An Epistemological and Methodological Study of Technology Foresight

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ABSTRACT

This research is an epistemological and methodological study of technology foresight. The low realisation rate (28%) of technology foresight has put into question as to whether foresight research is a scientific research, and whether foresight method is a scientific method. In this research, the notion of scientific method is critically analysed. A comparison between physical and social science research is also made in order to highlight their basic similarities and differences. The Delphi method, which is the fundamental method of technology foresight, is epistemologically evaluated, particularly with regards to its basic assumptions and premises. Apart from the above, the research also looks into practical issues and experiences of technology foresight in foreign countries. This will go a long way in helping Malaysia, a novice in the field of technology foresight, to avoid some of the pitfalls as experienced by those countries. It is the argument of this thesis that the concept of *la prospective* should be fully appreciated so that foresight research would prepare decision-makers for uncertainty instead of eliminating the uncertainty. In this respect, accuracy should not be the sole concern of foresight study; and spin-offs of foresight activities should be highly valued.

ABSTRAK

Kajian ini merupakan satu kajian epistemologi dan metodologi pencaman teknologi. Kadar realisasi pencaman yang yang rendah (28%) telah menimbulkan persoalan sama ada pencaman teknologi adalah satu penyelidikan yang saintifik dan sama ada kaedah yang digunakan untuk pencaman itu juga saintifik. Dalam kajian ini, ungkapan kaedah saintifik telah dianalisis secara kritis. Satu perbandingan di antara penyelidikan sains fizikal dan sains sosial telah dibuat untuk mengemukakan persamaan dan perbezaan asas di antara dua bidang ini. Kaedah Delphi yang merupakan kaedah asas pencaman teknologi juga telah dinilai dari segi epistemologi; terutama dari aspek andaian dan premis asasnya. Di samping itu, isu – isu dan pengalaman pencaman teknologi di luar negara turut dianalisis. Hasil analisis tersebut mungkin dapat membantu Malaysia, yang merupakan peserta baru dalam bidang ini, untuk mengelak daripada mengulangi kesilapan – kesilapan yang telah berlaku dalam perlaksanaan program pencaman di negara-negara tersebut. Tesis ini menganjurkan agar konsep *la prospective* dihayati sepenuhnya supaya pencaman teknologi dapat membantu pengubal dasar untuk menghadapi dan bukan menghapuskan ketidaktentuan. Dalam konteks ini, kejituan bukanlah satu-satunya tujuan pencaman, faedah-faedah sampingan aktiviti pencaman mempunyai nilai manfaat yang tersendiri.

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INTRODUCTION

An Epistemological and Methodological Study of Technology Foresight

1. Introduction

Prior to the 1997 economic crisis, Malaysia's economy was performing well. Between the year 1990 and 1995, the average GDP growth of our economy was at 8.7%. At certain stage, we were even perceived as the potential 5th "economic tiger" in East Asian, along with the other 4 Newly Industrialised Countries (NICs). The rapid economic growth of the country was largely powered by our industrialisation programme, which was reflected in our manufacturing output. In 1980, manufactured goods made up only 19% of the exports. By 1995, the figure had increased to 77.4% (Jomo & Felker, 1999: 1). It is in this context that technology, particularly industrial technology, plays an important role in our economic development. This is reflected in the the First Industrial Master Plan (1986-1995) which emphasised the country's need to "leap-frog" our technology from the "pre-standardisation" and "pre-commercialisation" stage to those at par with NICs and advanced industrial countries (Anuwar Ali, 1992: 37).

The importance of technology to economic development is no longer a point in contention. The subsequent question, however, is to decide on what technologies to develop. As the development of technology becomes increasingly expensive, nations,

particularly smaller nations, and firms find it difficult to accommodate all research programmes. Selectivity and priority setting is called for (Ziman, 1994). It is in the wake of this phenomenon of rapid technological change, shorter product life cycle, and higher research expenditure that technology foresight makes its way into various countries and gained acceptance as a way for rational decision making (Dijk, 1991: 223).

Inquiry into future knowledge is not a new phenomenon. It has probably existed as long as mankind has survived. Thousands of years ago, our ancestors had engaged in activities of prognostications, foretelling impending fortune and disasters with the assistance of supernatural power that they had faith in. The advent of technological age brought in technological forecasting. In the early age, much of the forecasting was done through "extraordinary" stories, of which we term as science fictions today. Scholars have suggested that the first genuine science fiction was written as early as 160 AD (Kyle, 1986: 12).

Technology foresight in its current form, however, is a relatively new concept[1]. It was popularised in the 1950s and 1960s as the advent of Cold War stimulated intensive search for weaponry with higher technological capability. However, the euphoric quest and confidence in technological forecasting faded in the 1970s as participants were disillusioned by inaccurate predictions. Early analytic techniques of

[1] The term "foresight" used in the context of technology has in it a certain connotation which is accepted among foresight researchers. It signifies a conceptual change from a deterministic outlook of future to a provisional one (Grupp and Linstone, 1999: 86). This will be further explained in the following chapters.

technology foresight, such as trend extrapolation and growth curve, which tend to focus on a single aspect of a complex social system, were unable to fully discern forces of technical change and thus failed to deliver the promises of technological forecasting (Linstone, 1999: 2-5).

This early disappointment, however, did not affect technology foresight negatively. Indeed, in the 1990s, we see a "global resurrection'' of technological forecasting (Grupp and Linstone, 1999). Today, many developed and developing countries are using technology foresight as an effective tool to look into the future of technological development. Malaysia has also joined the rank recently.

Malaysia first makes its policy statement on the need for a foresight programme explicit in its Seventh Malaysia Plan, where the need for a "national technology map to identify long-term technology development targets" is specified (Malaysia, 1996: 433). Subsequently, the Malaysian Industry-Government Group for High Technology (MIGHT), under the jurisdiction of the Office of the Science Advisor in Prime Minister's Department, undertook a National Technology Mapping Programme (NTMP) in 1997. Among others, the NTMP aims to identify the kinds of technology that need to be pursued by the nation in the longer term. Malaysia, however, is not the first Asian country to embark on such a foresight programme. Japan, has over the past 30 years, consistently carried out technology foresight programme in a five-yearly interval (Kuwahara, 1999).

2. Literature review

Technology forecasting has only emerged as a systematic field of research in recent decades. As stated above, the arrival of Cold War had prompted US military to engage itself extensively with technological forecasting in the 1950s and 1960s (Linstone, 1999). Many of the early publications in this field drew strongly from results of these efforts. One of these is the book *Technological Forecasting for Decision-Making* by Joseph Martino, published in 1972 (Linstone, 1999:3). Prior to this, Erich Jantsch's had also published a book entitled *Technological Forecasting in Perspective* in 1967, which according to Martino (1999:13), had served to legitimise technological forecasting and provide it with intellectual credential. Other books like *Technological Forecasting for Industry and Government* by James Bright (1968), *The Year 2000* by Herman Kahn and Anthony Wiener (1967), and *The Art of Conjecture* by Bertrand de Jouvenel (1967) are no less important in setting the foundation for this area of research. A journal wholly devoted to this field of study, *Technological Forecasting and Social Change*, had also been published in the year 1969 (Linstone, 1999).

The journal *Technological Forecasting and Social Change* is one of the major sources that carries debates and discussions on issues of technology foresight for the past 20 – 30 years. Inside the journal, we can find discussions and debates on technological forecasting ranging from the fundamental philosophical issues to practical policy implications. From the available literatures, we can basically divide foresight researches into three areas, bearing in mind that this, however, does not

imply that these areas are mutually exclusive. Much of them are inter-related in one way or another.

The first kind of literature is basically reports and analysis of practical results of technology foresight. Most of these publications were done over the past fifteen years. The book *Research Foresight: Priority Setting in Science* by Martin & Irvine (1989) is a seminal piece of its kind. Many of these publications are practical experiences of the members of the Organisation of Economic Co-operation and Development (OECD). Experiences of these countries are recorded, among others, in journals. The journal *Science Technology Industry Review* devoted its 17th Volume (1996) to these technology foresight experiences of OECD members. And the journal *Technological Forecasting and Social Change*, in commemoration of its 30th anniversary, devoted its 60th Volume (1999) to technology foresight, updating some of these experiences by including newcomers to the field of foresight research. With the proliferation of information technology in recent years, some of these materials are now also available on internet. An example is a web-site maintained by the Australian Science, Technology and Engineering Council at:

http://www.dist.gov.au/science/astec/astec/future/intpers/contents.html.

The publication of these experiences will no doubt help to propagate the activity of technology foresight. In recent years, countries in Central Europe (Blind, Cuhls, & Grupp, 1999), Korea and certain Asian countries (Shin, Hong, & Grupp, 1999) have also joined the rank. By highlighting problems and issues, weaknesses and strengths of foresight approach in different countries, these literatures help to advance

the knowledge of technology foresight. In fact, exchanges of views and opinions among different countries have also opened up the possibility of international co-operation in technology foresight (Martin, 1996: 43-45).

The second type of literatures that can be identified are those concerning foresight methodology. Future knowledge is generated by using future research methodology. As the uncertainty of future knowledge remains unsettled, efforts are being made to improve the methodology. Earlier researchers have tried to refine foresight methods according to the mould of scientific method. This was the time when issues like reproducibility, validity and value-ladenness of foresight methodology were being debated (Amara & Salancik, 1972). In fact, Sackman (1974) made a relentless attack on Delphi method by comparing it with scientific method. As we will see later, this issue of science and non-science will continue to beset the foresight activity, and remain unresolved until today.

Literatures on foresight methodology come in many forms. Some books focus their analysis on a specific method such as the book *The Delphi Method: Techniques and Applications* (Linstone and Turoff, 1975). Others like *A Review of Technology Forecasting Techniques and Their Applications* by Saren and Brownlie (1983) provide analysis across various methods. Among all the foresight methods, Delphi is one of the most extensively studied (Rieger, 1986). Researches on Delphi method ranging from broad-base theoretical problems (Rowe, Wright, & Bolger, 1991) to miniature analysis of certain aspects of Delphi such as ways of analysing data from Delphi panels (Dietz, 1987). Apart from that, there are also researchers who look at

forecasting methods from specific perspective such as philosophy of science (Vught, 1987) and human psychology (Evans, 1982). This helps to clarify some of the fundamental problems which may oblivious to foresight researchers themselves. Though many efforts have been devoted to improving foresight methodology, a veteran foresight researcher Olaf Helmer (1989:39), however, opined that the progress in foresight methodology is rather slow. This is partly a result of distrust of foresight as a scientific research.

The third kind of literature deals generally with the issue of validity of future knowledge. As we know, future facts are non-existent. One can only know whether a piece of knowledge about future holds when it materialised in future. Hence, the question of whether future knowledge is reliable arises. This scepticism is a legitimate one. How can one tell whether a piece of future knowledge is true, even if it is based on genuine and prudent analysis? We can not unless we can make a time travel into future. The first Japan's Delphi research indicates that average realisation rate of technology foresight is only 28% (Kuwahara, 1999: 12). It is thus hardly convincing for decision-makers to base their judgement solely on foresight results.

It is against this backdrop that the concept of *la prospecting* was developed (Godet, 1986). This concept acknowledges the uncertain nature of future knowledge. It inspired foresight researchers nowadays to conjure up a few (instead of one) images about future in their foresight analysis. An example of analysis on the validity of foresight knowledge is an article by Bell and Olick entitled *An Epistemology for the Futures Field: Problems and Possibilities of Prediction* (1989). The lack of accuracy

in future knowledge has left many rooms for scholars to deem technology foresight an unscientific endeavour and foresight method a non-scientific method. A defence against this attack is exemplified by an article *Is the Futures Field an Art Form or Can It Become a Science* (Bell, 1987). However, some future researchers themselves concede that foresight research is an art rather than a science. Jouvenel (1967) unambiguously reflected this belief in the title of his book, *The **Art** of Conjecture* (emphasis added). Coates (1975), in defence of Delphi method, had also admitted that Delphi is not a scientific tool; and as such, to his opinion, Sackman's (1974) critique of Delphi as unscientific was totally misplaced. All these point to the fact that foresight knowledge is yet to achieve a satisfactory level of credibility parallel with scientific knowledge.

The literature review above has highlighted the major research niches in the field of technology foresight. These are areas involving practical, methodological and philosophical issues of technology foresight. It has provided a panoramic view of research activities in the field of technology foresight.

3. The research problem

As mentioned earlier in Section 1, foresight researchers see a "resurrection" of the activity of technology foresight in recent years. This, however, is achieved amidst the unsettled and incessant problem of foresight inaccuracy. With a foresight accuracy

rate of 28%[2] (Kuwahara, 1999: 12), one may wonder how this resurrection is made possible in the first place. It also raises question of whether this resurgence can be sustained.

The outcome of Japan's first Delphi survey has basically rendered the issue of predictability of future technological development unsettled. A realisation rate of 28% basically means that future technological development could only be partially foresighted. The problem of foresight inaccuracy could be a result of an inferior methodology and/or the inherent nature of uncertainty in future development[3]. Which ever the case is, it will have a bearing on the future development of technology foresight. It may discourage enthusiasm of participants. In fact, a veteran forecaster and the founder of Delphi method, Olaf Helmer, in a brief review of the field of future study, has attributed the lack of development in the field in recent decades as partly contributed by the distrust of the field as an activity with sound scientific underpinning (Helmer, 1989:40). The lack of confidence in foresight research, particularly with respect to the issue of predictability of science and technology development[4], has also been identified as one of the major reasons to why response rate of German Delphi survey is only 30% (Breiner, Culhs, & Grupp, 1994:144).

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[2] If items partially realised are included, the average realisation rate can rise up to 64%. Please refer to Chapter 3 (section 3.3.) for more details.

[3] In Japan's Delphi survey, experts agreed that if realisation rate is lesser than 17%, then technological development will be considered as occurring in random (Martin, 1995: 144). A realisation rate of 28% has basically defied this idea of random technological development.

[4] In a German Delphi survey, one typical German respondent make the following remark, "I hope that, in the best case – the policy impact of the Delphi will be zero. You can not predict science. Government planners should know this. Strong priority setting enforces meaningless projects..." (Breiner, Culhs & Grupp, 1994: 144).

As Malaysia has also engaged herself with the activity of technology foresight in 1997, an in-depth understanding of the practice of technology foresight is necessary. Besides, Malaysia should also tap widely into foresight experiences of other countries in order to save herself from reinventing the wheel of others. As the newcomer to the field of technology foresight, Malaysia lacks not only practical experiences, but also basic understanding of the philosophy, logic and principles of technology foresight. All these issues need to be addressed in order to be better prepared for a beneficial use of technology foresight. This research is part of the efforts toward that end.

4. The scope of research

The scope of this research is divided along three lines of investigation. First, as regard to the foundation of future knowledge. As the accuracy rate of technology foresight is only 28%, it would be necessary to find out what are the factors contributing to this mediocre performance. To this extent, the research is basically an epistemological study. It is a study about the validity of future knowledge. The causes and sources of uncertainty in foresight knowledge will be surveyed. As future knowledge is generated through the application of foresight methodology, the research will also look into this particular aspect. The Delphi method (as the backbone of foresight methods in recent years) will be used to illustrate the procedure, underlying assumptions, strengths and weaknesses of foresight methodology. Prior to this, the research will also make an exposition into the scientific method (as an established

method of knowledge acquisition) and identify its limitations when used in the "less exact"[5] field of social study.

Second, as regards to foreign foresight experiences. With a renewed enthusiasm, many countries have started their programme of technology foresight in recent years. Some of these researches have been completed and results published. The organisation structure, methodology, difficulties and benefits of foresight research are presented in these reports. These valuable experiences are very useful to a country like Malaysia, which is still at the early years of its foresight programme. The foresight experiences of these countries will be summarised as issues of technology foresight. As far as these issues are concerned, these are practical foresight knowledge of various organisations from different countries. These issues, whether settled or unsettled, will be included in this research as long as they are deemed relevant and important to the practice of technology foresight.

Third, as regards to the strategy of technology foresight. The recent resurrection of foresight activity is paradoxical in the sense that it is a renewed interest amid bewilderment of the reliability of foresight results. The question thus is how can one bypass this issue of lack of foresight accuracy (28% of realisation rate) in doing foresight research? In this respect, the research will look into strategies employed and justifications adopted by foresight researchers and decision-makers in resolving the paradox. These will include discussion on changes in the concept of technology

[5] Some scholars regard the study of social environment as an "inexact" science as compared to the "exact" physical/natural science (Helmer, 1983:25-31).

foresight, together with its methodological and practical implications. Apart from that, the research will also seek to identify other underlying forces that help to shape this renewed passion in technology foresight. Other criteria used in justifying the usage of foresight approach, apart from foresight accuracy, will be determined.

In brief, the research will look into both the philosophical and practical aspects of technology foresight. In terms of philosophical analysis, it will limit itself to the aspect of foresight epistemology, i.e., issue concerning the validity of foresight knowledge. It will not, however, deal with metaphysical issues of technology foresight, i.e., existential issues concerning the "reality" of future. On the practical level, it will survey the empirical foresight experiences in other countries. These will be summarised as issues of technology foresight. Subsequently, the research will try to identify strategies employed in technology foresight in dealing with the uncertain nature of future occurrences, hence, future knowledge.

5. Research objectives

Malaysia is a novice in the field of technology foresight. The concept of technology foresight is relatively new to this country. As stated in Section 1, it was only introduced to the country in 1997, when Malaysia Industry-Government Group of High Technology (MIGHT) first launched the National Technology Mapping Programme (NTMP). As such, it is most appropriate for researchers to carry out research at a more fundamental level. It is with this understanding that the objectives of this research are laid. Among others, the research seeks to:

a. Explore the concept of technology foresight

There is an urgent need to gain an in-depth understanding about the activity of technology foresight at both the conceptual as well as practical level. The very meaning of technology foresight need to be scrutinised and its underlying philosophical assumptions need to be analysed. Only with an understanding of principles of technology foresight, can we organise our foresight plans and execute them with efficiency and effectiveness.

b. Analyse foresight experiences of other countries

Many countries, such as Japan, Australia and United Kingdom, have launched and completed part of their ongoing foresight programme[6]. By looking into their experiences, we may save ourselves from part, if not all their troubles. These experiences can be summarised into various issues of foresight research. Some of these are contentious issues that have remained unresolved over the years.

[6] Martin and Irvine (1989) collected foresight experiences of some of the Western countries, Australia and Japan in their book *Research Foresight: Priority Setting in Science.* The journal *Science Technology Industry Review* has also devoted its entire 17th Volume (1996) to foresight experiences of these countries. The journal *Technological Forecasting and Social Change* has updated this information in its 60th Volume (1999) where experiences of newly joint countries in Central Europe and Korea are also included.

c. Study the knowledge base of technology foresight

Technology foresight is an activity that delves into the future knowledge[7]. It is an activity about estimating, if not pin-pointing, the emerging future technologies. As we all know, future has not materialised; thus future facts, or *futura* (Jouvenel, 1967:3) are actually non-existent. In this case, how do we justify what we know about the future? How can foresight researchers distinguish themselves from fortune-tellers? In order to answer this, the research will attempt to look into the foundation and validity of future knowledge. This will include an exposition on the notion of scientific knowledge and scientific method which are highly regarded.

d. Study the underlying logic of Delphi method

To be able to do foresight research, we must first acquainted ourselves with the technique, or method of technology foresight. The evolution of technology forecasting has seen the methodological tool changing from quantitative mathematical models to more qualitative scenarios and visions. In recent years, the Delphi method has been widely used and become the backbone of technology foresight (Grupp & Linstone, 1999: 85). This research will analyse the procedure and underlying assumptions of Delphi method to illustrate the basic tenets of foresight method.

[7] In this research, the word "knowledge" is used in a loose sense that takes both the meanings of *episteme* (knowledge) and *doxa* (opinion). In philosophical discussion, the former is certain and indubitable knowledge while the latter is mere human opinion (Popper, 1972:93).

e. Ascertain the task of technology foresight

To predict accurately is once the major pursuit of technology foresight. However, today, the resurgence of technology foresight has been achieved without really relying on accurate foresight. The average accuracy rate of technology foresight in Japan is only 28% (Kuwahara, 1999:12). This brings us to the question of re-defining the task of technology foresight. If accuracy is no longer a major quest of technology foresight, what is the task of technology foresight then? This is one of the questions the research intends to look into.

6. Methodology

As an effort to clarify some of the basic issues of technology foresight, the research will rely greatly on secondary sources as its input. As such, it will be mainly a library research. This will include the survey on books, thesis, dissertations, journals, magazines, newspapers, etc.

Research materials will be gathered from local and foreign publications through their universities and other research institutions. Public and private institutions dealing with issues of science and technology will also be targeted as a source of information. Individuals with vast experiences in this field will also be approached for their viewpoints.

Once collected, these materials will be divided into four groups. First, those concerning foresight experiences of various countries. These are results, analyses and comments about foresight programme in these countries. Second, those focus on the methodological aspect of technology foresight. These include materials discussing either specifically on a particular method or a cluster of methods. Third, those probing the fundamental issue of foresight knowledge. These are materials related to the sources and validity of foresight knowledge. And fourth, other materials that can not be squeezed into any of the above categories. Within each group, articles are arranged according to alphabetical order of author's name for easy reference.

7. Conclusion

Science and technology have become a decisive factor in economic and social development. However, at the same time, research expenses in these fields have also escalated. These, couple with the increasing need to formulate science and technology policy, have prompted the growth of foresight research in the past one and a half decade. The need to do technology foresight in Malaysia is no less imperative. With the increasing trend of globalisation, Malaysians come under strong pressure to catch up in the field of science and technology in order to be able to compete at international level. And as a developing country, the need to optimise resource allocation is even more pressing.

The practice of technology foresight in Malaysia is still at its infancy stage. At this initial stage, we have no choice but to rely on experiences of others to develop the

local foresight programme. As such, a study on foresight lessons of other countries is most needed. Besides, to be able to fully grasp the concept of technology foresight, a study on the basic philosophy of technology foresight is also necessary. This concerns mainly with the issue of the foresight reliability. Aside from that, issues of methodology are also no less relevant. For at the end of the day, one can not carry out foresight study without an understanding of its means. This research is an attempt towards a better understanding of technology foresight at both general and specific level. This understanding is important for us to avoid unnecessary mistakes.