Technological Forecasting & Social Change 119 (2017) 237–245

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

Institutional basis for research boom: From catch-up development to advanced economy

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ARTICLE INFO

Article history:
Received 6 January 2016
Received in revised form 23 May 2016
Accepted 24 May 2016
Available online 3 June 2016

Keywords:
Technological forecasting
Innovation policy
Catch-up development
Value chain
Logic model
Research boom

ABSTRACT

Historical best practice emphasizes that the decision for large-scale R&D investment is important to catch-up growth. It is desirable in most developing countries to establish coherence between technological forecasting and science, technology, and innovation policies. This study demonstrates that national foresight has disadvantages in implementing such policies because of insufficient monetized information with discriminant power for investment. To compensate for such disadvantages, a logic model is indispensable, and can be achieved by subsequent foresight at the time of each decision rather than by one-time national foresight. The example of the Korean government emphasizes that decision-making involving consecutive value-based technological forecasting can act as an institutional framework to progress from catch-up development to being an advanced economy. Despite a tradition against aggressive R&D investment in Korea, quantitative ex-ante evaluations with a feasible value chain have given the financial authorities' confidence. This is what has made Korea's research boom possible. If developing or transition countries plan to achieve catch-up growth by expanding R&D investment, the institutional cases in this study will be an important reference.

1. Introduction

In order to understand what technological forecasting (TF)[1] is today, it is useful to delve into its history. During World War II, TF in the United States was highly focused on anything that could affect military affairs (Dryer and Stang, 2013). In that context, it is vital to know how to win a war. After World War II, large TF exercises were carried out in the defense sector and the civil sector under the tension of the Cold War (Missiroli and Ioannides, 2012; Anderson, 2012). TF in the defense sector continued focusing on "strategic" issues related to national survival until the end of the Cold War, where it co-evolved with innovation studies as a navigator for economic growth around advanced capitalist countries (Georghiou, 2001). Capitalist countries had many success stories of technology-push-type innovations coming from dual-use technology (Serfati, 2008; Callois, 2008),[2] but communist countries could not receive such benefits. At the same time, some developing countries began using TF to achieve catch-up growth.

Since the end of the Cold War, economic competition has replaced the confrontation of ideologies, and increased interest in economic growth has become an overarching concern (Dryer and Stang, 2013; Betts, 1997). Developing countries and transition countries have begun looking for future opportunities in technological competency and productivity in order to catch up to advanced capitalist countries. In this case, they may benefit from being latecomers to TF because they have the results of work conducted in advanced industrial economies to draw upon. Contrary to expectation, a successful policy instrument in one country does not always guarantee success in other countries. A science, technology, and innovation (STI) policy, followed without criticism in a developing country, may cause problems (Lee, 2005). Catch-up growth has not been achieved in many countries, with the exception of a few successful countries such as South Korea, Taiwan, and Japan. Accordingly, developing countries should consider their inherent contextual environment comprehensively before imitating internationally shared success stories.

Catch-up growth is considered a question of relative speed in a race along a fixed track. Technology is understood as a cumulative unidirectional process (Perez, 1988). The speed of progress on the track has been uneven, with some catching up rapidly, while others lag behind. Large-scale investment can explain this difference in catching up in the creative imitation stage and the innovation stage (Perez and Soete, 1988; Lee and Lim, 2001). The case of Central America, unsuccessful in terms of catch-up economics, emphasizes that, in the short term, a lack of funding and weak national commitment to innovation systems are important as a source of social and economic development (Padilla-Pérez and Gaudin, 2014). Based on that historical perspective,

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[1] In this study, technological forecasting, futures studies, and foresight are considered elements in the same continuum under the label of TF.

[2] Dual-use items are products and technologies normally used for civilian purposes, but which may have military applications. Global positioning systems, rocket technology, the internet, and nuclear power technology are typical examples.

http://dx.doi.org/10.1016/j.techfore.2016.05.022

the decision to embark on large-scale research and development (R&D) investment is important because it can create a shared vision from TF to be implemented as an STI policy.

Among various success stories, Korea deserves special mention in using TF as a developing and transition country, because it has been one of the most successful latecomer economies to achieve rapid economic growth and is approaching the ranks of advanced economies. Korea has recently become one of the world's most research-intensive economies by investing 4.29% of its gross domestic product in R&D (Noorden, 2016). The reasons for its success, enabling such aggressive R&D investment, can offer guidance to developing countries suffering from a lack of resources and investment. The high correlation between the characteristics of national foresight studies and the Global Innovation Indicator (Meissner, 2012) deserves attention too. This high correlation implies that the innovation planned using TF is a key factor in Korea's success in catch-up economics. The divided national state of Korea also drives Koreans to keep and to improve policy instruments for developing countries, because successful unification depends on the catch-up growth of North Korea.

The remainder of this paper is structured as follows. Section 2 reviews the background of the institutional basis of the large-scale R&D investment in the context of Korea's STI policy. The methodological approaches are presented in Section 3. Three hypotheses are demonstrated by means of a statistical analysis in Section 4. Section 5 introduces and discusses the case studies, and the final section concludes the paper and suggests areas of possible future research.

2. Background

2.1. Coherence between TF and an STI policy

Although the notion of generations in innovation (Rothwell, 1994; Dodgson et al., 2005) and foresight (Miles, 2008; Reger, 2001; Georghiou, 2001; Tegart and Johnston, 2004; Schlossstein and Park, 2006; Linstone, 2002) have co-evolved, there has been a recent decoupling of these trajectories. The misalignments with innovation, as well as the emerging complexities in foresight explain this decoupling (Andersen and Andersen, 2014; Barré and Keenan, 2008; Weber et al., 2009), which can be classified into coordination failures, communication failures, market failures, and political failures (Pietrobelli and Puppato, 2016). These failures are all evident in developing countries, depending on their stage of development (Rodrik, 2000; Tavares and Wacziarg, 2001; Chan and Daim, 2012). A strong link and coherence between TF and STI policy in developing countries can be achieved by private sector involvement (Hausmann et al., 2008; Hausmann and Rodrik, 2006), a well-organized institutional basis for STI policy with the long-term benefits of TF (Crespi et al., 2014), and linking with global value chains (Pietrobelli and Puppato, 2016). Cumulative empirical studies on catch-up development have revealed that choosing the correct technology or standards and creating initial markets are crucial to successful leapfrogging (Lee, 2005).

If a country tries to implement these practices, a logic model (Jordan, 2010; McLaughlin and Jordan, 1999) will help to justify how the outputs from TF can reduce these substantial risks by mapping values from R&D programs (Kingsley and Melkers, 1999). The structure of many policies can be modeled by logical flows. For example, STI policies can be formulated by a logical flow such as a global value chain (Kexin et al., 2015), a global production network (Ernst and Kim, 2002), or a supply chain (Eksoz et al., 2014). In most cases, TF can formulate a logical basis for implementing an STI policy. If certain policy parameters are adjusted when formulating the policy, the policy can be recognized as being persuasive, with high enforcement power. Tinbergen's (1952) process is convenient to formulate a quantitative policy, and a prospective cost-benefit analysis may be an ideal form.

2.2. The organizational system for STI policy in Korea

STI policies have been studied using diverse approaches (Lundvall and Borrás, 2005; Elder and Georghiou, 2007; Cimoli et al., 2005). Among them, the perspective of Lundvall and Borrás (2005) can be useful to understanding the organizational system for STI in Korea. They argue that STI policies have instruments that are better suited to promote specific areas (i.e., science, technology, or industry), but that their design and implementation should follow a systemic strategy. Because the most important activity of a science policy is basic science, the relevant actors in the science policy are universities and research organizations. Technology policies emphasize the links between science and industry, while innovation policies focus on an industrial policy that influences the process of innovation.

The STI policy in Korea is organized around many ministries engaged in policy formulation, implementation, and evaluation. Among them, the Ministry of Science, ICT,[3] and Future Planning (MSIP) and the Ministry of Trade, Industry, and Energy (MOTIE) are essential because they account for more than 60% of total public R&D expenditure. The MSIP's major roles are the science policy and technology policy. The MOTIE deals with the technology policy and innovation policy. The Ministry of Strategy and Finance (MOSF) is also involved in the STI policy in terms of budget allocation. The Korea Institute of Science and Technology Evaluation and Planning (KISTEP) supports the MSIP and the National Science and Technology Council (NSTC) in coordinating and evaluating national R&D programs, as well as the MOSF in allocating R&D budgets.

2.3. The institutional basis of large-scale R&D investment in Korea

The preliminary feasibility study (PFS), a specialized version of *ex ante* evaluations for the Korean government, was introduced in 1999 to encourage a cautious approach to new large-scale projects by enhancing fiscal efficiency and helping the MOSF. This is performed by verifying the feasibility of projects or programs with budgets of over 50 billion KRW[4] (around U.S. $50 M) and governmental burdens over 30 billion Korean won (around U.S. $30 M). Two indispensable parts of a PFS are the economic analysis and policy analysis. The economic analysis estimates the demand, benefit, and cost, and then the economic feasibility in order to provide information on "*how much to invest*." The policy analysis determines whether R&D program objectives correspond to STI policy agendas, which are derived from national foresight. Each evaluation item is rejected or accepted, yielding a score between 0 and 1. A final decision on "*whether to invest*" is made by synthesizing the results of the economic analysis and the policy analysis, with the help of the analytic hierarchical process (Saaty, 1990). If the overall scores are less than 0.5, the program is always recognized as unacceptable, and cannot be invested in, by law. The detailed PFS methods are summarized in the general guidelines (KDI, 2008).

The PFS was tried on large-scale R&D investments in 2006, and mandated in 2008. This period, as shown in Fig. 1 (b), corresponds to the middle of South Korea's research boom period (Noorden, 2016). The Korean experience of leapfrogging has resulted in one other indispensable analysis item, namely the technological analysis, which supplements the economic and policy analyses. A technological analysis can help to reduce two substantial risks, namely choosing the correct technology and creating the initial markets, using an R&D logic analysis, technological viability, and overlap possibility. An R&D logic analysis includes the overall framework of logical linkages and rationales for the examined program, based on a logic model aligned with economic values (Jordan, 2010; Kingsley and Melkers, 1999). This analysis

[3] Information, Communications Technologies.

[4] Korean won.