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Investigating the Merge of Exploratory and Normative Technology Forecasting Methods

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Investigating the Merge of Exploratory and Normative Technology Forecasting Methods

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Abstract—This paper aims to investigate the origins and historical evolution and revolution of technology forecasting (TF) methods. A thorough review on TF techniques is conducted to help researchers easily capture numerous methodologies as well as research gaps in the TF field. For over 60 years, a number of TF methods have been developed and recently become a distinct field of investigation of future world. The study introduces a historical overview of the development of TF. A variety of TF approaches, initiated in the 1950s, with the pioneering researches carried out by US department of Defense, and some researchers of The RAND Corporation. The paper also offers a classification of the approaches and methods that are available for TF studies. Mostly revolutionary techniques would have been to combine different methods characterized by the several disciplines, such as exploratory and normative approaches. Finally, the paper proposes research gaps of the main TF techniques, identifying their methodological origin and characteristics. Some concluding remarks and lessons learned complete the research.

I. INTRODUCTION

Technological change is associated with a high degree of uncertainty. Technology forecasting (TF) is continuously recognized as influences in the transformation of individual behavior, organization, economy, society and culture in such a turbulent world. Therefore, government and companies should strive to predict the impacts which technology developments are likely to have on future society as well as business environment. To my knowledge, the first major attempts to forecast technological trends was implemented by National Resource Commission (NRC) in 1935 [1]. In 1941, Japanese’s devastating raids to Pearl Harbor asked US Air Force to assemble a group of top scientists to review aeronautical research and make recommendations about the future of air force in light of probable scientific opportunities in the decades to come [2]. Since 1945 much of work in TF has been developing as a discipline and planning tool, initiated by US Department of Defense, a few aerospace firms, and specialized consulting firms [3][4]. In the 1950s and 1960s, TF was driven by military competition with the Soviet Union, specifically following the “Sputnik Crisis” in 1957. The objective of TF is to anticipate the technological capability of enemies for the defense planning at this time.

With the strong confrontation of technological change, U.S. Air Force put most effort to develop TF techniques and provide unprecedented long range planning, mainly published in 1962 by Ralph Lenz who was head of the Dayton Research Institute’s Technological Forecasting Program, and Joseph Martino who was chief of the Environmental Analysis Division of the Air Force Office of Research and Analysis, as well as its think tank, the RAND Corporation. Companies such as Douglas and Lockheed, its aerospace contractors, also made some efforts on TF [5]. Historically, a number of TF is of much interest to government and to other research institutions, and most of them have been employed to plan technology policy for specific R&D program and to progress the government agendas. Therefore, many governmental organizations have adopted and developed various TF and foresight methods and practices.

The limits of systems analysis became evident and the influence of the RAND brain trust waned [5]. In 1972, the Office of Technology Assessment (OTA) was established as an arm of the U.S. Congress to provide resourceful analysis of the intricate and scientific and technical matters. Post cold war, public policy initiatives and national security are main drivers of TF to predict future technological change as a means to secure a decisive competitive market in the world.

On the other hand, the primary needs of TF shifted from government to private companies. In 1968, Erich Jantsch pointed out that the company started to focus on the integration of technological forecasting with long-range planning, and the implications for organization structure and operations [3]. Furthermore, with the rapid change of technology platform, while many companies are integrated with other functions and government policies, TF activities such as the technology roadmap, business/technology strategy, and information technology (IT) has gained more significance than the accuracy of prediction. In practice, TF is inevitably needed to help to identify and assess opportunities and threats in firms’ competitive business environment in R&D portfolio and new product development and creating strategic alliances such as licensing in/out and joint ventures.

The paper is organized as follows. In Section II, the general background of this study is presented. Section III discusses the characteristics such as its inception, original reference, assumptions, limitations, advantages, and disadvantage with respect to each method. Finally conclusion and recommendations for future research are proposed at Section IV.

II. BACKGROUND

A variety of TF methods have been developed and applied to various industries, organization by diverse
purposes. The corporate has made its efforts on environmental scanning such as bibliometric/patent analysis and market analysis to indentify increasingly diversified needs of customers. Systematic technology innovation management should be established, based on the prediction of technological change. The first step starts with forecasting activity. In the last four decades, especially after the widespread availability of IT, some of the different approaches using much information like patents, journals, and research awards have been continuously developed by different researchers combing with many other tools.

The research questions with which I started this exploration of TF methods are:

- What types of techniques and approaches are employed chronologically?
- What are historically major trends with respect to TF methods?
- What sorts of characteristics of these methods?
- What kinds of techniques have been developed to improve the accuracy of TF?
- Which methods have been and could be combined with each other?
- What applications are in TF domain?

The first thing is to choose the right forecasting method which is most appropriate to the analysis and technology characteristics such as disruptive vs incremental technology. It would depend on uncertainty surrounding technology development, data availability, technology difficulties, funding for R&D. The study reviews various TF methods at each domain which is categorized as explorative and normative. Finally, the paper attempts to answer research questions and provide some aspects on how to integrate two or more approaches into decision making process.

### III. CLASSIFICATION OF TF METHODS

The TF methods are commonly classified under the headings of ‘exploratory’ or ‘normative’ [6][7]. This study divides TF techniques into normative, exploratory, and the combination of two groups, according to Technology Futures Analysis Methods Working Group [8]. (See Table 1)

Exploratory TF is the attempts to predict the technological state-of-art that will or might be in the future [6]. It starts from today’s assured knowledge of what has happened in the past up to the present day and is predicting towards the future events. It includes those methods based upon an extension of the past through the present and into the future. To some extent, exploratory forecasting is regarded as illustrating the inevitable future, so that there is little left to affect or alter through planning [3].

Normative TF first assesses future goals, needs, desires, missions, etc. and trace backward to the present at some desired or possible state of events not only determining steps necessary to reach the end point, but also assessing the probability of their success [6]. It starts from the future backward. It mainly focuses on the possible statements that what ought to be or needs to be realized at certain future time. Normative TF aims to provide groundwork to allocate technology-generating resources such as investment, human resource and others in order to reach organizational objectives. Typical characteristics that lead to exploratory as well as normative forecasting include the following.

#### A. Normative / Explorative TF

1. **Delphi method**

The Delphi method is one of the oldest techniques of eliciting responses and refining expert group decisions [9]. Helmer, Dalkey, Rescher, and others at RAND Corporation developed the Delphi method in the early 1950’s, which was designed to remove conference room impediments to a more structured expert consensus [10]. A variety of TF and national technology foresight studies mainly use Delphi with the participation of hundreds or thousands experts [11]. It can provide a more feasible forecast in terms of emerging technology and long range (20- 30 years) planning, if trend analysis based on historical quantitative data is not possible.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Characteristics</th>
<th>Citation</th>
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</table>
| Exploratory        | The attempts to predict the technological state-of-art that will or might be in the future. | - evolve on a predetermined curve such as S-shaped  
                      |                                                                              | - too naive  
                      |                                                                              | - project anticipated consequences  
                      |                                                                              | - suggest alternatives to the proposed allocation                    | [6][8] |
| Normative          | The statement of what ought to be or needs to be possible at some future time | - more proactive  
                      |                                                                              | - too complex and mathematically intricate  
                      |                                                                              | - meaningfulness of its treatments of goals is significant  
                      |                                                                              | - recognition of economic potentials  
                      |                                                                              | - recognition of responsibility towards society or nation  
                      |                                                                              | - awareness of constraints (natural resources, company resources, etc.)  
                      |                                                                              | - recognition of an ultimate technological potential  
                      |                                                                              | - hedging against threats                      |          |
| Normative/Exploratory | Can be used in two different approaches                                       | - merging two different characteristics described above                          |          |
2. Nominal Group Technique (NGT)
NGT was introduced by Delbecq, Van de Ven, and Gustafson in 1968 as an organizational planning tool [12]. In contrast to the Delphi method, NGT not merely holds effectively structured meetings facilitated by a third party moderator, but also involves efficient discussion among participants concerning each expert’s initial opinion [13]. NGT allows bandwagon effect of majority such that the group leader or a strong expert may affect the panel consensus with limited range by prioritization using secret ballot during discussion of vote phase.

The NGT has been mainly used for participatory problem solving approach by group analytical decision making in social science field [14] and extended the application to almost any problem and field such as health care studies [15][16][17], social service [18], consumer research [19], new product development [20], and information system [21].

3. Scenario Planning/Writing
Scenario planning formally started from the use of computer simulation to measure probabilities of the atmosphere and planet catching fire in the Manhattan project in 1942 [22]. The Rand Corporation also mainly introduced scenario planning for US military purpose by Herman Kahn in 1950s, based on the previous groundwork of computer simulation, game theory, and war games [23]. Furthermore, private companies such as Royal Dutch/Shell and GE developed scenario planning technique for corporate strategic planning in the late 1960 and early 1970s [24][25][26]. For example, Shell’s adequate and timely reaction to the oil crisis in 1973 drew attention to the scenario analysis [25][27].

Scenario planning can be classified variously based on different aspects of it such as project topic, process design, time and etc [28][29]. There are two kinds of distinct scenario approaches with respect to TF: projective (descriptive) and prospective (prescriptive) [30][28][31]. Projective scenarios explore possible future images from current situations like future forward. They describe what can happen. On the contrary, prospective scenarios describe probable or preferable futures on the basis of different visions of the future. They write scenarios how to reach several significant objectives like backcasting.

4. Technology roadmapping
Technology roadmapping was first used by Corning and Motorola to build up corporate and business strategy in the late 1970s [33]. Motorola popularized its own technology roadmap which has a single layer roadmap, focusing on the technological evolution associated with a product and it’s features as a business planning tool in 1987 [34]. Technology roadmapping attempts to reveal a specific characteristic or an attribute of technology development over designated future time.

Technology Roadmapping typically takes a retrospective (top-down) approach which backwardly illustrates how to accomplish a given target from decades past to the present or a prospective (bottom up) approach which looks forward from the present to the future and also has a combination form of them [35]. Most of technology roadmaps, however, involve prospective process which has two different types analysis: market pull and technology push [36][35]. The prospective approach is typically employed in TF.

B. Exploratory TF Methods
1. Growth Curves; S-Curves
The growth curves are the oldest techniques, and also widely used in practical applications for TF. The growth curves typically exhibits an “S-shaped” characteristic like life cycle over a period of years, because technologies tend to evolve on patterns similar to the growth curves of biological systems from experience [37][4]. It associates with fitting a growth curve to a set of data over time of technological characteristics. Like life cycle, substitution curves are a type of growth curve that project the substitution of one technology for another or the rate of penetration of some technology into a market [38][39].

Like life cycle, substitution curves are a type of growth curve that project the substitution of one technology for another or the rate of penetration of some technology into a market [38][39]. Since Mansfield, as a pioneer, proposed technology diffusion model incorporating the rate of imitation and technology adoption, a variety of growth curves such as the Mansfield-Blackman model (1961, 1972), the Fisher-Pry model (1971), the Extended Riccati model (1976), the Bass Model (1969), Weibull (1980), NSRL¹ (1981) and Harvey (1984), etc, have been developed to forecast S-shaped pattern of technological advance [40].

<table>
<thead>
<tr>
<th>Types</th>
<th>Characteristics</th>
<th>Inception</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intuitive Logics</td>
<td>- developed by Shell</td>
<td>Late 1960s</td>
<td>[27][32]</td>
</tr>
<tr>
<td></td>
<td>- appropriate for short-term forecast</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- restrict the diversity of the constructed scenarios</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trend Impact Analysis</td>
<td>- employed by the Future Group</td>
<td>early 1970s</td>
<td>[32]</td>
</tr>
<tr>
<td></td>
<td>- a combination of statistical extrapolations with probabilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cross-Impact Analysis</td>
<td>- practiced by Battelle with BASICS and the center for Futures Research (INTERAX)</td>
<td>1966</td>
<td>[24][32]</td>
</tr>
<tr>
<td></td>
<td>- a highly formalized method</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ NSRL: Non-Symmetric Responding Logistic
2. Bibliometrics

Literature Analysis

McKeen J. Cattell, a pioneer as a psychologist, first used literature data to measure performance and productivity of scientists in 1906 [41]. There were some bibliometric studies around 1920, using statistical techniques, although using the older terminology ‘bibliography’ [42]. The term ‘Bibliometrics’, however, was coined from Pritchard who introduced it to replace ‘statistical bibliography’ in 1969 [43]. One of the general definitions is “the search for systematic patterns in comprehensive bodies of literature” [44]. Bibliometrics aims to analyze the impact of different fields and a set of researchers through exploring a wealth of historical literature data. In the context of TF bibliometrics can be defined as the research of statistical analysis to produce and disseminate the information with respect to the use of recorded literatures for forecasting and decision making.

Bibliometrics is typically classified in descriptive research and behavioral studies [44]. Since Science Citation Index was established in 1961 and Compendex, COMPuterized ENgineering in DEX, also was started in 1970 as an Engineering Index, bibliometrics has been popularized and becoming more significant in TF over the years with the advancement of DB system [45][46].

Since 1927, various types of bibliometric tools have been developed to analyze descriptive statistics, affiliation, authors, countries, and collaboration of literatures. Since D. Price first analyzed the literature linkage using citation index to identify scientific structure, bibliometric citation network analysis has been used to identify research gaps and track emerging research fields in literatures [47][48].

Patent Analysis

There are much more similarities than discrepancy between literature biliometrics and patent bibliometrics [49]. Patents provide complementary information in bibliometrics. Patent data have valuable information such as geographical distribution of particular inventions, citation networks and patterns in terms of particular technology in order to monitor technological trend as well as innovative activities and new product development for forecasting [50][51].

To the best of my knowledge, the first attempt to analyze patents statistically was made by Applebaum in 1920s [52]. Thereafter, a number of studies have used patents to measure innovativeness and difference, technological advance, and the rate and direction of technology development since 1930s [53][54][55][56][57].

Gilfillan used the inventive cycle of patent as a technique for TF in 1935 [58][59]. With respect to patent statistics, cumulative or actual patent counts in application or grants, a time-series of patent trend, and percentage of patents in total are most widely used in a measure of innovativeness, a rate of technological change, and research output [60][61][62][63]. Patent trend analysis provide growth pattern of a technology with the lifecycle of it.

3. Data Mining; Text (Data) Mining

Through rapid evolution of IT as well as flood of data, Data Mining (DM), Text Mining (TM), Tech Mining, Database Tomography (DT) have become practical techniques for assisting the forecaster to identify early signs of technological change [5][70][71][4][72][73][64]. Lovell, Michael C. first used the term ‘DM’ to propose econometric data mining in statistical variables’ tests in 1983[65]. Data mining can be identified as a subset of Knowledge Discovery in Database (KDD), since KDD process is comprised of data preparation, data selection, data cleaning, data mining, incorporation of appropriate prior knowledge and proper interpretation of the results [66][67].

DM typically makes use of structured database. Textual data mining, however, is concerned with the process of extracting interesting and non-trivial patterns or knowledge from unstructured text documents [68]. TM appears a subject of DM, since text is just different form of data. In recent years, TM tool has gained popularity to explore the textual based documents such as literature and patents in bibliometrics [69].

<table>
<thead>
<tr>
<th>Approach</th>
<th>Characteristics</th>
<th>Inception</th>
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<tbody>
<tr>
<td>Data Mining</td>
<td>- time-consuming</td>
<td></td>
<td>[70]</td>
</tr>
<tr>
<td></td>
<td>- relatively expensive</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- appropriate for discontinuous technology forecasting</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>- multword phrase frequency analysis</td>
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<td></td>
<td>- phrase proximity analysis</td>
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<td></td>
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<tr>
<td></td>
<td>- time-consuming</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>- identify promising/emerging research/technology opportunities</td>
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<tr>
<td></td>
<td>- develop an independent R&amp;D taxonomy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Tomography</td>
<td>- time-consuming</td>
<td>1991</td>
<td>[45][46]</td>
</tr>
<tr>
<td></td>
<td>- relatively expensive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Text Mining</td>
<td>- time-consuming</td>
<td>1995</td>
<td>[71]</td>
</tr>
<tr>
<td></td>
<td>- relatively expensive</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- appropriate for discontinuous technology forecasting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tech Mining</td>
<td>- not restricted to mining abstract publication and patent records. It combines text and numerical data to best answer the questions</td>
<td>2000</td>
<td>[64]</td>
</tr>
</tbody>
</table>
4. Analogies; Comparison-Based Prediction
   Analogy is typically defined as recognizable similarity or resemblance of form or function, but no logical connection or equivalence - as distinguished from a model. Forecasting by analogy attempts to predict possible futures by systematic comparison of the technology with similar one in a certain industry by investigating historical data. Analogies is a natural process using an intuitive thought based on similarities and is commonly used in inductive inference [72][4]. Thomas O’Connor provided insightful overview and various applications of analogies techniques in different field such as mythology, science, economics, politics, military, philosophy and religion [72].

5. System Dynamics
   The System Dynamics (SD) method was first introduced by Jay Forrester at MIT in 1961[73][74]. SD is an analytical approach to analyze dynamic behavior of complex social systems and to understand and influence how things change over time, based upon traditional management, cybernetic theories or feedback theory and computer simulation [75][76][24]. In 1968, its application expanded from corporate modeling to broader social systems [77].
   With respect to TF application, SD is used not to predict the emergence of particular technologies, but to forecast future performance and system behavior or a pattern of variation of current system with no modification over a period of time [78]. SD is completely deterministic modeling focusing on causal connections, based on the assumption that the system of past development will hold in the future [79].

6. TFDEA
   Data Envelopment Analysis (DEA) which was developed by Charnes et al. in 1978 and extended by Banker et al. (BCC) in 1984 [80] can provide the systematic process for evaluating alternatives, implementing strategies, and improving performance by benchmarking other decision making units. It also offers clear understanding key characteristics to forecast technology trend by using benchmarking other companies as fast-followers. In this viewpoint, since its inception in 2001, TF using DEA (TFDEA) method can offer quite a bit implementable tool to decision makers. This technique is to measure the technological rate of change in order to forecast future technological advance. There have been some case studies to validate the method usability applied to a variety of industries including enterprise database systems, microprocessors, hard disk drives, portable flash storage, fighter jet and Turbofan Jet Engines [81][82][83].

C. Normative Forecasting Methods
1. Relevance Trees
   The relevance trees are one of the most traditional normative TF methods. The concept of relevance trees linked with decision making was first addressed in 1957 by Churchman et al. [84]. Qualitative relevance trees were first designed to aid decision making process [4][84]. Thereafter, quantitative relevance tree techniques were pioneered by the PATTERN (Planning Assistance Through Technical Evaluation of Relevance Numbers) scheme which was first applied to military and space activity program in large scale by Honeywell’s Military and Space Sciences Department in 1963, refined and extended to all military and space activities in which Honeywell have interest in 1964 [85][86].

2. AHP (Analytic Hierarchy Process)
   AHP is a method that uses criteria and pair-wise comparisons between the criteria to ascertain the relative importance of each with respect to each other. Since Thomas Saaty introduced AHP method in 1980 [87], it has widely been accepted as a technique to prioritize the elemental issues in complex problems in decision making process with the various applications of forecasting, selection, evaluation, Benefit-Cost analysis, allocations, planning and development, priority and ranking [88].
   There are few application literatures discussing the TF using AHP method, even though TF using AHP provides an opportunity to contain the tangible as well as non-tangible elements, and the capability to develop environmental factors [89]. AHP was employed in forecasting the technological capabilities with growth curves [89]. Recently, this technique was applied to as a part of the technology roadmapping framework [90].

3. Morphological Analysis
   J.W. Goethe introduced the term of “Morphology” to denote the principles of formation and transformation of organic bodies. This early theoretical morphology was eclipsed by Darwinian evolutionary theory in late 19C. Goethe initially provided methodological type-concept in his conception of morphotypes [91]. However, Max Weber simplified, generalized and popularized typology analysis as a simple concept-structuring method applicable to virtually any area of investigation [92]. Morphological analysis (MA) was coined by Fritz Zwicky, a Swiss astrophysicist and aerospace scientist, who was using the method in 1942, and who propagated it by founding a Society for Morphological Research [93].
   MA is used to analyze the structure of problems and to derive the performance requirements for individual element among the remaining solutions for normative TF [4]. This method has been not only extended to the areas of policy analysis and future studies, but also computerized to structure and analyze intricate policy issues, develop future scenarios and model strategy alternative [94][95].

4. Backcasting
   Backcasting is one of the normative technology future analysis methods which involves setting policy goal at first
and then determining how those goals could be reached from desirable future to the present [8]. Backcasting is not intended to indicate what the future will likely be, based on the probability, but to indicate the relative feasibility and implications of different policy goals and alternative future on the basis other criteria like scenario approach [96]. Historically, this method has the same origin as the strategic and multiple scenario approaches which was popularized by Shell in the early 1970s [97]. Backcasting technique adopts a scenario approach in order to identify possible alternatives and to analyze consequences and conditions for these futures to be achieved [98].

IV. ANALYSIS OF THE RELATIONSHIP AMONG TF METHODS

In this section, the paper attempts to analyze the historical relation between normative and exploratory methods in literatures and identify the methodological linkages among them. Some TF methods are tightly employed together to predict the technological change or innovations, but others are not. It is, however, theoretically inappropriate to use composite methods among them in order to solve practical forecasting problems, in case of that it has the conflict of assumptions based on them. Furthermore, the selection of proper TF methods depends on the nature of the technologies [99]. Therefore it requires experience and expertise in various TF techniques to select the appropriate forecasting models. This paper categorizes TF techniques according to exploratory and normative approaches. This study analyzes the applicability of technology characteristics such as disruptive/discontinuous and continuous technology. Figure 1 presents a matrix of TF methods by type of techniques and technological characteristics. Within each cell, TF methods are listed in descending order of frequent and effective uses.

Methodologies in TF are not fixed, a combination of different approaches and methods are required to improve the accuracy of forecasting in many cases. Hybrid methods, combinations of different forecasting methods, are superior to forecasts based on a single method [100]. A combination of multiple techniques enables forecasters to analyze various perspectives (organizational, technology, personal, social, and environmental) [101]. The famous experts in TF argue that complexity science and rapid social change required the need for emerging tools and combined forecasting methods with exploratory as well as normative techniques [102]. During the last four decades, especially after the emergence of IT, some of the different approaches using much information like patents, journals, and research awards, have been continuously developed by different researchers combing with many other tools. Figure 2 shows the chronological tree of TF methods in a timely mannered way.

There are a number of papers to combine with other TF tools in order to offset weaknesses of one forecasting technique such as technology roadmapping with scenario technique [103], Delphi with cross impact analysis [104], Bibliometric with growth curves and system dynamics [101], and technology roadmapping with morphological analysis and text mining [105], etc. This study identifies research method linkage for TF through literatures review. Fig. 3 provides the correlation between TF methods. Some articles combine the exploratory and the normative approaches to TF. Most of linkages are related with between exploratory and exploratory/normative methods or normative and exploratory/normative techniques. Furthermore, there are a few direct linkages between normative and exploratory methods, just except the combination of text mining and morphological analysis. These characteristics of relationship among TF methods reflect similarities in assumptions as well as methodological backgrounds among them. Research gap can be found in this correlation map among TF techniques.

![Fig. 1. A Matrix of technology forecasting tools](attachment:image.png)

Fig. 2. The Chronological Tree of Technology Forecasting techniques

Fig. 3. The correlation map among TF techniques
V. CONCLUSIONS

This paper starts with an introduction to TF in historical overview and analyzes diverse characteristics, advantage/disadvantage, origins and chronological evolution in a variety of TF methods. Finally, the study ends with some evolutionary figure not only to identify research gap but to select applicable and practical TF methods for future study in terms of different field like biomedical device. Further researches are needed to survey the efficiency and effectiveness of combined methods in order to compare outputs in this paper. Text mining or co-word analysis in literatures of composite TF techniques leads to future research to analyze quantitatively the relationship among TF methods. Lastly, more comprehensive reviews which include econometric, correlation method, causal model, simulation and TRIZ, etc would be a good benefit for this analysis. In summary, the study provides an informative summary of TF methods for the researchers and practitioners for their future work. New approaches with different combination of TF tools would be open to all forecasters.

REFERENCES