Technological Forecasting & Social Change 95 (2015) 312–327

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

FROM MY PERSPECTIVE

Catch-up models of science and technology: A theorization of the Asian experience from bi-logistic growth trajectories

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ARTICLE INFO

Article history:
Received 19 April 2013
Received in revised form 22 January 2014
Accepted 9 February 2014
Available online 28 February 2014

Keywords:
Asian economies
Bi-logistic curves
Catch-up models
Growth cycles
Papers and patents
Science and technology

ABSTRACT

This paper attempts to examine the strategies of national innovation system that shaped the science and technology cycles of South Korea, Taiwan, Singapore, Malaysia and China by theorizing the science and technology (proxied by papers and patents) trajectories of these economies using Meyer's taxonomy of bi-logistic growth. The findings suggest that the strategic catch-up models of South Korea and Taiwan have resulted in a much longer pulse in the growth trajectories during the transition towards knowledge-based economy than countries that are dependent on FDI for learning and acquiring technology during the early catch-up period such as China and Malaysia, while the results are mixed for Singapore. The catch-up strategy of supporting new start-ups for pioneering technology facilitated the development of capabilities of indigenous firms in the case of South Korea and Taiwan. This provides a policy lesson for transition from industrial-based to knowledge-driven development through the formation of evolving dynamic propagating behavior in science and technology.

1. Introduction

Many Asian economies particularly of East Asia are being acknowledged as the most competitive and dynamic in the developing world. For example, the newly industrialized economies (NIEs), South Korea, Singapore and Taiwan, are notable for sustaining their economic growth by various upgrading approaches and science and technological catch-up [1,2]. South Korea and Taiwan, in particular, had specific preference in their science and technology policies for developing and deepening indigenous technologies. They consciously enforced a series of policy interventions to allow indigenous firms to develop their science and technology capabilities, resulting eventually in export activities [2–11]. Developing countries of Asia, such as China and Malaysia, emerged as fast-growing economies and have been among most successful in attracting high technology multinational corporations (MNCs) that bring manufacturing activities into the country. In the transition to a developed and knowledge-based economy, these economies incentivize MNCs to upgrade their science and technologies by undertaking various upgrading projects that will eventually benefit the local subsidiaries. China and Malaysia are now placing emphasis on learning and searching activities by raising national investments in R&D for prioritized research areas since the 1990s to develop their science and technological capabilities. Many universities and public research entities are mandated to engage with MNCs to develop state-of-the art science and technologies.

To date, although many studies [2,4,10–27] have been conducted to examine the extent of science and technological growth and development in Asian emerging countries, a systematic approach to theorize the diverging growth trajectories of science and technology is still severely lacking in the literature. The focus of previous studies on diffusion and development [for example, 3,12,22–24] without the consideration of the specific models of science and technology policies and the systemic perspective of structural change in economic activities limits the retrospection of science and technology

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http://dx.doi.org/10.1016/j.techfore.2014.02.005

growth in the development process of Asian economies, particularly in light of the recently pursued knowledge-based economic development. By empirical demonstration, this study extends the assessments of self-propagating diffusion and sustainability of science and technology production in previous studies [3,22–24] by theorizing the science and technology (proxied by scientific publications and patents respectively) growth trajectories in the context of the taxonomy of bi-logistic growth curves (explained in Section 3) that are capable of projecting a spectrum of wave patterns for growth cycles and systemic change processes. By means of theoretical analysis, this study seeks to integrate insights from institutional theory and innovation studies to provide a coherent view on the national institutional dynamics that shape the transition of Asian innovation systems. A comparative analysis is conducted on selected NIEs and fast-growing economies in Asia. South Korea, Taiwan, Singapore, Malaysia and China are included in this study for their different levels of achievement in development and adoption of different models for science and technology development.

We are aware that comparisons between these economies may be either inexact or incompatible in some aspects due to differences in resource bases such as endowment of resources and industrialization mission goals. Nevertheless, despite the differences, our comparative study from a systemic perspective uncovers valuable insights and warrants some discussion of the Asian innovation system. First, the science and technology development path of these economies shared many similarities in their evolution of innovation systems and avenues of innovation[1] [7,25–27]. The governments of the selected economies have been well-known for their pro-economic intervention through various policies and government enterprises involvement in the general open market setting to acquire their envisaged national innovation systems [7,10,11]. They have been able to provide their economies a strong regulatory framework to cushion a period of socio-economic adaptation to achieve their desired economic outcomes. Second, the selected economies pursued different science and technology policies that can be broadly categorized into one of the two models discussed above. It would therefore be interesting to compare the extent of divergence in science and technological growth trajectories of these economies in the theorization of their experience.

2. Science and technology catch-up models

This section describes the context of catching-up strategies useful for explaining the growth trajectories of science and technology. We revise past studies that are germane to our discussion in the following.

The evolving models of science and technology policies led to divergence in the trajectories of science and technology growth and diffusion. Many studies [2,4,11,13,25] suggest the generic technological capability development routes that are shaped by two distinctive models:

- New Start-ups for Product Technology Pioneering Model: The model generally involves government incentives and supports to fuel entrepreneurial activities, reduce risks faced by firms with costly investment for innovation, and stimulate R&D investment for science and technology [16]. The supports are consciously directed to those who are perceived by the state as capable in achieving efficient and productive outcomes for the economy (the agent of change). The government, on the other hand, functions as an agent to monitor and discipline the supported entrepreneurs' activities to ensure, from time to time, their interests remained coherent with the overarching national goals. Technology policy is basically designed to avoid over-reliance on MNCs' (multinational corporations) technologies during the early industrialization stage. State intervention is essential for building technology capabilities and competencies, particularly during the infant stage of industrial development. The development process starts with the expansion of various infrastructures for growth, followed with technology and finally the co-evolution of science and technology (when the allocation of resources for science increases to support new technology) [11, p. 34–36, 14–16]. Science policy has an explicit role to play not only in advancing scientific activities but also to ensure that the scientific activities are aligned to their envisaged co-evolving state with technology development.
- FDI Leveraging Model: Technology policy is developed to favor the MNCs that aim to upgrade their manufacturing process capabilities to manufacture new and advanced products. The spillover of know-how from the multinationals would spawn many local supporting industries and lead to an increase in technology adoption through linkages of local firms [2,11 p. 34–36]. This model focuses on the provision of basic infrastructure, ensuring political stability and maintaining security to support export-intensive manufacturing activities. Science policy is established to advance scientific activities to achieve an eventual outcome that benefits the technology producers to identify or spawn new technologies.

The late-industrializing economies like South Korea and Taiwan have traditionally placed emphasis on techno-entrepreneurial activities and the development of locally-owned manufacturing industries, while FDI-leveraging countries like Singapore and Malaysia gave priority to develop institutions that facilitate the operation of MNCs and spillover of technology from the MNCs to the local subsidiary firms. In the search for workable science and technology policies, China operationalized the two competing models at the local (or regional) level[2] for science and technology development [17]. Nevertheless, the majority of China's value-added high technology exports are produced through joint ventures with foreign firms or those owned by the foreign subsidiaries of MNCs based in industrialized countries [18]. The degree of success in catching-up with the frontiers in the promotion of indigenous innovations remains to be observed [19].

The strategic “new start-ups for product technology pioneering model” was effective for South Korea and Taiwan in acquiring technology capabilities (particularly in ICs and semiconductors), and their economies succeeded in catching-up and moving towards the world production frontier. Foreign

[1] The use of information and communication technologies (ICT) is particularly essential for economic growth in these economies.

[2] The improvised strategy is viable due to the size and diversity of the country [17].