China's technology catching up: an introduction

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1 Introduction

Since the market reform, China has achieved remarkable economic growth with a high annual GDP growth rate of 10% (from 1981 to 2004) (World Bank, 2006). China reached a nominal GDP of US $2.68 trillion in 2006 and was listed as the forth largest economy in the world, only following USA, Japan and Germany (China Daily, 2007).

Along with its amazing economic performance, China has achieved significant technology progress since the start of the reform in 1978. Noted examples in the past several years include the followings in biotechnology, astronautic technology, and information technology:

- In 2001, together with five other countries who lead in genomic research, the USA, Japan, Germany, and France, China participated and finished the Human Genome working draft (IHGSC, 2001).
- In 2003, following Russia and the USA, China became the third nation that has launched a man into the space in 2003 (CNN, 2005).
- In 2004, after the USA and Japan, China turned into the third country with the super computing prowess via the development and application of 10 trillion floating point operations per second (TFlops) super computer. The super server Dawning 4000A has a peak performance of 11 TFlops (Shankland, 2004).

In addition to its achievement in Science and Technology (S&T), industrialisation based on high-tech has progressed rapidly; China has been evaluated as having a surprisingly competitive S&T export economy (Pillsbury, 2005). In 2004, China overtook Japan as the world's third largest exporter. Electronic goods accounted for a third of the Chinese exports.

While many are impressed by China's excellent economic performance, they are curious about causes for China's economic growth. In today's knowledge economy, the contribution of technology to economic growth has been increasingly recognised by industrialised countries, as they maintained their heavy investment in R&D. Nevertheless, how important is knowledge or technology to emerging economies like China? Does China have a knowledge economy?

Some scholars have emphasised the role of technology progress to economic development in China and documented how the transformation of national innovation systems and certain government technology policies have promoted indigenous R&D (Gu, 1999; Liu and White, 2001; Fan, 2006; Fan and Watanabe, 2006; Motohashi and Yun, 2007). This echoes with the view that stated innovation has been the critical source of growth in the Newly Industrialised Economies (NIEs) (Hobday, 1995; Kim, 1998). Within the context of rapid technology development and globalisation that has transformed the earth into a 'flat world', how well has China fared in technology catching-up? Can China's experience provide policy implications for other developing economies?

It is under this circumstance that this journal has decided to publish a special issue on China's technology catching-up, with a focus on domestic firms and the role of the government. Six papers featured in this special issue present findings on:

- technology strategies of innovative Chinese firms as late comers, including those small and medium-sized ones
- industrial standards as a strategic tool for leap frog and technology development at the industrial level
- effective technology transfer
- industrial upgrading.

The six papers employed rich cases from various high-tech industrial sectors, namely, information technology (such as telecom-equipment, high-performance computer, and high-definition video disc player), biotechnology, nuclear, and petroleum industries. In the following section, I will provide an overview of the papers featured in this issue.

2 Summary of the contributions

Does China have innovative companies? If so, what are their technology strategies, internal development, external alliance, or technology transfer? What are the location strategies? Can domestic companies utilise the advantages over the multinationals? In their contribution 'Technology strategies of innovative Chinese domestic companies', Fan, Gao and Watanabe addressed the above questions through studying seven innovative domestic companies in various industries. They focused on discussing three technology strategies of these companies: internal development vs. external alliance, location of R&D functions, and innovation through understanding of home demand. First, they emphasised that internal development and self-developed technologies have been the key for the seven companies' industrial leadership. Second, the companies' R&D functions have been strategically concentrated in the triangle of Beijing-Shanghai-and Shenzhen to take associated location advantages. Third, these companies have transformed their better understanding of home demand into pressure and motivation for innovation and thus

created local advantages over the multinational corporations. Fan, Gao, and Watanabe further argued that government intervention is essential and demonstrated that how government have effectively stimulated domestic companies' development of innovation capability along the three dimensions. First, they pointed out that financial incentives from the government for self-developed technologies have encouraged innovative domestic companies to further concentrate on internal development as their basic technology strategies. Second, high-tech parks constructed by the government have proven to be the right magnet for R&D functions of domestic companies. Third, the government direct or indirect intervention in home demand condition may promote a demand-stimulated innovation.

In catching up economies like China, small and medium-sized firms are faced with more difficulties and challenges compared with large and leading firms, especially because the market does not have a well-established funding system that aims at nurturing innovative small and medium-sized firms, as the ones in western economies. In their contribution 'Overcoming 'latecomer disadvantages' in small and medium-sized firms: evidence from China', Gao, Liu, Chai, and Li argued that these firms need to overcome resource disadvantage and reputation disadvantage as latecomers. They developed four propositions regarding latecomer disadvantages and some specific strategies dealing with these disadvantages, such as, focusing on new technology and product development, seeking financial resources outside of the firm, and gaining support from loyal customers as well as non-customer stakeholders. To further illustrate the propositions, they analysed two small and medium-sized firms, Founder in laser typesetting technology and Datang in TD-SCDMA technology. They emphasised that developing effective strategies to gain support from non-customer stakeholders such as scholars and government officials is of critical importance and the strategy of sticking to the development of most advanced technology is effective in gaining support from these stakeholders.

While indigenous development is essential, China has always utilised technology transfer concurrently for technology catching up. How can China, as a technology recipient, effectively manage technology transfer to maximise its own technological capability? In his contribution of 'China and technology transfer: the 'Boomerang Effect' as a strategic tool', Degravel introduced a concept and tool initially used on the supplier side of technology transfer, 'BE', and illustrated how it can be used as a valuable managerial tool for the recipient side. He thus proposed a larger model 'BE Supplier + Recipient (S + R)' and discussed its implications and potential benefits for managers and political leaders. de Gravel utilised a case of a large technology transfer between France and China in the nuclear industry to illustrate the model. The technology transfer involved Electricite de France to build two 944 MWe pressurised water reactor nuclear power plants with other Chinese partners at Daya Bay in Guangdong Province. de Gravel pointed out that in order for the BE to get its maximum efficiency for technology transfer, integrating suppliers and recipients, as well as other stakeholders, such as industrial partners, government entities, and rivals will be essential.

Should Chinese domestic firms continue to follow the technological trajectory of the multinational corporations or skip some stages or even creating their own path different from the foreign forerunners? In his contribution, 'From path-following to path-creating, some paradigm shifts in China's catching-up', Yu argued that while path-following strategy shortens the gap between China and the western world rapidly, it would keep China staying at the low-end of value-chain as a technology follower. He further noted

that some leading domestic Chinese firms have started to shift their technology catching up strategies from path-following to path-creating. He analysed this shift of the catching-up paradigm via the case of TDSCDMA, China's own third generation (3G) mobile communication standard. Nevertheless, path-creating catching-up involves less predictability of technological performance and high market uncertainties. Therefore, Yu pointed out that intense inter-firm collaboration under the continuous institutional support seems to be critical for path-creating catching-up.

With globalisation and technology development, industrial standards are becoming an important strategic tool for competition. In their contribution 'Industrial standard based competition and Chinese firm strategic choices', Wang, Wang and Li examined the role that industrial standard played in the development of domestic firms' technology capability in China. They noted that major multinational corporations have secured significant competitive advantages from their active role in industrial standard formation and have put domestic firms in a disadvantageous position. They argued that Chinese firms should consider industrial standard competition as a strategic weapon. They further illustrated how Chinese firms can make such move in two industries: mobile communications and high-definition video disc player industries. In their conclusion, Wang, Wang and Li proposed four hypotheses that emphasise the importance of firm level initiatives along indigenous R&D, industrial level initiatives along industrial alliances and consortiums, Chinese traditional culture, and the constructive role the government can play for domestic firms to achieve more competitive advantage through standard based competition.

After eventful 30 years of China's economic reform, Chinese firms are now faced with a new set of challenges, pressures, and opportunities to upgrade their technological and managerial capabilities. To address this issue, this special issue concluded with Ernst's contribution 'Beyond the 'Global Factory' model: innovative capabilities for upgrading China's IT industry', with implications of Chinese firms' future direction of technology upgrading. Ernst first described a 'global (high-tech) model' that characterised China's economic development after the reform and its integration to the global network of production and innovation through formal corporate networks and informal social networks. He, however, pointed out that China needs to move beyond the model as the model has led to technology dependence, low profit, and unequal integration in the global network. Therefore, Ernst introduced a new concept of 'industrial upgrading' with two dimensions: firm-level upgrading and industrial-level linkage. Firm-level upgrading involves specialising products and choosing types of production with greater upgrading potentials. Moreover, to sustain firm-level upgrading, strong supporting industries, dense linkages with universities and research institutes are required. Ernst emphasised that 'soft' entrepreneurial, management and system integration capabilities need to complement 'hard' R&D. Further, he argued that to be cost-effective, 'technology diversification' can serve as a complementary to 'radical' innovation.

3 Conclusion

While great challenges exist, opportunities can be identified and some domestic companies have already strategically managed their technology catching up with the multinational corporations. Fan et al. emphasised internal development, location strategy

for R&D functions, and manipulation of domestic demand. Gao et al. pointed out certain strategies to overcome resource and reputation disadvantage, such as specialisation, outside financing, and support from loyal customers and non-customer stakeholders. de Gravel illustrated that as recipient of technology transfer, a good understanding of the BE model can improve the efficiency of technology absorption, adaptation, and improvement. Yu demonstrated that domestic firms can leap frog in their technology ladder, instead of being a path-follower, via intense inter-firm collaboration and strong institutional support. Wang et al. highlighted how domestic firms as a group can collaborate and benefit from industrial standard formation. Ernst emphasised the importance of soft capability and technology diversification that complement to hard R&D and radical innovation.

More importantly, this issue highlighted the role that the government can play in promoting domestic innovation and technology catching up. Studies of innovative companies, including innovative small and medium-sized ones, indicated that government can assist domestic firms to overcome resource and reputation disadvantages, establish favourable financial and physical environment (high-tech parks) that stimulate innovation, or directly or indirectly involve in market demand for demand stimulated innovation (Fan et al., Gao et al.). Industrial standard (Yu, Wang et al.) is another area that government can and should play a significant role to rightfully represent the interest of domestic firms, especially when bargaining with multinational corporations or other national government. Finally, for China to move beyond its current 'global factory' model, industrial linkage that characterised by supporting industries, universities, and research institutes need to be tightly integrated in its national innovation system, coordinated and led by the government.

It is worth noting that there has been growing interest in understanding technology development in China. In the past four years, five different journals devoted special issues related to China's technology development, R&D management, and innovation policies (Table 1).

Table 1 Special issues on China's technology development in recent years

Special issue editors	*Year*	*Journal*	*Theme*
Maximilian von Zedtwitz	2004	*R&D management*	Managing R&D in China
Maximilian von Zedtwitz	2005	*Technology Analysis and Strategic Management*	The evolution of research on R&D and technology management in China
Yu Zhou and Yifei Sun	2006	*China Review*	Science and technology development in China
Mingfang Li	2007	*Journal of Technology Transfer*	Innovation management: Chinese experience and global implications
Yifei Sun, Maximilian von Zedwitz, and Denis Fred Simmons	2007	*Asia Pacific Business Review*	Global R&D in China

Source: von Zedtwitz (2004, 2005), Zhou and Sun (2006), Li (2007) and Sun et al. (2007)

This special issue focused on technology strategies of domestic companies and the role of the government in responding to domestic companies' need. We hope that our contribution, along with the above mentioned special issues, will enrich the growing literature on technology development and innovation policies and provide insights for entrepreneurs and policy makers in other catching-up economies.

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