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1 *Introduction*

The past three decades have witnessed rapid economic growth and a fascinating transformation of China's economy and industry, from an economy dominated by agriculture to one that is referred to as a 'world manufacturing plant', from a small exporter of resource- and unskilled-labour-intensive products to a major producer of manufactured exports. The total industrial output of China increased from US\$91 million in 1980 to US\$3,728 million in 2013, and the share of industrial products in total exports has increased from 50 per cent in 1980 to more than 95 per cent in 2012 (NBS, 2013).

Increasing industrial competitiveness as revealed through surging exports and upgraded export composition has also astonished the rest of world. China's total exports and imports increased from US\$38 billion in 1980 to US\$4,265 billion in 2012. China's share in the world markets for exports of goods rose from 0.9 per cent in 1980 to 11 per cent in 2012. More significant is the export of manufactured products from China, which increased from US\$9 billion in 1980 to US\$1,948 billion in 2012, 38 per cent of which constituted high-technology products, accounting for 16.5 per cent of the world's total high-technology exports (UNCTAD, 2014). China is now the world's largest economy in terms of trade. The country has also maintained a fast growth rate despite the recent global economic crisis that severely affected the industrialised economies.

However, the country also faces significant criticisms of its growth model because of its heavy dependency on foreign technology transfer and imitation and its lack of creativity and indigenous capabilities in core technology. Moreover, with the amount of surplus unskilled labour in China falling, and the resource and environmental constraints for sustainable growth becoming increasingly significant, China is being forced towards a more skill-intensive and technology-intensive growth path as its own Lewis Turning Point approaches, that is, when the surplus labour in the subsistence sector is fully absorbed into the

modern sector. China now faces significant challenges in moving from imitation to innovation. The success of this transformation will be of crucial importance for China to avoid the middle-income trap and sustain its long-term economic growth (Wu, 2013).

Therefore, given China's remarkable achievement in industrialisation and modernisation in the past three decades as well as the challenges of sustainable development and structural change ahead, it is pertinent to ask the following questions: What was China's path to innovation in the past, and whither the future? How has China managed to develop and upgrade its technological capabilities at such a remarkable speed? In the twenty-first century, how can China significantly enhance its indigenous innovation capability and accomplish the transition from imitation to innovation, thereby becoming an innovative nation? As one of the major economies in the world, how can China develop a path of compressed development and leapfrog the conventional latecomer path of imitative industrialisation, progressing up the value chain, taking a lead in the low-carbon industrial revolution and reemerge as the world's leading innovation power as documented for an earlier era in Joseph Needham's (1954) seminal work? Is there a China model of innovation? What are the lessons that other countries can learn from China's experience? These are all important questions of great interest not only to academic researchers but also to policy makers and practitioners.

As the world's second largest economy and one that is still firmly on a path of stable and promising economic growth, any fundamental changes in China will have significant impact on global business and global economies. Moreover, China has increasingly been seen as an exemplary model for other emerging economies. Its successes and challenges will thus be closely watched by policy makers in both developed and emerging economies. Therefore, findings from this book will have significant policy and practical implications for both developed and other developing countries.

Innovation and its sources

Innovation is a process of creative destruction, taking place as a 'process of industrial mutation that incessantly revolutionises the economic structure from within, incessantly destroying the old one, incessantly creating a new one' (Schumpeter, 1942: 83). It is widely recognised as a major driver of long-term growth and a key element of

industrialisation and catch-up in developing countries (Romer, 1990). In the present context, innovation concerns not only novel innovations but also innovation via diffusion of existing ideas and techniques. It includes not only technological innovations but also non-technological innovations, such as new management practices and new institutional structures. In other words, innovation refers to the introduction or adoption of new products, new production processes, new ways of organisation and management, new methods of marketing and new business models. A complete innovation chain includes both the creation and commercialisation of new knowledge.

Innovation can occur as a result of a concerted focus by a range of different agents, by chance or as a result of changes in industry structure, in market structure; in local and global demographics; in human perception, mood and meaning; in the amount of already available scientific knowledge, and so on (Drucker, 1985). At the micro level, the sources of innovation may come from internal focus efforts, for example, R&D activities or other organised innovation efforts, or externally from the acquisition of useful technology or knowledge created by other organisations or by users of the technology, that is, the so-called end-user innovation identified by von Hippel (1988). Currently, with the innovation paradigm shifting from closed to open, firms may also open up their innovation process and create new products and processes by tapping into external resources and collaborating with other partners (Chesbrough, 2003). At the macro level, innovations may be created by focused efforts or by chance from a range of different agents in the country, such as firms, universities and research institutions. They may also emerge as a result of acquisition of innovations created in foreign countries through several channels.

Innovation can be diffused between firms and across regions and countries through various transmission mechanisms. These include (1) licensing; (2) movement of goods through international trade, especially imports; (3) movement of capital through inward and outward foreign direct investment (FDI and OFDI); (4) movement of people through migration, travel, and foreign education of students and workers; (5) international research collaboration; (6) diffusion through media and the Internet of disembodied knowledge; and (7) integration into global value chains to benefit from the foreign technology transferred within the supply chain. Some knowledge is transferred intentionally from the knowledge owner to the recipient – and this may spur

a learning process – but a large proportion of knowledge spillovers take place as unintended knowledge leakage. In recent years, the mode of innovation is becoming more and more open and good use is made of external resources. International knowledge diffusion can therefore benefit firms' innovation at every stage of the innovation process. The growing technological diversification of companies makes successful integration of new external knowledge into the innovation process increasingly important. Such successful integration further fosters innovation performance. The factors that explain the accelerating trend of utilising external sources of knowledge include, among others, technological convergence, declining transaction costs of acquiring external R&D inputs and shortening product cycle times (Narula, 2003).

The development strategies for industrialisation and catch-up in late-comer developing countries, the relative role of international technology transfer and indigenous innovation and the role of industry policy in the process have been the most important but also controversial issues in development studies and science and technology studies. One of the controversies is whether the sources of technological change are indigenous or rather based on foreign innovation efforts or a combination of the two, and which combination of different foreign sources of innovation with different degrees of emphasis. On the one hand, innovation is costly, risky and path dependent. Hence, it is more efficient for developing countries simply to acquire foreign technology created in developed countries. In principle, if innovations are easy to diffuse and adopt, a technologically backwards country can catch up rapidly, even leapfrog through the acquisition and more rapid deployment of the most advanced technologies (Soete, 1985; Grossman and Helpman, 1991, 1994; Romer, 1994; Eaton and Kortum, 1995).

On the other hand, there is the view that technology diffusion and adoption are neither costless nor unconditional. They rely on substantial and well-directed technological efforts (Lall, 2001) and on absorptive capacity (Cohen and Levinthal, 1989). An additional related difficulty in the debate on indigenous versus foreign technology upgrading is that technical change is often biased in a particular direction so that foreign technologies developed in industrialised countries may not be appropriate to the economic and social conditions of developing countries (Atkinson and Stiglitz, 1969; Basu and Weil, 1998; Acemoglu, 2002; Fu and Gong, 2010). In addition, we cannot simplistically assume that the private interests of multinationals coincide with the social interests of the host countries (Lall and Urata, 2003). The available

empirical evidence on the effects of the sources of indigenous or foreign innovation is mixed. Studies largely fail to provide convincing evidence indicating significant positive technological transfer and spillover effects of FDI on local firms (Gorg and Strobl, 2001).

Accompanying this ongoing and inclusive debate on the role of technology transfer and indigenous innovation, the role of state and industry policy in the process of industrialisation and economic development is also subject to a wide, ongoing debate. While some argue that industry policy is crucial for the success of the newly industrialised economies (NIEs) such as Japan, South Korea and Singapore (Amsden, 2001; Chang, 2003; Pack and Saggi, 2006), there are also strong arguments for the role of the market and free competition in allocating resources efficiently and enhancing the productive efficiency of the enterprises in an economy based on the recent success of the East Asian Tigers such as Malaysia, Thailand and the Philippines (Kruger, 1974; Bhagwati, 1982; World Bank, 1996, 2005).

Some argue for a third way for structural change to occur, suggesting that sustained economic development is driven by changes in factor endowments and continuous technological innovation; therefore, industry policy should encourage the development of sectors that comply with a country's comparative advantage while the private sector and the market should be the major players in the process (Lin, 2011). Market forces and private entrepreneurship would be in the driving seat of this agenda, but governments would also perform a strategic and coordinating role in the productive sphere beyond simply ensuring property rights, contract enforcement, and macroeconomic stability (Rodrik, 2004). This debate on the role of the state and policy is relevant for our analysis of national innovation capabilities and performance because of the nature of innovation as a public product, the significant positive externalities that knowledge and ideas may generate and the presence of market failures resulting from the great uncertainty related to the innovation process.

The literature

China's experience with innovation and technological upgrading is also the subject of wide-ranging interests amongst a variety of stakeholders in economics and politics. The literature in this area can be broadly classified into several categories. The first category relates to studies of the impact of China's rising innovation and technological capabilities on the rest of the world, for example, MacDonald et al. (2008), Barlow (2013) and Someren and Someren-Wang (2013). These studies argue

that the United States, the EU and China have reached a crossroads, and whether China will be a threat or an opportunity depends on the main players in government and public and private organisations rethinking their innovation policies and business development paths (Someren and Someren-Wang, 2013). They also contend that the 'rules for survival' in R&D and education are changing in favour of China, in terms of basic R&D parameters such as research expenditure, scientists trained, papers published and patents awarded (MacDonald et al., 2008).

The second category in the literature on China's innovation capabilities concerns one or several individual factors in the national innovation system or one type of innovation in China, for example, university-industry linkages, state-firm coordination, high-end talents, disruptive innovation in China and cost innovations (e.g., Zeng and Williamson, 2007; Feng, 2009; Simon and Cao, 2009; Tan, 2011). The third stream of literature relates to industry case studies, most of which focus on the high-technology industries, the information and communication technology (ICT) sector and green technologies (e.g., Lu, 2000; Jakobson, 2007; Wang, 2012; and Liu et al., 2012).

All these studies have provided useful insights about the development of innovation and technological capabilities in China. However, they are based on studies of a particular industry, a particular type of innovation, or one specific driver of innovation. What is China's national strategy and path to innovation? Comprehensive and systematic analysis of China's overall innovation strategy, driver and outcome is rare with very few exceptions (e.g., Varum et al., 2007; OECD, 2008). Varum et al. (2007) present a comprehensive description of the transformation of innovation policies and the reform of science and technology systems in China from 1978 to 2004. OECD (2008) provides a comprehensive and systematic review of China's national innovation system. Features and performances of each of the major players, that is, government, industry and universities, and the role of policy and governance are examined. Both of these studies set up their analysis under the national innovation system framework. They provide a valuable description of the relevant policies and the status and performance of the important agencies in China's national innovation system. However, *how* China achieved its current success and how china can achieve its new objective to transform itself into an innovation-driven economy is still under-researched. Our understanding is limited with regard to the evolution of China's path to innovation, in particular the evolution of strategies,

processes and drivers of innovation at different stages of development and their impact on China's innovation capabilities and technological upgrading.

The objective and structure of the book

The objective of this book is to provide a systematic, comprehensive and rigorous study of China's drive towards innovation in the past and for the future. It draws on my research of more than a decade to understand, analyse and evaluate this process. The research employs the rigorous analysis and empirical methodology of modern economics as well as in-depth case studies of representative industries and leading Chinese companies. Much of the evidence is based on either survey data or longitudinal data at firm-, industry-, regional- or country-level. But a systematic approach is adopted: economic and management theory, development and evolutionary theory, institutional analysis and political economy are used to explain the motivation, sources, obstacles, policy measures, firm responses and consequences of China's drive towards being an innovative nation, and the roles played by the state, the market, the private sector and the non-market, non-state institutions such as universities and public research institutions.

In addition to the analysis of China's experience in the past three decades, the book also investigates some of China's most recent efforts in innovation, for example, internationalisation of Chinese MNEs and outward direct investment for technology acquisition and upgrading, international innovation collaboration, reforms of incentive structure at multiple levels, and the development of green technologies. Moreover, the research places China in a global context, and an international comparative perspective is taken comparing China with other emerging economies such as India and more advanced countries such as the UK. The book also critically reviews China's experience, provides an in-depth discussion of the likely way forward, and what other countries can learn from China's experience.

In light of the economic and management theories on the sources of innovation, taking on board the innovation systems framework and the capabilities approach, the book is organised into three parts focusing on the drivers of innovation at different stages of development, in addition to the Introduction and Conclusions chapters. Part I examines the role of international knowledge transfer and technological takeoff in China

at the early stage of the reforms. Part II analyses the development of indigenous innovation capability in the catch-up stage of industrial development in China. Part III focuses on China's current efforts to leapfrog the country into the role of global innovation leader and assesses the role of incentive structure, institutional arrangement and unconventional knowledge sourcing and co-creation measures in the process. Before embarking on these analyses, an overview of China's innovation efforts and performance in the past three decades since the reforms is presented in Chapter 2.

Part I on the role of international knowledge transfer and technological takeoff in China includes four chapters. Chapter 3 investigates the impact of foreign direct investment on the development of regional innovation capabilities using a panel data set of Chinese regions. It finds that FDI has a significant positive impact on the overall regional innovation capacity. FDI intensity is also positively associated with innovation efficiency in the host region. The strength of this positive effect depends, however, on the availability of the absorptive capacity and the presence of innovation-complementary assets in the host region. This increased regional innovation and technological capability has contributed further to regional economic growth in China's coastal regions but not in the inland regions. It concludes that the type and quality of FDI inflows and the strength of local absorptive capacity and complementary assets in the host regions are crucial for FDI to serve as a driver of knowledge-based development. Policy implications are discussed.

Chapter 4 examines the impact of processing trade-oriented FDI on the export competitiveness of indigenous firms using disaggregated firm-level production data and product-level trade data from China covering 2000 to 2007. The estimation results show that processing trade-FDI has generated significant positive information spillover effects on the export performance of indigenous firms. However, the effect of technology spillovers on the development of international competitiveness in indigenous firms is limited and in fact exerts a significant depressive effect on the propensity to export in these firms. Indigenous innovation, economies of scale and productivity are found to be the main drivers of export performance in indigenous firms in the high-technology industries.

Chapter 5 explores the role of indigenous and foreign innovation efforts in technological upgrading in developing countries, taking into account sectoral specificities in technical change. Using a Chinese