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China

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The national system of innovation (NSI) conceptual framework has been playing a key role in enabling China to catch up and move forward to become an innovative country (Cassiolato and Vitorino 2009), as well as to build a prosperous society according to the 'Outline of National Medium and Long-Term Science and Technology Development Plan (2006–2020)' (State Council 1996). The idea of the NSI looks at the innovation process as an integrated and systemic (not linear) process. Hence, not only the enterprise, institutions and organisations, but also how they interact, is an important element of the NSI. Furthermore, history and context would affect the dynamics of the NSI, which requires us to investigate the relationship between the state and the NSI within a dynamic historical context.

This chapter deals with the role of the state in the evolution of China's NSI, and we consider the history that started with the 1978 reform and opening-up policy as the focus of this analysis. This chapter is structured as follows: the following four sections introduce the current context of China's NSI. The next section describes the evolution of the current form of state. We then analyse the institutions and policies of the state concerned with innovation. The fourth section discusses the specificities of the system of innovation in the country and its relationship with the state. The next section reviews China's explicit and implicit state policy towards science, technology and innovation (STI). We then analyse the outcomes of state policy and state institutions on the NSI. The last section summarises the main conclusions of this chapter.

China's Development Model

China has recently entered a historical phase where the established development model must be changed in order to attain the official macroeconomic objective of a growth in the GDP per capita from US$ 1,000 to US$ 3,000. In 2003, China's GDP per capita was $1,090, and reached $ 3,266 in 2008. International experiences indicate that this is a sensitive period which combines economic restructuring with accompanying changes in social formation. Corresponding with the above inevitable situation, two major changes have to take place: first, the marginal contribution rate that some key elements such as labour, resources, investment, and land have on economic growth will decrease, and the importance of knowledge and technological innovation will significantly increase; second, the official model of economic growth is in a critical stage of transition from a resource-based and extensive type into an intensive, high value added type. Therefore, only innovation can be a way to progress in accordance with these changes.

China has possessed the necessary conditions of the great-leap-forward development with the rapid economic growth of recent years. The Chinese economy is now the world's second largest in terms of its macroeconomic performance (*China Statistical Yearbook* 2010), and it has become a major destination for foreign direct investment (FDI) and a trading nation of global rank. Scientific output, in terms of publication of scientific research papers, grew at an annual rate of 8.9 per cent in 2009; and the number of granted patents increased at an annual rate of 41 per cent in 2009 (National Bureau of Statistics and Ministry of Science and Technology 2009). These conditions have laid a strong foundation for China to shift its development model into an innovation-based one.

The Constraints of the Traditional Development Model

China's industrialisation path was basically traditional relying mainly on natural resource endowments, and was developed on the basis of long-term intensive exploration and exploitation of natural resources and ecological environment. For example, China's consumption of coal, steel and fresh water accounts for 32 per cent, 27 per cent and 15 per cent of the total consumption of the world respectively (Chinese Academy of Sciences 2006). At present, China is suffering great pressure from resource constraints, environment damage and population growth.

In contrast with these factor inputs, however, China's innovation capability is relatively low, which has mainly manifested in a number of aspects. In the first place, the capability of technological invention is too low, with the number of annual authorised invention patents accounting for only 22.1 per cent of the total authorised patents, and 49.1 per cent of the intellectual property rights belonging to overseas inventors (*China Statistical Yearbook on Science and Technology* 2010). Second, most industries lack core technologies. Third, the enterprises' proclivity for technological innovation is weak. Fourth, technology is introduced repeatedly without digestion and absorption. Fifth, the key elements of innovation are isolated from each other, which makes it difficult to develop the country's comprehensive innovation capability, and the government, industry and research do not combine with each other effectively in innovation activities. In the development chain of science and technological innovation as well as enterprises' R&D activities, the allocation of innovation resources is unduly skewed, with the government putting too much emphasis on universities and colleges rather than on enterprises, especially innovative private enterprises.

In conclusion, these factors all indicate that China's economic development model has not broken off from the traditional one yet.

Regional Disparities in Economic and Social Development

As a big developing country with a large population and a vast land area, China has experienced a rapid and sustainable socio-economic growth as a result of the reforms in the past few decades. At the same time, the differences between urban and rural areas have been widening, and the regional development imbalance has become increasingly prominent. First there is the uneven distribution of income, mostly evident in the differences between urban and rural areas; second there is the uneven distribution of property; third is the employment and wages disparities, which means the differences of employment opportunities among workers in different regions (the imbalance of employment opportunities is an important factor for the widening gap of income and wealth distribution); fourth is the education disparities between urban and rural areas.

Regional Imbalances in Innovation Capability

The regional imbalance of innovation capability has experienced a historical evolution. Since 1949, when China was founded, the central government allocated a variety of resources in areas with better industrial basis, primarily in the north-east provinces, followed by eastern and northern China. In the 1960s, China shifted the strategic emphasis of industrial and science and technology layout, which improved the technological capability of western areas rapidly. However, the southern coastal areas with the exception of a few national-level investments, such as Fujian, Zhejiang, Guangdong, and other provinces, have only a few state-owned enterprises (SOEs), and their industrial infrastructure was weak and the development of science and technology lagged behind the rest of the country. Before China's reform and opening-up, the innovation capabilities of southern coastal areas generally lagged behind those of northern areas.

In 1978 a critical strategic decision leading to the reform of the political economy and the opening-up of the economy to global markets was made on the Third Plenum of the Eleventh Chinese Communist Party (CPC). Since then, China shifted its development emphasis into eastern coastal areas, by establishing special economic zones and opening the coastal port cities, and so on. The coastal areas became an important window for China to attract foreign capital as well as the most active centre for international technology transfer. In addition, this area attracted a large number of domestic skills to take part in innovation activities. Therefore, a significant change of China's regional innovation capability after the reforms and opening-up is the great improvement of innovation capability in southern and eastern coastal areas, while the development of innovation capability of the central and western areas was relatively slow, and the regional imbalance was reversed, that is to say, the differences of innovation capability between eastern and western areas have been widening.

The differences between urban and rural areas still exist. At present, China's development of rural science and technology innovation is very weak in general, and has become one of the weakest sections in China's science and technology programme. The problems include seriously insufficient inputs in rural areas, an inadequate scientific and technological innovation and service system, a relatively weak dissemination of science and technology, and the general inability of available technologies to meet the needs of peasants. The interaction between a poorly developed science and technology base and economic development may become a vicious circle. Compared with the urban areas, the rural areas lack effective policies and measures to attract and train scientific and technological personnel, so the phenomenon of skills loss is serious. In addition, a new scientific and technological service system which meets the economic market rules and requirements has not been established yet and the construction of an information-sharing platform is relatively slow.

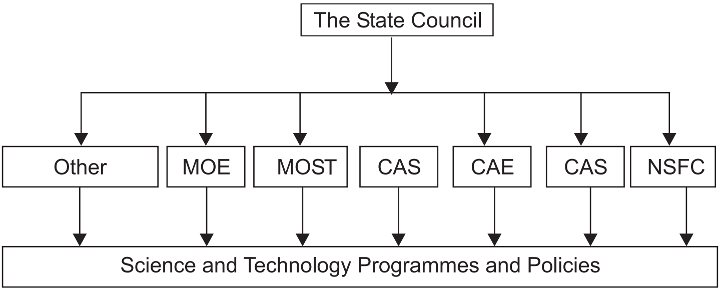
At the 17th National Congress of the Chinese Communist Party in 2007, China put forward the ideology of 'Scientific Outlook of Development' as a strategic decision to develop and utilise indigenous innovation and build an innovative country.[1] This policy was adopted to enter the global economy with the rapid development of science and technology. China regards enhancing indigenous innovation capability as a development strategy of science and technology, and promotes an indigenous innovation path parallel to the great-leap-forward development of science and technology. In addition, China is establishing a new balanced NSI to attract more innovators and enterprises to join in, not only to promote innovation, but also to promote the construction of a harmonious society that more people may benefit from.

Evolution of the Current Form of State

The administration of China's innovation system consists of several major bodies: the Ministry of Education (MOE), formerly the State Education Committee; the Ministry of Science and Technology (MOST), formerly the State Science and Technology Committee (SSTC); the Chinese Academy of Sciences (CAS); Chinese Academy of Engineering (CAE); Chinese Academy of Social Sciences (CASS); and the National Science Foundation Committee (NSFC). These agencies cooperate with other industrial ministries, which also have their own research institutes and projects, including the Ministry of Industry and Information Technology (MIIT), and the National

Development and Reform Committee (NDRC). Together these administrative bodies formulate and implement national science and technology programmes and policies. Figure 5.1 provides the organisation form.

Figure 5.1: *Main Administrative Bodies of China's Innovation System*



Source: Zhong and Yang (2007).

In this administrative framework of the NSI, the Chinese government's economic functions can be divided into two stages marked by the reform and opening-up.

The role of the state in a centrally planned economy prior to 1978

From 1949, the founding of the new China, to 1956, China almost completed the socialist transformation, which was a process wherein the state gradually extended into the private economic sector and eventually replaced the autonomy of the private sector in production and consumption. Since 1958, the state has at all levels completely dominated the entire economy, and controlled every aspect of the economy, including production planning as well as a coupons-based supply system for a variety of subsidiary food and manufactured goods for daily use.

The formation of the single public ownership and the planned economy resulted in the need to accelerate industrialisation, that is to say, at that time under the conditions of shortage of capital, China increased capital investment relying both on depressing domestic consumption and improving accumulation. In the 25 years from 1953 to 1978, China maintained a relatively high economic growth rate, and almost set up an autarkic industrial system, which was closely and inseparably related to such a high rate accumulation. In addition, the single public ownership and planned economic system has another function: to guarantee social security to all the people in China, to insure social stability during a period of high accumulation and deficiency in goods and materials, although this kind of social security is at low levels of income.

Originally, the planned economy was designed to reduce economic operating costs and to avoid inappropriate resource allocation and waste caused by business and individual production without government control. However, because the information for decision-making in the planned economy was insufficient, there were many uncertain factors and bureaucratic obstacles in the implementation process, which has led to a number of mistakes in allocation. Public ownership also did not play the expected function of arousing people's enthusiasm for production. In rural areas, the collective production and average income distribution in the People's Commune model have suppressed the farmers' enthusiasm for production. In urban areas, the phenomenon of 'workers eating from the same big pot of their enterprises, and enterprises eating from the same big pot of the country' also suppressed the enthusiasm of enterprises and workers.[2] Since in both, the single public ownership and the planned economic system, the desired economic performance and the goal of stimulating enthusiasm of all the people have not been achieved, the Chinese government has had to explore new ways and seek new approaches to improve the socialist economic management system.

The role of the state and the emerging mixed economy since 1978

After the Third Plenary Session of the 11th Party Central Committee in 1978, and with the deepening of the reforms and opening-up, China has gradually formed an economic framework in which a variety of economic sectors coexist, and the market mechanism plays a basic regulating role. Accordingly, the government's economic functions have consciously or unconsciously changed. This change can be roughly divided into two phases: the first phase was from 1979 to 1991, where the focus was to remove the old functions the government had, that was to narrow the government's economic management scope and power; the second phase was from 1992 to present, the focus of which was innovation and the re-establishment of the government's functions in accordance with the market economy.

In the first phase, the government's original economic function under the conditions of single public ownership and planned economy gradually cleared up on two fronts. The first was decentralisation, which allowed the existence and development of a non-public economy as well as the 'three capital' enterprises.[3] During this phase, the reform of rural areas was most prominent and made the greatest achievements. In urban areas, the reform of SOEs moved forward slowly, but from the implementation of reducing administrative power and decentralisation to the 'contract system', enterprises' autonomy and share of profits were increased significantly. This relaxation of government control on public economy and obtaining surplus has been one of the driving forces for China's rapid economic growth in the 1980s. During the reform of the public-owned economic system, the Chinese government also adopted the policy of opening up to the outside world, and encouraged urban and rural job-waiting persons to be self-employed or become 'specialised households' in order to let the market mechanism regulate. Thus, another highly vigorous economic sector has been established besides the existing public-owned system.

The second was the gradual relaxation of administrative control on the whole economy, which means that the government withdrew from some areas to allow the alternative regulation of market mechanism. In this aspect, the guiding ideology of the Chinese government shifted from a model of a 'planned economy-orientation with market regulation as a supplement' to the one that was 'combining planned management with market regulation', then to the top-down model of 'government adjusting market, and market guiding enterprise', and finally went back to an ambiguous formulation of 'combining planned economy with market regulation' in 1989. These changes in China's guidelines clearly show that the Chinese government has been giving increasing space to market regulation rather than direct state control. The obvious feature in this transition of the government's economic function was the reform and improvement of the economic system based on public-ownership and planned economy under the guidelines of 'emancipating the mind and seeking truth from facts' and China's 'four cardinal principles'.[5]

In the second phase, the market economy was commonly accepted as the goal of China's reform, and the measures taken by the Party and the government were to move towards this goal. The transition of the government's economic function took the initiation from 'feeling the way across the river' (Chen 1995: 279) in the 1980s, to establishing a basic market economy framework at the end of the 20th century, then to establishing a mature market economy in the first 20 years of the 21st century.

The reform of the government's economic function focused mainly on two aspects in this period. The first was the total adjustment and reform of the state-owned economy, which was the last bastion of the old system. The course of this reform was that in the first half of the 1990s, transforming operational mechanisms and establishing a modern enterprise system were emphasised; after 1996, the establishment of a modern enterprise system was combined with the policy of 'invigorating large enterprises while relaxing control over small ones' proposed in the document, 'A Number of Decisions on Major Issues about State-Owned Reform and Development by CPC Central Committee' in 1999 (The fifteenth Central Committee of the Chinese Communist Party, the Fourth Plenary Meeting 1999), as well as joint-stock transformation, during which the government transferred some state-owned economy, even totally withdrawing from some fields. Another is that the government constructed a management system in accordance with the market economy. In 1993 and 1998, two rounds of large-scale reforms of government institutions were conducted, which not only strengthened the government's macro-management functions, but also strengthened the government's regulating function on enterprises' behaviour and market order. In addition, a new social security system was included as a main duty of the government. At present, the government's economic functions have transformed from the overall direct control-type model before 1978 into the indirect adjustment–type model (Wu 2003).

Periodisation and Analysis of Institutions and Policies of the State Concerned with Innovation

Corresponding to the government's economic function, China had implemented a planned science and technology system before

1978, during which the enterprises, scientific research institutions, universities, and national defence research institutions were independent systems, in order to promote the science and technology projects and knowledge transfer (Fang and Liu 2004). In the situations of international blockade and extreme scarcity of domestic science and technology resources, this system has played a very important role in centralising limited resources, setting up an intact science and technology system and infrastructure. Over 20 years this science and technology system trained a large number of outstanding talents, solved a series of great scientific and technological problems in social, economic development and defence construction and greatly narrowed the gap between China and some advanced countries.

However, this planned science and technology system confronted some challenges at the end of the 1970s. At that time, the wave of new technological revolutions was surging and profound changes had taken place in almost all fields. Technological achievements were popularised and applied into production rapidly, which in turn brought tremendous changes in social productivity and accelerated global economic growth and industrial restructuring. In the meantime, the inherent structural defects of China's existing science and technology system appeared gradually. First of all, it was a closed system with vertical structure, with the result that the science and technology sector and the economy were separate. Second, there was little sense of intellectual property rights and there was no mechanism through which science and technology could be transferred with compensation in China, which hindered technology innovation and diffusion. Third, the government had intervened too much through administrative means on scientific research institutions, and the phenomenon of 'getting an equal share regardless of the work done' existed at that time, which was not conductive to arouse the initiative and enthusiasm of scientific research institutions. Therefore, the reform of the existing science and technology system was imperative.

Since that period until now, the Chinese government has made a great effort in policy making to push science and technology system reforms, which can be roughly divided into three phases according to the adjustment of reform objectives and focal points of the policy.

The first phase (1985–1992): The reform of the funding system and governance relaxation on scientific research institutions

In this phase, the main policy direction of science and technology was to give more flexibility to scientific research institutions, scientific and technological personnel. Policies in this period concentrated on the funding system, the technology market, organisational structures and the personnel system. During this period the reform of the science and technology sector proceeded on five levels.

The first thrust was on the reform of the funding system. According to the characteristics and division of science and technology activities, China divided national scientific research expenses into specific categories. For those scientific research institutions mainly engaged in technological development, the government would completely reduce the funding of their operating expenses over a five-year period. For those scientific research institutions mainly engaged in basic research, the government would implement a funding system which would subsidise a portion of their operating expenses. For those organisations engaged in social public welfare research and agricultural research, the government would still subsidise their operational expenses. The main purpose of this reform was to change the existing dependency relationship of scientific research institutions on their administrative departments, and in this manner to force scientific research institutions to serve economic development as well as to strive for multi-channel sources of funding. In this process the overall science and technology sector would be reoriented towards a market economy and overall investment on science and technology would be expanded in order to accelerate the commercialisation of scientific and technological achievements.

The second reform was to open the technology market. Technological achievements were acknowledged as a commodity in policy and legal system at that time, and a mechanism was established that technology transfer should be compensated in accordance with its value. In addition, the government promulgated the 'Patent Law', the 'Technology Contract Law' and some corresponding implementing regulations, which provided basic rules for technology transactions such as technology development, technology transfer, technology consultation, and technology service, and so on.

The third was the reform of the management model of scientific research institutions. The principles and direction of the reform was the separation of responsibilities between research divisions and administrative divisions in the departments of the State Council in order to decentralise the authority of scientific research institutions, to change the direct control model into the indirect management model that the Chinese government has as regards scientific research institutions. This reform was meant to expand the autonomy of scientific research institutions and to encourage the union among scientific research institutions, educational agencies, design units, and production units, as well as to strengthen the capability of enterprises in technology absorption and development.

The fourth thrust was to support and develop private scientific and technological enterprises. The government encouraged scientific and technological personnel to set up private scientific and technological firms engaged in technology development, technology transfer, technology consultation, and technology service in accordance with the business principles. These principles included self-financing, voluntary cooperation, making one's own management decisions, and taking full responsibility for their own profits and losses. This was meant to make these firms a vital force in the development of high-tech industries outside the existing system.

The fifth level of reform was to establish pilot high-tech industry zones. In May 1988, the State Council approved the establishment of the Beijing High-Tech Industry Pilot Zone and provided 18 preferential policies to it. By April of 2011, 86 national-level high-tech industry zones were established all over the country.

The second phase (1992–1998): China's support on basic research

In this phase, China carried out high-tech research and other projects that had long-term significance on economic construction, social development and national defence, and during which China has developed a growing body of science and technology personnel which is progressively placing it on the global market. In addition, China emancipated different kinds of R&D institutions which can directly serve China's economic construction and social development, as well as encouraged commercialisation and industrialisation activities of science and technology achievements in order to make them market-oriented. The main policies and measures taken are listed in the following paragraphs.

First, the government encouraged all kinds of scientific research institutions to implement the integration of technology, industry and trade, or to cooperate with firms in technology development, production and management. On the other hand, the government also encouraged scientific research institutions to adopt commercially oriented management models, with an emphasis on the relevant provisions of corporate finance such as independent accounting, and gradually achieved a balance of payments, economic self-reliance and assumed responsibility for its profits or losses. Second, the government granted managerial authority to some suitable scientific research institutions to operate state-owned assets, and encouraged them to invest in setting up scientific and technological enterprises or groups, merging and acquiring firms or being a shareholder of a firm in order to enjoy returns in accordance with the law. Third, the government provided support to eligible scientific research institutions in their cooperation with large and medium-sized enterprises or enterprise groups in various ways. Fourth, the government promoted social welfare organisations to become new legal entities. These organisations mainly relied on national policy-based input, social investment and income generation from their own scientific and technological business, and the Chinese government encouraged them to establish a mechanism of self-accumulation, self-operation and self-development with reference to foreign non-profit organisations. These organisations should be supervised and administrated by society, and conduct non-profit-oriented business activities and service for the society, which can be exempt from income tax and value-added tax. In this way the income of these organisations may be used to support their own development.

The third phase (since 1998): The policy of 'relying on science and technology to rejuvenate the nation' and building a national innovative system

In this phase, substantive adjustments were conducted to the science and technology development strategy and system, and 'Relying on Science and Technology to Rejuvenate the Nation', which was formulated in 'Decision on Accelerating Science and Technology Progress by the Central Committee of the Chinese Communist

Party and the State Council' in 1995 (Central Committee of the Chinese Communist Party and the State Council 1995), became a national-level strategy. Strengthening the NSI and speeding up industrialisation of scientific and technological achievements became a main policy direction of this period. Virtually all policies concentrated on restructuring scientific research institutions and improving the innovation capability of enterprises and industries, and so on.

With the accelerated pace of reform in government agencies, the State Council decided to conduct the administrative system reform of 242 scientific research institutions attached to 10 state-level bureaus managed by the State Economic and Trade Commission at the end of 1998, the means of which included transition into scientific and technological enterprises or technology intermediary service institutions, as well as mergers with enterprises in order to realise firm-based transformation (State Council 1999c). The goal of this reform was to reduce the number of independent state-level research institutions, encourage enterprises to set up their own applied research institutions and transform enterprises into the main actors of technology innovation. Thereafter, another 134 technological development scientific research institutions affiliated to the State Council had also carried out the transformation into enterprises (Ministry of Science and Technology 2000). At the same time, the government began to promote the transition of public welfare-based research institutions into non-profit organisations. These changes have transformed each of the main components of the NSI. The business sector has become the dominant R&D actor, now performing over two-thirds of total R&D, up from less than 40 per cent at the beginning of 1990. The share of public research institutions has declined from almost half of total R&D to less than one-quarter over the same period. The relative weight of higher education institutions (HEIs) has increased moderately, from 8.6 per cent to 9.9 per cent.

There has also been a vigorous promotion of the commercialisation of scientific and technological achievements. In May 1996, the Standing Committee of the National People's Congress approved 'China's Promotion Law of Commercialisation of Scientific and Technological Achievements' (Standing Committee of the National People's Congress 1996). In 1999, the General Office of the State Council transmitted the policy 'Some Provisions on Promotion of

Scientific and Technological Achievements' (Ministry of Science and Technology et al. 1999) from seven departments such as the Ministry of Science and Technology. The aforementioned policies established the following norms:

(*a*) If the high-tech achievements are regarded as assets invested to the limited liability company, the value of them can amount to 35 per cent of the total registered capital, except otherwise agreed by the parties.

(*b*) Scientific research institutions, colleges and universities should reward the author and related people when they want to commercialise the technology achievements, and the reward should be no less than 20 per cent of the net income of commercialisation, or no less than 5 per cent of the newly increasing profit that gained from new achievements for three–five years in succession. If a stock company wants to commercialise, it may also reward no less than 20 per cent of the value of technological achievements when they are regarded as share(s).

(*c*) Scientific research institutions, colleges and universities should reward the author(s) in form of donation of share or stock rights according to their contribution. The author(s) wouldn't pay personal income tax when obtaining these shares or capital ratio; but they would pay income tax if obtaining ratio of dividends or transferring investment shares.

(*d*) If the scientific and technological personnel have completed their assumed work in their own units, they can engage in R&D and commercialisation in other units.

A series of technological innovation policies was introduced, including: (*a*) 'Some Provisions on Mechanism of Venture Capital Construction' (State Council 1999b), which were used to boost the development of venture capital in China; (*b*) China established 'Innovation Funds for Small and Medium-sized Technology-based Firms' (1999), in order to promote the development of these firms; (*c*) the former State Economic and Trade Commission and the Ministry of Science and Technology have all proposed the 'Technology Innovation Project', in order to boost both enterprises' and regional innovation; (*d*) the government put forward some innovation policies to improve industries' innovation capability, the most important of which is 'Policies on Encouraging Development of Software Industry and IC Industry' (State Council 2000) issued by the State Council in 2000, which boosted the development of these two industries.

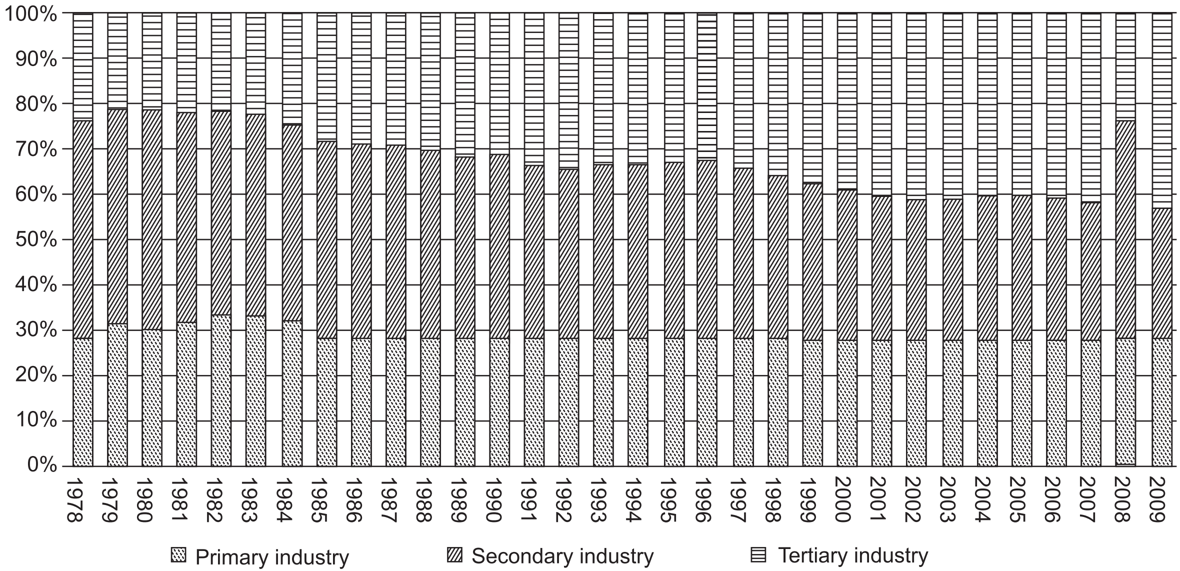
In January 2006, the National Science and Technology Conference was held in Beijing, where the 'Outline of National Medium and Long-Term Science and Technology Development Plan (2006–2020)' (State Council 1996) was issued. This policy marked that China's science and technology development strategy would transform from imitation-based innovation into indigenous innovation. This outline was based on the position of China in the global market and included a comprehensive plan and strategic proposal of China's science and technology development in the next 15 years. It aimed to enhance indigenous innovation as the main development strategy as well as setting innovation-oriented construction as a key national goal. This was a programmatic document to guide China's science and technology development in the new era.

Specificities of the System of Innovation in the Country and Its Relationship with the State

Since reform and opening-up in 1978, China's economic structure of primary industry, secondary industry and tertiary industry has changed a lot, which can be seen from Figure 5.2. During the past 32 years, the absolute value of these three industries has increased by 3328.32 per cent, 8932.71 per cent, and 16821.73 per cent respectively, which manifests the great economic achievements China has made. The proportion of primary industry decreased from 28.19 per cent in 1978 to 10.30 per cent by 2009, while the proportion of tertiary industry increased from 23.94 per cent in 1978 to 43.36 per cent by the same year, and the proportion of secondary industry has maintained the level of less than 50 per cent. Therefore, China has undergone a dramatic transition from an agriculture-based country into a manufactures-based country since reform and opening-up.

In the secondary industry, China's high-tech technology has also developed very fast. As Figure 5.3 shows, the percentage of China's added value of high-tech industries in the manufacturing sector has been increasing and by 2007, this percentage reached 12.7 per cent, which surpassed Italy, and the gap between China and other developed countries has been reduced significantly. Figure 5.4 shows China's

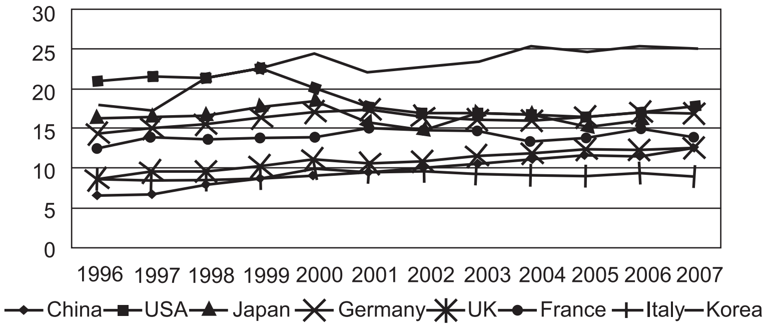
Figure 5.2: *Structural Evolution of China's Primary, Secondary and Tertiary Industries, 1978–2009 (percentage)*



Source: *China Statistical Yearbook* (2010).

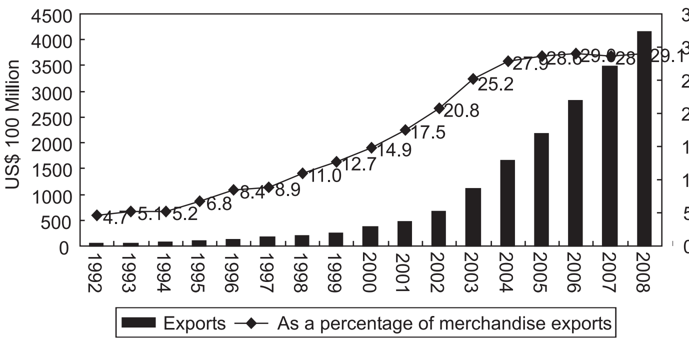
high-tech products exports and its percentage of total merchandise exports from 1992 to 2008, from which we can see that China's high-tech exports have increased from US$ 4 billion to US$ 416 billion, and its percentage of total merchandise exports has increased from 4.7 per cent to nearly 30 per cent.

Figure 5.3: *Value Added of High-tech Industries as a Percentage of Manufacturing in China and Selected Countries, 1995–2007*



Source: China Statistical Yearbook on High Technology Industry (2004a, 2010).

Figure 5.4: *China's Exports of High-tech Products, 1992–2008*

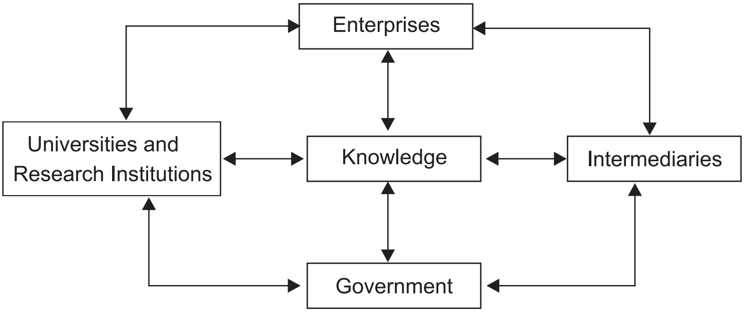


Source: China Statistical Yearbook on High Technology Industry (2004a, 2010).

China's NSI has developed with the transition from a planned economy into a market economy, as well as from an agriculture-based country into a manufactures-based country. China also has the potential to develop a NSI that will be a powerful engine for sustainable growth and facilitate the smooth integration of China's expanding economy into the global trading and knowledge system

(OECD 2008). China's NSI includes the following main actors: enterprises, universities and research institutions, government, intermediaries; their interaction is shown in Figure 5.5.

Figure 5.5: *China's NSI*



China's NSI has a number of unique characteristics, which have been emphasised by most scholars. In the first place, the Chinese government plays a critical role in the NSI and through the reform of the science and technology system has promoted the improvement of the NSI since China's reform and opening-up. Second, the establishment and implementation of national key science and technology programmes and projects has promoted the integration and cooperation among enterprises, scientific research institutions and universities, which became main actors of China's NSI. Third, Chinese enterprises are still lacking innovation capability, and the planned economic system developed in the past has been a serious impediment to the innovation of enterprises. It is therefore critical for China to establish a modern system and strengthen enterprises' innovation capability. Finally, the incentive system of innovation and the service system of intermediary organisation are imperfect, and all kinds of key elements have not developed an appropriate innovation structure and network.

The role of the state in the NSI depends on their own political system, on the nature of the economic system, and on the economic development stage of different countries, that is to say, governments play different roles in the national systems of innovation of different countries. As far as China is concerned, the functions that the government plays in the NSI can be summarised into five categories. It guides the allocation of innovation resources effectively; it facilitates and stimulates the interaction among all kinds of innovation elements; it creates a suitable mechanism and good environment for innovation activities; it intervenes where market failure exists; it monitors and assesses the implementation of the NSI.

Although the Chinese government has done a large amount of work in promoting and establishing the NSI, and the reform of the science and technology system has also made prominent progress, China's NSI still has some serious obstacles and weak segments from the perspectives of the current increasingly international competitive challenges and the requirements to carry out the policy of 'Scientific Concept of Development'. These obstacles and weaknesses still constrain the improvement of China's innovation capability.

The macro policy design and management system

There are a number of areas of weakness in macro policy-making and the management system in China. The macro policy-making system and mechanism for STI does not meet the needs of development since it lacks a national-level permanent agency engaged in consultation, assessment and supervision; there is still a large scope for the improvement of this function. The system of policy-making and implementation is also marked by fragmentation. Since the goals of each government department are different, there are disconnections in the innovation management process among them. As a result of the shortcomings inherited from the pre-reform planned economic system and the low national-level arrangement for the overall system, China's innovation chain was fractional and the problem of long-standing segmentation of the economic sector, science and technology sector, educational sector, and industrial sector could not be resolved fundamentally. Moreover, the allocation of scientific and technological strengths is irrational, and the regional allocation of innovation resources does not match with national-level economic and social development configuration. Most innovation resources were allocated in Beijing, Shanghai and other developed coastal areas, whose environment could attract talents and technological achievements from home and abroad. Therefore, the gap between developed eastern coastal areas and undeveloped central as well as western areas in China is wider than ever before.

The innovation capability of the main performers of innovation

Chinese enterprises do not, as yet, have strong indigenous innovation capability, and have not really developed a competitive technology innovation system. For a long time, Chinese enterprises have been attaching great importance to the introduction of technology and equipment with short-term efficiency while ignoring technology digestion, absorption and innovation. That is to say, the production capability of Chinese enterprises was maintained and upgraded mainly through technology imports, and enterprises spent more money on technology import than on their own R&D before 2000 (as shown in Table 5.1), which led to considerable difficulties in enhancing their innovation capability.

Table 5.1: *R&D Expenditure and Technology Import (US$ 100 million)*[6]

	Expenditure on R&D	*Share of Total Sales, %*	*Expenditure on Technology Import*	*Share of Total Sales, %*
1995	17.1	0.46	43.4	1.17
2000	42.7	0.71	29.6	0.49
2005	152.7	0.76	36.2	0.18
2009	470.0	0.96	57.8	0.12

Source: China Statistical Yearbook on Science and Technology (2004b, 2006, 2010).

As far as indigenous innovation capability is concerned, less than 1 per cent of all Chinese enterprises have applied for a patent, and only around 2,000 domestic enterprises, 0.03 per cent of the total, own their own intellectual property rights (*China Daily* 2005) despite the emergence of successful Chinese firms in the high-technology sector and in the international market. The innovation capability of Chinese enterprises is mostly focused on incremental innovation with little radical innovation, which can be observed from the patenting activities of the enterprises. Patents registered in China are classified into three categories: (*a*) invention, (*b*) utility model and (*c*) design (appearance). Design refers to new appearance and utility model refers to functionality modification or improvement without substantial technological contents. The invention patents are thus presumably more R&D intensive than the other two types of patents. Chinese enterprises have relatively high patenting activity in utility model and design, which accounts for the largest increase in the total number of patents, but is low in invention patents. However, since 2000, the number of invention patents granted has also increased more rapidly than before (see Table 5.2).

Table 5.2: *Patents Granted in China, by Type of Patents (in number)*

	1995	*2000*	*2005*	*2009*
Total number of patents granted	45064	105345	214003	581992
Share of invention patent (%)	7.5	12.0	24.9	22.1
Share of utility model patent (%)	67.6	52.0	27.1	35.0
Share of design patent (%)	24.9	36.0	38.0	42.9

Source: China Statistical Yearbook on Science and Technology (2004b, 2006, 2010).

Furthermore, the patenting activities differ significantly between domestic and foreign firms in China. For instance, even though both domestic and foreign firms have rapidly increased their patent applications, the largest increases in both invention patents applied and invention patents granted are from foreign firms.

Chinese scientific research institutions generally lack original innovation capability. China's conditions of scientific and technological support, resources integration and social sharing are insufficient, and the utilisation efficiency of resources as well as innovation efficiency is relatively low. In addition, the capability of China's social welfare research institutions is low. Because of inadequate awareness and deficient attention of the nature and value in research activities they are engaged in, investment has been insufficient to carry out many urgent scientific researches in China for a long time.

As an important base in personnel training and innovation, the potential of universities has not been brought into full play, and there are some defects in the system. Currently, applied research occupies the largest share of R&D activities in universities. For instance, in 2006, the shares of basic research expenditure, applied research expenditure, and experimental development expenditure in universities were 31.1 per cent, 53.4 per cent and 15.5 per cent respectively, and the shares of R&D personnel were 41.1 per cent, 51.3 per cent and 7.6 per cent respectively, which is contrary to that of developed countries (*China Statistical Yearbook on Science and Technology* 2010).

Finally, the strength of professional intermediaries is weak, which has a negative impact on the movement and integration of innovative elements, as well as the overall function of the innovation network. Intermediaries have developed gradually during China's transition from a planned economy into a market economy, so they have heavy government-run overtones and are not independent economic entities, and could not play a full role in optimising the combination of scientific and technological elements.

The innovation mechanism

Elements involved in the innovation activities are disconnected, separate from each other, and lack cooperation. In addition, the exchange of knowledge and information is not smooth. The interaction mechanism of production, teaching and research is imperfect since the connections, cooperation and exchanges among firms, scientific research institutions and universities are weak. Universities and scientific research institutions are unable to participate in the processes of technology introduction, digestion, absorption, and innovation in enterprises. On the contrary, enterprises also cannot participate in the national scientific research tasks undertaken by scientific research institutions and universities.

The investment mechanism of science and technology is still insufficiently developed to meet the requirements of innovation. In recent years, although the total amount of state financial investment in science and technology has increased, its proportion in all financial expenditure for the same period did not simultaneously increase, and there is little monitoring of the expenditure of national scientific and technological funds in the entire process. In addition, there is no well-formed mechanism to guide and encourage investment by a variety of social resources.

There are also still deficiencies in the incentive mechanism, which should reflect the principle of a 'people-oriented' concept, promote scientific and technological innovation, as well as accelerate the transfer of scientific and technological achievements. The role of the market mechanism to guide and promote innovation has not been fully played out. Finally, the planned management system does not keep pace with the country's development. Innovative activities should be totally different in scientific research organisations for they have different laws. The existing single innovation mechanism does not meet the diversity of the legislation on innovation.

Constraints in the innovation environment

The legal system governing innovation and the relevant policy environment still need to be improved on a number of levels. Legislation has not evolved fast enough to accommodate the requirements of scientific and technological development. The construction of the infrastructural platform for science and technology is relatively lagging behind. The infrastructure for science and technology is still relatively weak, and the limited resources could not be used reasonably, which constrains the serious development of many important research and development fields; it is difficult to provide basic guarantees to increase national-level innovation capabilities. The basic role of the market mechanism is still to be put to full use in innovation. During the process of promoting scientific and technological innovation, and with the withdrawal of the previous strong direct participation of the state, the fundamental role that the market mechanism plays still needs to be further strengthened. The existing pool of scientific and technological innovation talents is still insufficient to meet the needs of development. While this pool is large, its composition is ill-suited to the development needs of the NSI and the overall innovation capability is not high. In addition, qualified R&D personnel have still not been given full play in scientific and technological innovation, and their enthusiasm has not been fully aroused.

The culture of innovation

A number of aspects of the current culture of innovation do not meet the development requirements of the NSI. In the first place, academic democracy has not been given full play and some academic agencies and scientific research institutions tend to be overly administrative. Second, the cooperative spirit is insufficient, and the phenomenon of partition exists as a serious problem, which hinders the interaction and communication among all innovative mainstays and increases the obstacles to innovation. Third, there is evidently an over-emphasis on short-term quick success and instant benefits to the detriment of long-term development. Finally, the spirit of competition and innovation needs to be strengthened. Both the long-term impact of the planned economic system, as well as the corresponding imperfection of the scientific research system and incentive mechanism lead to the weak driving forces of competition and the low competitiveness of researchers, as well as an insufficient level of entrepreneurship.

Since the government includes both the central-level and regional-level tiers of administrative influence, the NSI can also be analysed from these two levels. In the NSI, the central government always tries to achieve sustained, stable development in accordance with international competitive norms through good policies, legal guarantees and infrastructure for innovation activities, organising important innovation programmes and projects, as well as promoting the cooperation between industry and research from an overall perspective of the national economic development situation. In a regional innovation system, the local government always develops local innovation and development policies in accordance with national guidelines and related policies, in order to promote industrial upgrading and high-quality economic growth. Thus, the local government is to create a regional innovation environment, while the national innovation environment is largely created by the central government. Moreover, the local government generally needs to specify and combine the innovation policies and rules made by the central government into their local policy making and economic operation, which can reflect local characteristics and have a direct effect on local economic development.

Therefore, the local government plays an important role in the construction of a regional innovation system and the NSI. The local government is familiar with regional situation, such as the resources, market demands, talents, technology, and management of local firms, which can reduce the cost of innovation system construction. The fact that China's market system is still in a transition phase requires intervention by local government in the innovation system. On the one hand, the regional policies which are intended to encourage innovation are always more specific and operational; on the other hand, many factors which maintain the market system, such as property rights and provision of public goods, need to be improved by the local government.

Explicit and Implicit State Policy towards Science, Technology and Innovation

Over the past three decades since reform and opening-up, China's science and technology system has transformed from a planned one based only on planning into a market-based system built on both planning and policy, during which the science and technology policies and regulations have played an increasingly important role, which is not only a parallel process with China's transition from a planned economy to a socialist market economy, but is also a formation process of science and technology policies and a legal system with Chinese characteristics. Before reform and opening-up, the Chinese government played a dominant role in the allocation of science and technology resources. In China's transition from a planned economy to a market economy, the intervention of the Chinese government in scientific and technological activities has diminished gradually, but did not disappear. The government has always been a provider of science and technology policies, so guiding and regulating scientific and technological activities through relevant policies in order to compensate for market failure is an important function the government should assume in the field of science and technology.

Science and technology policies in the 1980s

From the perspective of science and technology policy supply, purely science policies were relatively few in the 1980s, and the science and technology policies were much inclined to the technology side, which is consistent with the general direction of the science and technology development strategy of China at that time, that was emphasising high-tech industries, in line with the strategy that 'economic construction must rely on science and technology, and science and technology must work for economic development'. In this phase, the science and technology policies focused on the following areas:

(a) High-Tech Development and Construction of Key Laboratories

At that time, the State Economic and Trade Commission, the State Planning Commission, the National Science and Technology Commission, and other departments successively promulgated a number of science and technology policies, most of which focused on high-tech development and the construction of key industrial laboratories, while few focused on basic research. For example, the State Economic and Trade Commission issued the 'National Key Scientific and Technological Planning' in 1982 (State Economic and Trade Commission 1982a), which consisted of 38 key research projects. This was the first national-level science and technology plan in China in order to resolve key scientific and technological problems in national economic construction and social development. Later, the 'Planning of State Key Laboratory Construction' (State Economic and Trade Commission 1984a) and the 'National Key Industrial Pilot Projects' (State Economic and Trade Commission 1984b) were introduced in 1984. Other examples such as the 'National Key Technology Development Plan' (State Economic and Trade Commission 1980) and the 'National Technology Upgrading Plan' (State Economic and Trade Commission 1982b) introduced by the State Economic and Trade Commission in the early 1980s and 1982 respectively, all reflected that China attached great importance to technology development at that time.

(b) Development of Technology Market

China had a good-sized technology market at that time. The development of the technology market experienced three stages in general: (*i*) the stage of technology market cultivation, which can be characterised by the voluntary cooperation between scientific research units and production units in jointly launching key projects, when scientific research units began to get compensation from production units for their technology transfer, consultant service and technology problems solving; (*ii*) the stage of technology market formation. At the National Science and Technology Awards Conference held in 1982, the CPC Central Committee and the State Council put forward the strategic approach of 'economic construction must rely on science and technology, and science and technology must work for economic development', which facilitated China's comprehensive development in science, technology, economy, and society, as well as accelerating the formation of the technology market; (*iii*) the stage of technology market development. In January 1985, the State Council proposed the 'Provisional Regulations on Technology Transfer' (State Council 1985a), and in March pointed out that the 'technology market is an important component of socialist commodity market' in the 'Decision Made by the Central Committee of the Chinese Communist Party on Reform of Science and Technology' (State Council 1985b). So the status and role of the technology market in China was affirmed, and China made a breakthrough in some principle problems of commercialisation of technology achievements.

The overall development of the technology market can be measured by the total number and total value of technology transactions. In 2009, the size of China's technology market (contract value) was estimated at US$ 44.5 billion, nearly five times its size in 2000 (*China Statistical Yearbook on Science and Technology* 2010).[7]

(c) Establishment of China's National Nature Science Foundation (NNSF)

In February 1986, the State Council approved the establishment of the National Natural Science Foundation in order to support basic research, which developed into two blocks: project funding system and talent funding system. In addition, this foundation established a support pattern consisting of three levels: common project fund, key project fund and grand project fund, as well as a series of special funds. It has also developed an integrated personnel training and support system mainly consisting of the National Basic Science Talent Fund, Youth Science Fund, National Outstanding Youth Science Fund, and Innovation Research Group Fund through the implementation of a strategy of attracting and training excellent young scientific talents.

(d) Technology Policies

After 1986, China has changed the former policy-making pattern that combined science policy with technology policy, and formed a new separate technology policy-making system. Technology policy is an important basis to introduce the science and technology development planning, economic and social development planning, as well as guiding scientific research, technological innovation and introduction, industrial structure adjustment and development. Technology policy generally includes development objectives, industrial structure, technology options and ways to promote technology progress. At that time, China's technology policy made progress in the following areas: In 1986, the State Council issued the technology policy outlines in the 12 fields of energy, transportation, communication, agriculture, consumer goods industry, machine building, materials, building materials, urban construction, rural construction, urban and rural housing construction, and environmental protection. In this case, a number of national-level technology policies were developed, which also accelerated the research on technology policy and encouraged various sectors and regions to build up their own development policies.

(e) All Kinds of Science and Technology Plans

In high-tech areas, the Ministry of Science and Technology has developed the 'Spark Programme', '863 Programme', 'Torch Programme', as well as opening up the technology market and strengthening intellectual property rights protection by establishing high-tech zones, incubators, and so on. For programmes to support the commercialisation of research, such as the Torch Programme and the Spark Programme, the government accounts for no more than 2 per cent to 5 per cent of total funding, while local governments and enterprises typically provide large shares of funding for programmes related to innovation and dissemination of technologies.

Early in 1986, the Chinese government approved the implementation of the 'Spark Programme', the purpose of which was to introduce advanced and applicable technology to rural areas, guide hundreds of millions of farmers to develop a rural economy relying on science and technology, improve the overall quality of rural labour, as well as promote the sustainable, rapid and healthy development of agriculture and rural economy in China.

The '863 Programme' upheld the mission of 'focusing on the key fields with limited objectives', which conformed to the world-wide high-tech development trends and China's reality and demands. Seven fields were selected as keystones of China's high-tech research and development. These were bio-technology, space technology, information technology, laser technology, automation technology, energy technology, and new material technology (marine technology was included in 1996). The purpose of the '863 Programme' was to focus on a small number of elite forces, aiming at the forefront of the world in selected fields, thus narrowing the gap with developed countries, stimulating the achievements of science and technology in related fields, cultivating a number of high-level technical talents, as well as preparing for the development of high-tech industries in the future.

The Torch Programme was introduced in 1988, the purpose of which was to make good use of China's scientific and technological strengths and potential, to be market-oriented to facilitate the commercialisation, industrialisation and internationalisation of high-tech achievements. The Torch Programme encouraged researchers in universities and research institutes as well as technical entrepreneurship to go into business and start up high-tech firms. Since the State Council approved the establishment of the Beijing High-Tech Development Pilot Zone in 1988, China has established 86 state-level high-tech industrial development zones.

The main strengths of these programmes lie in their power to allocate public resources to the national priorities identified by the government (OECD 2008). It is widely recognised that these programmes have played a significant role in advancing science and technology in China by introducing the new funding mechanisms needed to move from the old science and technology system to the new market-based one, feeding economic development with science and technology inputs.

(f) Science and Technology Laws and Regulations

The development of the legislative framework of China's science and technology sector can be divided into two aspects. The first is that the effective implementation of science and technology legislative work has provided a better legal ground for administrative decision-makers. Since China's reform and opening-up, a series of legal documents have been issued, which improved the science and technology legal system further. Second, the technology law, regulations, as well as technology policies have constituted the initial legal framework of China's science and technology system.

In China, the first law for technology was about introducing technology in the field of cooperating with foreign firms or government. At the beginning of reform and opening-up, China introduced the 'Provisional Regulations on Technology Introduction and Equipment Import' (State Council 1981) and the 'Regulations on Technology Introduction Contracts' (State Council 1985c) in 1981 and 1985 respectively, in order to make technology introduction more normative.

The second important law was the 'Decision on Science and Technology Reform by the Central Committee of the Chinese Communist Party' issued in 1984, which began a prelude to China's reform of science and technology, and especially introduced a competition mechanism to encourage scientific research institutions to involve themselves in economic activities in various ways. Since then, China has developed a series of policies and programmes to promote changes in the science and technology system and to shape a new system combining science and technology with economic development.

The third far-reaching law was related to the high-tech development zones and technological start-ups. In 1988, the ‘Provisional Regulations of Beijing High-Tech Development Pilot Zone’ (State Council 1988) was introduced, which was the first approved set of regulations supporting new technology and high-tech technology by the State Council. Firms in pilot zones can enjoy a series of business concessions, such as tax reduction, export subsidy and loan, and so on. In order to stimulate the enthusiasm of different regions, besides Beijing, many cities such as Shanghai, Tianjin and Harbin, all developed local laws and regulations for the development of new technology and high-tech industries.

The fourth important law was the ‘Patent Law of China’ formally promulgated in 1984. In the era of planned economy, China lacked such a law, which severely limited the incentive for Chinese firms and individuals to engage in innovation. Consequently the introduction of this law has laid a far-reaching foundation to promote technology innovation and attract foreign direct investment (FDI). Without this law, China could not make today’s scientific and technological progress, and would find it impossible to become the developing country attracting the most FDI.

Therefore, the laws and regulations framework at the beginning of China’s reform and opening-up was very limited; all relevant laws and regulations were introduced in time in some important scientific and technological fields later.

Science and technology policies in the 1990s

The development of China’s science and technology system entered a new phase marked by the holding of the 14th National Congress. In 1992, China established the development direction the construction of a socialist market economic system, and required that the science and technology policy should be adjusted around the development of the market economy. In the same year, the State Council issued the ‘Key Points on Acclimatize Development to the Socialist Market Economy, and Deepen the Implementation of Science and Technology System Reform’ (State Council 1992). In 1999, the National Innovation Conference was held, at which the ‘Decision on Strengthening Technology Innovation, Developing High Technology, and Realizing Industrialization’ (State Council 1999a) was issued. These policies stimulated further reform of the science and technology system in China.

(a) 'Relying on Science and Education to Rejuvenate the Nation' became a new science and technology development strategy

In May 1995, the 'Decision on Accelerating Science and Technology Progress by the Central Committee of the Chinese Communist Party and the State Council' (Central Committee of the Chinese Communist Party and the State Council 1995) was formally promulgated, which made clear that China would boost the economic and social development relying on science, technology and education, and also pointed out that science and technology are primary productive forces, and scientific and technological progress is a decisive factor on economic development. China should develop medium and long-term scientific development planning according to the national long-term needs, strengthen basic research and high-tech research, and accelerate the industrialization of high technology.

With the holding of the National Science and Technology Conference, 'Relying on Science and Education to Rejuvenate the Nation' has become an important development strategy in China.

(b) Establishing National Knowledge Innovation System and Attaching Importance to Sustainable Development

In June 1998, the first meeting of the National Science, Technology & Education Leading Group was held, at which 'the Report Outline on Pilot Implementation of Knowledge Innovation Programme' was discussed and passed, and it was determined that the Chinese Academy of Sciences would first initiate the 'Knowledge Innovation Programme' as a pilot base in establishing the NSI. In order to implement this important thinking, in August 1999, the Central Committee of the Chinese Communist Party and the State Council made the 'Decision on Strengthening Technology Innovation, Developing High Technology and Realizing Industrialization', and pointed out that 'strengthening technology innovation, developing high technology and realizing industrialization' is not only a solution to the deep-rooted problems faced by China's national economic development, but also a strategic choice for China to deal with international competition.

(c) Putting Forward and Implementing the Three Strategies of 'Talents, Patents and Technology Standards'

During the 'Tenth Five-Year' period (2001–2005), the Ministry of Science and Technology put forward the three strategies of

'Talents, Patents and Technology Standards', and for the first time integrated technology standards into the practice of science and technology.[8] In 2002, after the approval of the National Science, Technology & Education Leading Group, 12 important science and technology programmes including 'A Study on Important Technology Standards' (National Science, Technology & Education Leading Group 2002) were formally started. The first strategy was a human resources strategy, which was used to stimulate the participation in a scramble for international talents. The second was patent strategy, which was used to strengthen intellectual property rights management. The third was a technology standards strategy, which was used to establish and improve the system of technology standards in China. China is striving to promote its own technology standards and to comply with international standard settings. China's size, the dynamism of its domestic market and its rapidly evolving technological capabilities give it unique opportunities. It is now a strategy for China to use the standards regime to foster innovation.

(d) Issuing Financial and Taxation Policies Closely Related to Science and Technology

In 1996 and 1997, the Ministry of Finance in conjunction with other relevant departments developed the 'Management Rules of Three Items of Expenditure on Science and Technology' (Ministry of Finance 1996c), 'Notification on Finance and Taxation to Promote Technology Progress' (Ministry of Finance 1996e), 'Management Approach on Science and Technology Working Capital' (Ministry of Finance 1996a), 'Grant Funds Management Approach on National Key New Products' (Ministry of Finance 1996b), 'Loan and Discount Management Approach on Innovation Development of Large Equipment-Made Project' (Ministry of Finance 1997a), 'Loan and Discount Management Approach on Application of Electronic Information' (Ministry of Finance 1997b), 'Loan and Discount Management Approach on Special Technology Renovation Project' (Ministry of Finance 1997c), and so on. The promulgation of the above policies beneficially promoted the implementation of technology policies.

Many fiscal and taxation policies promulgated during this period were closely related to the development of science and technology at that time. The introduction and implementation of these policies have promoted the rapid development of science and technology to some different degrees. Moreover, with the gradual establishment of China's market economic system, the financial and taxation measures have increasingly accounted for a large proportion of all measures in promoting science and technology development, which were also much better than those measures simply relying on administrative allocation in the period of the planned economy.

There are three very important financial policies that closely related to science and technology. The first is the 'Rules on the Implementation of the Budget Law of People's Republic of China' (State Council 1995) promulgated by the State Council in 1995. The second is the 'Management Rules of Three Items of Expenditure on Science and Technology' (Ministry of Finance 1996c) issued by the Ministry of Finance in 1996, in which the three items of expenditure on science and technology refer to expenses for trial manufacture of new products, expenses for intermediate experiments, and subsidies for major scientific research projects established by the government to support science and technology development. The third is the 'Notice on Financial and Taxation Issues in Promoting Enterprises' Technological Progress' (Ministry of Finance 1996d) also issued by the Ministry of Finance in 1996, which encouraged enterprises to increase their technology development input and undertake more joint development with institutions, such as research institutes and universities, which also aimed to accelerate the industrialisation and commercialisation of technology achievements from enterprises, as well as promoted the upgrading of their machines and equipments.

Enactment of some taxation policies has had a more obvious effect on science and technology development. For example, the State Council and the General Administration of Customs promulgated the 'Provisional Rules on Scientific Research and Teaching Equipments Exempt from Import Taxation' in 1997 (State Council and the General Administration of Customs 1997), which pointed out that a certain number of scientific research and teaching equipments imported by non-profit scientific research institutes and universities used for scientific research and teaching directly could be exempted from both value-added tax (VAT) and consumption tax. In 1999, the Ministry of Finance and State Administration of Taxation issued the 'Notice on Taxation Policies to Accelerate the Commercialization of Science and Technology Achievements' (Ministry of Finance and State Administration of Taxation 1999), which proposed that scientific research institutes and universities' income from technology transfer could be exempt from turnover tax.

(e) Implementation of the 'Decision on Strengthening Technology Innovation, Developing High-Tech and Realizing Industrialization by the Central Committee of the Chinese Communist Party and the State Council'

In August 1999, the Central Committee of the Chinese Communist Party and the State Council held a meeting in Beijing, at which the 'Decision on Strengthening Technology Innovation, Developing High-Tech and Realizing Industrialization by the Central Committee of the Chinese Communist Party and the State Council' was issued. This was a decision made by the CPC in line with the actual situation of world economy and technology development trends, as well as the development of domestic economy, science and technology. This policy was a typical top-down policy-making model, which aimed to emphasise innovation and industrialisation of high and new technology. Therefore, the introduction of this policy has far-reaching effects on China's technological innovation.

The Science Conference held in 1978, the National Science and Technology Conference held in 1995 and the National Innovation Conference held in 1999 all reflected the new demands of the evolution of science and technology policies and economic development on science and technology development strategy. Corresponding with the National Innovation Conference, the Central Committee of the Chinese Communist Party issued many new policies in this period, such as the policies on promoting the transfer of scientific and technological achievements. In February 1999, the General Office of the State Council transmitted the 'Suggestion on Reform of Scientific Research Institutions Affiliated to 10 State-Level Bureaus and Managed by the State Economic and Trade Commission' (Ministry of Science and Technology et al. 1999) made by six departments including the Ministry of Science and Technology and the State Economic and Trade Commission. In addition, the State Council issued 'Policies on Encouraging Development of Software Industry and IC Industry' (State Council 2000). Therefore, a surge of policies promoting technology innovation and developing high-tech emerged around 1999.

(f) Science and Technology Laws and Regulations in the 1990s

Most of China's science and technology laws and regulations were introduced in the 1990s. In July 1993, the Standing Committee of the National People's Congress discussed and passed the 'Science and Technology Progress Law of People's Republic of China' (Standing Committee of the National People's Congress 1993), which came into operation on 1 October, 1993. This science and technology law was a basic one to guide and promote the development of science and technology in the new era, which was not only a fundamental norm to promote science and technology progress, but also the foundation to develop a set of corresponding laws and regulations. At present, most local governments formulate the 'Regulations on Science and Technology Progress' (National People's Congress 1993b) in accordance with this. Overall, the 'Law on Science and Technology Progress of People's Republic of China' (National People's Congress 1993c) combined the basic strategy of governing the country by law with the development strategy of 'Relying on Science and Education to Rejuvenate the Nation', and played a very important role in promoting, guiding, regulating, and safeguarding China's science and technology progress and innovation.

The mission of science and technology development in the 1990s was to promote the commercialisation of scientific and technological achievements. On the one hand, this was due to the acceleration of the international scientific and technological revolution, especially the push of knowledge-based economy from US; on the other hand, the high rate of domestic economic development needed the contribution from the science and technology sector.

In July 1993, the National People's Congress passed the 'Agricultural Popularization Law of People's Republic of China' (National People's Congress 1993a), which was to strengthen the popularisation of agricultural technology, promote the application of agricultural scientific and technological achievements into agricultural practice as soon as possible, as well as ensure the development of agriculture and realise the modernisation of agriculture.

In August 1999, the Central Committee of the Chinese Communist Party and the State Council promulgated the 'Decision on Strengthening Technology Innovation, Developing High Technology and Realizing Industrialization', which was an important decision for China to deal with world-wide scientific and technological revolution. Before this decision, the Chinese government has issued seven supporting policy documents. In March 1999, the 'Provisions on Promotion of Commercialization of Scientific and Technological Achievements' (Central Committee of the Chinese Communist Party and the State Council 1999b) was introduced, and in May 1999, the 'Regulations on Science and Technology Progress Award' (Central Committee of the Chinese Communist Party and the State Council 1999d) was issued, and in December, the 'Implementing Rules of Science and Technology Progress Award' (Central Committee of the Chinese Communist Party and the State Council 1999a) was launched; other dozens of laws and regulations were also issued such as the 'Regulations of Natural Sciences Award' (Central Committee of the Chinese Communist Party and the State Council 1999c).

(g) Knowledge Innovation Project

In June 1998, the National Science, Technology & Education Leading Group discussed and approved the 'Report Outlines on Pilot Implementation of Knowledge Innovation Project' by the Chinese Academy of Sciences, with which the Chinese Academy of Sciences started to implement the science and technology system reform and innovation. The basic tasks of the Knowledge Innovation Project were the following:

First, developing and maintaining a strong national-level knowledge innovation capability. The Knowledge Innovation Project was to engage in basic research and strategic research to resolve the basic, strategic, comprehensive, forward-looking, and critical scientific and technological issues in China's industrialisation construction, by aiming at national strategic targets and the frontier of world-wide science and technology.

Second, speeding up the dissemination of the latest scientific and technological knowledge. On the one hand, the Knowledge Innovation Project was to train and continuously provide a large number of high-quality scientific technological personnel with a stream of information on cutting edge innovation during the process of scientific research. On the other hand, the Knowledge Innovation Project was to enhance the popularisation of science and technology, and make a contribution to improve people's scientific and technological capabilities.

Third, promoting knowledge and technology transfer comprehensively. The Knowledge Innovation Project was to promote the development of China's high technology sectors such as information, new material, biotechnology, as well as the technology upgrading of traditional industries. In addition, it was to provide a solid foundation and knowledge sources to enhancing China's innovation capability.

Fourth, providing technological and scientific advice to national macroeconomic policy-making. The Knowledge Innovation Project was to strength the Chinese Academy of Sciences and the strategic development research of national science and technology, education, economy, and safety, in order to provide advice and basis, as well as make recommendations and conduct a scientific evaluation of China's macro policy-making.

Fifth, training and fostering a contingent of world-class professionals with a good mastery of advanced science and technology through the principles of open and fair competition on the basis of merits.

Sixth, strengthening the construction of national knowledge innovation bases continuously. The Knowledge Innovation Project was to deepen the reform of the science and technology system, gradually improve and establish a new modern national research agency system in conformity with the international practice and domestic actual situation, focus on building and supporting those world-class national knowledge innovation bases among which a number of bases should strive to become one of the acknowledged international research centres in the world or an important part of international research centres.

Taking various factors into account, the central government developed additional pilot special funds for the Knowledge Innovation Project during 1998–2002.

(h) Enterprise-based Reforms in Applied Science Research Institutions

With the accelerating pace of reform of government agencies, the State Council decided to start the management system reform of 242 institutes affiliated to 10 state-level bureaus, which were managed by the National Economic and Trade Committee at the end of 1998, through which these institutions turned themselves into scientific and technological enterprises or intermediary services. The purpose of this reform was to reduce the number of independent state-level applied research institutions, encourage enterprises to establish their own applied research institutions and become a mainstay of technological innovation. In order to promote the implementation of this science and technology system reform smoothly, the relevant national ministries issued numerous complementary policies, including taxation policies, industrial and technology policies, and so on.

Science and technology policies in the 21st century

The strategic significance of indigenous innovation was formally established at the National Science and Technology Conference held in 2006, and the 'Outline of National Medium- and Long-Term Strategic Plan for the Development of Science and Technology (2006–2020)' (State Council 2006a) was also issued at this conference, which marked and indicated a significant transition and readjustment of China's science and technology development strategy from imitation-based innovation to indigenous innovation. Based on the actual local and global conditions, regarding the enhancement of indigenous innovation capability as a core strategy, constructing an innovation-based country as a goal, this plan made an overall scheme and deployment plan for China's science and technology development in the next 15 years, and was a programmatic document in guiding the new era. This plan pointed out that the guideline of China's science and technology development in the new era was to build an innovation-based economy by fostering indigenous innovation capabilities, to foster an enterprise-centred technology innovation system and enhance the innovation capabilities of Chinese firms, to achieve major breakthroughs in the targeted strategic areas of technological development and basic research.

To this end, the State Council announced late in 2006 a new policy package covering nine broad categories:

(a) Protecting Intellectual Property Rights, and Improving Intellectual Property Rights System

In view of the current status that intellectual property rights have not yet played a significant role in supporting China's indigenous innovation strategy, the State Council issued the 'Several Related Policies of the Outline of National Medium- and Long-Term Strategic Plan for the Development of Science and Technology (2006–2020)' (State Council 2006b), which pointed out that the introduction of five policies by the Chinese government would protect intellectual property rights, further improve China's intellectual property rights system and create a legal environment respecting and protecting intellectual property rights. The contents of these policies covered the property rights of key technologies and products of indigenous innovation, the establishment of international standards, the reinforcement of an intellectual property rights system, stronger control on intellectual property rights protection, shortening the patent review cycle, and a preferential treatment in government procurement for new products.

(b) Giving Full Support to Talented Personnel

There are about 14 policies on supporting talented personnel, which have developed detailed and operational rules mainly for post-doctoral, high-level overseas talents, innovative talents cultivation, scarce talents in key areas, and continuous education for professional and technical personnel.

In order to further improve the post-doctoral system and give it full play to strengthen high-level professional and technical talents team construction, the Ministry of Personnel promulgated the 'Eleventh Five-Year Plan on Post-Doctoral System' (Ministry of Human Resources and Social Security 2006) in October 2006, which set the main objective, stressed the necessity to increase investment and implement the Special Assistance Scheme. Moreover, this plan required that the annual subsidiary standard for each post-doctoral should increase 67 per cent after 2006, more attention should be paid to the construction of post-doctoral workstations, and the international exchanges and cooperation for them should be expanded.

There are several programmes on nurturing outstanding scientific talents in China now, such as the Yangtze River Scholar Programme, the Chinese Academy of Sciences (CAS) Hundred Talents Programme, the Truth Award, the Special Research Fund for University Doctorate-Awarding Units, the Fund for Overseas Chinese Scholars, and so on.

Four departments including the Ministry of Finance issued the 'Guidelines on Implementation of Incentive Distribution System of Indigenous Innovation in Enterprises' (Ministry of Finance 2006a) in October 2006, the core requirements of which were that high-tech enterprises can reward critical R&D staff by equity (shares) or by a certain coefficient of income from the sales price (shares) during the implementation of corporate capital transformation into share capital. The Ministry of Science and Technology issued the 'Interim Procedures of Strengthening Innovative Talents Training in the Implementation of Major Projects' (Ministry of Science and Technology 2006b), which emphasised that the proportion of young researchers (no more than 45 years old) in a team should be no less than 60 per cent in principle; the proportion of young leaders in a major project (no more than 45 years old) among all project leaders should be no less than 60 per cent in principle.

(c) Increasing Science and Technology Investment

There are about seven policies relevant to science and technology investment, which introduced a number of management regulations mainly targeting the 973 Special Programme, 863 Special Programme, National Science and Technology Support Programme, Public Welfare Special Programme. They focused on standardising and strengthening national management of these special programmes so as to improve the capital efficiency. On 30 September 2006, the Ministry of Finance and the Ministry of Science and Technology issued the 'Management Measures of Special Funds in National Key Basic Research Development Programme' (Ministry of Finance and the Ministry of Science and Technology 2006a), which clearly notified that the expenditure of the 973 Special Programme should include 11 items, and also provided a very detailed rule of management fee; on the same day, these two ministries also issued 'Management Measures of Special Funds of National Science and Technology Support Programme' (Ministry of Finance and the Ministry of Science and Technology 2006b), which clearly distinguished the fund free of charge and the loan-funded financial support, encouraged the exploration of other sources of funding, and guided the social capital to enter fields of science and technology.

(d) Strengthening the Construction of Science and Technology Innovation Bases and Platforms

There are about 11 policies to support the construction of science and technology innovation bases and platforms, which are mainly for the National Engineering Laboratory, science and technology parks in universities, technological business incubator, National Engineering Centre, firms' technology centre, State Key Laboratory, and so on.

In July 2006, the National Development and Reform Commission promulgated the 'Guideline on Construction of National Engineering Laboratory'. In November 2006, the Ministry of Science and Technology and the Ministry of Education jointly issued the 'Identification and Management Rules of National University Science and Technology Park (USTP)' (Ministry of Science and

Technology and the Ministry of Education 2006b), which gave a detailed illustration of the identification and management of university science and technology parks, and especially highlighted a number of conditions of the application of national university science and technology parks. For example, more than 50 per cent of enterprises in university science and technology parks should have a strong relationship with universities in technology achievements and talented personnel; more than 85 per cent administrative managers should have a bachelor's degree or above; the number of enterprises in the incubator should be more than 50. In addition, the 'Suggestions on Further Promoting Research Bases and Its Facilities Open to Enterprises and Community' (Ministry of Science and Technology and the Ministry of Education. 2006a), the 'Guideline on Construction of National Key Laboratory Relying on Transformed Institutions and Enterprises' (Ministry of Science and Technology and the Ministry of Education. 2006c) and other policies were issued.

(e) Enhancing the Development of Education and Science Popularisation

There are about seven policies to support education and science popularisation, which include some guidelines, notifications and management rules mainly for the construction of national key disciplines, national-level programmes for sending people to study abroad, carrying out science popularisation activities, and enhancing the innovation capability of universities. For example, in October 2006, the Ministry of Education issued the 'Guidelines on Strengthening the Construction of National Key Disciplines' (Ministry of Education 2006a), which emphasised the importance of establishing multiple input mechanisms for the construction of national key disciplines, integrating resources to speed up the development of national key disciplines, as well as giving full play to the role of national key disciplines as backbone and model. At the same time, the Ministry of Education also issued the 'Provisional Measures on Construction and Management of National Key Disciplines' (Ministry of Education 2006b), which clarified identification and evaluation issues. In order to carry out the task of science popularisation, in November 2006, seven departments including the Ministry of Science and Technology, the Ministry of Education, and the Propaganda Department of the Central Committee of the Chinese Communist Party jointly issued the 'Guidelines on Carrying Out

Science Popularity Activities by Scientific Research Institutions and Universities to the Society' (Ministry of Science and Technology et al. 2006), which required that the participation units should create good conditions and gradually increase the opening hours of science popularity activities, so that by the end of 'Eleventh Five-Year' Plan, the annual opening hours of science popularity activities should be no less than 15 days in general. Moreover, seven departments including the Ministry of Science and Technology jointly issued the 'Guidelines on Strengthening Capability of National Science Popularization' in January 2007 in order to promote the capability of science popularisation through a number of measures.

(f) Venture Capital and Financial Policies

There are about nine policies on financial support, which are mainly for the credit guarantee system for small and mid-sized enterprises, high-tech enterprise insurance services, establishing and improving intellectual property trade market, funds on guiding venture capital for technological small and medium-sized enterprises, and so on. In order to resolve the problems in the construction of a credit guarantee system for small and mid-sized enterprises, in November 2006, the General Office of the State Council issued the 'Notification on Strengthening the Construction of Credit Guarantee System for Small and Medium-Sized Enterprises' (State Council 2006a), which emphasised the necessity to establish and improve the risk compensation mechanism and the tax preference policies in security agencies, as well as promote the mutual beneficial cooperation between the security agencies and financial institutions, and so on. In December 2006, the China Banking Regulatory Commission issued the 'Guidelines on the Reform of Commercial Bank and the Enforcement of Financial Services for High-Tech Enterprises' (China Banking Regulatory Commission 2006a) and developed 18 detailed guiding rules, in order to create a better financial environment to support and encourage indigenous innovation. At the same time, another policy of 'Implementing Regulations of Financial Policies to Support National Key Science and Technology Programmes' (China Banking Regulatory Commission 2006b) was issued, which proposed some requirements from the perspectives of supporting areas, conditions, risk prevention and control, and so on.

(g) Tax Incentives for Innovation in the Business Sector

There are about nine policies relating to tax incentives, which are mainly for income tax preferential policies on enterprises' technological innovation, provisional regulations tax exempting scientific and technological development equipment imports, taxation policy on national university science and technology parks as well as scientific and technological incubators, and regulations of exempting scientific research and educational equipment imports from tax, and so on.

In December 2006, the Ministry of Finance and the State Administration of Taxation jointly issued the 'Notification on Income Tax Preferential Policies for Enterprises' Technological Innovation' (Ministry of Finance and the State Administration of Taxation 2006b), which clearly required that after 1 January 2006, the new high-tech enterprises setting up in the National High-Tech Development Zones can enjoy income tax exemption within the two years after they show profit, and enjoy the 15 per cent annual income tax after the first two years. At the same time, another policy, the 'Notification on Adjustment of Pre-Tax Deduction Policy of Income Tax' (Ministry of Finance and the State Administration of Taxation 2006a) was also issued.

(h) Public Procurement Policies

Public procurement can help promote innovation and accelerate the diffusion of innovative products and services. Public procurement should give priority to products developed by domestic firms through indigenous innovation. The Chinese government has recognised this point and began to implement it. There are about six policies relating to public procurement, which are mainly for identification of national indigenous innovation products, budget management of government procurement, evaluation rules, contract management rules, import and export management regulations, order management regulations, and so on.

On 26 December 2006, the Ministry of Science and Technology, the National Development and Reform Commission, and the Ministry of Finance jointly issued the 'Management Regulations on Identification of National Indigenous Innovation Products (For Trial Implementation)' (Ministry of Science and Technology et al. 2006), which was to develop rules on identification of indigenous innovation products. Subsequently, the Ministry of Finance successively issued a series of policies, such as the ‘Management Rules on Government Procurement Budget of Indigenous Innovation Products’ (Ministry of Finance 2006), ‘Regulations on Government Procurement Evaluation of Indigenous Innovation Products’ (Ministry of Finance 2006c), ‘Management Rules on Government Procurement Contract of Indigenous Innovation Products’ (Ministry of Finance 2006d), and so on, which were conducted to promote China’s indigenous innovation and improve the competitiveness of indigenous innovation products.

(i) Science and Technology Legislation

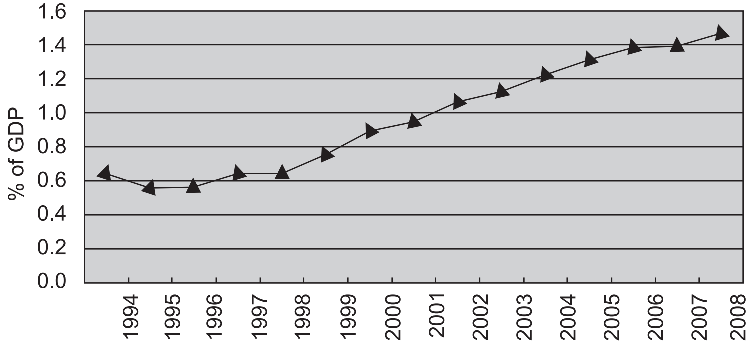
The science and technology policy in China affects all public policies. Many of these science and technology policies were established to match with the reform and development of the national science and technology strategy and system. From the 21st century, with the setting of the development of indigenous innovation as China’s national strategy, a number of new science and technology policies were issued. With the release of the ‘Outline of National Medium- and Long-Term Science and Technology Development Planning’ in January 2006, a development guideline was proposed as ‘indigenous innovation, achieving a leap-frog development in key fields, sustainable development and guiding the future’, and the goal was set as ‘improving the capability of indigenous innovation and constructing an innovation-oriented society’. With the gradual improvement of the socialist market economic system and implementation of national medium- and long-term science and technology planning, China’s science and technology innovation policies and relevant economic supporting policies should be readjusted in keeping with the new context, which proposes new requirements to improve national science and technology legislation further, and especially, the science and technology legislation should keep pace with the development of science and technology innovation. The highlights of the major amendments of the ‘Science and Technology Progress Law’ on 1 July 2008, were that indigenous innovation and construction of an innovation-oriented society were included in this law. The view that enterprises should become the main actors of scientific and technological innovation was also included in this law, and establishing modern scientific research institutions was clearly proposed.

Outcomes of State Policy and State Institutions on the NSI

Since the 1980s, the Chinese government at all levels has taken a variety of measures, such as policies promulgation, implementation of science and technology planning, direct financial investment or subsidies, tax incentives, financial leverage regulation, public procurement, implementation of science and technology awards, as well as involvement of technology management elements in resource allocation, in order to promote science and technology progress and innovation. The policy portfolio includes direct means, as well as indirect means, and targeted as well as neutral intervention. In the key fields of science and technology development, the reform of the science and technology system, conditions and basic platform of scientific research, industrialisation, science and technology intermediary service system, flow of scientific and technological talents, as well as international cooperation, the Chinese government has developed and implemented a large number of normative policy documents and created a good environment for science and technology progress and innovation. These policies have played a very important role in the development of China's science, technology, economy, and society, which are mainly represented as the following areas:

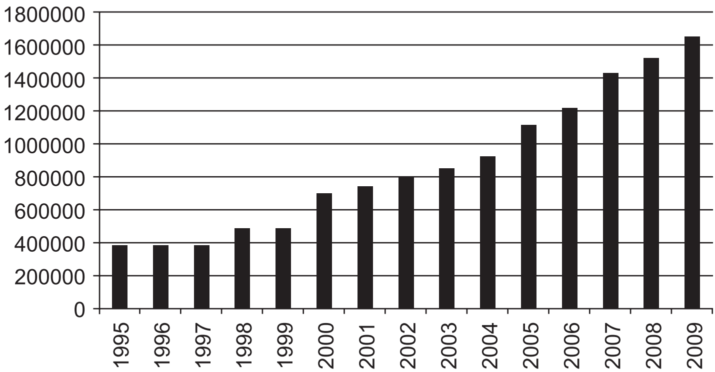
First, they greatly enhanced the awareness of scientific and technological innovation as well as competition, and the adaptive changes of these minds are an important foundation to the development of innovation activities. For example, the R&D intensity — the ratio of gross domestic expenditure on research and development (GERD) to gross domestic product (GDP) — of China's economy has increased spectacularly. It reached 1.47 per cent of GDP in 2008, up from 0.6 per cent in 1995 (Figure 5.6). In addition, China has developed a huge pool of human resources for science and technology. With 1.64 million full-time equivalent (FTE) researchers in 2008, China has ranked second in the world since 2000, after the United States (Figure 5.7).

Figure 5.6: *China's R&D Intensity, 1994–2008 (GERD as a Percentage of GDP)*



Source: *China Statistical Yearbook on Science and Technology* (1996–2010).

Figure 5.7: *The Number of Researchers in China, 1995–2009: Total Researchers (FTE)*



Source: *China Statistical Yearbook on Science and Technology* (1996–2010).

Second, they promoted the combination of science, technology and economy. The role that science and technology plays has increasingly influenced economic restructuring, the transformation of traditional industries, as well as the development of high technology. Many scientific research institutions further defined the development direction of scientific and technological innovation in accordance with the industrial or regional economic development strategy and market demand after their transformation. In addition, these scientific research institutions also participated in the major national or local scientific and technological projects jointly with other enterprises, carried out the R&D and application of major common technology, developed high technology, and drove the upgrading of traditional industries, which made the support power of science and technology on economic and social development increase gradually.

Third, the transformation of technology development–based research institutions into enterprises promoted the process during which enterprises have become innovation subjects. Since 1985, China has made great efforts in promoting the market-oriented reform of the science and technology system, which sped up the transformation of application-oriented research institutions into enterprises, promoted the enterprises to become innovation subjects, as well as cultivated a large number of scientific and technological enterprises. The percentage of enterprises' R&D expenditure in total social R&D expenditure increased from 59.95 per cent in 2000 to 72.28 per cent in 2007 (see Table 5.3).

Table 5.3: *R&D Expenditure by Performer in China, 2000–2007 (percentage)*

Year	*Enterprises*	*Research Institutions*	*Higher Education*	*Others*
2000	59.95	28.80	8.56	2.68
2001	60.43	27.67	9.82	2.07
2002	61.18	27.28	10.14	1.40
2003	62.37	25.92	10.54	1.18
2004	66.83	21.95	10.22	1.00
2005	68.32	20.94	9.89	0.85
2006	71.08	18.89	9.22	0.82
2007	72.28	18.54	8.48	0.69

Source: *China Statistical Yearbook on Science and Technology* (2001–2008).

Fourth, the scientific and technological business incubators, productivity promotion centres, science and technology advice and evaluation agencies developed fast, which gradually constitutes a scientific and technological service system. By 2007, China had more than 1,000 productivity promotion centres, more than 500 scientific and technological business incubators, more than 400 venture capital institutions, more than 400 science and technology information and intelligence agencies, as well as more than 2,300 various kinds of scientific and technological advice and evaluation agencies, which all promoted the science and technology innovation and industrial development. A large number of independent intellectual property rights accumulated by colleges, universities and scientific research institutions have been commercialised into practical productivity rapidly, during which a number of forces engaged in commercialisation of scientific and technological achievements are developed. For example, Tsinghua University, Peking University and Shanghai Jiao Tong University all have their own listed companies. By the end of 2005, the number of national private technological companies had reached 143,991, the total revenue of which was 6.1218 trillion Yuan. Among these enterprises, the revenue of 8,168 was more than 0.1 billion Yuan, the revenue of 874 was more than 1 billion Yuan (Ministry of Science and Technology 2006a). In addition, many high-tech enterprises with considerable international competitiveness have emerged, such as ZTE, Huawei, and so on.

Fifth, they promoted the development of high-tech industries. Since the 1980s, China has promoted the development of high-tech industries through the establishment of high-tech industrial development pilot zones. In May 1988, the State Council approved the establishment of the Beijing New Technology Industry Development Pilot Zone and granted 18 preferential policies to it. In August of the same year, the implementation of the 'Torch Programme' was started. At present, China has established 54 National High-Tech Industrial Development Zones all over the country. In 2006, 30,403 enterprises were identified as high-tech in these zones, the new product sales revenue of which was 811.98 billion Yuan, and the new product sales revenue accounted for 22.5 per cent of total product sales revenue (Ministry of Science and Technology 2008).

Sixth, the promotion of industrialisation of scientific and technological achievements enhanced the industrial core competitiveness. Through the implementation of relevant national industrialisation plans, China has made major breakthroughs in the information industry, bio-industry, new material industry, new energy industry, manufacturing industry, and so on, which made a great contribution to promote the upgrading of industrial structure, enhance the industrial core competitiveness and promote China's economic and social development.

China has made great achievements in the development of science, technology, economy, and society due to the introduction of all these policies, but a wide gap still exists between these achievements and the demands of China's economic and social development, and a number of obstacles and problems in China's scientific and technological innovation and development need to be resolved. Chinese enterprises have not really become as active as they could be in the commercialisation of scientific and technological achievements. As most Chinese enterprises are lacking in technological capabilities and participate in market competition relying mainly on cost advantages both at home and abroad, they usually do not have enough capability of transforming new technology into innovation. They also tend to be risk averse and suffer from a low level of financing capability. A corresponding fact to this is that universities and scientific research institutions have become the performers of technological innovation. As a large number of scientific and technological achievements come directly from science and technology projects supported by the national level rather than the market players with demands of commercialisation, many of them do not have high technical practicality and only stay at the laboratory stage, so that it is difficult for them to meet the actual needs of enterprises. For example, in all national-level science and technology programmes, the projects assumed by universities and scientific research institutions account for 90 per cent, and the technical and economic practicality of achievements of these projects is not high and cannot meet the actual needs of enterprises.

The environmental factors for commercialisation of scientific and technological achievements need to be improved. At present, there are many imperfections in the state support for the industrialisation of indigenous innovation achievements. The law and regulations on promoting industrialisation of scientific and technological achievements still need extensive refinement. Intellectual property rights protection is weak and the problem of infringement of intellectual property rights is still serious, which leads to the fact that it is difficult for enterprises to appropriate the returns on their investments in indigenous innovation. The financial system to support the industrialisation of scientific and technological achievements in China is still weak. The support and incubation services for start-up enterprises are weak and the implementation of government procurement measures is still ineffective. Because of these factors, the state is still not providing enough support on indigenous innovation achievements.

It is still very difficult for talents to flow between research institutions and enterprises. Since enterprises on their own cannot provide a stable research environment and there is a gap between research institutions and enterprises in research conditions, it is difficult for talents to flow between enterprises and research institutions. At present, there are tens of thousands of engineering Ph.D. graduates every year in China, most of whom enter into universities and scientific research institutions, leaving only a small portion to enter into enterprises.

Conclusion

In the past three decades since the reform and opening-up, China's NSI has experienced deep structural changes. First, the core of the NSI has transformed from the scientific research institutions into enterprises. Second, the base of the NSI has transformed from a dependence on imported innovation to an increasing reliance on indigenous innovation. Third, the composition of innovators has been transformed from only state-owned enterprises into a mix of public and private sector enterprises. Fourth, the NSI has transformed from a close innovation model into a global innovation model. Fifth, the NSI has transformed from the one led by cost advantage into that led by innovation. These five aspects have greatly changed China's innovation pattern. During the transition, as an initiator of the NSI, the government has been playing an irreplaceable role.

In spite of its significant and remarkable achievements, China still has a long way to go to build a modern, enterprise-centred and efficient NSI. To achieve this goal, it will have to maintain a high level of investment in R&D, innovation and education and overcome the remaining institutional and structural weaknesses of its current innovation system.

The near future is a critical period for China to implement the strategy of indigenous innovation. In order to promote the construction of the NSI in the new era, the Chinese government must play a leading role in the establishment and improvement of the science and technology system in the basic framework of a socialist market economic system. In addition, the relationship between the market mechanism and the state should be more fully addressed. The guiding, planning and encouraging role of the national science and technology policies as well as macro science and technology management rules must be given full play, and the market mechanism should play a basic role in the allocation of scientific and technological resources. China's allocation and integration of scientific and technological resources must be implemented from the perspective of a national strategy in order to improve the capability of science and technology innovation and comprehensive competitiveness in essence on a national level.

China should continue to deepen the reform of science and technology system, and construct an institutional framework of the NSI. Two tasks in the reform of the science and technology system are essential to the construction of the NSI. One is to deepen the reform of scientific research institutions, and the other is to change the role of the state. The core elements of the NSI are enterprises, scientific research institutions and government agencies, which correspond to the technological innovation, knowledge innovation and institutional innovation respectively, and are the backbone of the NSI. The reform of science and technology policy is designed to put all performers of innovation in the right positions and make them perform their respective duties. The government should play a role in the three aspects. It should construct an institutional and policy environment conducive to innovation, including a venture capital management system and an intellectual property system, which are necessary both to increase the propensity of domestic firms to innovate and to maintain China's attractiveness for knowledge-intensive foreign direct investment. It should play a leading role in the areas marked by a prevalence of market and systemic failures through direct involvement in technology innovation activities and the provision of public goods and common basic technology. Finally, it should guide the science and technology development of some specific industries following the principle of 'to be aware that there are things must be done and things must not be done', as well as make the innovation resources in line with the interests of specific industries through making good use of various financial means.

China should continue to improve the organising mechanism for science and technology programmes and major science and technology projects and straighten out the relationships among all kinds of innovation subjects in order to improve the efficiency of the NSI. Various kinds of science and technology programmes and major special projects are the most important innovation activities, and the government usually invests and allocates innovation resources through the organisation of these innovation activities, so they can be regarded as a lubricant for the NSI. The successful organisation of these major innovation activities, to a large extent, can improve the NSI and its efficiency. During the process of organisation of major science and technology innovation, initiating the full mobilisation of various innovation subjects in the NSI should be considered. Meanwhile, an innovation aggregation should be established, which regards enterprises as a core element and forms a close relationship among the government, industry and learning. The application of science and technology projects should require not only the participation of enterprises, but also the support and incubation of innovation activities of enterprises, and the conditions created for enterprises' technological innovation through various financial means. Led by the national science and technology programmes, all performers of innovation in the NSI should interact with each other frequently, so that the mutual cooperation can be realised as well as their complementary advantages can be finally developed.

China should explore diversified scientific and technological investment and financing means, and guide the development of the NSI in line with the interests of the country. The government guidance on the NSI refers to the innovation resources allocation that the government implements through the means of science and technology investment, personnel training, policy-making, and so on, which make the development of the NSI in line with the national interests and development strategy. How to use the science and technology investment policy to guide the efficient allocation of science and technology resources in the NSI is a challenging task that the Chinese government is facing. Only a wide range of science and technology investment and financing methods are explored actively but China can achieve the purpose of allocating resources through science and technology investment and making the resources from all aspects of society flow and participate in science and technology innovation activities. The Chinese government should utilise its capability of mobilising and allocating the scientific and technological resources of the whole society through direct financial investment, tax incentives and other means. The state financial input is mainly used to support public science and technology activities, such as basic research, cutting-edge high-tech research, social welfare research, and major common technology, which the market mechanism cannot resolve effectively. For those projects with high degree of market-orientation and good market prospects, enterprises should be guided actively to become the main investment agents.

Finally, a systematic science and technology evaluation and monitoring mechanism should be established, which is used to monitor and evaluate the efficiency of the NSI. The evaluation and monitoring of the NSI refers mainly to scientific and technological projects and investment. In developed countries, they have already established relatively efficient systems for science and technology evaluation and monitoring. Compared with the year-on-year increase of scientific and technological investment and the improvement of scientific and technological system, the construction of China's science and technology evaluation and monitoring system lags behind. The existing science and technology evaluation and monitoring is still at the project level without top-level design. A systematic scientific and technological evaluation and monitoring mechanism as well as the relevant laws and regulations should be established urgently, and which also should be implemented into practice in order to adjust the allocation of science and technology resources and improve the efficiency in using these resources.

Notes

1. 'Scientific Outlook of Development' was proposed by President Hu Jintao in the speech 'Hold Highly the Great Banner of Socialism with Chinese Characteristics, and Strive for New Victories in Building a Moderately Prosperous Society' at the 17th National Congress of Chinese Communist Party on 15 October 2007.
2. This was a popular metaphor to describe the egalitarian phenomenon during China's planned economy.
3. 'Three capital' refers to three types of foreign-funded enterprises: foreign joint ventures, Sino-foreign cooperative enterprises and wholly foreign-owned enterprises.
4. 'Emancipating the Mind and Seeking Truth from Facts' was proposed by Mr Deng Xiaoping in the speech 'Emancipating the Mind, Seeking Truth from Facts, Look Forward as a United One' at the closing ceremony of CPC Central Committee Working Conference on 13 December 1978.
5. 'Four Cardinal Principles' was generalised by Mr Deng Xiaoping in the speech 'Uphold the Four Cardinal Principles' at a CPC theory-discussing meeting on 30 March 1979.

6. The nominal values of R&D expenditure and technology import in RMB were converted to US$ using the annual average exchange rates in 1995 (1US$ = 8.31 RMB), 2000 (1 US$=8.28 RMB) and 2005 (1 US$= 8.19 RMB).
7. The nominal values of R&D expenditure and technology import in RMB were converted to US$ using the annual average exchange rates in 1995 (1US$ = 8.31 RMB) and 2005 (1 US$= 8.19 RMB).
8. These three strategies were proposed by Xu Guanhua, minister of science and technology, in the speech 'Making Overall Arrangements, Emphasizing Key Points, and Making Earnest Efforts to Do Science and Technology Work Well in 2002' at the National Science and Technology Work Conference on 9–10 January 2002.

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