Innovation Management and Decision Making

The Third International Conference on Design Creativity (3rd ICDC)
ISBN 978-1-904670-60-5
Bangalore, India, 12th-14th January 2015

CLASSIFICATION OF FORECASTING METHODS WITH RESPECT TO THEIR STRUCTURE

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Abstract: Forecasting and Future mapping are indispensible methods used by researchers, strategists, leaders and visionaries to know possibilities for future and make arrangements to get prepared for the consequences. This is the foundation thought that supports universal harmony and sustainability at large. One aim of this paper is to identify a commonality among various forecasting techniques to identify an underlying structure and define a generalized and prospective forecasting process. Furthermore, different forecasting methods have their unique strengths and focus areas that define their application areas. This paper also aims towards discovering these specific focus areas and highlights convergence of various techniques to form a wholesome solution for more challenging tasks such as forecasting for a long term horizon or social forecasting.

Keywords:*Forecasting methods, future mapping, structure,business innovation*

1. Introduction

Technology and Culture reflect the time we live in. The products that we use indicate the available technology, materials, systems, manufacturing processes, and various needs that were considered while designing them. In a way, they are a reflection of the available resources and capabilities of thatspecifictimezone. Deeper study of evolution of technology indicates As the technologydeveloped, new materials became available, new needs came up, the products also evolved (Franssen 2009). Products associated with daily life give an overview of people's life, society, their customs, belief system and culture. Taking a cue from the past, if we want to peep into the future, one of the possible approaches could be to project into the future of these available technologies and culture. This forecasting approach is based on the current capabilities, developments in technology and areas of active scientific research.

Future visions help generate long-term policies, strategies, and plans, which help bring desired and likely future circumstances in closer alignment with the present potentialities. Businesses use futures mapping methods to enhance understanding of future markets. Social leaders use them to develop and test both possible and desirable future visions (Glenn 2000).

Furthermore, the use of future methods enhances anticipatory consciousness, which in term improves the foresight to act faster or earlier making the organization or individual more effective in dealing with change. (Glenn 2000). Any institution that takes care of present while planning for future, is more resilient to meet the needs of the society, both in the present and the future.

Though different by approach, most of the Technology forecasting methods work on basic methodology of data gathering, trend identification and simulation. But on close observation of the industries and various forecasting experiments in which these methods were deployed and a common structure was identified. These key parameters, which define the pillars of any forecasting method, work as providing a skeleton.This paper looked at various existing forecasting methods and tried to classify them on the basis of their internal structure. This classification clearly indicate that these forecasting methods can be differentiated from each other on the basis of their focus towards one step over the other. This further shows relevance of using various forecasting methods in congruence to each other so that they could suffice each other and provide a more wholesome solution.

2. Types of Forecasting Methods

It has been observed that the cornerstone for innovation forecasting is *monitoring* of specific data and further analysis. Future Studies literature comprehends various classifications of its methodologies on the basis of -***Quantitative*** (numerical or measured) and ***Qualitative*** (hypothesis or judgement) (Puglisi 2002); OR ***Explorative*** (looking at ongoing trends and exploring where they may lead us in future) and ***Normative*** (establish objective first and indicate ways to reach there with given conditions) (Gordon 1992, Puglisi 2002).
Theseclassifications may or may not be empirically based, allowing for, on one hand, detailed empirical facts of the past and present situation and, on the other hand, the inclusion of intuitive, speculative, and hypothetical (Puglisi 2002).
Various researchers have tried to categorize forecasting methods on the basis of commonalities of approach, process, nature, etc. But broadly, on the basis of application and domain focus, these forecasting techniques can further be classified on the basis of *Technology*, *Social* and *Environment*.

2.1. Forecasting methods focussed on Technology

These forecasting methods focus on looking towards the future of technology by various techniques such as:

- Gathering intelligence data over current researches and areas of thrust: *Bibliometrics* (DeBellis et al 2009)
- Trend mapping and analysis
- Understanding the concept via theories of Causation: *Causal Layered Analysis* (Inayatullah 2014)
- Asking panel experts: *Delphi studies* (Helmer 1967)
- Doing Simulation: Scenario writing, gaming models, mathematical models, *Futures Wheel* (Glenn 1971)

Limitations: Overt dependance on data (historical or fresh market data), ability to see through the underlying trends. Furthermore, due to reliance on historical data, it is innately based on a premise of history extending itself, which might not be holding true always. The results obtained are good for short term forecasting mostly and fuzziness increases as we aim for long term, with increased complexity and depth of probing.

2.2. Forecasting methods focussed on People / Social

In these type of Forecasting methods, prime focus is on evolution of human needs on individual level as well as social level (Maslow's law). The past data is collected and analyzed to identify latent trends for the future. While in some other cases, focused interviews of domain experts (Delphi panel studies) help us get an insight.
Limitations: increase of fuzziness due to variation in thought of stakeholders. Exceeding reliance on large number for better clearer forecast is another limiting factor.

2.3. Environment relatedForecasting methods

These forecasting methods deal with higher level of complexity due to increase in number of factors and variables. Besides Sustainability issues, what type of environment and type of resources that will

be available in future, will determine the structure of design. Techniques like LCA (Life Cycle Assessment) help us take a step back and look at the product development and manufacturing in a new light. While the insights from LCA analysis allow us to identify product development pathways towards better sustainability through an innovative process, it is equally relevant for people in the society and environment itself.

Limitations: There are very few environment related forecasting methods in this area primarily due to complexity of factors involved. LCA is a good simulation tool which can be realized on people, social and environment level also. Furthermore, there is a limited availability of research and domain expertise in this area.

3. Structure of Forecasting Methods

Puglisi et al (2002) outlineddifferent stages of the visioning work in generic steps. But the more recent approaches also include other factors such as people's collective knowledge and impact of environment. Thus, the forecasting methods observe growing need to identify and manage the perturbation in the forecast or need to simulate for better communication of results. These raise new questions and a need to define a common structure that outlines the similarities across a wider range of forecasting methods. This would, inadvertently, also indicate how one method is unique in terms of its strength, and should be chosen in specific conditions or used in combination with other methods.

3.1. Methodology adopted for identifying structure

Various researchers (Glenn 2000) studied forecasting methods viz-a-viz their area of application and the industries. These methods were studied in detail alongside their hypothesis, objectives, requirements, methodology, nature of results, area of application. Thus, a common structure was deduced in 4 key components and a 6 stage process.Further, these forecasting methods studied were then plotted into the structure with reference to their areas of application and mode and the intensity of focus area was marked from a scale of 1 to 3.

3.2. Key Components of Structure

Forecasting methods have various steps which have been observed to be common across all the methods. These steps outline the structure and define the entire process. However, different methods vary from each other due to the focus and propensity of using these factors that depends on nature of technique itself and the purpose of forecasting. Thus, a multi-disciplinary approach that is focussed on utilizing strengths of various methods is used, to create a convergent solution.

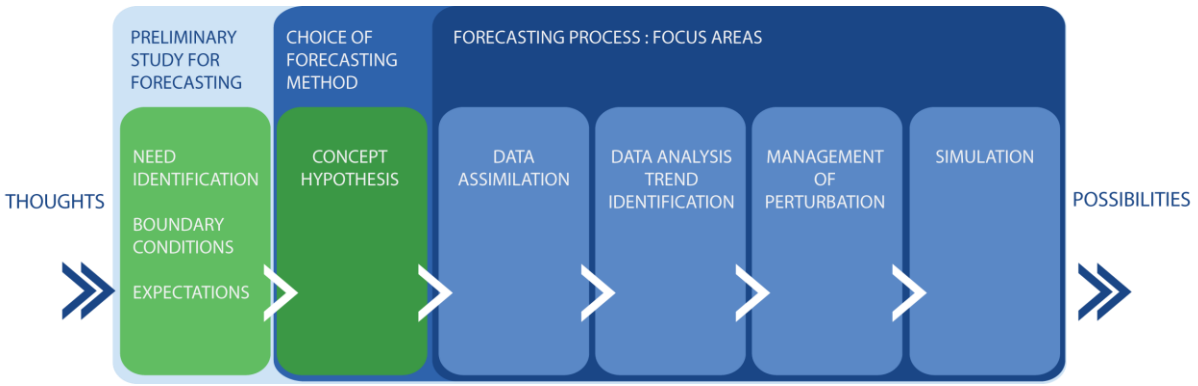

Fig 1. Structure of Future Mapping methods

3.2.1. Initial study for Forecasting

This phase is an essential entry point for any forecasting method. There are various factors that govern how we choose the appropriate forecasting method.
- **Need:** Reason to do forecasting defines "why are we doing forecasting". Peeping into future enables us to prepare for the same. Whether it is to boost the sales of our product in future by developing future-ready versions of our existing range of products, or predict a future technology or forecast a change in our social behaviour, the level of complexity increases as we move from a focussed to a wider objective. The number of perturbations multiply due to the increase in factors at work.
- **Goal:** Objective of Forecasting outlines the expectations. We are sometimes looking for broader *insights* that outline patterns (Consumer studies, Trend watch) or are very specific, such as for specific band of numbers (Sales projections) or we are looking for broad directions for even a meagre possibility (Forecast for longer time horizon). Our set of expectations define if we have to take a Qualitative or Quantitative, Normative or Exploratory forecasting approach.
- **Boundary Conditions**: Availability of data, time at hand, resources and expectations (time horizon, etc) define the choice of Forecasting approach. Depending on limitations of situations, e.g. if historical data is inaccessible, one forecasting method is chosen over another. On the other hand, the availability of historical data makes it easy to identify trend patterns in the past and thus, base a short-term forecast faster and relatively more confidently.

3.2.2. Concept (Hypothesis)

As Evans (2004) stated "Futures can not be determined by analysis alone", the word 'strategy' describes 'an underlying *logic* beneath the flow of decisions which creates the future' (Bruce &Bessant 2002). Concept of a forecasting method gives a glimpse about its hypothesis and working principle. This is one of the key factors that impacts the *decision* to prefer one forecasting method over another. Broadly, concept (hypothesis) of the forecasting method includes the following details:-

- Description of technique, methodology
- What is needed: list of requirements, special apparatus, data or special group of experts/people
- Boundary conditions
- Result Expectations: outline of results

3.2.3. Data Assimilation

Next important step in forecasting process is Data Assimilation. Every forecasting model will need some basic data to start from. **Quantitative methods** tend to use numerical data, mathematical calculations, measuring instruments and equations. **Qualitative methods** basically use intuition, invention, hypothesis and judgement.Quality of data determines the quality of results. Every small anomaly or wrong assumption may amplify into larger perturbations.

Methods to gather data

- Historical data gathering:- Statistical data, sales data
- Current market study:-Literature studies such as Bibliometric analysis, Scientometricanalysis
- Opinions:- Workshops/interviewsare means to gather data for opinion studies (Delphi study)

3.2.4. Data Analysis and Trend Identification

Assimilated data is then analysed closely to identify causal behaviors and underlying trend patterns. There are various means to perform data analysis which largely depends upon the quality and type of data that needs to be worked upon:-

- **Quantitative methods**:- The numerical data is usually numerical in nature plotted against time and other variables. Methods used are Mathematical models, statistical models, etc.
- **Qualitative methods**:- The data in this case is in the form of opinions, statements and observations and is thus, more qualitative in nature. Methods such as *Field Anomaly Method, FuturesWheel, Causal Layered Analysis* are used.

After data analysis, an underlying pattern is identified, that helps the future researchers to formulate a hypothesis which describes the reason for the pattern. This trend pattern is then projected in future to make a calculated guess. Various trend patterns that are observed in Forecasting methods include :-

- ***Short term trends***, such as Fashion trends
- ***Seasonal trends***, such as Winters causing increase in Crude prices due to more consumption
- ***Cyclic trends***, such as (Kondratiev cycles)Wave patterns that indicate a cyclic repetition of positive and negative growth in world economy over specific time zones
- ***Isolated variables*** that influence trend patterns when they emerge. For example, bad rainfall influences cost indexes and causes inflation, war atmosphere cause negative impact on business economy and sentiment

3.2.5. Management of Perturbation

As cited by many Future theorists, timescale is a key factor in the accuracy of any forecast or prediction. As identified, whether it is a *forecast* (generally not point-specific to time or place) or a *prediction* (a specific), usually quantitative statement about some future outcome does necessitate a more time-centred focus. The longer the time scale of time horizon of the forecast, the more is the level of perturbation, and thus, less specific and fuzzier statements. Evans (Evans 2003) identified the relation between time scale and abstraction. He proposed that the further into the future we look – the more conceptual our approach – the broader, less defined these insights become. The focus and narrative of these predictions alter with an extended timescale.

Furthermore, it is also believed that the more we zoom out of an existing system, the number of factors influencing or affecting the system increases exponentially. Thus, from Technology to Social paradigm and from Social to Environmental paradigm, the number of influencing factors increase, thereby increasing the complexity and level of perturbation.

These perturbations or anomalies are often observed carefully and then, controlled to whatever extent possible. In Qualitative approaches such as *Delphi*, the variation in opinions of the Delphi experts panel is controlled by guided revisions. Similarly, in Field Anomaly Relaxation (FAR) method, extreme anomalies are purged from entire range of possible futures plotted in a matrix, when critical uncertainities are considered along with their range of possibilities (Coyle 2001).

While in some other methods, such as Social Forecasting, which involve people on a mass level, thereis a strong likelihood of anomalies and variations due to increasing complexities. An effort to run the forecasting method in a controlled manner helps in marginally controlling errors by cancelling individual biases and generic public influences through. Similarly, in Environment related forecasting methods (e.g. weather forecast), the number of influencing factors rise further and thus, the complexity.

3.2.6. Simulation

Forecasting methods usually have one or many ways to represent the analysis and results. These ways to represent or communicate data in an easy-to-understand manner are *Simulation.*

Simulation methods are usually focussed as the objective is predefined. However, they could possibly be loose and descriptive or specific and definitive, depending upon the Forecasting method and the expected results. Simulation provides better representation through effective communication to interpret and understand the highlights of the forecast.

3.3.Examples of Forecasting process

Example 1: While undergoing a short term projection for Sales Volume for coming Financial year, the availability of historical data can be used to anticipate trends and then, base the prediction on it.

Example 2: While undergoing a long term forecast, there is neither an availability of historical data nor there could be accurate projections of technology, materials or usage patterns. Thus, *Delphi Studies* is used to generate data, which can then be used to create simulations in the form of *Scenarios*. Thus, a combination of different forecasting methods can be used leveraging on their individual strengths.

S. No.	Initial Study			Choice of Forecasting method	Forecasting methods: Focus areas			
	Need	Aim	Boundary conditions	Forecasting method	Data assimilation	Trend Analysis	Management of Perturbation	Simulation
1	Sales projection for next Financial year to plan for manufacture and facility upgradation	Identify trends in the past and project the next FY targets	1) Historical data available	Trend Analysis	2	3	1	1
2	To devise a communication device for year 2050	Broad directions for future communication devices	1) No historical data available	Method 1: Delphi Studies	3	2	1	1
		Analyse current developments in Technology and their future projections	2) Evolution of new material or technology can not be projected on longer time horizon	Method 2: Scenarios	1	2	3	3

Fig 2. Examples of Application of Forecasting process

4. Focus in Forecasting Techniques

Different forecasting techniques have different set of hypothesis and thus, distinct approaches. The focus of the methods deployed is distinctly different. While comparing them to each other, one can easily see the difference in intensity of these factors in various methods.

In some techniques which require more openness of thought such as *Scenario Writing*, the core focus is on the hypothesis simulation / articulation of vision. Although it is in the form of a narrative, the scenarios are usually picked by amplifying some of the important causal factors of today and projecting them in future yielding to more fuzziness of thought and more perturbation.On the other hand, techniques, such as *TRIZ*, that have a more defined set of boundary conditions have a clear focus on data assimilation and simulation of the structure.

In situations where historical data is available and accessible, *Trend analysis methods*, take a leverage of the same by doing rigorous Data Analysis and identifying latent trends, that can be used later for future projections. In these cases, since the vision is based on pre-existing casestudies, perturbations are much more controlled.

Table 1 comprises of an enhanced version of *Taxonomy of Future research methods* proposed by Glenn (2000), plotted against the above mentioned structures. This clearly shows the difference in focus areas of various techniques. Furthermore, the table asserts the importance of Method, assimilation of data and simulation for each forecasting type irrespective of the nature of forecasting technique.

Table 1: Mapping of Forecasting techniques with reference to the structure & prime focus area

Forecasting technique	Data Assimilation	Data Analysis and trend identification	Perturbations / (Chance of error)	Simulation
Bibliometrics	3	2	1	1
Delphi Techniques	3	2	1	1
Environmental Scanning	3	2	1	1
Interactive Scenarios	3	1	2	3
Multiple Perspective	3	1	1	3
Text Mining	3	2	1	1
Participatory Methods	3	1	1	1
Causal Layered Analysis	2	3	2	1
Cross-Impact Analysis	2	3	1	2
Econometrics and Statistical Modelling	2	3	2	3
Structural Analysis	1	3	2	2
Technological Sequence Analysis	2	3	1	2
Trend Impact Analysis	2	3	1	2
Road Mapping	1	1	1	3
Scenarios	1	2	3	3
Simulation-Gaming	1	1	3	3
Agent Modelling	2	2	2	3
Decision Modelling	2	1	2	3

Field Anomaly Relaxation	2	2	2	3
Futures Wheel	2	1	2	3
Genius Forecasting	2	1	1	3
Relevance Trees and Morphological Analysis	2	2	1	3
Systems Modelling	2	2	1	3
TRIZ	2	1	1	3
Sustainability	2	1	1	3

Note: **1**-has to be present but not the key focus area; **2**-important; **3**-very important and key focus area

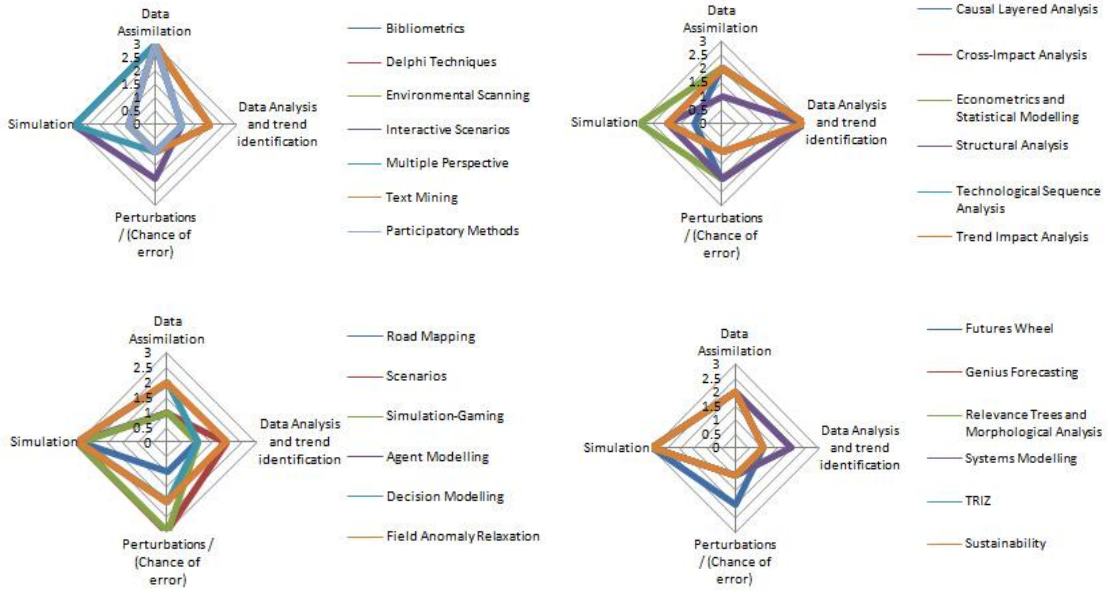

Fig 3. Focus areas of various forecasting methods

4.1 Observations from the Mapping of forecasting methods on the basis of focus area

Most of the techniques work on an established concept (hypothesis set) but the primary focus area is usually dependent on their individual strengths that comes from their requirements, resources at hand and methodologies. A strong historical data set driven forecasting method will have more focus on Data Analysis and Trend Identification. While in cases where we do not have large data sets, the main aim of that forecasting method (such as Bibliometric or Scientometric Analysis techniques) would clearly be to assimilate data for synthesis and analysis. These individual methods may further collaborate with other analysis methods to gather results that could be simulated.

5. Importance of forecasting for design

Designers have always been expected to be a visionary, a futurist and foresee the incoming trends. An important aspect of Designers' strengths is the ability to look into future and endeavour creating it. Page (Page 1966) defined it appropriately as the imaginative jump from present facts to future possibilities. Many researchers such as Evans (2003) believe methods such as *Trend forecasting* to be an integral part of design process itself when he quoted, *"The notion of what the future holds is often central to design process. In essence, it is part of the design process, intertwined with form, function, usability, suitability, sustainability, manufacturability, desirability, and the many, many other considerations designers address."* Thus, future mapping and forecasting are the new generation tools for designers to open new *doors of opportunity* for future. While a designer's usual strength lies in comprehension and synthesis of visual information, they are able to visually represent the results and provide 'vision' for easy understanding.

6. Conclusion

Future visions help generate long-term policies. They provide aid and direction in devising strategies and plans to bring desired and likely future circumstances in closer alignment with the present potentialities. Businesses use various future mapping methods to enhance understanding of needs for future and design products that would represent the evolving needs of the society. The forecasting departments working in these complex fields are multidisciplinary in composition and approach. They include domain experts from various backgrounds alongside the designers. Various specialists work on statistics, ethnographic research, trend analysis, socio-economic data analysis, etc. to envision and articulate all of the nuances and information involved in forecasting.

While several of these approaches have their own focus areas driven by their latent strengths. This has led to convergence of several methods to form a wholesome and coherent solution for more complex situations. The proposed process and identified focus areas in this paper can be used as a stepping stone to formulate newer methods or plan this coherent convergence that can leverage from individual strengths. This can contribute much in the upcoming fields of long term forecasting, design forecasting, social forecasting and environment related forecasting.

References

Bell, W. (1997); *Foundations of Future Studies*, Vol 1-2, Transaction Publishers, New Brunswick, New Jersey

Bruce, M &Bessant, J (2002); *Design in Business*, Prentive Hall. In : Evans, M. (Ed.) (2002); *A Design Approach to Trends and Forecasting*, presented at FutureGround, The Design Research Society Conference, Monsh University, Melbourne, Australia, 17-21 November 2004

Coyle, R. Geoffrey (2001); *Chapter 19: Morphological Forecasting- Field Anomaly Relaxation (FAR)*, AC/UNU Millenium Project

De Bellis, Nicola (2009); *Bibliometrics and citation analysis: from the Science citation index to cybermetrics*. Scarecrow Press. p. 417

Evans, Martyn (2003); *Trend Forecasting for Design Futures*

Evans, Martyn (2004); *A Design Approach to Trends and Forecasting*, presented at FutureGround, The Design Research Society Conference, Monsh University, Melbourne, Australia, 17-21 November 2004

Franssen, Maarten, et al (2013); *Philosophy of Technology*, The Stanford Encyclopedia of Philosophy (Winter 2013 Edition), Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/win2013/entries/technology/>

Glenn, Jerome C. (2000); *Introduction to the Future Research Methods Series*, AC/UNU Millennium project

Glenn, Jerome C. (2000); *Chapter 4: The Futures Wheel*, AC/UNU Millennium project

Gordon, T. J. (1992); *The Methods of Futures Research*, ANNALS AAPSS, July

Helmer, Olaf (1967); *Analysis of the future: The Delphi Method*, RAND Corporation

Inayatullah, Sohail (2014). *Causal Layered Analysis Defined*. *The Futurist* (World Future Society) **48** (1)

Mavrommati, I (2001); *Creativity Techniques*. In: Baumann & Thomas; User Interface Design for Electronic Appliances, Taylor & Francis. London, 51-76

Page, J. K. (1966); *Design Methods*

Puglisi, M& Perry, B (2002); *Conducting Future Studies: The Science of What-If*. In : Evans, M. (ed.) (2002)

Poggenpohl, S (2002); *Design Moves*. In :Frascara, J.; Design and the Social Sciences: Making Connections. Taylor & Francis. London. 66-81

Puglisi M. (2001); *The study of the futures: an overview of futures studies methodologies*. In :Camarda D. (ed.), Grassini L. (ed.). *Interdependency between agriculture and urbanization: Conflicts on sustainable use of soil and water*. Bari : CIHEAM, 2 001 . p. 439 -463