maintained and subordinates do not have to differ with senior executives face to face. The final result is a statistical group response based on interactions combined with controlled feedback. Questionnaire is to be emailed to a large number of participants from various professions to get a better forecast. The questions should be carefully framed and should not contain any parallel events or compound events. The questionnaire should be simple and easy and ambiguous and complicated

questions should be avoided as far as possible. Depending upon the object of forecasts, various rounds of questionnaires are made and sent to participants based on reply received from previous rounds.

2. TREND EXTRAPOLATION

It is a method using extrapolation of graph of a known, available and in use technological events for which datas are available. The future value of a technical capability, or production from a technological activity, is an extension of its past performance, at least into near-term futures that is obtained by extrapollating using various techniques according to available data related to that events.

The forecasts are generally obtained using statistical time extrapolation technique using data of a technology available and then extrapolating the trend in near future and then forecasting is done. The basis of trend extrapolation methodologies is that 'the past trend is the historical result of a large number of interacting forces which will generally continue to act in the same way unless there are obvious reasons to expect a change in the trend due to introduction of new efficient and reliable inventions or process / methods.'

The forecasts give the approximate future conditons and not the exact numbers.

Methodologies of Trend Extrapolations are
   a. Linear Extrapolation
   b. Extrapolation Using Exponential Trend
   c. Double Exponential Extrapolation
   d. Regression and Curve Fitting Techniques
   e. Substitution Technique

a. Linear Extrapolation

In this method, data of a technology or production is collected over the year and then the parameter to be forecast is linearly plotted against time, and the resulting plot is extrapolated into reasonable future time spans to get near accurate forecast.

For example, the temperature sustaining capability of plastics has increased linearly with time and this trend can be extrapolated to project the high temperature capability of plastics in the near future.

b. Extrapolation Using Exponential Trend

It is observed that many technological functional capabilities and technological parameters have shown exponential growth over fairly long time periods. So in this method, the logarithm of a particular technological capability, or production trend from a specific technology is plotted against time; these semilog plots, which are frequently linear, are then extrapolated into the future to make forecasts.

c. Double Exponential Extrapolation

There are technologies for which R&D efforts are concentrated in the early phase of their development using pushing method by injecting a large number of manpower and money. In theses cases the technological development is multifold as more inputs are provided. In such cases normally the double exponential extrapolation method is used for forecasting in which the logarithm of a specific technological parameter is plotted with time and these plots, if they

follow a linear trend, can be extrapolated for forecasting future values of these parameters in near future.

For example, the output emerges from lasers in the area of laser technology show this type of exponential growth.

d. Regression and Curve Fitting Techniques

This method is used where large volumes of past data of technological events are available. For reliable results, in this technique, a large volume of past data is required. Straight line or first degree polynomial is used to fit the data on past performance where growth is characterized by a linear trend. Second degree polynomial or a parabola is used, where the trend is characterized by one bend. Higher degree polynomials are used if the trend is of a complex nature.

e. Substitution Technique

The parameters of a technology or a process can often be forecast by extrapolating the rate of substitution of that technology or process by some other recent innovative, efficient, reliable and cost effective technology. Many technological advances can be considered as competitive substitutions of one method of satisfying a need, by another newer method of satisfying the same need in a more reliable, efficient and / or cost effectve technology or processes.

If the time periods for the initial few percent of substitution are known, extrapolation of the substitution curve can be used to predict the extent of substitution in the future.

Some of examples are substitution of:

Natural fibers by synthetic fibres; Open heart steel-making process by electric arc process; zinc oxide and lead oxide in paint pigments by titanium dioxide; Oil based paints by water-based paints; Natural rubber by synthetic rubber; Natural rubber by synthetic rubber; Soaps by detergents; Inorganic insecticides by organic insecticides; and natural tyre fibres by artificial fibres.

3. NORMATIVE FORECASTING

In this technique first future goal is decided and then one recedes from future goals to the present and intermediate-term technological needs. There must be many existing technologies or intermediate-term technologies available in near future which needs to be selected for achieving the future goal. It is primarily need-based forecasting.

4. GROWTH CURVES

It is observed that similarities between biological growth and the growth of many technologies or technological parameters have been noticed over the period. The growth of technologies using biological growth curves has been used for forecasting.

5. CROSS-IMPACT ANALYSIS METHOD

Present and future events or acts interact with each other and influence the probability, timings, and impact of one another. It is based on bringing out interactions between forecasts to have better forecasting. It is learnt that two events or acts can interact in three ways:

1. Mode interaction – one event or act may enhance or diminish the likelihood of

another event or act; advance or delay; necessitate or obviate; or enable or prevent it.

2. Force Interaction – the influence of one event or act on another can be strong or weak.

3. Interaction time lag – the interaction between one event or act and another may start as soon as the first event or act occurs or the influence may be felt only after say ten years.