Introduction

Elspeth Thomson

The role of science and technology is pivotal in any country's economic development. Many forces shape a country's national agenda for science and technology research initiatives. The obvious ones are the political system, planning and funding allocation mechanisms, number of government levels and research institutes involved, availability of capital, availability of labour with the required specialised scientific skills, physical scientific infrastructure, etc.

Equally important, but less quantifiable are competitive economic and political pressures from other countries, as well as the presence or lack thereof, of an entrepreneurial culture, informal networks among all participants, synergy between the academic research community and the industrial sector, agglomeration forces, etc.

It is imperative for governments to continuously review the administrative structures in the science and technology sector in order that the society's changing needs can be met over time and that research overlap and redundancy can be avoided. Decisions pertaining to a country's development of its science and technology sector require expertise in economics, finance, management as well as the many branches of science.

The Chinese leadership is now devoting considerable attention to the development of technologies which will make the country globally competitive. As the "factory of the world", China already wields formidable economic influence. However, this success has been largely based on the use of foreign technologies to make manufactured goods.

The Government is keenly aware that global economic leadership and power will be increasingly driven by intellectual property, not the export of manufactured goods. Thus, to become globally competitive, China confronts two challenges: not only to greatly develop its indigenous technological abilities, but to make rapid, substantial progress in indigenous high technologies.

This book is devoted to examining China's development of its science and technology sector in the context of globalisation. China is still affected by its being a developing economy and one that is in transition from central planning to market socialism. There are enormous physical as well as bureaucratic problems to overcome. However, modernising much later than the western world, China is in the fortunate position of being able to "leapfrog" some development processes. Tremendous progress can be expected to occur over the next few decades as Chinese researchers become increasingly integrated with global companies, research institutes and centres. In today's interconnected world, the decisions that the Chinese Government makes now with respect to science and technology will potentially not only affect the Chinese population for many generations, but also the world as a whole.

In the first chapter, Cao provides an overview of the technological development challenges faced by Chinese industry. The fundamental question he asks is whether or not China has the technological wherewithal to maintain its momentum in terms of economic growth and modernisation, and at the same time integrate into the world economy.

Cao is generally pessimistic. He argues there is no endogenous and indigenous technological capability because (a) many industrial firms have little in the way of financial resources to do innovative

R&D work; (b) there is a serious lack of trained people due to the brain drain of talent to other countries and foreign-invested enterprises located in China; (c) most of the spending on technology imports has been devoted to hardware instead of technology licences, i.e., it has been easier for domestic companies to import technology than to take the risk of doing their own R&D; (d) enterprises lack interest in engaging domestic learning institutions with respect to R&D. Many flatly do not wish to acquire technology from domestic sources; and (e) few Chinese enterprises own independent intellectual property rights (IPR) in core technologies. They have been more interested in utility model and design patents.

It is acknowledged that China's economic and industrial development has progressed at a high speed and that the country has become a globalised economy, able to manufacture and export good-quality, low-priced products to expanding consumer markets. However, Cao contends that any stature that China's high-tech sector has gained to date has been through the huge influx of foreign capital and components, and through FDI-embodied technology. He worries that using FDI as a means of tech-transfer may reinforce dependency, and he also raises the concern that some enterprises may become so large and bureaucratic that they may lose both their ability to innovate and their entrepreneurial spirit.

The next two chapters are concerned with patenting activity in China. Governments grant patents to inventors in order to prevent others from making, using or selling the invention without the permission of the inventor. They are granted for new industrial processes or for significant improvements to existing ones for a fixed period of time and become the property of the inventor.

Lu and Hu examine the regional variation in patenting in the light of local economic institutions such as business participation and technology market development. The geographical distribution of innovation is important in a country as large and diverse as China. The Government cannot be seen to be ignoring the research efforts of the more remote areas. The analysis reveals large differences in science and technology capability and activity among China's regions. These are a function of variations in human capital,

pre-reform conditions, inherent development potentials, location with respect to international markets, government policies, speed of economic reforms, etc. Another factor is researchers' varying propensities to patent, which in turn may be related to enforcement of proprietary rights, technology market conditions and degree of international transactions.

A patents production function is estimated to test the main hypothesis that the re-orientation of China's national innovation system from a centrally planned system towards a market-driven one is critical in explaining the variation of patent output across China's regions. The key findings are that (a) higher participation of enterprises has facilitated research on proprietary technologies; (b) a more developed technology market has had similar effects; (c) better patent protection for proprietary technology accelerated reforms of state-owned enterprises in the late 1990s and China's joining of the WTO have all positively affected such research.

Lin and Zhang reveal that individuals, as opposed to industrial enterprises and research institutes, have accounted for over 70 percent of all patent applications filed domestically; that innovators in China, including the industrial enterprises, have been devoting their R&D resources disproportionately to small innovations (utility models and external designs), rather than to major ones (inventions); and that there is no evidence that the large- and medium-sized enterprises are the main force for innovation in China.

The authors believe that a major factor hampering innovation activity in China may be the low degree of industrial concentration. They attribute it primarily to regional competition and regional protectionism in China. They also contend that China must replace its industrial-oriented innovation policy — one where the Government has tightly controlled which resources, especially foreign direct investment, are allocated to which selected industries and projects — with one that is market-failure-based, i.e., one in which market forces guide resources towards industries requiring R&D investment the most.

The fourth chapter is devoted to reviewing some of the key standard-setting cases in China and the world. A company or country that develops a technical standard first can dominate that industry for years or even decades afterward. Standards have sometimes been used as weapons by multi-national companies to protect themselves.

The patent portfolio of Chinese companies in the United States is small and the majority of patents granted by the Chinese Patent Office are still held by foreign-based companies. Suttmeier and Yao note that Chinese companies have suffered complaints from IPR holders in Japan and the United States, and that the lack of patent and technical standards has seriously affected the competitiveness of Chinese companies. Thus, the Chinese Government is today strongly supporting the development of various industrial technology standards in a number of areas.

Standardisation has in recent years become a very important element of China's technology strategy. On the one hand, China would like to harmonise interests and development among China, Japan and Korea. On the other, it would like to establish its own technological platform in as many areas as possible to gain independence from foreign high-tech companies and drastically reduce the level of licence fees. Being able to establish, or at least influence global standards has become vital in national technological efforts. Defining and owning new international standards is a matter of pride and prestige for China's high-technology industry.

Although China is adapting to the realities of techno-globalism, a "neo-techno-nationalism" characterises China's technology policy and standards strategy. It is expected that China's standards strategy, as outlined in the *Medium and Long-term Plan for Scientific Development,* will see many adjustments over the next 15 years. It will necessarily be a gradual process because the industrial, government and research sectors all have varying preferences.

The next chapter examines some of the financial aspects of China's R&D. With the largest foreign exchange reserves in the world and an enormous trade surplus, the Chinese Government

would seem to be in an enviable position with respect to nurturing domestic research and importing foreign technologies.

While a considerable amount has been written on how to encourage high-tech industrial development, little has been written on the consequences of high-tech industry on the economy, particularly the financial consequences. Ma employs a three-sector overlapping generations model to assess the impact of the development of high-tech industry on the traditional industries (low- and medium-low-tech industries with mature, traditional technology) and the impact of financing the high-tech industry on the deposit and lending rates of bank loans, the total amount of loans borrowed by the traditional and high-tech sectors and the implications for household savings (the primary source for bank loans). While the household sector maximises its inter-temporary utility by allocating income into saving and consumption, the banking sector maximises its profits by offering banking services to their clients (depositors and borrowers).

The results reveal substitution and expansion effects on the bank loans. The substitution effect tends to substitute the loans borrowed by traditional industry by that of the high-tech industry while the expansion effect tends to increase the total bank loans due to the new activities in the high-tech industry. It supersedes the substitution effect rendering an increase in total bank loans. The implication is that deposit rates must rise to attract more savings from the household sector, meaning that the banks must charge a higher lending rate to the traditional industrial sector to cover the increased finance costs. Thus, the government ought to subsidise high-tech firms to give them greater incentive to innovate, and also ought to subsidise the traditional firms during the transition process. Alternatively, Ma suggests the provision of open-bid grants to both high-tech and traditional industries.

The sixth chapter spotlights two key regions where the Government in recent years has boldly encouraged R&D in the high-tech sectors. When making plans for the development of China's remote western provinces and autonomous regions, the hope was expressed that "footloose" high-tech industries would be suitable because the physical inputs required are often minimal

compared to most other industrial pursuits. The main requirement is highly trained labour. As the coastal region becomes more crowded and the costs of living there rise, perhaps more high-tech industries will indeed locate in some of China's more remote areas. However, in the meantime, most of the highest-level R&D is occurring in areas in the east and south where agglomeration forces have been at work for several decades.

Sigurdson focuses on Ningbo and Dalian, where there have been long traditions of industrial activity. In recent years, the Government has established zones specifically designed for high-tech industrial development. The various projects launched to promote high-tech industries are described in detail. Ningbo, near Shanghai, is well known for its entrepreneurship. Several new universities and colleges have been established there to generate large numbers of graduates trained in cutting-edge research. Ningbo will continue to produce a wide range of manufactured goods, ranging from motorcycles to mobile phones but in the coming years will also incubate a number of high-tech industries in biotechnology and Internet-related products.

Dalian's economic history has also involved multiple industries, ranging from machinery manufacturing, shipbuilding and fisheries to chemical engineering and electronics. The city is now also famous for its software industry which began in the 1980s. Software contracting for export began in the early 1990s and Dalian has achieved notable international stature in this area. Today, there are over 450 software companies in the vicinity. The Government has actively nurtured this industry, designating large parcels of land and investment packages for incubators, labs, high-tech parks and zones. Sigurdson describes the history and current research thrusts of some of the key domestic and foreign companies in Dalian. Although numerous institutions of higher learning have been built in Dalian, there are still critical shortages of labour trained in software development.

Over the past 30 years, the country has faced a severe brain drain. Many of the brightest minds left China to work abroad or went to study abroad and never returned. In recent years, however,

many of these people have returned. At the same time, fewer students are choosing to remain abroad. Another factor contributing to the shortages of skilled labour are vestiges of central planning which delay a fully efficient use of R&D manpower.

The penultimate chapter charts the progress and challenges faced in one particular sector, the "chips" industry. Semiconductor devices, or "chips" are found in almost all electronic products nowadays. More and more products, ranging from home and office appliances to weapons, use them. The production of chips in China lags far behind demand. Heng notes that it is presently mainly foreign companies operating in China, including Taiwan, Hong Kong and Macau companies which require the chips for their manufacturing enterprises, and that most of the demand is for low-end chips, i.e., specific-application chips (personalised digital products) and commodity memory chips. At the end of 2005, China had 479 chip design houses. About 380 were domestic firms and the others were design units of international MNCs operating in China. The Government is anxious to upgrade the chip industry from "made in China" to "innovated in China."

The book ends with a discussion of some of the political/social issues surrounding the rapidly expanding use of the latest communications technologies in China. While the Chinese Government acknowledges that the Internet creates tremendous opportunities for the global sharing of information of all kinds, it regards it as a potential threat to domestic political stability.

Due to the country's enormous size geographically and demographically, the Chinese Government is constantly worried that localised grievances could expand, gain momentum and wash across the country in an uncontrollable wave. With the introduction of the Internet as well as mobile phones, the Government has little ability to prevent instantaneous communications across the country. Since the quiet, seemingly imperceptible organisation of a massive Falun Gong demonstration in 1999, the Government has taken many steps to try to monitor Internet use.

Lagerkvist considers how the managers (entrepreneurs) of news, i.e., people operating news portals and networks satisfy the often

opposite demands of the state (propaganda departments) and the citizenry. The main subject areas which seem to give the Chinese Government the greatest cause for concern are pornography, online gaming, religious superstition, negative discussions about the Chinese Communist Party and its leaders, succession from the state and some foreign policy issues. Non-Chinese online media companies, such as Yahoo, Google and Microsoft are also very aware of potential state action should they encourage any "unhealthy" activities.

In recent years, instead of using harsh, abrupt language when trying to dissuade "unhealthy discussions" and resist cultural globalism, the state has made allusions to "traditional" Chinese values, or "new Confucianism". Blurring the lines between culture and politics, the masses are implored to cultivate and uphold high morals, and be loyal towards the current political system.

Throughout history, advances in science and technology have typically occurred in waves. Flurries of activity and astonishing results have sometimes been followed by longish periods of seemingly low productivity. In the case of China, the national system of innovation is being transformed, i.e., the responsibility and process of carrying out technological learning is being shifted from the central research and design institutes to enterprises, and enterprises are learning to play the supply–demand market game. There are bound to be delays as the leadership determines what course of action best corresponds to its conception of market socialism. The Chinese Government is beginning to recognise that projects which apparently have no commercial success can nonetheless generate economic, societal and/or environmental benefits.

China, as a whole, is rapidly gaining an entrepreneurial culture. In any country, and particularly in one such as China with its extraordinary size and diversity, technological innovation will take place in a number of its regions. Huge numbers of innovations — of a gradual and incremental nature — are already taking place in manufacturing firms all over China, though primarily in the dynamically evolving coastal areas. As industrial experience and technological

capacity accumulate at the enterprise level, the Chinese rate of innovation will rise sharply, and though it may seem a long way off now, China may one day be setting the standards for most products and technologies simply by virtue of the size of the Chinese market and the rapid growth rate of the economy.