



# Technology foresight in China: Academic studies, governmental practices and policy applications



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## ARTICLE INFO

### Article history:

Received 30 November 2015

Received in revised form 5 August 2016

Accepted 9 August 2016

Available online 18 August 2016

### Keywords:

Technology foresight  
Academic studies  
Governmental practices  
Policy applications  
China

## ABSTRACT

Technology foresight has received increasing attention in China among academic scholars and policy makers. This paper, based on an analysis of global technology foresight features, systematically summarizes and discusses academic studies, governmental practices, and policy applications regarding technology foresight in China, associated with bibliometrics, expert interviews, and desk research methods. The evidence of both theoretical studies and practical activities indicates that technology foresight has rapidly developed in China. This development process can be divided into three periods: the exploration, rapid development, and maturation periods. Technology foresight activities in China enable stakeholders to consult with each other, which leads to a technology foresight culture. Further, many problems in developing and planning with science, technology, and innovation can be solved when comprehensive approaches are adopted to conduct technology foresight activities, including large-scale Delphi survey, scenario analysis, technology roadmap, and bibliometrics, among others. Currently, technology foresight is not only an essential instrument, but is also widely applied in China to develop planning and policies regarding science, technology, and innovation activities. Alternatively, the methodology of Chinese technology foresight and its application to science and technology planning must further improve.

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## 1. Introduction

Motivators for science and technology progress are increasingly complicated. This trend has changed, from “internal factors of the technology system determine the trajectory of technology development” to “interaction between technology and social and economic development determines the trajectory of technology development,” which then evolved to “the technology trajectory has multiple possibilities and the future trajectory can be selected through present policies” (Research Group of Technology Foresight towards 2020 in China, 2006). At the same time, confronted with increasing global economic competition, policy-makers and scientists are grappling with the problem of how to select the most promising research areas and emerging technologies on which to target resources and, hence, derive the greatest benefits (Martin, 1995). To develop oriented-future policies in this situation of complex driving forces, technology foresight (TF) has been considered an appropriate method to manage science, technology and innovation activities (Georghiou, 2013). The term “Technology Foresight” took off in the 1990s, as European, and then other, countries sought new policy

tools to deal with problems in their science, technology and innovation systems (Miles, 2010). Technology foresight activities and studies effectively assist in planning and managing uncertainty levels, which have received more and more attention in emerging countries.

Technology foresight has gradually become the focus of academic research and policy-making, which is particularly significant in China, as this large emerging country requires science and technology strategies to realize advancing development based on innovation. An increasing number of scholars and policymakers in China consider technology foresight as an integrated, comprehensive platform for developing science and technology (S&T) planning and policies. They regard technology foresight as a crucial approach to identifying national strategic demands, and grasping the trend of innovative, global science and technology. Recently, technology foresight has reached a new peak to meet S&T planning and demands in implementing China's innovation-driven development strategy, and has been applied to dynamically adjust S&T strategies and policies to optimize resource allocation.

Technology foresight provides an approach of developing policy in the complex context. It is imperative to discover more scientific, reasonable ways to develop science, technology and innovation policies when facing social and economic development uncertainties amid increasingly complicated international situations. As links between modern S&T and socioeconomic development have tightened, and science and

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technology discussion topics have penetrated various social and economic fields, features differ in developing and implementing long-term S&T planning, compared to previous periods. For example, science and technology policies have integrated with policies in other fields, such as agriculture and industry, in various ways. In spite of those in science and technology circles, the policy development process has begun to involve more stakeholders, including enterprises and the public. Therefore, the policy-making process requires each stakeholder's participation and consultation (Grupp and Linstone, 1999). Before technology foresight exercises in policy-making, decisions were commonly made by a few elites based on their unique personal insights. Technology foresight provides an interactive policy-making process and participation of different parties. As are argued in Martin (1995), foresight is a 'process', not just a set of techniques, and involves consultative procedures to ensure feedback to and from relevant actors. We should note that foresight does not predict a predetermined future, but actively shapes the future through the involvement of players and decisions in the present (Cachia et al., 2007; Meissner, 2012).

Technology foresight provides an interactive and communicative platform among all kinds of stakeholders in policy-making. Foresight exercises are seldom limited to small expert groups, and are participatory, involving a wide range of stakeholders. This opens stakeholders' minds to new possibilities for the future (Cachia et al., 2007; Meissner, 2012). The technology foresight process enables all stakeholders to discuss how to shape society in the future. Each group communicates during this process to reach a consensus for future directions, which creates a mechanism and network for realizing future development. Researchers from institutes and colleges, as well as personages from both enterprises and the public, participate in this process, which facilitates the efficient communication of opinions from different perspectives to agree on the key issues in developing relative policies. As this process can reduce risk and avoid incorrect decisions as to the technology development trajectory as much as possible, it enhances scientific, reasonable approaches to developing innovative policies for science and technology (Ren, 2008; Fan, 2003). Policymakers using technology foresight results can clearly indicate to the science, technology, and innovation communities that they are broadly considering a bottom-up approach, rather than purely top-down (Meissner, 2013, p.59).

Although technology foresight techniques have obtained much progress, the review research of practices or applications in the specific-country context is rare in the extant literature. Some relevant researches are focused on the advanced countries (see, Georghiou et al., 2008), and few literature gives attention to the development and applications of technology foresight in emerging countries. China is one of emerging countries earlier introducing and applying technology foresight to develop S&T planning and policies. However, current literature lacks a systematic summary of academic research and its latest applications, as well as how it supports S&T planning and formulation. A review of technology foresight activities in China is needed and attractive in terms of governmental practices and policy applications, which may provide some potential implications for technology foresight practices and studies in future. Since technology foresight can't escape from the social-economic factors in one country, some interesting and specific findings are expected in the specific context of China. This paper provides a comprehensive summary of the methods, academic research, and policy applications of technology foresight as adopted in China. It also conducts a comparison and analysis of technology foresight from an international perspective, and aims to provide a reference for technology foresight in China.

The rest of this paper is organized as follows: Section 2 analyzes global trends in journal articles and technology foresight practices, as well as global technology foresight features. Section 3 discusses domestic developmental trends in journal articles and governmental practices of technology foresight in China. Section 4 reviews and analyzes Chinese technology foresight methods. Section 5 illustrates the latest national technology foresight activities in China since 2013. Section 6 discusses

how technology foresight impacts and supports S&T planning and formulation in China. Finally, Section 7 provides a summary and some directions for future research.

## 2. A summary of international studies and practices in technology foresight

International trends in technology foresight are analyzed in this study from two aspects: journal articles and practices. The former is observed through the number of journal articles relevant to technology foresight by searching the SSCI (Social Sciences Citation Index) periodical database, adapted to retrieve international articles. As the manner of technology foresight presentation differs in international articles, the retrieval is conducted according to subjects containing "technology foresight," "technology forecasting," "technological foresight," "technology forecast," "technological forecasting," or "technological forecast." This provides the greatest extent of comprehensive coverage, and 416 journal articles are obtained (1967–2015).

Combining technology foresight practices and research trends as illustrated in Fig. 1, global technology foresight exercises can be divided into two stages. First, the exploratory stage occurs before 1990, when technology foresight activities initially began, and few countries organized and conducted such exercises. Moreover, Japan's technology foresight was the most representative. The number of journal articles from 1971 to 1990 regularly fluctuated once every five years, which parallels Japan's conducting of technology foresight activities every five years. This means that Japan's technology activity guided the global academic study of technology foresight prior to 1990.

The high-speed development stage ranges from 1990 to the present. From 1990 to the early twenty-first century, academia and various countries' governments gradually began to discover the importance of technology foresight. Many countries, including the United Kingdom, China, France, Germany, Italy, India, and Korea, launched technology foresight activities, and the number of countries performing technology foresight activities significantly increased. After the early twenty-first century, the number of countries conducting technology foresight activities still increased worldwide, and the annual average number of journal articles was at its peak (see also Fig. 1). As a result, technology foresight's importance reached a new height. Significant technology topics and their development trends, identified by technology foresight activities, are essential references for grasping the development trends in science and technology, and for nationally cultivating new competitive advantages. Presently, countries' technology foresight activities have five basic features, as follows:

First, technology foresight closely focuses on not only the development of future science and technology, but also the market's pull. Technology foresight, in other words, includes the selection of critical technologies as well as the recognition of economic and societal demands. For example, future vision research studies have been prioritized by several large-scale technology foresight activities in China. Instead of pursuing the full coverage of academic departments or technical classification, key points are stressed in accordance with demands. Additionally, S&T planning for future technology development paths and development strategy selection can be performed by constructing a future social vision.

Second, more focus has been on future prospects to support transformations in manufacturing and industrial growth. In early 2010, the United Kingdom's Government Office for Science published a report, *Technology and Innovation Futures: UK Growth Opportunities for the 2020s*, in which one of the key messages is "there are strong opportunities for growth in the UK economy through the 2020s if businesses can harness scientific and industrial capabilities to take advantage of technology-enabled transformations in manufacturing, infrastructure and the Internet". The same department published another report in 2013, *The Future of Manufacturing: A New Era of Opportunity and Challenge for the UK*. The analysis and advice in this report will help the

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