UNIT 5 QUALITATIVE METHODS OF FORECASTING

Objectives

Upon completion of this unit, you will be able to:

- know the forecasting and qualiltative forecasting in specific;
- acquaint with various methods of judgemental forecasting;
- develop expertise on delphi techniques and its operational details;
- familiar with delphi study and its guidelines, advantages and its variants;
- learn forecasting based on cross-impact analysis and its basics;
- apply Monte Carlo simulation for cross-impact analysis.

Structure

5.1 Introduction
5.2 Judgmental Forecasting
5.3 The Delphi Technique
  5.3.1 Opinion-Capture Technique
  5.3.2 The Operational Details
  5.3.3 The Forecasting Delphi
  5.3.4 The Decision-Analysis Delphi
  5.3.5 Delphi as a Group Process
  5.3.6 Guidelines for Conducting a Delphi Study
  5.3.7 Guidelines for Selecting the Delphi Panelists
  5.3.8 Advantages
  5.3.9 Common Pitfalls of Delphi
  5.3.10 Variants of Delphi
  5.3.11 Final Remarks on Delphi and its Variants
5.4 Forecasting Based on Cross-Impact Analysis
  5.4.1 History of Development
  5.4.2 The Basis Concepts of a Cross-Impact Matrix
  5.4.3 The Cross-Impact Theory of Gordon and Hayward
  5.4.4 Cross-Impact Theory based on Bayesian Rules
  5.4.5 Deterministic Dynamic Simulation based upon Cross-Impact (Kane, 1972)
5.5 Summary
5.6 Self-Assessment Exercises
5.7 Further Readings

5.1 INTRODUCTION

Forecasting generally deals with estimating future values of variables and telling in advance about the occurrence of future events. Variables generally take quantitative values. Thus, we can associate quantitative values to variables such as sales production, profit, market share, rainfall, and population. A series of values of a variable at equidistant time points forms a time series. A number of rigorous approaches exit in the literature to forecast time series. Forecasting occurrence of future events, however is altogether different. Events, such as development of a new technology or a new product, arrival of a new competitor, formation of a new coalition, and calling a labour strike are difficult to quantify. Therefore they elude a rigorous mathematical treatment. We adopt less rigorous, more subjective methods to deal with forecasting such events.

In this 'connection we wish to mention that forecasting events is in some way similar to fortune telling that has a long pedigree. Palmistry, astrology, and gazing into glass objects, the art of fortune telling, are still popular in many countries of the world today. The arts of science fiction writing and futurology are of recent origin. Although they are not treated as very scientific, they have produced wonderful. scenarios of the future which have often come true. A variety of approaches have been forwarded in the past three decades to make the art of event forecasting more rational, if not exactly scientific.

Qualitative forecasting is relevant to the broad field of social science that is widely known to be an inexact science. Inexact science contrary to natural sciences, are characterized by the following:

1) Reasoning is informal. Terminology in inexact science exhibits certain amount of vagueness, and intuitively facts and implication are given high credence.
2) Attributes are not amenable to exact measurement.
3) Mathematical derivations are rarely used.
4) Predictions are not made with great precision and exactitude.

Helmer and Rescher (1959) suggest that forecasting qualitative events in such inexact science should develop along the following lines:

1) Quasi-laws should be given more credence. Quasi-laws are those that have limited generalization and allow exceptions because the condition under which these are applicable may not be met in certain situation. Such laws are not rated as belonging to physical science.
2) Forecasting should be accepted on far weaker evidence than explanation. This epistemological asymmetry stems from the fact that explanations can be validated by a comparison with factual statements and data while forecasts are not. While one explanation must be more credible then its negation, a reasoned forecast must be more tenable and credible then its comparable alternative. An unreasoned prediction, on the other hand, is not validated by plausible arguments but ex post facto by a record of success on the parts of the forecaster.
3) Prediction should permit associations of subjective (or personal) probabilities are a measure of a persons confidence in the truth of some hypothesis in the light of certain evidences.
4) Experts must be motivated to use their background knowledge in forecasting exercises. A forecast expert is one
   a) who is rational,
   b) who has large background knowledge, and
   c) whose forecasts show a record of comparative successes in the long run.

A rational person is one

a) whose mental preferences are consistent and who is ready to correct the inconsistencies if pointed out to him,
b) whose subjective probabilities are stable over time provided he receives no new relevant evidence,
c) but which are affected by new relevant evidences, and
d) these probabilities should reasonably agree with the probabilities when derivable from observed facts.

To an expert, statistical information matter less then his knowledge of underlying regularities about the past instances. Quasi-laws can play an important role for the expert judgement. The function of an expert is intrinsic in the sense that he operates with in a theory or a hypothesis and that he is invoked only after an hypothesis is a formulated and its probability is estimated.

A forecast expert should be able to

a) sketch out general direction of future developments,
b) anticipate major junctures (branch points) on which the course of developments will hinge, and
c) make contingency forecasts with respect to alternatives associated with them.

It is thus to be understood that the basis of forecasting very fax into the future has to be' subjective, being based on the-power of judgement of the experts.

In this write up we have presented three important approaches to forecasting events.They are the judgemental forecasting (section 5; 2), the Delphi technique (section 5.3), and the cross-impact analysis (section 5.4).

5.2 JUDGEMENTAL FORECASTING

Judgemental (subjective) methods are those in which the process used to analyze the data has not been well specified. They may use objective data or subjective impressions as inputs, they maybe supported by form-al analysis, but the critical aspect of these methods is that the inputs are translated into forecasts in the human mind.

Various methods of judgemental forecasting are listed below:

1) Personal Interviews
2) Telephone Interviews
3) Traditional Meetings
4) Structured Meetings
5) Role Playing
6) Mail Questionnaire
7) Delphi
8) Cross- Impact Theory
9) System Dynamics

Various types of errors are associated with judgemental forecasting. But the most serious ones are

1) Bias, and
2) Anchoring

Bias is caused by preconceived notion about the world. Bias is also caused by the judgements of a person who stands to lose/gain from the forecast. Although bias can be caused by the researcher and from the situation, the most serious form of bias is caused by the judge. Judges often mention what they hope should happen rather then what they think should happen. Optimism is one form of bias often associated with judgemental forecasting.

Anchoring is the tendency to start with an answer while making a forecast. A conservative judge uses the pastas an anchor for marking a forecast.

Armstrong (1985) gives the following suggestion for carrying out judgemental forecasting:

1) Don't use judges who stands to gain or lose from the forecasting exercise.
2) Decompose the problems whenever possible, particularly when uncertainty is high, prior theory exist, and when different judges have different information.
3) Provide only the minimum relevant information to the judge.
4) People think in terms of unit differences rather than percentage changes. This should be kept in mind particularly while presenting information on the exponential growth.
5) Present historical growth as a decreasing function by using the inverse form.
6) Include projective questions for sensitive issues. In a projective test a judge-: responds to an ambiguous question or reports how someone else would react.
7) Use eclectic research. It demands that alternative forecasting methods are used instead of only one while attempting to make a forecast.
8) Assessment of uncertainty about forecasts. can be made either by ;ad4g the judges to rate their confidence or by comparing different judgmental forecast
9) Bootstrapping methods can be sometime applied to model the judgmental process of

the judges .These method are of two types :(i) Direct bootstrapping , and (ii) Indirect Bootstrapping .Direct Bootstrapping translates the judge's rules in to a model often it is sufficient to ask, the judges what rules they are using. Often, however, judges are not aware of how they make decisions. In such cases, the judges may be asked to think aloud We making the forecast. The researcher records this thinking and translates it into specific rules, Alternatively, the rules are stated as questions that can be 'Yes' or 'No'. In directed bootstrapping, the judge's forecast, taken as u dependent variable, is regressed with the variables that the judge uses while making a forecast. These methods have been found to be useful (a) for repetitive forecasts,(b)as a first step toward developing an objective forecasting , (c) as a quantative model where no data exist, so that hypothetical data can be created, and (d)as a tool to understands the rules that do judges is using so that prejudices if any can be highlighted.

Activity A

Forecast may be made by a group or by an individual on the basis of experience, hunches or facts about the situation. Explain in tern-is of your organizational context.

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Activity B

It has been said that qualitative forecasting methods should be used only as a last resort. Comment

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Activity C

What is the, direction between Recasting and planning? how can organisations become confused even forecasting when this distinction is not clear?

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5.3 THE DELPHI TECHNIQUE

5.3.1 Opinion-Capture Techniques

Collecting the opinion of experts to analyze the genesis and odor lads of a problems and to come up with recommendation for As solution has been a very desirable task among planners and Administrators, and particularly so among the technology forecasters. One can distinguish four categories of opinion-capture techniques that are generally employed for the purpose of forecasting:

- genius. (single individual) forecasting
- survey (polling) forecasting
- panel (face-to-face interaction) forecasting,
- Delphi (survey with feedback without face to face interaction) forecasting

By and large, it is Accepted that an interacting group is superior to a non-interacting group" at all levels of task difficulty, though for to most difficult judgment tasks, the interacting groups may not reach the level of their most accurate members.

A panel or a committee ,·which allows face -to -face interaction, usually suffers from certain deficiencies such as predominance of certian member, difficulty in changing the opinion once expressed, and difficulty in expressing a view contradicting that by a leading To get over these difficulties of a face-to-face group interaction, Helmer and his colleagues at the Rand Corporation, USA devised during 1953 an innovative way of a structured communication among experts which did not allow a face-to-face interaction. They conducted a succession of interactive inquiries from a panel of experts to arrives at a refined consensus with regard to the future development of military warfare techniques. A panel of seven experts was used. Five questionnaires were circulated. These were prepared in such a fashion that the responses were quantifiable. The ratio between the largest and the smallest responses, which was initially 100 to 1, dropped finally to 2 to 1, thus indicating a great degree of consensus among the panelists. Helmer and his colleagues called this technique "The Delphi Technique" after the place "Delphi" in ancient Greece where oracles were cited to make predictions about the future.

For security reasons, the above-mentioned study could be publicly reported only during 1963 (Dalkey and Helmer, 1963). This work, however, went almost unnoticed. Gordon and Helmer (1964) carried out a Delphi study to assess the direction of long -rang trends with special emphasis on the science and technology and their probable effects on the society and the world. Six topics were identified. They were scientific breakthroughs, population control, automation, space programme, war prevention, and weapon system. The panelists estimated the year by which there would be a 50% chance of the development occurring. This study was later included in a book by Helmer (1966). Helmer, Dalky and their associates at the Rand Corporation continued to apply the method in various field and investigate the Delphi method in grate detial. Most of the study results are available as Rand Corporation papers. These reports were frequently republished by various scientific and technological journals, giving widespread attention to the Delphi methodology.

As the application of Delphi spread and increased, criticisms emerged Sackman (1974) of the Rand Corporation criticized the method for lacking a theoretical base and for being beset with many problems. These included the subjective definition of experts the infrequent use of random sample because of the use of experts, the exclusion of the benefits of face- to-face interactions, the inclusion of value judgments, and unmeasured reliability, content and construct validity. The criticisms gave rise to the number of studies by the proponents of Delphi. The 1975 autumn issue of the journal Technological Forecasting and Social change was devoted to defending and reviewing the Delphi technique in the light of Stickman's critique. An edited book by Linstone and Turnoff (1975) was published in response to Sackman's criticism. The book is one of the best documents of the Delphi methodology. It provided a comparative digest of the origins, philosophy, developments, modifications, examples of studies and evaluations of Delphi. The book totally rejected the. Stickman's comments as unsound. However, Sackman (1976) continued to remain a skeptic while admitting that the book offered the best source on the Delphi technique.

Stickman's criticisms notwithstanding, the Delphi method continues to be very popular and widely accepted particularly when a group consensus is needed. Linstone and Turnoff (1975) have given a general definition of Delphi.

"Delphi may be characterized as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to to deal with a complex problem."

This “structured communication” is a made possible due to four identifying characteristics:

1) anonymity among the panelists,
2) statistical assessment of the group response,
3) controlled feedback of individual and group contributions of information and knowledge to all panelists, and
4) opportunity to review views given by any panelist. The Operational Details

The Operation Details

A small monitor team conducts a Delphi exercise. The team designs a questionnaire and sends it to a larger respondent group of participants. The participants are usually asked to make an evaluation of the problems under consideration according to some type of rating scheme. Upon receipts of responses to this first round questionnaire the monitor team summarizes the results by the computing some statistcs of the group response. Based upon this first-round response; a. second round questionnaire is prepared and sent to the participants, thus giving each participant an opportunity tore-examine his views based upon the feedback of group response. As the round proceed, a group consensus evolves.

As a general rule the statistical variance in the ratings reduces as the rounds proceed. Although Delphi technique is applicable for a variety of problems, its principal uses have been in the areas of (i) forecasting and (ii) decision analysis.

5.3.3 The Forecasting Delphi

The original and the most common use of Delphi is to forecast a future event. Organization have used the technique to forecast the future demand for their products and to foresee advent of future technology. The procedure for conducting a Delphi study is a follows:

1) In the first round the participants are asked to write what they expect to happen in the future.
2) Upon receiving the suggestion from the first round, the participants are asked in the second round to specify the year in which they expect the suggested events to occur. Often the question may be framed asking the participants to estimate the probability of occurrence of the event during a particular year. Thus, the year when the event is most likely to occur or the probability of its occurrence in a particular year-becomes the rating scale. The monitoring team receives everyone's response and calculates a measure of the central tendency and of the dispersion (usually the median and interquartile range) for each suggestion.
3) In the third round, all the suggestions, the statistical measures, and any written comments are sent back to the panelists. Given the feedback of group response, they re-estimate when the events will occur. Reanalysis of the statistics usually indicates a narrowing of the interquartile range, thereby indicting that there is a greater degree of consensus among the participants.

Additional rounds can generate greater precision, but most Delphi exercises do not generally go beyond four rounds, since little extra information or narrowing of opinion is achieved for the effort expended.

5.3.4 The Decision-Analysis Delphi

Another application of Delphi process has been made to the process of decision making. Turoff (1970), while developing this application, calls it the "Policy Delphi". He has pointed out that Delphi in such uses is not a decision-making tool, but rather a decision-analysis tool.

In this type of Delphi exercise, the planning horizon is held constant, and the participant evaluates various objectives or alternatives according to their importance, desirability, feasibility, ease of implementation, or probability of occurrence. The rounds are fairly similar to the forecasting Delphi. In the first round, the participant is presented with the problem and is asked to recommend alternative solutions. In the second round, he rates each alternative for its importance, and feasibility, etc. The third round consists of a re-rating, given the statistical feedback of the ratings from the second round. At the end of the rounds, the alternatives can be assessed for the degree of consensus and their worth whileness according to different rating criteria.

The Delphi technique ha^{g} been applied in the following areas :

a) Forecasting,
b) Gathering current and historical data not otherwise accurately available,
c) Evaluating possible budget allocations,
d) Delineating the pros and cons associated with potential policy options,
e) Developing casual relationships in complex economic or social phenomena,
f) Distinguishing and clarifying real and perceived human motivations,
g) Exposing priorities or personal values and social goals,
h) Setting corporate goals and objectives,
i) Generating and evaluating strategies,
j) Exploring urban and regional planning options, and
k) Planning health care systems.

5.3.5 Dephi as a Group Process

A lot of research works point to the Delphi method as an effective means of structuring group communication process. Some of them are discussed below in brief (Martino, 1972)

A) Accuracy.

Dalkey experimented with "almanac" questions, for which were know, but were not known to the participants. Responses were obtained either by anonymous feedback or by face-to- face discussion. Experiments showed that medians for anonymous feedback were more near the true answers than those obtained by face – to –face discussions.

B) Group Interaction

Salancik conducted a Delphi study in which he asked for 50% likely dates for half the physicians to use computers in particulars applications Reasons were categorized as dealing with benefits, cost, and feasibility .He regressed the median dates for each application with the number of statements dealing with various categories of reasons . The regression equation explained 85% variance in median dates. He concluded that panelists assimilate comments from panel members into their aggregate estimates.

C) Regularity in the Estimate

Dalkey analyzed the standardized deviates for the estimates and found them to follow a long normal distribution . He concluded that the estimate is a "lawful" behaviour.

D) Precision of the Estimates

Martino analyzed more than 40 Delphi studies. He found the spread of estimates between 20 % - 90 % likely dates to vary linearly with positive trend with 50% likely dates for several events by the same panel (Figure 5.1 and 5.2). He concluded that the higher the length of the forecast the higher is the spread.

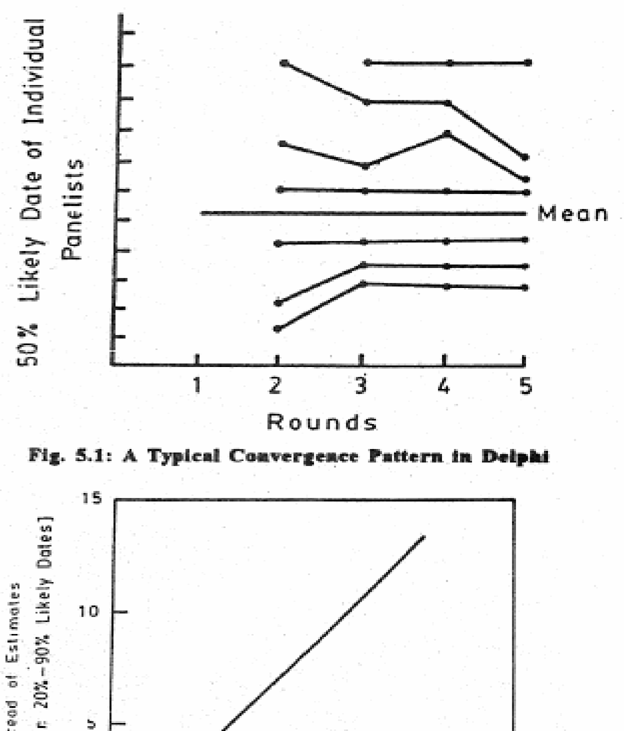

Fig. 5.1: A Typical Convergence Pattern in Delphi

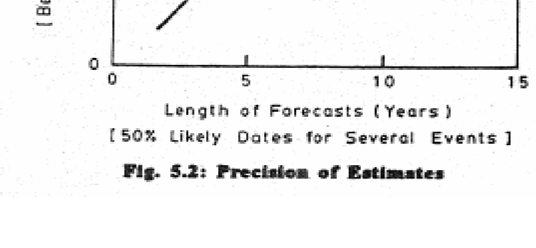

Fig. 5.2: Precision of Estimates

E) Reliability of the Estimates

Dalkey asked almanac questions. First round responses were treated as a population. Samples of various sizes were drawn from the population. Correlation between the median and the true answer was computed. Mean correlation coefficient over all questions for several sample sizes was taken as a measure of panel reliability A plot of panel reliability versus panel size indicates an asymptotic growth of the curve to 1 as the panel size increases (Figure 5.3).

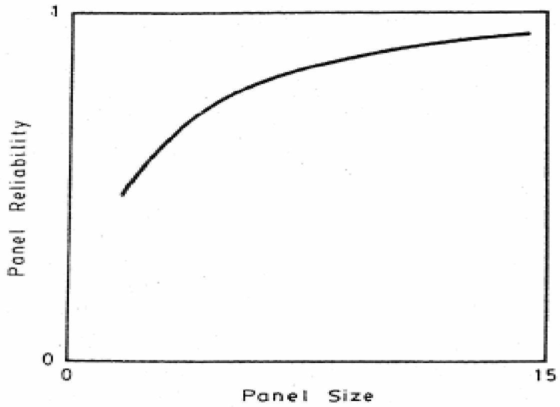

Fig. 5.3: Reliability of Estimates

F) Optimism/Pessimism in Forecasts

Ament analyzed two Delphi studies on the same topic conducted during 1964 and 1969 where the panelist were asked to estimate probability of occurrence of events by a particular year in the future. He noted that probability estimates, made during the year 1964, were significantly less than those made during 1969. He concluded that long-range forecasts tend to be pessimistic whereas short-range forecasts are optimistic.

G) Optimism/Pessimism Consistency by Panelists

Martino analyzed 10%, 50% and 90% likely dates. He computed three standardized deviates for each individual and for each given event. Means were computed for each individual and each likelihood. He noticed that panelists are consistently optimistic/ pessimistic with respect to the three likelihoods. He also noticed that standard deviation is comparable to, or greater than, the mean. He inferred that individual panelists tend to be biased optimistically or pessimistically with moderate consistency.

5.3.6 Guidelines for Conducting a Delphi. Study

The following guidelines should be followed while conducting a Delphi study

a) All members should agree to serve on the panel.

b) The procedure for conducting the study should be explained to the panelists in detail.

c) If possible, the panelists should be paid at the usual consultancy rate.

d) Every panel member should be assigned a code number.

e) Two copies of each questionnaire should be sent to the panelists in each round so that he can retain a copy for his own record:

f) The questionnaires should be easy to understand.

g) It should not contain too many statements. A practical limit is suggested as 25.

h) Statement should be neither very lengthy nor very short. Optimum word length is generally 25 for familiar events. It has to be higher for unfamiliar events.

i) Contradictory forecasts should be included to initiate debate.

j) Injection of moderator's opinion should be avoided becalm it has been found to substantially bias the results.

k) A statement should not contain possibility of occurrence of compound events.

l) A statement should not be changed.

m) When editing the respondent's comments for clarity, the intent for the originator should not be lost. Similarly, when editing from round to round, meaning of a statement should not be changed.

n) Occasionally, by keeping track of how different subgroups of a respondent group vote on specific items, it is possible to know how polarisation are taking place.

o) The questionnaire should be pre-tested on any willing guinea pigs outside the respondent group.

p) Delphi responses can be computer processed.

5.3.7 Guidelines for Selecting the Delphi Panelists

A general principle for selecting a panel for a Delphi study is that a variety must be introduced to avoid bias. Therefore, the panelists should belong to different schools of thought, different age groups, different institutions, different geographical locations, and different sexes, etc.

If the subject matter for a Delphi study concerns an organization only, then naturally, most of the panel members will be chosen from within the organization. However, external members must be included whenever they are likely to contribute greatly to thinking process.

Internal members must naturally have deep knowledge of the organization. They must maintain the secrecy. Since the top managers of the organization are usually a very busy set of persons, the internal members may be chosen from among the managers who are about 2-3 levels lower in the organizational hierarchy.

External members are expected to be outstanding in the relevant field. They may be selected from peer judgments, suggestions from internal experts, and suggestions from other panel members.

5.3.8 Advantages

Delphi is always preferred to any other method whenever a consensus of a large number of informed individuals is desired. Compared to the committee meetings Delphi has the following advantages:

a) The undue influence of dominant or eloquent personalities is absent.

b) One need not publicly contradict prestigious personalities.

c) The tendency to be carried away by majority opinion is absent.

d) One can always change his views "since anonymity is preserved without causing any embarrassment to himself.

e) Diversified opinion of many informed individuals will always be collected in this process.

f) It economizes on the time required by busy individuals sine questionnaires can be filled up at the individual's convenience,

g) It is relatively cheap to administer.

h) It facilitates conceptualizations of difficult phenomena.

i) It has no geographic and scheduling restrictions to get participants together.

j) It has shown high success in encouraging group and individual consideration of factors that might otherwise be dismissed or neglected in planning.

The other advantages that are claimed for Delphi are the following:

a) It has great utility in obtaining results when other methodology is appropriate.

b) It is a creative technique and encourages innovative thinking. Hence it is applicable to ill-structured problems.

c) By generating a consensus of opinion, it facilitates a change in an individual's social values and the overall climate of the organization.

d) Ratings from Delphi studies provide quantitative scores for evaluation and can aid the choice of a course of action.

e) The two-way communication in a Delphi study facilitates understanding and learning on the part of the participants.

f) The Delphi consensus leads to a commitment that leads to easy implementation. Moreover, a Delphi exercise may be used to identify roadblocks to implementation.

g) It blends the subjective and the objective, the rational and the extra-rational.

h) Delphi can be used along with such other aids as simulation-games, role playing, cross-impact matrix, trend extrapolation, and scenario writing.

i) It is very flexible, and applicable to many situations.

5.3.9 Common Pitfalls of Delphi

Delphi is not without certain drawbacks albeit the many advantages claimed in its favour. Most of the drawbacks originate due to deficiency in the design of the Delphi study by inexperienced monitor teams. The following is a list of the major deficiencies:

a) The inability to make the Delphi objectives specific,

b) The inability to identify and motivate many "informed individuals" to participate,

c) The inability to stimulate response,

d) The inability to appreciate and highlight consensus and divergence,

e) The inability to refrain from imposing monitor and preconceptions of a problem upon the respondent group by over-specifying the structure of Delphi,

f) Though advanced as a structured communication device, the method suffers from the following:

   i) the communication is too restricted for many problem situations,

   ii) the requirement of written feedback editing, and distribution places a high cost on the communication of ideas.

g) The Delphi panelists often give inconsistent views (Mohapatra et a1., 1984).

5.3.10 Variants of Delphi

Over the year, many variations on classical Delphi have been forwarded. Some of these variants are the following:

a) An initial list of events or some information on the problem context can be provided to the panelists. .

b) The panelists may be asked to suggest 10%, 5% and 90% likely dates of events (instead of the conventional most likely date of occurrence).Median of the 50%date is taken as the median of the group response, whereas the spread between the median of 10% and 90% dates is taken as the interquartile range of the group response.

c) On-line real-time Delphi can be practised if facilities exit. Here the concept of a round because redundant. A panelist directly keys in his scores and is informed of the updated group response immediately.

d) Direct interaction among the panelists may be allowed.

e) The number of rounds (the stopping criterion) for a Delphi study can be determined by examining if the stability of group response has been achieved. This can be done by studying examining if the stability of group response for individual statement from round to round or by studying the histograms of response for individual statement from round to round or by analyzing the changes in the coefficient of variation between rounds or even by carrying out statistical significance tests for comparing the variation of group response between rounds.

f) A hierarchical stopping criterion is often suggested (Figure 5.4). Such a criterion is quite comprehensive. Though ideally it look very appealing it is difficult to apply.

Gustafson et al (1973) present a framework for designing an opinion capture technique. They divide the group opinion capture techniques into three types:

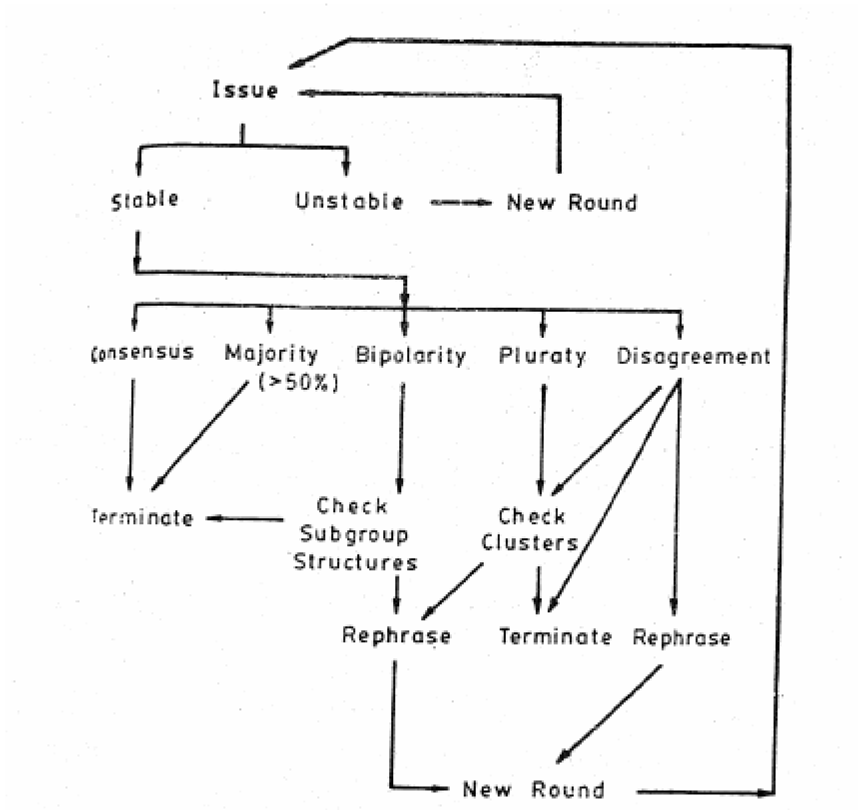

Fig. 5.4: Hierarchical Stopping Criterion

a) Talk Estimate (TE):Interaction Group Committee or Panel

b) Estimate -Feedback Estimate (EFE): Delphi

c) Estimate-Talk-Estate (ETE): NGT

Naturally, "talk" enhances interaction, “feedback” indicates one-way back communication, anal. “estimate” is the decision process.

5.3.10.1 The Nominal Group Technique (NGT)

Of the many variants of Delhi which have lately been proposed, the Nominal Group Technique (NGT) has exhibited the greatest potentialities (Ven and Delbecq 1974).

In its basic form, the technique requires participants to generate ideas in private. Participants then engage in a round-robin meeting in which each offers an idea at time. Discussion is then allowed. Finally an appropriate form of vote is taken to determine the Group's final answer However, NGT was designed for the generation and capture of ideas rather than for the estimation of prescribed quantities.

5.3.10.2 The Estimate-Feedback-Talk-Estimate (EFTE) Procedure

This procedure is developed by Nelms and Porter (1985) and is also referred to by them as an "interactive Delphi" procedure. The procedure has the following ten steps:

a) Participants are given background information.

b) Participants assemble face to face m a conference room: The Delphi leader provides \the background information and raises the partinent question. Discussion among the participants is discouraged.

c) A Delphi questionnaire is given to each participants. After completing, the . participants return them to the Delphi leader.

d) Results are summarized and displayed before the group. Answers are ranked from high to low Medium, quartiles and range are also computed and provided to the participants.

e) Feedback of results are discussed freely among the participants. The 'name of an 'individual who may have been made a particular response is not disclosed publicly

f) A second Delphi round is performed. In addition to the questionnaire, the panelists are given index cards for anonymous questions and comments. These are then return to the Delphi leader.
g) Results are summarized and posted. Anonymous questions are read and recorded for display.
h) Discussion on the feedback is allowed.
i) Results are examined for stability of response of each panelist (not consensus). In case of sufficient stability, The process is terminated. Otherwise, steps 6 through 9 are repeated.
j) Final results are summarized on paper. Additional statistical analysis is performed. These are distributed to all the participants for comments.

The following advantages are claimed for the EFTE procedure:

- Protection from group effects,
- Face-to-face interaction,
- Feedback, and
- Stability as stopping criterion leading to fast start to finish.

5.3.11 Final Remarks on Delphi and its Variants

Over the years, popularity of Delphi and its variants is growing. With new applications of Delphi studies and its variants and with continued research on its methodological aspects, one hopes that it would become an important tool in the hands of planners. With careful use, well-thought-out design, and integration with other techniques, Delphi and its variants can help collect opinion of a large group of experts in the ill-structured areas of forecasting, objective setting, and long range planning.

Activity D

How could the Delphi method be used to predict for 5 years into the future, the demand for the hospital beds in a given community? Under what circumstances would you recommend use of Delphi method.

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Activity E

Explain how a Delphi techique delivers a concensus forecast.

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Activity F

Conduct an Estimate-Feedback-Talk-Estimate (EFTE) procedure for forecasting as your organization.

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5.4 FORECASTING BASED ON CROSS'IMPACT ANALYSIS

5.4.1 History of Development

In a Delphi study conducted by Gordon and Helmer, panelist complained of a difficulty in estimating of occurrence of future potential events apeared to be interrelated. The panelists thought that if an event. Helmer and Gordon worked on this problem and developed in 1966 the "Future, A Simulation Game" For Kaiser Aluminium and Chemical Corporation. This hand simulation game gave way to the first computer-based approach (Gordon and Hayward (1968).

Over the years, many variations have been proposed over the basic cross-impact methodology suggested by Gordon and Hayward. The basic methodology by Gordon and Hayward will however be discussed here because of its historical value, simplicity and elegance. It will be followed by a mathematically more accurate approach suggested by Sage (1977). Finally, a deterministic cross-impact simulation model developed by Kane (1972) will be discussed.

5.4.2 The Basic Concepts of a Cross-Impact Matrix

The basis of cross-impact theory is a cross-impact matrix. The matrix has all the possible future events in its rows as well as in its columns. The columns the affecting events, and the rows show the affected events. Each cell represents the strength and direction of the impact of the column event on the row event. Since no event can be enhancing type or inhibiting type. An enhancing impact increases the probability of occurrence of the impact event due to the occurrence of the impacting event. An inhibiting impact reduced this probability. Of course, this probability may remain unaffected as in the case of the diagonal elements of the matrix.

The impacts are estimated quantitatively in a scale ranging from -Ito +1-1 indicates maximum inhibition, +1 maximum enhancement, while zero represents no impact. Figure 5.5 shows below an example of a cross-impact matrix.

	e_l	e_2	e_s	e_4	e_5
e_1	-	+0.1	0	0	0
e_2	+0.8	-	0	0	+0.1
e_3	0	0	-	0	0
e_4	0	0	0	-	+03
e_5	0	0	0	-0.6 '	-

Fig. 5.5 Cross-Impact Matrix for Indian Tea Industry

In Fig. 5.5 the events are defined as follows:

- e_1: Complete understanding of the chemistry of tea plants
- e_2: Breakthrough in the development of high yielding clones
- e_3: Mechanical plucking of the tea leaves
- e_4: nationalization of the industry
- e_5: Restriction on domestic consumption of tea

In Fig. 5.5, the entry in the ij-th cell indicates the impact of the j-th column cell event on the j-th row cell event. Consider the impact of e_4 on e5. The corresponding cell has an entry of -6. It implies that if the tea industry is nationlized, it will most likely permit more tea to be retained in the country for domestic consumption rather than be exported, thus reducing restriction on domestic consumption of tea.

It is to be noted that the entries in the cells are to be estimated by the Delphi panelists.

5.4.3 The Cross-Impact Theory of Gordon and Hayward

5.4.3.1 Evaluating the Conditional Probability of Occurrence of an Event

Assume the case of two event e_l and e_j whose conditional probabilities of occurrence P(i) and P(j) have been estimated independently. Further asume that the actual occurrence of the event e_j is expected to affect the probability of occurrence of the event el. The problem is to assess the new probability of occurrence of e_l. P(i/j) is a function of the unconditional probability P(i), the direction of impact (I)), the strength of the impact (S), time (t) in the future of the occurrence of e_j, and time (t_i) in the future for which the probability of occurrence of the event e_i is to be estimated:

$P(i/j) = f [P(i), D, S, t_j, t_t$

Some properties of the curve showing the funtional dependence of P(i/j) on P(i) are the following :

a) If an event e_l is certain to occur, or not occur then the occurrence of another events e_j Qualitative Methods of Forecasting will not alter its probabilities of occurrence :

If P(i) = 0, then P(i/j) = 0,

if P(i) =1, then P(i/j) =1

b) For the evenbt e_j to affect another event e_i, the time of occurrence of e_j must be prior to the time of occurrence of e_i;

$t_i < t_j$

c) If future times of occurrence of the events e_j and e_l are the same, then the unconditional and the conditional probabilities must be equal to each other:

If t = t, then P (i/j) =P (i)

Fig. 5.6 shows this diagonal straight-line relationship between P(i/j) and P(i).

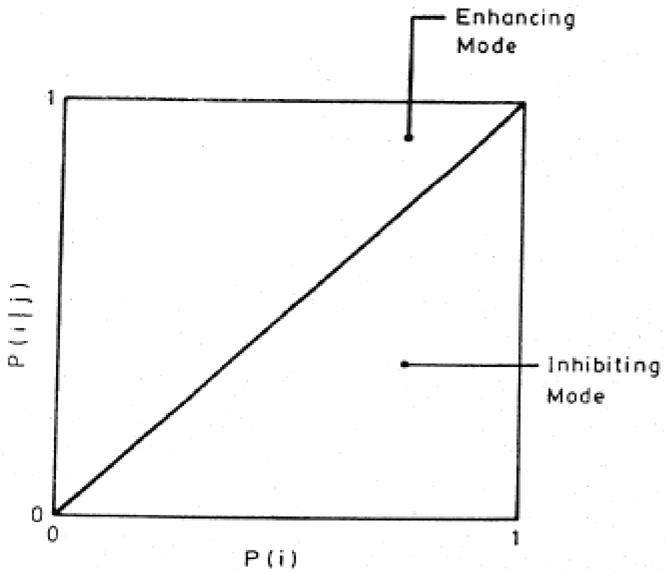

Fig. 5.6: Enhancing and Inhibiting Modes

d) In case the impact of enhancing type, the curve will lie above the $t_{.}^{=} t_j$ line in Fig. 5.6; otherwise the curve will lie below this line, indicating that

P(i/j) > P (I). i.e., e_j enhances e_i (5)

P (i/j) <P (I), i.e., e_j enhances e_i (6)

e) For a given impact of e_j on e_i P(i/j) cannot decrease with an increasing value of P(i). That is, the curve depicting variation of P(i/j) with P(i) will monotonically rise:

$$\frac{dP(i/j)}{dP(i)} >=0 \qquad (7)$$

Fig.5.7 shows two arbitrary shapes of curves showing possible variation of P(i/j) with P(i)

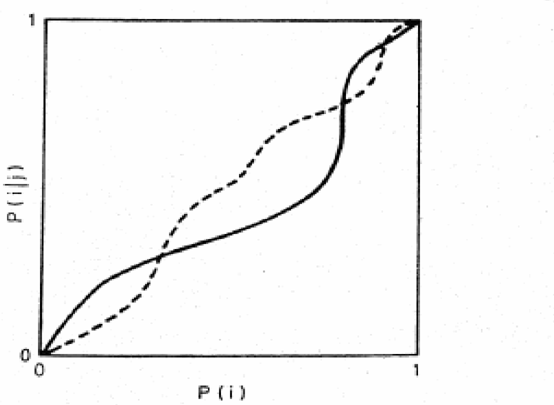

Fig. 5.7: Monotonically Rising Conditional Probability Curves

Assume a quadratic relationship between P(i/j) and P(i):

$$P(i/j)\ a\ [P(i)]^2 + b\ P(i) + c \qquad (8)$$

Using conditions defined in equations (1) and (2), equation (8) is reduced to :

$$P(i/j) = P(i) - a\ [1 - P(i)]\ P(i) \qquad (9)$$

One notices from equation (9) that

for enhancing impact a<0,

for an inhibiting impact a>0, and

for the independent events a=0

The above is a consideration to reckon with while estmating a value of `a'. The value of `a' should also depend on the estimated strength of the impact (S) and the future occurrence times; and t. Gordon and Hayward assumed the following relationship:

$$A = -I_{ij} * (1 - \frac{t_j}{t_i}) \qquad (10)$$

where I_{ji} is the entry in the ij-th cell of the cross-impact matrix.

Combination equations (9) and (10), the following conditional probability results:

$$P(i/j) = P(i) + I_{ij} (1 - \frac{t_j}{t_i})\ [1 - P(i)]\ p(i)] \qquad (11)$$

Thus if the impact is enhancing (t > 0), then P (i/j) > P(i). Also the higher the value of t compared tot, the greater is the value of P (i/j) compared to P(i).

5.4.3.2 Monte Carlo Simulation for Cross-Impact Analysis

Once the Delphi panelists enumerate the likely fortune events, estimate their probabilities of occurrence, and agree on the values of the cells in the cross-impact matrix, the task is to refine these probabilities if certains really occur. Monte Carlo simulation comes as a handy tool for this.

Figure 5.8 shows, in a flow chart form the steps and the logic of the simulation. Uniformly distributed random numbers are compared with the probability estimate for an event e_j. to suggest if e_j has occurred. If e_j is deemed to occur, then Eqn. (11) is used to compute fresh probability estimates of impacted events.

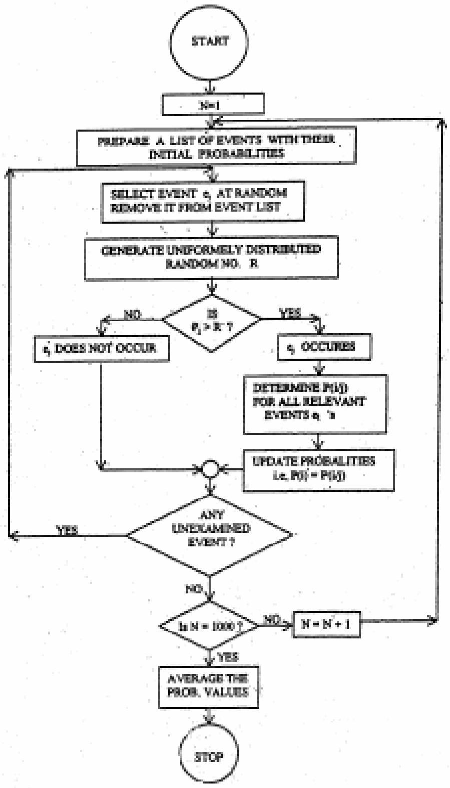

Fig. 5.8: Flow Chart of Monte Carlo Simulation for Cross Impact Analysis

It is to be noted here that for Eqn. (11) to be applicable, one has to estimate probable year Qualitati^ve methods or Forecasting of the events also.

A number of parameters can be evaluated from a Monte Carlo simulation:

a) The probability of occurrence of an event can be computed either as an average over all simulation runs of the computed probabilities or as an average of the ratios of frequency of occurrence of the event to the number of simulation runs.

b) A statistical hypothesis test can be carried out to compare the computed probabilities with the initial probability figures.

c) Frequency of occurrence of events by year can be computed.

The, advantages of a cross-impact analysis are the following:

a) The forecaster can identify "surprise" futures not obvious otherwise.

b) "Critical" events, whose occurrences can change probabilities significantly, can be identified.

c) Sometimes a policy intervention is modeled as an event. The effectiveness of a policy can be studied with the help of cross-impact analysis.

d) It is possible to carry out sensitivity studies with respect to variations in estimation of event times and event occurrence probabilities.

e) An internally consistent forecast becomes possible.

Recent studies have added new features to cross-impact analysis:

a) Non-occurrence matrix and its effect on the probabilities have been incorporated.

b) Limits to the assessed probabilities of the dependent events have been set.

c) Input probabilities have been taken to be mutually dependent estimates.

d) Cross-impact matrix has been taken to consist of revised probabilities rather than impact strength.

e) Event-trend-trend interactions have been incorporated.

f) Conditional probabilities are estimated following Bayesian rules (Sage, 1977).

5.4.4 Cross-Impact Theory Based on Bayesian Rules

Bayes' rules specifies a relationship between the probabilities P(i) and P(j) of events e_i and e_j:

$$P\,(i/j) = \frac{P(j/i)}{P(j)} P\,(i) \qquad (12)$$

5.4.4.1 Upper Bound for P (i/j)

From the laws of joint probability, we have

$$P\,(i) = P\,(ij) + P\,(ij) \qquad (13)$$

where P(ij) is the probability of occurrence of e P(ij) is the probability of occurrence of e and nonocurence of e_j

Using the conditional probability law,

P (i) =P (j) P(ij) +[1-P(j)l p(i/j)

Hence,

P (i)>=P (j).P (i/j)

Or, P(i/j) <=P(i)/P(j) = aP(i) (14)

The number a must be positive and greater than 1.

5.4.4.2 Lower Bound for P (i/j)

From the probability law for compound events the probability that e_1 or a or both will occur is

P(iUj) = P(i)+P(j)-P(ij)

$= p(i) + p(j)-p(i/j)\, p(j)$

since this probability must lie between 0 an 1,

$$P(i/j) >= \frac{P(i)+P(j)-1}{P(j)} = \frac{P(i)-1}{P(j)} + 1 \quad (15)$$

The upper and lower bounds are illustrated in Figure 5.9 and Figure 5.10.

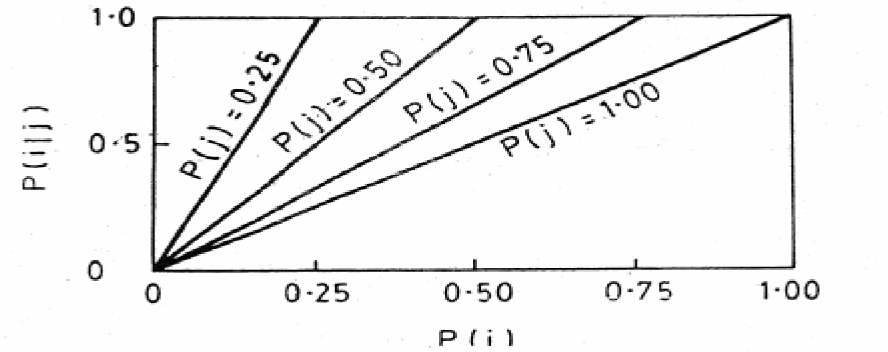

Fig. 5.9: Upper Bound for P(i/j)

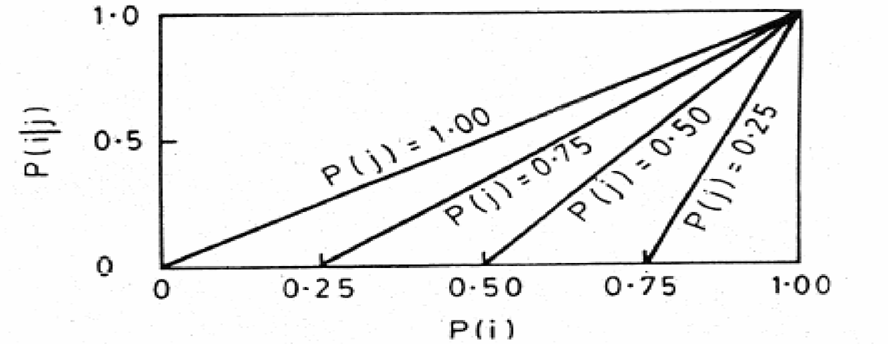

Fig. 5.10: Lower Bounds for P(i/j)

1

If e_j occurs, then the relationships are summarized as

$$P(i) <= P(i/j) - \left[\frac{1}{p(j)}\right] P(i) \text{ , j enhancing} \quad (16)$$

$$1 + \left[\frac{1}{p(j)}\right][P(i) - 1] - p(i/j) <= p(i) \text{ , j inhibiting} \quad (17)$$

if e_j does not occur then it may shown that

$$P(i) <= P(i/j) <= \frac{P(i)}{1-p(j)} \text{ , j inhibiting} \quad (18)$$

$$1 - \frac{1-P(i)}{1-p(j)} <= p(i/j) <= p(i) \text{, j enhancing} \quad (19)$$

If three of the probabilities, P(i), P(j), P(i/j) and P(j/i), are specified, the fourth can be determined from Eqn. (12). The bounds given in Equations (16) through (19) must be satisfied while estimating the probabilities. This ensures consistency.

5.4.4.4 An Example

As an example , if P(i) ,P(j),P(i/j) , are estimated as0.5 and 0.25 respectively , then for e_j enhancing:

0.5<= P(i/j) <=1,0.33<=P(i/j)<=0.5 , and for e_j inhibiting

0<= P(i/j) <= 0.5 .5<=P(i/j)<=0.67

Assuming that occurrence or non-ocurence of e_j is at an earlier time than occurrence or non occurence of e. the event tree (Fig.5.11) shows the way the four joint probabilities P (ij), P (^{ij}), P (ij) and P (ij) can be determined.

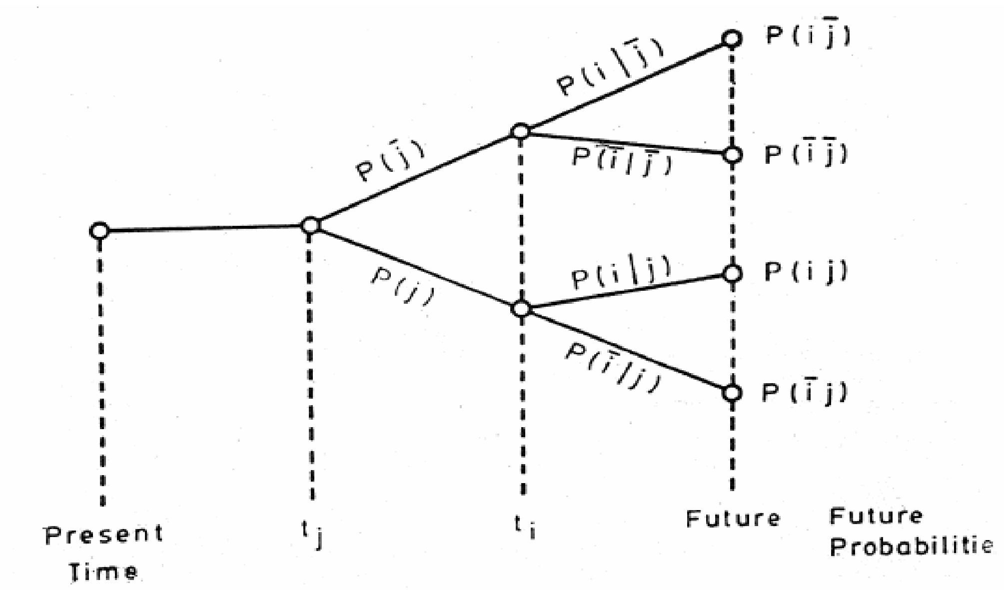

Fig. 5.11: Event Tree for Computing Probabilities

Following the scheme in Fig.5.11, the corresponding bounds on the futures are given by for e. enhancing:

0.125 <= P(ij) <==0.25, 0.25 <=P (ij) <=0.375

0 <=P(ij)<= 0.125, 0.375 <= P(ij) <= 0.5

for ej inhibiting :

0<=P(ij) -<= 0.125, 0.375 <=(P(ij) <= 0.5

0.125<= P(ij) <= 0.25, 0.25 <= (P(ij)<= 0.375

Suppose in addition to the probabilities P(i) and P(j), it is known that e_j is enhancing e_i. Since PO) = 0.25, P(j) = 0.75. So most likely ej, will also not occur. Comparing bounds between P(ij) and P(ij) for the case of e. enhancing e,, one may conclude that most likely e will also not occur.

5.4.5 Deterministic Dynamic Simulation Based Upon Cross-Impact (Katie, 1972)

Instead of estimating conditional probabilities for use in cross-impact, Kane and his colleagues assumed that a group estimates the impact of various state variables upon the rate variables of a first-order differential equation. This approach is mathematically less elegant than many simulation models, but it allows the judgement of the policy makers to be used directly.

5.4.5.1 The Mathematical Foundation

This simulation model, developed by Kane and referred to as KSIM, is based on the following assumptions:

a) All state variables are bounded, since no variable of human and physical significance can increase indefinitely. With scaling all state variable can be bounded between 0 and 1.

b) A rate variable will increase or decrease depending upon whether the net impact of all state variables is positive (or enhancing) or negative (or inhibiting).

c) Bounded growth and decay of state variables exhibit the familiar logistic shape. When a state variable is near its bounds of 0 and 1, the impact on its rate of change decreases to zero.

d) All other things being equal, a variable will produce greater impact on the system as it grows larger.

e) Complex interactions are described by a cross-impact matrix.

Assume that there are N state variables in a system In KS1M, it is assumed that the rate of change of the ith state variable is computable from:

$$\frac{dx}{dt} = \sum_{j=1}^{N} (a_{ij} x_j + b_{ij} \frac{dx_j}{dt}) x_i 1n x_i \tag{20}$$

Here, when x = 0, dx/dt =0; also when x_i 1, In x = 0, and so dx/dt = 0 -(Assumption c). The term (x_i 1n x) modulates the summed impacts and forces the derivative to be between 0 and 1, and thus bounds the state variables (Assumption a). a_i; and $b_{i;}$ are adjusted to enforce satisfaction of assumption b and d.

A_{iJ} represents the impact of x. upon the rate variable d x_i/dt, and b_{iJ} represents the impact of changes in x dx/dt upon the rate variable dx/dt. But a group faces difficulty in estimating N.., and so, at times, b_{ij} is assumed zero.

Rewriting the earlier equation in the following fashion: N

$$\frac{dx}{x_i} = \sum_{j=1}^{N} (a_{ij} x_j + b_{ij} \frac{dx_j}{dt}) 1nx_i dt$$

and integrating from t to t + ▲t (and regarding all functions of x on the right hand side of the equation as constants), one obtains

$$1nx_i(t+\Delta t) - 1nx_i(t) = \sum_{j=1}^{N} \left[(a_{ij} x_j(t) + b_{ij} \frac{dx_j}{dt} \right] 1n\ x_i(t) \Delta t \tag{21}$$

This can be written as

$$x_i(t+\Delta t) = x_i(t)^{qi(t)} \tag{22}$$

where,

$$q_i(t) = 1 - t \sum_{j=1}^{N} \left[a_{ij} \frac{b_{ij}}{x_j(t)} \frac{dx_j(t)}{dt} \right] x_i(t) \tag{23}$$

q_i (t) may be regarded as 1 minus the sum of the impacts by all state variables on x_j.

It maybe shown that for positive values of a and k_J (enhancing impacts), qi (t) is less than 1 and the accuracy of the solution suffers. To overcome, this problem, x(t) In x(t) is replaced by x(t) 1n x(t +▲t). This leads to a solution

$$x_i(t+\Delta t) = [x_i(t)]^{qi(t)}$$

where

$$q_i(t) = \frac{1}{1 + t * \sum_{j=1}^{N} \left[a_{ij} + \frac{b_{ij}}{x_j(t)} \frac{dx_j(t)}{dt} \right] x_j(t)} \tag{24}$$

Combining Equation (23) and (24)

$$q_i(t) = \frac{1 + \frac{1}{2} \Delta t \sum_{j=1}^{N} [Abs(I_{ij}(t)) - I_{ij}(t) x_j(t)]}{1 + \frac{1}{2} \Delta t \sum_{j=1}^{N} [Abs(I_{ij}(t)) + I_{ij}(t) x_j(t)]} \tag{25}$$

Where ,$I_{ij}(t)$ is the total impact of state variable j on the ith state variable, and is given by

$$qi(t) = \frac{1 = l\Delta t \text{ (magnitude of sum of inhibiting impacts on } x_i)}{1 + \Delta t \text{ (magnitude of sum of enhancing impacts on } x_i)}$$

Thus when the negative impacts are greater than the positive ones, q>l and x decrease, while if the negative impacts are less than the positive ones, $q_i < 1$ and x increases. Finally, when the negative and positive impacts are equal, $q_i = 1$ and x remains constant.

5.4.5.2 Steps to Establish a KSIM Model

Sage (1977) has suggested the following procedure to establish a KSIM model :

a) Identify fundamental problem elements. The approach to unified programme planning, interpretive structural modelling and structural group interaction such as Delphi exercises help in this regard.

b) Determine appropriate scale such that each state variable can be expected to vary between 0 and I.

c) Determine appropriate initial conditions for each state variable.

d) Determine cross-impact relationships. A group unfamiliar with quantitative techniques may begin this by assigning iteraction impacts to a matrix with numbers chosen to represent zero, low, moderate or intense interaction of an enhancing or inhibiting nature.

e) Determine the time response by computer simulation of Equations (22), (25) and (26)

f) Iterate steps (b) through (d) till the group accepts the model response as appropriate. By so doing, information supplied by the group is made explicit, and structural information is enhanced with numerical information.

g) Apply different proposed policies and policy interventions to the model. This is accomplished by using step functions for $a_{,ij}$ and $b_{,ij}$ terms to switch in defferent policies as a function of time.

5.4.5.3 An Example

A real world macromodel is developed to exhibit the comprehensive behaviour of the consequences of the unchecked use of technology. Therefore the variables in the system are taken as potentially harmful technology (t), pollution (P), affected population (A), social pressure (S), health care (H), pollution control (C_p), pollution taxes (T), and additional expenditure for pollution control and pollution taxes (E).

This model represents an industrial scene in a developing country like India. Technology, in this model, is a method of manufacturing and generates harmful pollutants. The pollution thus generated causes health hazards and the affected population increases with increasing pollution. Though the government has made several laws against pollution, they are seldom implemented in practice. Also, the people with low education and economic levels are less concerned with the degradation of the environment than in the economic development. This situation is presented in the basic model.

The people's concern can bring pressure (that is social pressure in terms of mass movements by people) on the government. Government can follow a number of alternative policies under social pressure to counter the environmental degradation. The alternative policies, open to the government, are to enhance health-care facility, to insist on pollution control measures, to impose pollution taxes, to restrict further use of technology, and some variations of these policies. Measures to control pollution through pollution taxes increase the expenditure for the industry As expenditure increases, the industry brings in counter-pressure on the government, thus reducing the effect of social pressure. The interactions among variables are best explained in the signed digraph given in Figure 5.12. The weighted cross impact matrix and the initial values are shown in Table 5.1. The model was simulated. Fig 5.13 depicts the basic model behaviour and Fig 5.14 presents the simulated behaviour with a combined policy of health-care, pollution control, and pollution taxes.

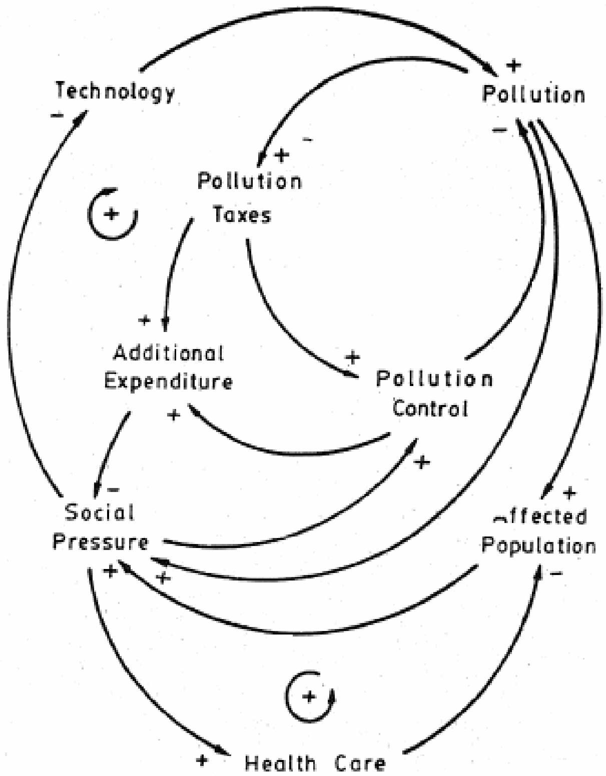

Fig. 5.12: Interactions among Variables

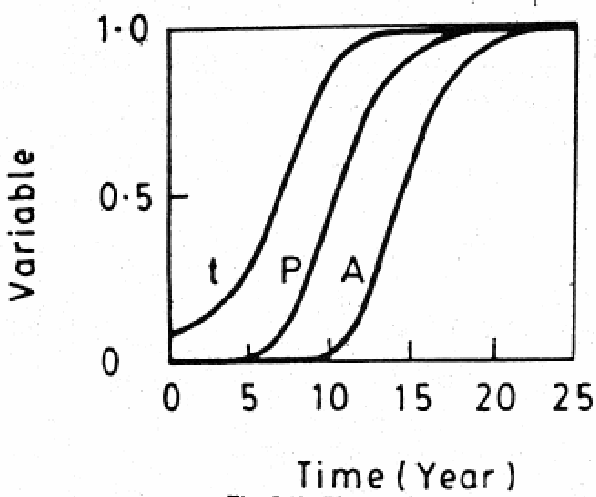

Fig. 5.13: The Basic Model

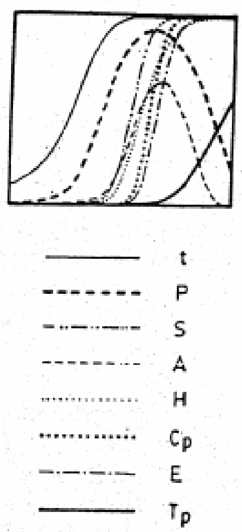

Fig. 5.14: The Effect of Policies

Table 5.1: The cross impact matrix and the starting values for the variables

variables	t	P	A	S	H	C_p	T_p	E	Initial values of the varriables
t	0.75	0	0	-1	0	0	0	0	0.100
P	0.5	0	0	0	0	0.9	0	0	0.005
A	0	0.5	0	0	-0.8	-0.8	0	0	0.005
S	0	0.5	1	0	0	0	-0.5	0	0.001
H	0	0	0	0.8	0.1	0	0	0	0.001
C_p	0	0	0	1.0	0	0	0.2	0	0.001
T_p	0	0.6	0	0	0	0	0	0	0.0001
E	0	0	0	0	0	0.1	0.15	0	0.0015

5.5 SUMMARY

In operation management, we deviate from the general business concept of business forecasting and define forecasting as the use of past data to determine the future events. Prediction, on the other hand, refers to subjective estimates of the future. A manager's *ills, experience, and sound judgement are required for good predictions; often statistical and management science techniques must be used to make reasonable forecast.

Three of the most important qualitative methods of forecasting are: i) Judgemental forecasting ii) The Dephi technique iii) Cross impact analysis. These methods are useful where historical data are not available or are not reliable predicting the future, Qualitative methods are used .primarily for long and medium range forecasting involving process design, facilities planning. Delphi Technique is gradually becoming an important tool in the hands of planners. Delphi and its variants can help collecting opinions of a large group of experts in the ill-structured area of forecasting, objective setting and long range planning. Cross impact analysis presents a matrix for analyzing the strength and direction of the impact of different events. An impact can be enhancing type of inhibiting type.

In many organisations, different forecasts are made by different departments and there is no co-ordinated planning. This may be caused by confusion about goals, plans, performance measures, and forecasts. To help overcome this confusion, the discussed techniques can be used.

5.6 SELF – ASSESSMENT EXERCISES

1) Contrast forecasting and predication and give and example of each.
2) Forecasting is important for operations subsystem decision. Explain what might be forecast for a supermarket operation.
3) What are some of the variables affect the accuracy of intuitive forecasts?
4) Compare intuitive forecasting to naive statistical forecasting models. As an operations manager, how would you forecast- intuitive or by model? Why?
5) What are the advantage and disadvantages of preparing a probability forecast of demand?
6) In a stockely company, marketing makes a sales forecast each year by developing a sales force composite. Meanwhile, operations make a forecasts of sales based on past data, trends and seasonal components. The operation forecast usually turms out to be an increase over last year but still 20 per cent less than the forecast of the marketing department. How should forecasting in this company be done?

7) How should be the choice of a (Alfa) be made for something?

8) A request has gone out to all sales people in a company to make forecast for their sales territories for next year. These forecasts will be aggregated by product lines, districts, regions and -finally- at the national level. Describe the problems in using this forecasting for planning aggregate levels of operations and scheduling decisions.

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