Chapter 7

REGIONAL INNOVATION SYSTEMS IN CHINA: INSIGHTS FROM SHANGHAI, SICHUAN AND LIAONING

7.1. Introduction

OECD countries are actively promoting public policies that strengthen regional innovation systems in order to boost economic growth. Innovation depends principally on the capacities of economic actors that either create demand for knowledge or generate such knowledge. The term regional innovation system (RIS) is used here to describe the interaction between these dimensions at the regional level. Factors which are important in regional innovation systems include:

- *Key actors* (public research organisations, universities, intermediary agencies and firms) are more likely to engage in innovation if they are linked and work systematically together. The individual and systemic performance of these actors drives the system.
- *Framework conditions* and the general business environment (set at regional, national or even international levels) promote or discourage investment and other decisions that would favour innovation.
- *Governance and funding flows* serve to frame the areas of public support that play a role in the RIS and the ways in which the level and flow of financing is adapted.
- *Public policies and programmes* support the innovation process, particularly through the steering, funding and distribution of publicly funded research and supporting infrastructures such as science parks, special economic zones, cluster promotion, etc.

The issue of innovation is increasingly central to the policy agenda of China's central and provincial governments, owing to the country's overall strategic objectives in terms of science and technology and private sector/enterprise development. These include reducing dependence on foreign technologies, raising R&D expenditure as a proportion of GDP to OECD levels, increasing the share of high-technology industries in manufacturing and placing China among the world's top 15 countries in terms of international patents by

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nationals. These goals, prominent in the most recent national science and technology development plan, all involve a strong push for R&D investment and commercialisation.

Differences in regions' innovation capacity can reinforce disparities among them. On the one hand, if R&D, education, business support structures and other elements of an effective innovation system are concentrated in core regions, divergences in regional performance may be reinforced, with important economic, social and political implications. On the other hand, efforts to strengthen the innovation capacity of non-core regions might play an important role in overcoming such disparities and contribute to the country's wider regional policy objectives.

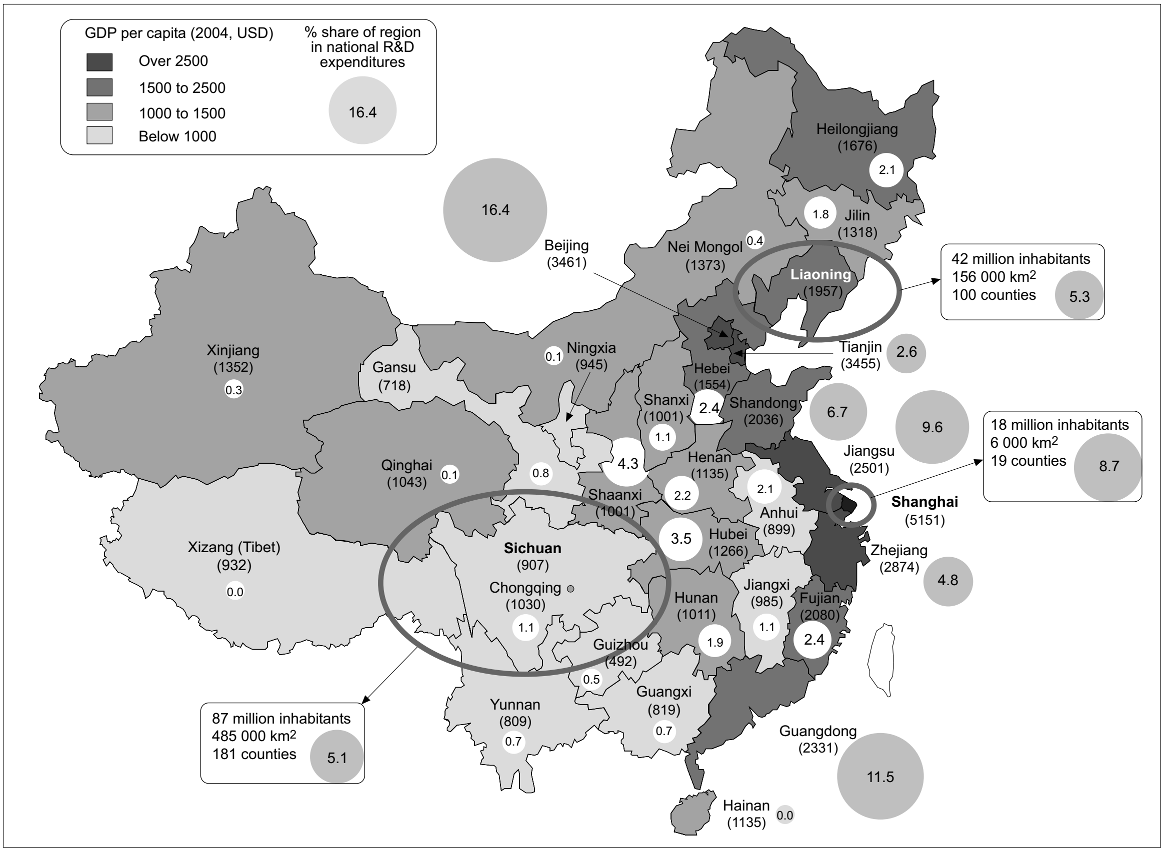
Given the size and diversity of China's territory, an analysis of innovation policy requires an understanding of the regional variations in innovation resources, planning, governance and policies. To address these dimensions, this chapter analyses China's quantitative indicators on the innovation system from the regional perspective, identifying commonalities and differences in innovation system building across three contrasting regions (provinces): Shanghai Municipality, Liaoning Province, and Sichuan Province. It explores how the S&T development planning framework and strategies adopted at the provincial level seek to respond to local needs and analyses the governance of innovation at the provincial and sub-provincial levels, including actors and their financing mechanisms. Special attention is given to the challenges of horizontal and vertical co-ordination across these government entities. In addition, the programmes, framework conditions and actors that structure the innovation system as well as variations in the nature of the interaction by actor and region are examined.

7.2. A profile of three regions

This section analyses China's innovation system from the regional perspective, identifying commonalities and differences across regions (provinces). The three case studies make it clear that some of the relevant factors are related to the broader national innovation policy context. At the same time, the three regions face their individual challenges for meeting their overall socioeconomic needs and for supporting regional innovation systems with different characteristics and strengths.

Shanghai Municipality (with provincial status) is located in the Yangtze River Delta region and is one of the three growth engines of China, designated by the central government to be a national economic centre. This large metropolitan region has a strong knowledge infrastructure and is at the forefront of technological progress in China. Liaoning Province, with its capital Shenyang, is an old industry base in the northeast and faces the challenge of revitalising and transforming itself into an innovative region with higher value added production. Sichuan Province, with its capital Chengdu, is in the western part of China with a history of military investment and a rudimentary technology level in the vast rural areas. The province faces issues such as improving its human capital and infrastructure, making better use of innovation assets and strengthening connections with national and international markets (Box 7.1).

Box 7.1. Profile of the three regions



Source: OECD based on information from China Statistical Yearbook on Science and Technology, 2005.

Shanghai is the largest city in China. As one of the three engines for China's economic development, it has grown dramatically since the 1990s. In 2005, it had a population of almost 18 million. The GDP of Shanghai Municipality reached RMB 915 billion (approximately EUR 92 billion), and ranked seventh among the provinces or province-level municipalities. Its GDP per capita in 2005 was RMB 51 474 (approximately EUR 5 100), putting it in first place in China. Since 1992, the Shanghai economy has maintained two-digit growth every year. Compared to 2000, GDP in 2005 increased by 75.3% at an annual growth rate of 11.9%. The tertiary sector has become the largest sector (50.5%) in Shanghai but the industry sector is only slightly smaller (48.6%). Major industries in Shanghai include information and communication technology (ICT), finance, trade and logistics, automobile, machinery and real estate.

Liaoning Province is one of the three northeastern provinces of China. As an old industry base, it faces critical restructuring issues. In 2005, Liaoning had a population of 42 million. Its GDP was RMB 800.5 billion (approximately EUR 80 billion), an increase of 12.3% compared to 2004, placing it eighth among the provinces or province-level municipalities. GDP per capita reached RMB 18 983, again eighth in the nation. Primary, secondary and tertiary industries account for 10.7%, 48.8%, and 40.5%, respectively. Major industries include raw materials (steel, iron, oil and petrochemicals, etc.) and equipment (general machinery, transport equipment, electrical machinery, ICT products and machinery tools, etc.).

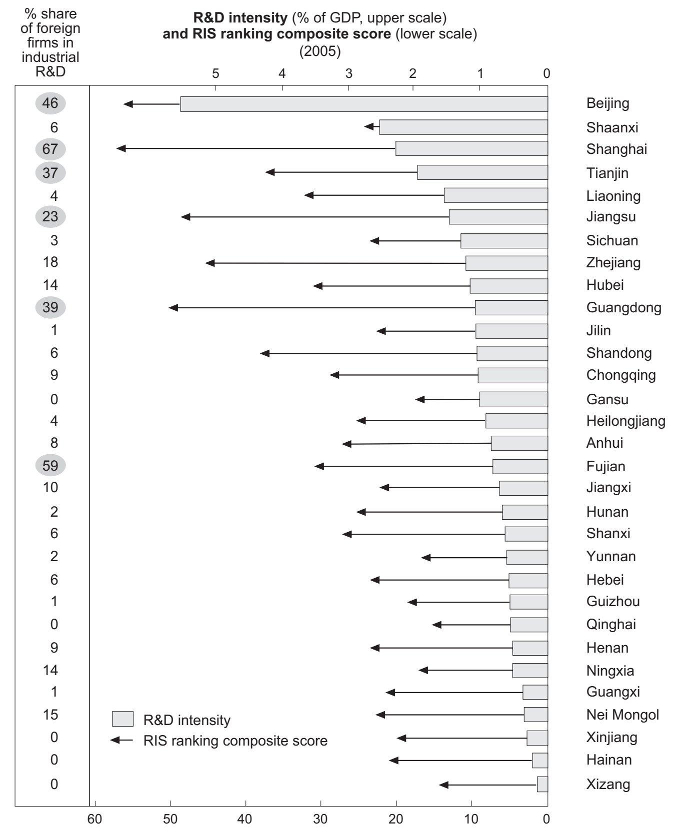
Sichuan Province in the southwest part of China is a large province with a population of over 80 million. In 2005, its GDP reached RMB 738.51 billion (approximately EUR 74 billion), putting it in ninth position among all provinces and first in western China, with 22.1% of the total GDP of that larger region. GDP per capita reached RMB 9 060 (approximately EUR 910) in 2005, for the 26th place. With 82.12 million people, it ranks fourth in population). As the most powerful economy in western China, its major indicators of total economic volume put it in first place among the western provinces. Its economic structure has improved continuously. Primary, secondary and tertiary industries now account for 20.7%, 41.4% and 37.8%, respectively. The private sector accounts for approximately 37% of provincial GDP. Major industries include electricity, gas, steel, cement, glass, fertiliser, silk, beer, television, machinery, electronics, chemicals, construction materials, food and pharmaceuticals.

Source: Annual government reports of Shanghai Municipality, Liaoning and Sichuan provinces.

While the unit of analysis is the province, regional "systems" do not follow administrative boundaries. The relevant geographical scale of a regional system – the space within which meaningful interaction takes place – can be larger or smaller than the province. For example, Shanghai's innovation system tends to encompass parts of the surrounding provinces to create a larger functional urban area. In Sichuan, by contrast, the urban centres are scattered and economic interaction among actors in different parts of the province are not intensive enough to merit viewing the province as a whole as a regional innovation system.

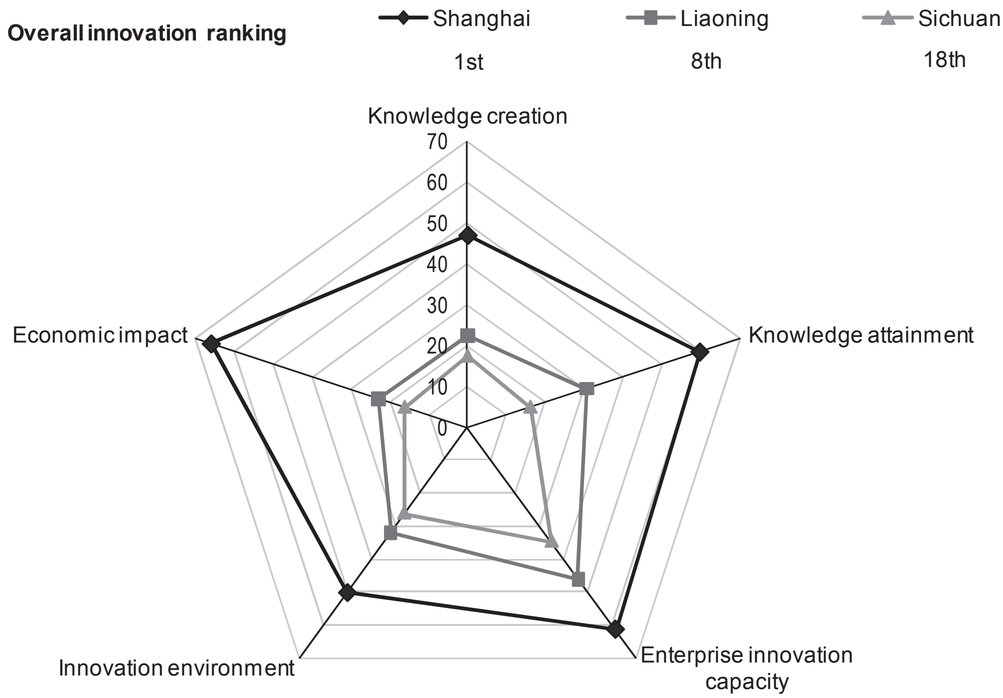
There are significant disparities among Chinese provinces in terms of innovation performance, with a clear group of top performers far surpassing the others. In general, the provinces and municipalities with provincial status on the east coast perform better than the provinces in the central and western parts of the country (Liu *et al*., 2005; Sigurdson, 2004).

Figure 7.1. Innovation characteristics by province



Source: China S&T Development Strategic Research Team, (2006). Annual Report of Regional Innovation Capability of China 2005-2006, Science Publishing, Beijing, pp. 8-9; National Bureau of Statistics (2005), Chinese Statistical Yearbook 2005, People's Republic of China.; Chengdu.

Figure 7.2. Innovation performance by field, 2005



Source: China S&T Development Strategic Research Team, (2006). Annual Report of Regional Innovation Capability of China 2005-2006, Science Publishing, Beijing.

According to an innovation index developed by the S&T Development Strategic Research Team, Shanghai Municipality, Liaoning Province and Sichuan Province ranked 1st, 8th and 18th, respectively, overall (Figures 7.1 and 7.2).[1] The base data for the index clearly show that the rankings disguise to some extent the disparities between the top group, including Shanghai, and the other provinces. The gap between Shanghai and Liaoning is actually greater than the gap between Liaoning and Sichuan. R&D intensity, a core innovation input, varies greatly by region and is increasing rapidly in some regions (Figure 7.1). In 2005 R&D intensity was over 5% of GDP in Beijing and over 2% in Shanghai but in most provinces it is around 1% or less. Growth in Shanghai, for example, has consistently outpaced the national average, and has been doing so at an increasing rate over the last few years.

The impact of differences in performance on the innovation indicators is reflected in the regions' economic development. Shanghai has the highest GDP per capita (EUR 5 100) while Sichuan has a GDP per capita of only EUR 910 (pulled down by Sichuan's large rural population). In a study of all provinces, Wang *et al*. (2001) noted major differences among Chinese provinces in terms of the correlation between S&T indicators (S&T funding, S&T professionals, turnover of technology products, patents and international publications) and GDP per capita. The data for Sichuan suggest that it has not yet been able to fully translate its S&T inputs into outputs that affect economic growth.

1. For a detailed explanation, see China S&T Development Strategic Research Team (2006), Chapter III. The overall index covers five major composite indices: knowledge environment, knowledge creation, knowledge attainment, enterprise innovation capacity and economic contribution. The team is composed of national S&T government officials, experts from research institutes and university professors.

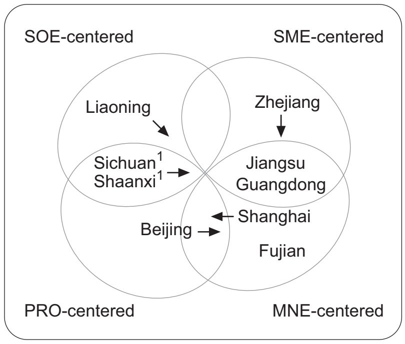
Compared to Sichuan and Liaoning, the major indicators of Shanghai's innovation system show a more balanced structure. It leads on most measures, having benefited from rich S&T resources and favourable national policies. Shanghai is well endowed in universities, research institutes, industrial assets and human capital, all of which provide a strong basis for innovation. Since the mid-1990s, Shanghai has been designated as a national economic centre, has received considerable support from the central government, and has positioned itself to become a "knowledge-intensive" city. Investment in innovation capacity building in the city has been tremendous. From 2001 to 2005, per capita R&D tripled from RMB 477 to RMB 1 201 (approximately EUR 48 to EUR 120). During the last decade, S&T investment (both public and private) has almost quadrupled (from RMB 10.5 billion in 1995 to RMB 41.9 billion in 2005, or approximately EUR 1 billion to EUR 4 billion).

Table 7.1. Detailed comparison of the three regions' innovation system, 2005

	Shanghai		Liaoning		Sichuan	
	Score	Ranking	Score	Ranking	Score	Ranking
Composite index	**56.97**	**1**	**32.05**	**8**	**23.37**	**18**
1. Knowledge creation	**46.96**	**2**	**22.5**	**8**	**17.48**	**17**
1.1 R&D investment	37.13	3	16.09	19	29.97	6
1.2 Patents	45.65	2	21.44	6	10.56	15
1.3 S&T papers	39.72	2	14.13	14	15.53	11
1.4 Input-output ratio	59.65	3	33.43	7	17.36	25
2. Knowledge attainment	**59.51**	**1**	**30.68**	**8**	**15.98**	**20**
2.1 S&T co-operation	50.98	2	46.60	8	22.64	25
2.2 Technology transfer	47.08	2	20.60	16	20.00	17
2.3 FDI	75.22	1	26.29	9	7.96	25
3. Enterprise innovation capacity	**61.19**	**1**	**46.02**	**6**	**34.57**	**12**
3.1 Enterprise R&D investment	54.97	5	49.76	8	47.53	9
3.2 Design capability	56.46	2	38.02	5	16.35	12
3.3 Manufacturing & production capacity	46.84	10	56.30	6	35.39	19
3.4 New product production capacity	80.13	1	40.77	11	33.21	15
4. Technology innovation environment & management	**50.07**	**2**	**31.97**	**8**	**26.07**	**15**
4.1 Innovation infrastructure	35.77	8	36.25	7	39.12	6
4.2 Market environment	65.41	2	36.88	13	32.82	17
4.3 Skills	71.18	2	35.17	7	27.22	25
4.4 Financial environment	24.52	7	20.48	9	11.94	18
4.5 Entrepreneurship	53.49	2	31.07	6	19.25	18
5. Economic contribution	**65.9**	**1**	**22.89**	**17**	**15.98**	**30**
5.1 Macroeconomy	72.39	1	26.09	15	15.90	25
5.2 Industrial structure	55.2	5	24.34	16	23.34	19
5.3 Industry international competitiveness	50.11	2	13.97	12	4.27	28
5.4 Income	91.72	1	34.84	13	10.77	29
5.5 Employment	60.09	2	15.19	30	25.64	27

Source: China S&T Development Strategic Research Team, (2006). Annual Report of Regional Innovation Capability of China 2005-2006, Science Publishing, Beijing.

Figure 7.3. A typology of Chinese regional innovation systems



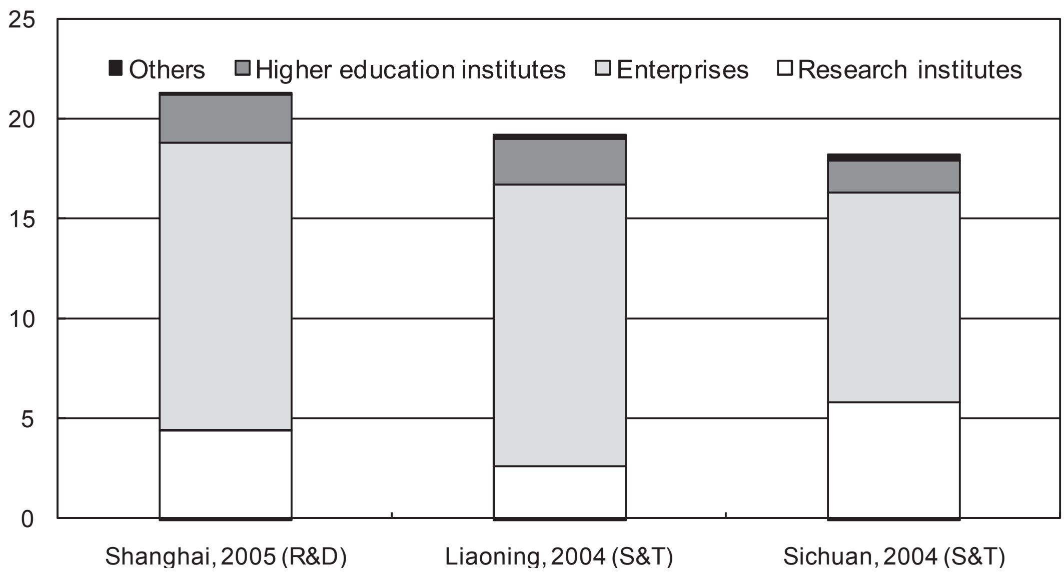
SOE: State-Owned Enterprises; SME: Small and Medium Enterprises; PRO: Public Research Organisations; MNE: Multinational Enterprises.
1. "Past Cold War" R&D intensive regions.
→ Direction of structural change.

Source: OECD analysis.

The differences among regional innovation systems also reflect the key actors. As illustrated in Figure 7.3, different endowments in terms of innovation assets and actors are largely due to history and national allocations of public research facilities or the development of the local industrial structure. The actors in the innovation system are described in section 7.5.

Figure 7.4. Use of S&T or R&D budget,[1] by actor

RMB billions



1. In the Chinese statistics, R&D is part of a broader concept, S&T activities, which includes not only R&D but the application of the R&D outputs and associated S&T services.

Source: Shanghai: Shanghai Municipality Science and Technology Commission and Shanghai Statistical Bureau (2006), Shanghai Statistical Yearbook on Science and Technology 2006, Shanghai Kepu Publishing; Shanghai; Liaoning: Liaoning Statistical Bureau & Liaoning Science & Technology Commission (2005), Liaoning Statistical Yearbook on Science and Technology 2005, Liaoning Statistical Bureau Publishing House, Shenyang; and Sichuan: Sichuan Statistical Bureau and Science and Technology Commission (2005), Science and Technology Bureau of Sichuan Province (2005), Sichuan S&T Statistical Yearbook 2005.

The nature of actors' R&D expenditure is one component of innovation systems. Many provinces reflect the central government's strategy of promoting an enterprise-led innovation system. Based on the 10th and 11th S&T development plans, R&D investment in Shanghai, including public funds, has gone predominantly to enterprises (67.3% in 2005) rather than research institutes (21%). It has focused on applied research and trial testing rather than fundamental research as in the past. In Shanghai, trial development represented almost 80% of total expenditure in 2005 (up from 70% in 2000). The other two provinces have also focused on applied research and investment in enterprise-driven R&D. In fact, owing to the presence of many large state-owned enterprises (SOEs), there is proportionately even more investment (mainly public) in S&T in enterprises in Liaoning (74% of S&T expenditure) than in Shanghai (67% of R&D expenditure) (Figure 7.4).

S&T's contribution to the economy of each of the provinces has increased, as evidenced by the growth of high-technology industries. In Shanghai, in particular, total production of high-technology industries almost quadrupled between 2000 and 2005 (from RMB 102.18 billion to RMB 396.95 billion). The share of high and new technology in Shanghai's total industry output increased steadily from 13.9% in 1995 to 28.6% in 2005. In Liaoning, owing in part to increased S&T investment, the value added of high and new technology industries increased from RMB 29.7 billion in 2000 to RMB 82 billion in 2005, at an annual growth rate of 26.2%. The ratio of total value added to GDP rose from 6.4% in 2000 to 10.3% in 2005. The seven province-level high-technology parks accounted for RMB 38.59 billion of the province's high-technology value added, at an annual growth rate of 39.5%. Over the same period, Sichuan's high-technology industry grew at an annual rate of 8.62% for total production and 10.36% in total sales (Jia *et al*., 2006), although its contribution to economic growth (19.38% of GDP in 2005) is small compared to Liaoning and Shanghai. While Sichuan ranks at a middle level in terms of high-technology production, sales revenue, R&D expenditure and S&T personnel, it ranks towards the bottom in terms of profit (Jia *et al.,* 2006).

Industry structure clearly affects innovation outcomes. Shanghai has a very diverse economic base, Liaoning's regional economy is strongly influenced by the number of large SOEs, and R&D in Sichuan is skewed by the presence of several large defence-related research institutes.

In Liaoning, the presence of SOEs in traditional sectors seems to adversely affect the contribution of S&T to overall growth. Its economy is still undergoing major restructuring; levels of high-technology firms and labour productivity are relatively low, perhaps because the region's SOEs, although large, are not national leaders and are in industries such as steel and petrochemicals, in which R&D activities tend to be low and local suppliers' needs in terms of high-technology inputs are limited.

In Sichuan, research institutes and defence industries play a relatively more important role in S&T spending than in other provinces. For example, while enterprises account for 57% of S&T spending, research institutes account for 32% in Sichuan, but only 14% in Liaoning. National research institutes in Sichuan cover fields such as information and telecommunications, new materials, nuclear technology, aerospace and heavy machinery manufacturing. Nonetheless, the region lags behind on many innovation and economic indicators.

Research institutes are important for building a regional innovation system in Sichuan. There are clear opportunities to better integrate these national institutes, which have large, nationally provided budgets, with local resources and economic development needs. The province has many well-known colleges and universities, such as Sichuan

University, and over 70 in all. Yet their R&D capacity, particularly for applied research, is relatively weak.

Sichuan ranks second nationally in defence enterprises, some of which have been successfully converted to civil use, but there is much room for growth. The military enterprise groups (such as nuclear energy, aviation, aerospace, new materials and military electronics) all have branch offices in Sichuan. The regional government needs to find a way to take advantage of military S&T resources for civil use and build bridges between the two types of technology applications and between the strong non-military research and educational institutions in cities such as Chengdu and Mianyang.

The challenges facing Sichuan go beyond S&T. The economy of Shanghai and Liaoning is sufficiently dynamic to overcome structural problems. Sichuan needs to increase its openness and visibility by improving its business development environment and national and international accessibility. Today, graduates from Sichuan universities tend to flow to the coastal areas in search of better opportunities. This sets Sichuan, along with other western provinces, apart from Shanghai and the leading group, but also apart from Liaoning where there is significant investment and international visibility.

7.3. Provincial S&T development strategies

China's current five-year plan for S&T development stresses the promotion of an independent innovation capacity, the strengthening of the role of enterprises, the intensifying of IPR protection and institutional reform of the S&T system. It demonstrates the political will to further strengthen China's innovation system in an increasingly market-led economy. Within the overall national policy framework, provincial and lower-level governments develop their own strategies. This allows local governments to respond to local needs and adapt policy to the local context. This section describes the S&T and innovation strategies adopted in the three provinces.[2] It shows the influence of national strategic orientations on local strategies and discusses these strategies in light of the local strengths and weaknesses described above.

7.3.1. Examples of S&T strategies

China's system of national planning buttressed by central planners' direct administrative control over the economy has been gradually abandoned. Nevertheless, planning documents continue to be key guides for public action in all fields. The 11th five-year plan, the most influential blueprint for the country's social and economic development, sets the broad orientations for S&T development.[3] The five-year and medium- to long-term S&T development plans complement the social and economic development plans and spell out orientations and projects in greater detail. Below the national level, provinces, municipalities and counties work out their own social and economic as well as S&T development plans, in line with the general framework set at the national level.

2. The current five-year S&T development plans for Sichuan and Shanghai had not been made public at the time of the analysis; the information on these two provinces therefore derives from the presentations made by local officials during the field missions.

3. Chapter 7 of the Plan is entitled "Implementing the Strategy of Developing China through Science and Education and the Strategy of Strengthening China through Tapping Human Resources".

The planning system is meant to make it possible to include local specificities in each level's planning document while ensuring overall coherence. Each level has its own plan, defined with reference to the plans of levels both above and below. The elaboration of provincial plans therefore involves prior consultation with lower-level governments and business associations. These associations are not independent from the government but they bring an enterprise perspective, generally sectoral, to the planning process.

Overall, provincial-level strategies reflect the broad strategic orientations set at the national level. In Sichuan and Liaoning, the institutional dimension, *i.e.* the strengthening of IPR protection and the improvement of the institutional framework for the design and implementation of S&T policies, receive less attention. In Shanghai they have greater weight.

In Sichuan*,* officials from the provincial Bureau of Science and Technology (BOST) described an overall strategy for S&T and innovation along four axes. One is to promote firm-led innovation, with a shift in R&D spending from public to private entities. The second is to strengthen comparative advantages on a sectoral basis. A third is to organise innovation more systematically around key projects and to look at firms in terms of a value chain. (In the past, funding went to a large number of smaller-scale projects and led to suboptimal use of time and resources.) A fourth is to stress economic development as the ultimate objective of technology development.

Liaoning's S&T Development Plan lists strategic principles and development targets for 2010 which echo those at the national level (see Box 7.2). Shenyang and Dalian are to play special roles, national-level engineering centres and enterprise technology centres and zones are to be constructed, and attention focuses on six broad high-technology industries (advanced manufacturing, new materials, ICT, biotechnologies, civil aviation, energy). Finally, the Plan defines 20 major research projects to be implemented during the five-year period and details the relevant policy measures. However, it does not include some national targets (*e.g.* rate of reliance on external technology); for others, Liaoning's aims are more ambitious, an indication of its relatively advanced position.

The basis of Shanghai's economic development strategy is development through innovation, rather than through basic resources. It is therefore striving to achieve goals comparable to those of OECD regions: a high level of R&D investment (3.5% of gross regional product by 2020) as well as high scores on international competitiveness rankings (*e.g.* the second category of the World Knowledge Competitive Index by 2020). The policies in pursuit of these goals fall under three headings:

- *Increasing inputs to innovation.* Policies include increased funding of R&D as a percentage of gross regional product, encouraging enterprises to invest more in innovation (*e.g.* through tax incentives), and attracting private investment (*e.g.* venture capital).
- *Improving the innovation environment.* Policies include regulations that, on balance, spur innovation; support for infrastructure such as high-technology parks, incubators and other facilities; use of government procurement to support innovation; improvement of intellectual property protection; and promotion of higher technical standards in firms.
- *Finding a better role for government.* The municipality also seeks to promote a paradigm shift in the role of government in the innovation process from control to support. Policy areas include increasing firms' access to financing, information collection and sharing, and support of professional service platforms for R&D.

Box 7.2. Comparing targets for Liaoning Province with national targets

The Liaoning 11th S&T Plan sets the following development targets for 2010:

Through 2010, establish an outstanding and distinctive overall S&T structure; construct an S&T and innovation system adapted to a market economy and to S&T laws; significantly increase the overall level of S&T; significantly reinforce the capacity of high and new technology industries; initiate and progressively build a strong S&T province.

1. Increase the value added of high and new technology industries to RMB 200 billion; achieve an average growth rate of over 19%; represent around 15% of GDP; have added value in high technology industry reach 3% of GDP; increase the average annual number of approved innovation patents by 10%; have the added value of new produced goods reach 20%; have advances in S&T contribute 50% to economic growth.

2. Establish an S&T and innovation system which puts enterprises at its core and closely integrates enterprises, universities and research institutes through collaborative relationships; set up a social innovation service system with various sorts of S&T intermediary bodies as main actors.

3. Form a relatively strong capacity for independent innovation; help scientific research and technology development reach an advanced level; in key high and new technology areas, attain an internationally advanced level.

4. Total R&D funds should represent more than 2% of GDP; enterprise technology development funds should represent more than 3% of annual income; a diversified and multi-channel new S&T investment system should be constructed with enterprises as main investors.

11th National Science and Technology Plan main targets for 2010:

1. Overall R&D investment: 2% of GDP.

2. Rate of reliance on external technology: less than 40%.

3. International citation of S&T papers: among the top ten countries.

4. Number of innovation patents obtained each year by Chinese nationals: better than 15th place worldwide.

5. Contribution of S&T progress to economic growth: more than 45%.

6. Added value of high technology industry/value of manufacturing industry: 18%.

7. Number of S&T human resources: 50 million.

8. Number of staff involved in S&T activities: 7 million.

9. Number of full-time scientists and engineers in R&D activities: 1.3 million.

Shanghai's long-term plan also echoes several of the key themes of the national S&T plan that are espoused by other regions. It aims to use knowledge and human capital to lead development, to strengthen S&T innovative capacity and to support "harmonious" economic and social development. It aims to support application-oriented autonomous innovation through a focus on: efficiency and the benefits of technological innovation without neglecting scientific research; innovation in several competitive fields; R&D in strategic and model projects; and enterprises as the main actor, supported by universities and institutes. The targeted fields fall under the HEAD project (**H**ealth, **E**cology, **A**dvanced Manufacturing and **D**igital), areas the municipality considers demand-driven. The plan also aims explicitly to build up its regional innovation system and innovation clusters.

7.3.2. Key issues

It is beyond the scope of this chapter to propose a systematic assessment of the pertinence of the S&T development strategies for overcoming the weaknesses and challenges observed in the three provinces. However, it is possible to raise several issues. First, the S&T plans may not sufficiently target funding to the gaps in the innovation process. In this area, Liaoning conducted an assessment of its S&T policy in collaboration with the local branch of the Development Research Centre, a prominent think tank with ministerial status at the central level. The assessment shows that spending focuses on basic R&D and on commercialisation, with too little attention to trial testing. This may be linked to the province's notable shortage of venture capital.

A second issue is too rigid use of performance targets, which induces, as in all countries, practices that do not necessarily help to meet the chosen objectives. In China, targets include the broad "development targets" of the planning documents, organisational targets that guide the activities of the different administrations involved, and the system of individual performance targets, for executives of administrations and of public service units such as universities. In several instances, it seemed that these performance targets, defined at the national level, either were not well defined or did not produce the desired results. Actors in the different regions indicated that professors were discouraged from engaging in applied research because it is not rewarded in evaluations. Also, the wish to refer to "objective" measures of S&T and economic development via visible markers, such as the creation of industrial parks or platforms, while it had indeed led to a multiplication of initiatives to foster interaction between research and production, this did not really succeed in developing effective relations between different entities, for instance in the form of techno-intensive clusters.

A third issue is the balance between national and sub-national (provincial and local) actors in defining their S&T development strategies. As mentioned, the planning framework is meant to allow regional entities to adapt the higher-level framework to local needs and context. Yet, it is likely that the more provinces or lower-level entities rely on financing from a higher level, the more they are likely to orient their strategy according to guidelines and objectives set at that level.[4]

A last issue is the insufficient extent to which provincial S&T development plans take into account regional development in different areas of the province. There are some attempts to consider the different lower level administrative districts. The Liaoning S&T development plan refers to the specific role played by the province's two leading cities, Shenyang and Dalian, and briefly describes the general orientation of other parts of the province. Shanghai municipality, which is smaller in terms of land mass than the other regions, recognises the importance of some co-ordination across districts within the municipality and is prioritising districts and using various labelling systems to direct its S&T investment. Many OECD member countries adopt a significantly different approach and distinguish between different types of zones/areas in the strategy design, identify a limited number of priority areas, use functional economic areas, or refer to cluster mappings.

4. For example, Sichuan's Bureau of Science and Technology (BOST) receives RMB 1.2 billion from the central level and RMB 0.1 billion from the provincial government. This effectively raises the question of the central government's role in the formulation of the province's S&T and innovation strategy. It would be interesting to see how the allocation of the central level funds contributes to shaping Sichuan's overall strategy and objectives.

7.4. Governance and challenges

China is an exceptionally decentralised country. Major spending responsibilities such as education, health and social welfare fall to regional governments. The sub-national share of total public expenditure exceeds that of all OECD countries. By contrast, S&T spending is quite centralised: in 2005, more than 60% of public expenditures for S&T were managed by the central level. This shows the weight in S&T investment of national programmes such as the Torch Programme, the Spark Programme or the National High-technology R&D Programme.

This section examines the governance framework for S&T policies at the provincial and lower levels, focusing on the key public administrations involved and their roles. While they represent less than 40% of total public expenditure, provincial, county and municipal governments nevertheless play an increasing role in local S&T development. An unclear division of labour across levels of government and problems of horizontal and vertical co-ordination may diminish the efficiency of public action and impede the development of a true regional S&T development strategy.

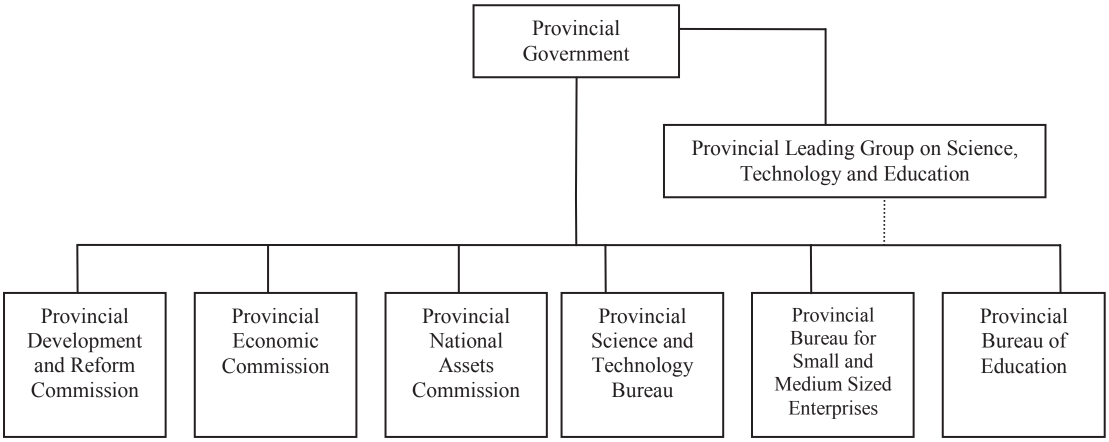
7.4.1. Public actors at the provincial and lower levels

7.4.1.1. Main public actors at the provincial level and their role

The institutional structure of administrations involved in S&T development at the provincial level (Figure 7.5) and below reproduces the pattern at the national level. That is, each administrative level (province, municipality, county) has local branches of all administrations. At the provincial level, the three main administrations involved in S&T development are the Provincial Development and Reform Commission, the Provincial Economic Commission and the Bureau of Science and Technology. The internal organisational structure of administrations is comparable at the different levels but shows some variation, sometimes owing to the province's or city's desire to emphasise a certain policy issue.[5] As Shanghai is a municipality with provincial status, there is no separate provincial level. Other important administrations playing a role in the field of S&T development include the Provincial National Assets Commission, the Provincial Bureau for Small and Medium-sized Enterprises and the Provincial Bureau for Education.

5. In Liaoning province, for instance, the Dalian S&T bureau is composed of the following departments: Central Office; Department of Policy Regulation and System Reform; IPR Department; Department for Development of High and New Technologies and for Commercialisation; Department for Rural Technology; Social Services Development Department; Results and Technology Markets Departments; International Co-operation and Business Attraction Department; Resource Planning Department; Rules Supervision Committee. The Tieling S&T bureau is composed of: Central Office, Overall Planning Office, High and New Technology Development and Commercialisation Office, Patent and Technology Office, International S&T Co-operation, Planning and Regulations Office, Information-based Management Office, Wireless Control Office (Municipal Wireless Management Committee Office).

Figure 7.5. Main institutions involved in S&T development at the provincial level



Provincial Development and Reform Commission. This is the local branch of the National Development and Reform Commission (NDRC), *i.e.* the former planning commission. It focuses mainly on macroeconomic regulation, but it plays a double role in relation to the innovation system, mainly through its High-technology Industry Division. It prepares the economic and social development planning documents, and, through investment projects, it plays a leading role in the effort to enhance the province's independent innovation capacity in high-technology industries.[6]

Provincial Economic Commission. Through its S&T Department, the Commission has two main areas of action. First, it supports the development of R&D centres in enterprises.[7] It focuses on accumulation of research funds and resources in enterprises and on the improvement of equipment and human resources. It may also seek to foster links between universities, research institutes and enterprises to support enterprise R&D centres, to encourage enterprises to adapt existing technologies or develop their own technologies, or to facilitate upgrading and restructuring.

Provincial Bureau of Science and Technology. The principal mandate of the BOST concerns R&D. It may also take a broader innovation approach for SMEs and rural enterprises. Its structure is not strictly the same from one province to another, but it has a range of departments covering issues such as: policy regulation and system reform; development planning; international co-operation; results and technology markets; development of high and new technologies and their commercialisation; education of human resources, rural and social development; and platforms (see below), a recently created area.

6. In the past five years, the Liaoning Development and Reform Commission (LDRC) organised and managed 132 projects for which they received RMB 1 million from the central government.

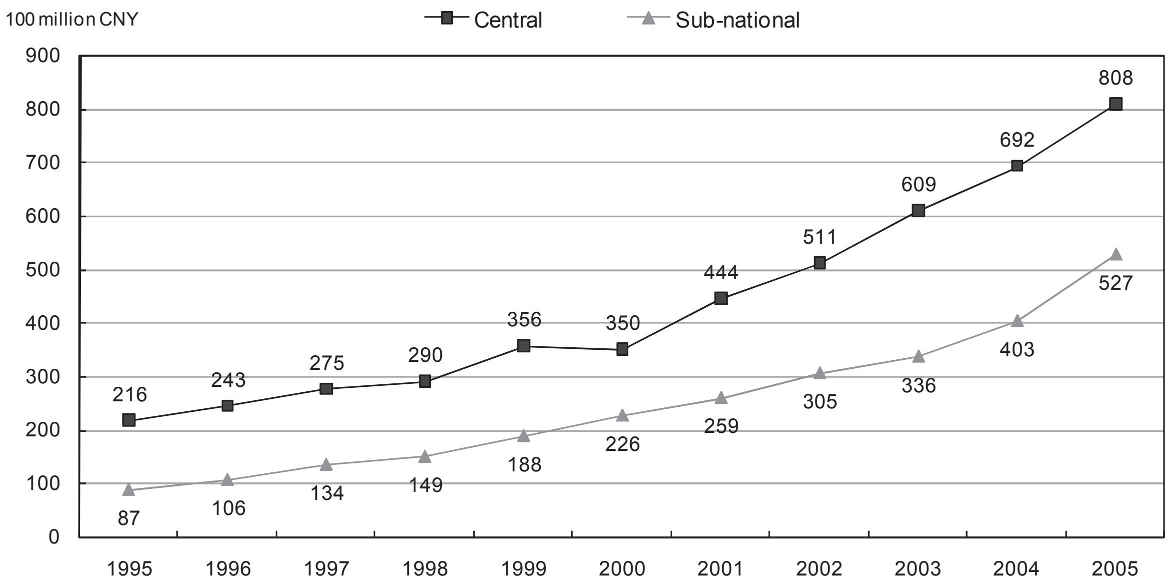
7. In Liaoning, for example, 144 provincial enterprises and 25 national enterprises have R&D centres. Liaoning ranks third after Chengdu and Shanghai in terms of number of national-level centres.

The BOSTs have responsibilities for planning, policy, projects and general S&T development. They take the lead in preparing S&T development plans and contribute to economic and social development plans. BOSTs have policy and regulatory power concerning management of projects, regulation of technology markets, and new and high technology development zones, for example. They manage a portfolio of projects defined in accordance with the S&T and economic and social development plans and give grants to enterprises, universities or research institutes. The selection process for the allocation of grants is organised with a view to minimising risks of corruption and making efficient choices. The process includes external experts and Internet submissions. Projects are evaluated periodically but local actors are seeking ways to improve the evaluation process. Other missions may include training and diffusion of new products or tools in rural areas. Finally, broader development of S&T infrastructure such as platforms is receiving increasing attention.

7.4.1.2. Resources for S&T at the regional level

As mentioned, public expenditure in the field of S&T is relatively centralised. Figure 7.6 shows a steady increase in the share of sub-national government expenditures for S&T in total government S&T expenditure.

Figure 7.6. Central and sub-national government S&T appropriations, 1995-2005



Source: Ministry of Science and Technology, China Science & Technology Statistics 2006, p. 15.

Information on public resources allocated to S&T at the sub-national level is generally scarce. Available data at the provincial level include government S&T appropriations by province, which amounted in 2005 to RMB 7.93 billion for Shanghai (4.78% of total sub-national government expenditure), RMB 2.80 billion for Liaoning (2.32%) and RMB 1.27 billion for Sichuan (1.17%). This includes four components: *i)* operating expenses for science; *ii)* S&T promotion funds; *iii)* capital construction for science research; and *iv)* other.[8] There are no regional data for government R&D expenditure.

While provinces have a fixed set of provincial-level agencies (see Figure 7.5), they have some flexibility in terms of the agencies' departments (see footnote 7). Each province also establishes its own vertical structure of public expenditure. Data on S&T expenditures below the provincial level are not available and there seems to be little strategic thinking about the overall allocation of funds within the province or the aggregation of expenditures at different levels.

Financial resources spent by the provincial level come either directly from their budgets or are received from the central government in the framework of national S&T programmes. Beyond these programmes, there are no fiscal transfers for S&T from the central government to the provinces.

Field interviews in the three regions revealed the important weight of the municipal level in sub-national S&T spending. For example, while the project budget of the Liaoning BOST is RMB 0.6 billion, Shenyang's budget is RMB 0.6 billion and Dalian's is RMB 0.5 billion. (Project budgets tend to be the largest part of S&T budgets.) This is also true for the staffing of BOSTs; when numbers are summed across lower levels, they can far exceed those at the provincial level.[9]

7.4.2. Division of responsibilities across levels of government

There are economic rationales for involving multiple levels of government in S&T development; the key question is in what capacity. Clearly, China, like OECD countries, has national-level objectives in terms of technology sectors and the importance of key economic drivers. The national level also has an interest in trying to avoid wasting resources through duplication of efforts in different parts of the country. However, there is a regional dimension to constructing an environment that facilitates interaction to support innovation, and regional and local actors are often best placed in this respect. In many OECD countries, in addition to initiatives at the regional level, national policies support the regional level's role in creating this innovative environment. Table 7.2 indicates some of the areas considered by OECD countries when determining which actors are responsible for supporting innovation.

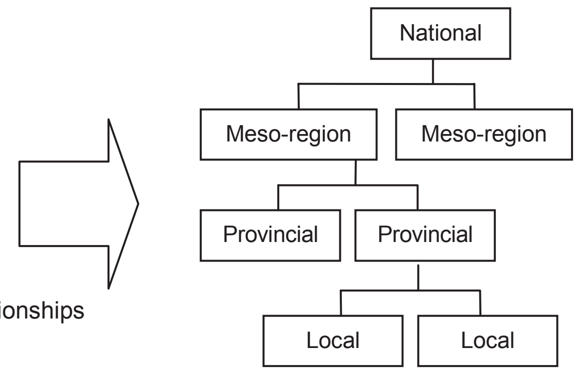
In China, the division of responsibilities across levels of government is not very clearly defined. Beyond Article 107 of the Constitution, there is no official division of responsibilities for S&T and innovation in this respect. In practice, the central government's S&T efforts focus on areas of national interest (*e.g.* national defence, health, security) and on fundamental research; sub-national governments enjoy a substantial degree of autonomy. The government's S&T priorities are framed in national programmes such as the Torch programme. In addition, the central level is the source of most of the (public) R&D investment, while sub-national S&T efforts focus more on technology development and applications. At the central level, 70% of the S&T budget goes to R&D, but only

8. The Ministry of Finance provides data for components i, ii and iv. Capital construction estimates are produced by the Ministry of Science and Technology through surveys conducted in all provinces. Given the methodology, information on the relative weight of the different provincial-level agencies involved in S&T is not available.

9. The average staff of a city-level bureau is 20. The lowest governmental level would have 2-3 employees. In comparison, the provincial bureau has about 60 staff.

30% at the sub-national level. Funding for the diffusion and application of existing technologies is more significant at lower levels of government. Because biotechnology is a new field of research, most of the funding comes from the national level. Yet, cities such as Shanghai and Suzhou, which are economically quite advanced, also invest in R&D in this field.

Table 7.2. Considerations for level of policy intervention

Criteria for consideration	Level of government in China
• National research and technology goals • Spatial dimension of regional innovation actors • Nature of spillovers and their spatial implications • Institutional frameworks • Financial resources (availability, redistribution issues) • Knowledge of actors in regional innovation and their relationships • Technical capacity	

Horizontal government links are stronger than vertical links. For example, the horizontal link between the bureau of S&T in a prefecture-level city and the corresponding city government ("xingzheng lingdao", *i.e.* administrative leadership) is *de facto* more important than the vertical link between the bureau of S&T and the provincial-level bureau ("yewu zhidao", *i.e.* business guidance). As a result, regional government agencies primarily serve the level of government to which they are affiliated. They should not be seen as devolved units of central administrations.[10]

There is thus flexibility at the sub-national level, but in the context of a nested hierarchical framework that encompasses the centre and the sub-national level immediately above. It is clearly acknowledged that each sub-national entity should develop its own goals and policy agenda, reflecting local specificities and constraints. The system of defining policy documents and plans allows for this combination of sub-national flexibility and overall coherence. Provinces participate in the elaboration of the national plan, and the central government does not intervene in the elaboration of provincial plans and other sub-national government policy documents.

Similar regulatory and policy approaches apply at all levels of government. There is no official guidance or limitation in terms of the types of policy tools a sub-national government can use. The only condition is that policies and regulations adopted at a given governmental level must not contradict those adopted at the level above (and at the

10. However, the Chinese system differs from a federal system in that local governments answer to the State Council at the central level, rather than to a local constituency.

central level). Yet, in practice, it is not unusual to find inconsistencies between regulations adopted at the sub-national level and those at the central level.[11]

Regional government entities participate in the implementation of national programmes. The national programmes are implemented by central-level institutes such as CAS and by sub-national research institutes or enterprises, whose participation follows a bottom-up process: they apply for grants via the appropriate sub-national unit to which they are affiliated.

7.4.3. Co-ordination mechanisms and challenges

The multi-level governance system presents two major weaknesses. The first, common to many other policy fields, is that the quality of regional public action will depend very much on local capacity. That capacity is likely to vary according to the province's level of development, and may create a vicious circle that hinders economic development. Problems of co-ordination constitute the second major challenge. This challenge, while not absent from OECD countries, is exacerbated in China owing to its size. While the planning documents support horizontal and vertical co-operation, the current governance set-up does not allow for the design and adoption of real, nationally co-ordinated, regional development strategies across and within provinces.

7.4.3.1. Challenges for horizontal co-ordination across agencies at the provincial level

Co-ordination of the various S&T and economic development plans with a view to coherence is more formalised in terms of strategy than of implementation. The horizontal allocation of responsibilities across entities, the overall planning framework, and the use of a co-ordinating body (the Leading Group for Science and Technology) all support efforts towards a certain degree of horizontal co-ordination. However, while the bureaus of S&T are the lead entity for S&T strategy, they only control a certain amount of provincial government S&T funding. Other commissions have their own S&T funding, whether from central or provincial sources. BOSTs are not necessarily the main actor at the provincial or lower levels of government. Typically, the regional Development and Reform Commission, which is responsible for supporting commercialisation, invests the bulk of S&T resources.[12] Furthermore, the different bureaus support various aspects of the innovation process that go beyond S&T.

As described above, S&T activities in a given region are determined partly by the level of government and partly by its participation in national programmes, which is the result of a competitive process that does not take account of local objectives or synergies. The ensuing problems of horizontal co-ordination were reported to be particularly challenging in Sichuan Province owing to the amount of funds the province received from the central government: these are allocated through the Ministry of Science and Technology (MOST), the Ministry of Education (MOE) and the NDRC, with little co-ordination at the central level. In an effort to address this problem, MOST is working on

11. The lack of regulatory coherence sometimes observed across levels of government is partly due to the lack of an efficient policy implementation mechanism at the local level. It should be noted that the size of the country is a challenge in this respect. Lax enforcement also serves various political purposes.

12. For instance, in 2006 the total public envelope for S&T development in Liaoning was RMB 4 billion, with about 50% of this sum being managed by the Liaoning DRC.

ways to work more effectively with provinces as a whole, rather than simply its provincial S&T counterparts.

OECD countries have used a range of strategies to promote greater horizontal co-ordination in support of innovation, at the central or regional levels (OECD, 2007). Such strategies include: cross-sectoral innovation plans or cluster programmes, co-ordinating committees (similar to the Chinese State Council's Science Technology and Education Leading Group) and jointly funded and/or administered projects. Often these innovation plans seek to overcome the classic divide between education-focused ministries or agencies, science and technology agencies and industrial agencies. Some OECD countries achieve a greater degree of co-ordination through joint administration of projects. This method was not observed in China, although many projects receive support from multiple government entities and lower levels select actors to participate in national level programmes.

7.4.3.2. Co-ordination challenges across governments at the same level and vertically across levels

A second major challenge is insufficient co-ordination among local governments, which leads to a waste of resources and investments. In fact, all provinces and prefecture-level cities tend to adopt comparable strategies and develop similar projects, in spite of their highly heterogeneous assets. A well-balanced use of resources is needed to ensure the healthy competition that leads to innovation.

It was reported that China had abandoned the planning system and that there would be "no return to the plan". Decisions on the allocation of resources or on the definition of precise objectives are not made top-down. In their supervisory role, provincial and lower-level S&T bureaus hold several meetings a year. Staff of the provincial BOSTs visit officials at lower levels regularly, but overall the centre or upper levels do not prevent local governments from developing certain projects.[13]

In view of the duplication in investments owing to the lack of co-ordination, central governmental "guidance" of activities at the regional level is gaining in importance. It takes the form of joint projects or co-ordination agreements between provinces and the central level ("shengbu huishang"). A dozen such agreements have been signed with provincial governments, including Sichuan.[14] They represent about RMB 5 billion, *i.e*. less than 10% of gross domestic government expenditure on R&D (RMB 64.4 billion in 2005). Their leverage power is therefore considered insufficient for the moment.

A system of labels also contributes to vertical co-ordination of administrations and non-governmental actors. National, provincial or municipal labels are attributed to projects, parks or centres and reflect their importance. For instance, the multimedia Industrial Park of Changning District in Shanghai has a central government label while the Software Centre and the Aviation Industry Park have a municipal label. Labels also make it possible to apply different policy treatments. For instance, if an industry zone has a national label, firms may receive significant tax incentives and access to cheaper land.

13 There has been top-down intervention to reduce growth of investment, in order to limit the overheating of the economy. These interventions are seen as part of overall macroeconomic regulation and are therefore irrelevant to the S&T field.

14. The text of these agreements is not public.

Such a label also increases the chances of winning competitions for financial support from that administrative level.

In OECD countries labelling is commonly used to increase innovation resources to priority areas, be they centres of excellence, clusters of firms or particular technologies. The credibility of the labelling process is a key consideration and has been questioned when it has been developed only by civil servants or when the number of labels is so broad that the designation loses significance. Like China, other countries have also sought to co-ordinate resource allocation to priority areas across levels of government by actively involving the regional level in the selection and funding of national programmes.

Provincial public actors in China are also beginning to promote inter-province co-operation in areas related to regional innovation in functional economic areas that do not always map to administrative boundaries. Shanghai municipality, for example, is working with the neighbouring provinces of Jiangsu and Zhejiang on certain technology-related matters. The Yangtze River Delta Commission serves as a forum for the science and technology officers of the three provinces to meet and to co-ordinate technology platforms and projects. One of the barriers to project-based co-ordination that they hope to remove is the lack of harmonisation across provinces of certain criteria related to participation in projects, such as the definition of a high-technology firm.

7.5. Engaging actors in the innovation process

Traditionally, Chinese authorities at all levels of government have adopted a strategy of grouping key actors together to support a system of innovation that is only recently being complemented by "platforms" to link them. They use more or less specific designations, ranging from broad-based development zones and industrial parks to more targeted science parks and incubators, in order to attract firms and other actors. However, Chinese officials increasingly recognise that while this strategy continues to be popular for economic development as well as science and technology policy, platforms are a way to build stronger links among actors. This section explores how regional actors in China work towards this goal. Incentives and disincentives for the various actors in the regional innovation system, and the challenges they may present, are also discussed.

7.5.1. Policies to promote the concentration of actors

China actively uses various types of zones and parks to bring firms and other actors together. Special economic zones are very broad-based initiatives, often aimed at attracting FDI through tax incentives. Industrial parks or zones tend to be more restricted in terms of size and benefits, although certain industrial parks have compelling tax incentives. Science parks, also referred to as research parks or technology parks, focus on science-related and high-technology industries. Finally, incubators and innovation centres, often affiliated with universities or science parks, provide opportunities for start-up firms and typically offer additional business development or technology support services.

China's nationally designated "parks" can be classified by both size and driver. There are five large special economic zones, 32 mid-sized high and new technology industrial development zones (HNTIDZ) and 58 science parks. Some parks serve as nationally designated regional hubs, some carry out national S&T programmes, some integrate the previous two types for national strategic purposes, some are initiated by demand factors, such as university-run science parks, and some are set up under foreign initiative (Park and Hong, 2005).

Over time, China's "science parks" (many of which are called high-tech zones in China) have evolved from a focus on high-technology manufacturing exports towards entities that more clearly support endogenous innovation. The 53 high-tech zones related to the Torch Programme emerged in the late 1980s and focused successfully on attracting FDI and promoting high-technology manufacturing for exports during the 1990s. Unlike conventional science parks in the United States, for example, they did not seek to develop relationships among actors, innovation or technology transfer (Sutherland, 2005). Another group of over 40 national university science parks, launched since 2000, serve as a base for Chinese and MNE research centres and offer services such as support with intellectual property licensing. Firms that locate in science parks hope that this will help leverage government support, in addition to other benefits such as preferential tax policies (Mei, 2004). In both settings, innovation centres and incubators have increased tremendously and been effective vehicles for linking actors and supporting spin-offs. The number of national incubators more than tripled from 164 in 2000 to 534 in 2005, and the number of incubated firms rose from 8 653 to 39 491 (see Chapter 4).

China has sought to replicate the success of "clusters" in OECD countries by promoting industrial and science parks, although they may be considerably larger and include a complex set of overlapping structures. The number of actors and the degree of government control are greater than what would be found in OECD countries. The Zhongguancun Science Park in Beijing, approved in 1988, is one of the first. It has 71 higher education institutions with 300 000 students, including Peking and Tsinghua universities, 213 research institutes, 65 MNEs and 54 multinational R&D centres as well as other intermediaries (Zhu and Tann, 2005). The Shenzhen High-technology Industrial Park in Guangdong Province in the Shenzhen Special Economic Zone has many incubators and the Shenzhen Software Park, which serves as a base for the national Torch Plan Software Industry Programme. It is also part of the Shenzhen High-technology Industrial Belt which includes 11 parks (nine high-technology parks, a university town and an ecological agriculture park) as well as 40 IT centres (Sigurdson, 2004).

In addition to the parks designated at the national level, there are provincial and local initiatives, but given their proliferation they are now prohibited from offering certain tax incentives. One estimate mentions around 12 300 "clusters" (presumably some form of park) across China (Park and Hong, 2005). Another finds approximately 6 741 development zones (presumably also a form of park) (Quan, 2004, quoted in Sigurdson, 2004). There are 120 regional-level high-technology zones but they do not have the same level of tax exemption.

In all three provinces, such entities have been the focal point of provincial policies and in some cases they have been very effective, with clear efforts to promote closer links or support cluster development. They have served to concentrate and accelerate economic development, more quickly in fact than in many OECD examples. Shanghai's Zhanjiang High Technology Park, mere farmland in the early 1990's, is now a leading international R&D hub for biotechnology which includes not only foreign pharmaceutical companies but start-up firms and support services for clinical testing. In another location, Anting Auto City has brought together research centres that actively work with firms, often through joint ventures. In Sichuan, two innovation centres play a concrete role in technology transfer and support of high-technology SMEs (see Box 7.3).

Box 7.3. Industrial and science parks: Shanghai and Sichuan

Shanghai's Pudong New Area is a massive development zone on the east side of Shanghai that was farmland when plans for its development began in 1990. This area is home to one of the nationally designated HNTIDZ, Zhanjiang High Technology Park. In 1992, it began to bring together firms and other actors in information technologies and biotechnologies. The park has received support from the Shanghai municipal government and many central-level actors, including the Ministry of Science and Technology, the Ministry of Health, the State Food and Drug Administration and the Chinese Academy of Science. In the biopharmaceutical sector, for example, approximately 20 central- and provincial-level research institutes have been established, as well as dozens of corporate R&D centres, many university and vocational training centres, more than 200 start-ups, and 30 contract research organisations for clinical trials. A recent success includes the decision by Novartis to invest USD 100 million in an R&D facility in Shanghai and to make it one of its top three international research hubs along with Boston (United States) and Basel (Switzerland).

Anting Auto City, which is in another part of the city and not exclusively high technology, has played a key role in bringing actors together within an automotive cluster. The municipality has played a major role in supporting both infrastructure and, along with the central level, research projects. The origins of the automotive industry in Shanghai can be traced to 1958 when the first car was designed, but the cluster development was triggered in the 1980s when the central government approved the production of automotive spare parts for Volkswagen through the Shanghai Automotive Industrial Corporation (SAIC) on land provided by the Municipality of Shanghai. In recent years, the City has brought together research institutes, including a campus of the reputable Tongji University. The supply chain of SMEs, however, remains underserved in this cluster.

In Sichuan, the Chengdu High Technology Industrial Development Zone (approved in 1991) focuses on ICT and is linked to an innovation services centre which manages three parks in the area. It ranked fifth in the country in 2005 and the services centre ranked 2nd in 2004. The park has administrative status as a district, so it reports directly to the municipal government. Firms in thus industrial park are mainly start-ups and SMEs who need services to understand the market and develop products and processes in a short-term perspective. They receive support when they apply for government-funded projects (from the Bureau of Science and Technology and the Development and Reform Commission) and when they seek financing via bank loans or venture capital. Over 140 000 technicians and specialists work at the park. The Chengdu Digital Media Industrial Base has become a key regional industry owing to support from the Sichuan government and the Chengdu municipal government.

In another location in Chengdu, Sichuan University has a science park established in 1999. It has a business firm and two affiliated centres have received labels/certificates from MOST as a science park and a high-technology innovation centre, respectively. The park has some 116 companies and provides services such as technology transfer, a technology support platform, commercialisation, including for large firms, and human capital training (includes classes for students and managers as well as specialised short-term training). The innovation service centre does not invest in R&D but brings together actors from outside the university. The park is co-financed by the university and the district, the municipality and the province (mainly the provincial level Bureau of Science and Technology and the provincial Development and Reform Commission). Firms participate financially in particular projects.

Korea's innovative cluster cities programme offers an interesting model, given China's infrastructure of massive industrial parks. It is part of Korea's Plan for National Balanced Development and seeks to transform seven regional industrial complexes from manufacturing centres into more innovation-oriented regional hubs. The aim is to strengthen these industrial complexes by systematic integration of R&D and development of networking by academia, industry and research institutions. It is expected that this pilot experience will be extended later to several other industrial complexes and then to all national industrial complexes. The cluster cities selected specialise in fields consistent with national priority industries.

7.5.2. Policies to promote connecting local actors

China is now seeking to strengthen relationships among firms, universities and research institutes through what are referred to as platforms. These may take a variety of forms. The 11th Five-year National S&T Plan (2006-10) explicitly recognises this platform concept for the first time. Given the novelty of the strategy, few resources have so far been dedicated to building such platforms. Provincial and local actors are also struggling with the modalities and incentives for building such platforms. As in OECD countries, these platforms can be anything from a website to joint R&D projects. Platforms may be initiated by the national or provincial level but may also be supported by municipalities or smaller units of government such as counties and districts. Some platforms are sector-specific and link actors in a similar sector or value chain. Others are general support mechanisms open to all actors.

In China, public actors have the three main vehicles used in OECD countries for engaging actors: an active facilitator role to bring actors together; collective or public services; and support for joint R&D projects, often with a requirement for collaboration among firms and/or with universities and research centres (OECD, 2007). In China, joint R&D projects appear to be the most common method.

7.5.2.1. The facilitator role: identifying and linking actors

OECD countries have used the facilitator concept under various forms to support innovation, with the public sector either playing that role directly or financing private actors to do so. It is generally accepted that there is a rationale for the public sector to finance facilitation, whether or not it does so directly, given that there are clear transactions costs for co-ordination but positive spillovers in terms of increased innovation and productivity. The nature of facilitation may differ according to the types of actors, the ease with which they can be identified, and the goals for working together. In the most basic form of facilitation, an animator or broker is employed to bring actors together for informational or social events. In more advanced forms, it may result in clear plans identifying common actions for a group of actors.

Within the three provinces, government actors understandably play the lead role as facilitators. This makes sense in China given the lack of a history of market-based collaboration or civil actors able to perform such functions. It is also easier for local actors to turn to government, which has traditionally been the source of information. S&T bureaus in all provinces serve this function as do other public actors. In Liaoning Province, the Economic Commission has organised conferences that attract universities, research institutes and enterprises. It encourages the creation of enterprise-university co-operation commissions in key universities and enterprises. Three commissions created in the last year link ten universities and 30-40 enterprises. It also organises with other public partners academic visits to enterprises (such as machinery, chemical and steel companies) to help diagnose technology difficulties and provide services. Finally, it facilitates co-operation between universities and enterprises. For instance, in 2005 it sponsored the "14+6" activity, which brought together 14 local economic affairs management commissions and six key universities and colleges to work together to identify market opportunities.

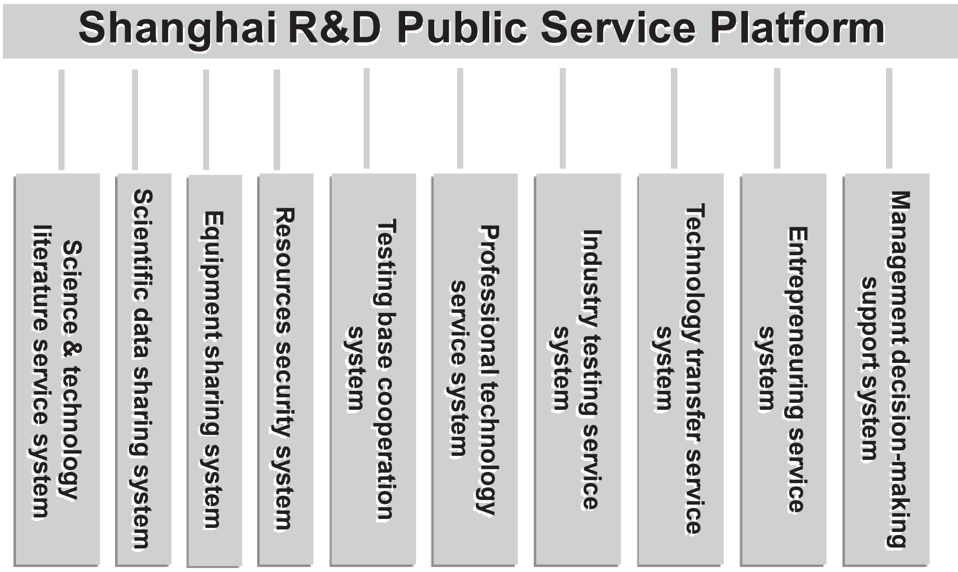
In the short term, the major challenge for Chinese regions is to develop a culture of linking actors, but in the long term engagement of the private sector will be an even greater challenge. In OECD countries, almost all programmes struggle with how to involve private-sector actors effectively so as not to depend too heavily on public actors. One of the most common evaluation results is that the public sector plays too prominent a role in the process. The existence of ongoing relationships beyond the programme funding period is considered a sign of success. Public actors in China will therefore need to consider how to have an active public-sector facilitator role in the short term that does not stifle long-term private-sector engagement. Some OECD country strategies to increase private-sector engagement include private-sector-driven programme development, private-sector selection of projects or co-financing. In the Georgia Research Alliance in the United States, for example, Georgia's industry leaders brought together business, research universities and state government players to support technology-based economic development.

7.5.2.2. Collective and support services

Another strategy for bringing actors together is to develop collective and support services for groups of firms. Many of these services are available in OECD countries, and they may be publicly provided or public programmes may finance privately provided services. Instruments to promote internal and external (including FDI and exports) business linkages often focus on the concrete needs of SMEs both generally and for access foreign markets. Such instruments include joint purchasing, partner search databases, using a common label, certification of standards, or the collection and dissemination of market and scientific intelligence. For example, "real services" to SME groups in Italy are expected to increase the competitiveness and market opportunities of user firms through structural modification of their organisation of production and their relation with the market. These services may include market information, testing and export support. Spain has also taken advantage of this model for publicly provided collective services in the form of technology and business development centres.

In China, the public sector takes the lead in trying to provide collective and support services that serve the innovation needs of firms and other local RIS actors. The lack of private providers of such services calls for an even greater public role in China than in OECD countries. As illustrated in Figure 7.7, Shanghai's R&D public service platform seeks to address a wide range of services similar in principle to what is found in OECD countries. These services cover the innovation development process from scientific information sharing to technology testing and transfer services to support in entrepreneurship and management.

Figure 7.7. Shanghai R&D service platform



Source: Shanghai Municipality Science and Technology Commission (2006), "The Innovation System of Shanghai", presentation made to an OECD delegation in Shanghai, China, 9 October 2006.

7.5.2.3. Joint R&D: beyond one-off projects

The mandate of Chinese science and technology bureaus and commissions is first and foremost to support research and development projects. For example, in Shanghai, two-thirds of the Shanghai Municipality Science and Technology Commission's budget is used to fund R&D projects; the balance supports financing instruments targeted at technology-focused SMEs.

Some local actors in China have recognised the limits to this project-based approach. Sichuan Province now favours investing in larger projects to achieve greater economies of scale and potentially increase their breadth. A potential constraint in the Chinese system relates to the rules concerning use of R&D project funds. A significant proportion, sometimes upwards of 70%, must be used for equipment. Given the need to pay for labour costs as well, there is little left for relationship development. Given the importance of engaging actors in joint R&D, most OECD programmes that promote joint research include funds for relationship building. For example, in Sweden's VINNVÄXT programme, at least 50% of eligible expenses had to be spent on R&D but other eligible expenses included process management, brand creation, organisation, strategic work, etc. In Finland's National Cluster Programme, which primarily involved collaborative R&D, 25% of funds were spent on cluster governance.

7.5.2.4. Incentives and barriers to engaging actors

Within OECD countries, relations between universities (or research institutes) and firms can be classified into three types (OECD, 2006a). In China, a fourth dimension also needs to be considered. First are relations between MNEs and world-class universities; the former externalise part of their R&D activities and look for the best laboratories, scientists and students. Second are relations between research universities and small high-technology firms, including spin-offs and knowledge-intensive business services. Third are regional relations between firms, often SMEs, and local universities or polytechnics; here, firms look for short-term, problem-solving capabilities. In China should be added the relations of universities and private firms with state-owned enterprises, which have special considerations in terms of incentives for innovation.

Relationships among RIS actors are determined by factors such as the relative strengths and specialities of different actors, the incentive structure in their operating environment and the ease of relationships (see Box 7.4). As noted earlier, the type of RIS is partly a function of the concentration of innovation resources among different types of actor. In Shanghai, for example, the research orientation of various actors determines in part their role in the RIS (Figure 7.8). It should be noted that there is a shift of public funding away from research institutes and towards universities, which increases the university's role in R&D.

Box 7.4. Research institutes, universities and SOEs: the Chinese context

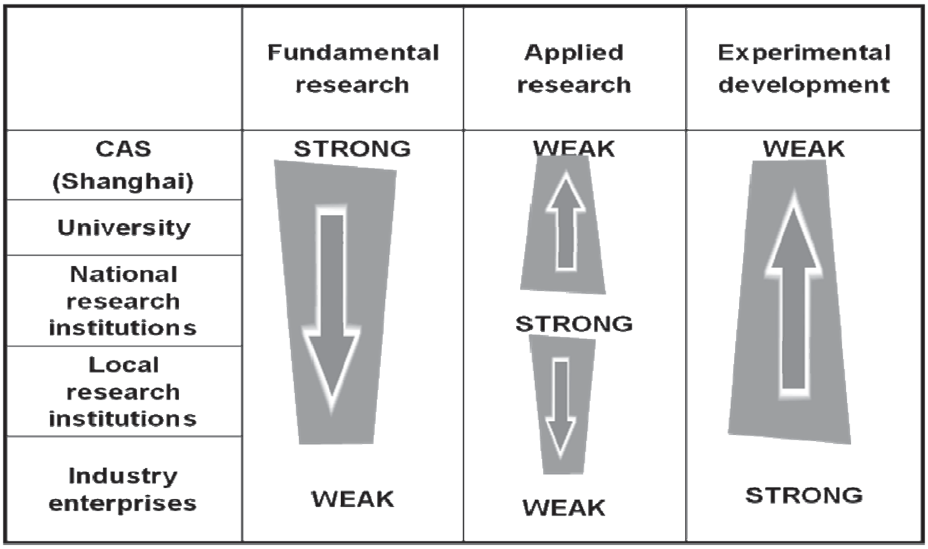
The system of research institutes separate from universities was developed in China along the Soviet model. These institutes are linked to various ministries, the Chinese Academy of Sciences (CAS) system, the Central Military Committee and SOEs. Their proliferation has resulted in weak co-ordination and potentially overlapping missions (OECD, 2006b).

Owing to a series of reforms since 1999, the research institutes play a lesser role than in the past despite greater autonomy in their operations. A reorganisation of the research institute system is being pursued with a view to consolidating them when possible, turning those with an applied R&D focus into technology-based companies and leaving those with a more public good aspect to remain as public service units. As a result, between 1998 and 2005 the number of CAS research institutes declined from 120 to 89 (OECD, 2006b). The basic funding of government institutes has been significantly reduced (RMB 35 billion in 2004 compared to RMB 36 billion in 1999). The percentage of funds from business contract research has also dropped overall despite incentives to find non-public sources of funding (Liu, 2006). In addition to the potential for greater efficiency due to consolidation, personnel policies are becoming more evaluation-oriented.

Universities in China are mainly public service units but a growing number have another status given their more private origins. Both national and regional universities can play an important role in a regional innovation system. National-level universities tend to be the most prestigious and have the most resources. Their personnel are subject to national-level regulations. In some cases, these prominent universities also receive co-funding from the province. Provincial-level universities tend to be less well-endowed and if anything focus more on applied areas of study and research. With the reform of public-sector units more generally, universities have also become more autonomous in terms of funding. Between 1999 and 2004, university research grants more than tripled from RMB 10 billion to over RMB 34 billion (approximately EUR 1 billion to EUR 3.4 billion) and the share coming from industry rose from just over 45% to 50% (Liu, 2006).

SOEs may be affiliated to the national, provincial or lower levels of government. If the private sector now produces more than 50% of China's GDP overall (OECD, 2005b), SOEs are still the main economic actors in many regions. In Liaoning, for example, the economy is dominated by SOEs, which produce between 60% and 80% of industrial output (World Bank, 2006). These firms are undergoing reforms and many are becoming private firms. Over time, their value added in the economy will continue to decline.

Figure 7.8. Research orientation of different Shanghai RIS actors



Source: Shanghai Municipality Science and Technology Commission (2006), "The Innovation System of Shanghai", presentation made to an OECD delegation in Shanghai, China, 9 October 2006.

While there are general trends across China, there are also clear regional variations in terms of the prominence of different types of actors in any given RIS. One analysis shows that MNEs are the main actors in Shanghai and Fujiang, in Sheijian SMEs are active and clustered while research institutes are less prominent, in Beijing research institutes are the most prominent, while in western China, large SOEs dominate (Liu, 2006). The Shenzhen Park in Guangdong Province, for example, is much more private-sector-oriented than other parks in China as it lacked a pre-existing endowment of educational and research resources (Sigurdson, 2004).

7.5.2.5. Framework condition incentives for and barriers to collaboration

The current legal status of universities and research institutes in China does not pose major barriers to their active engagement with local firms. In fact, their need to identify alternative funding sources encourages them to seek out such arrangements. Universities may own shares or entire firms and therefore have a financial incentive for a strategy of working with firms or supporting spin-offs. Therefore, they can generate spin-off firms, perform contract research for industry, sell licences and serve as consulting and service providers. Several leading universities have successfully used this strategy, such as Fudan University in Shanghai and Northeastern University, the founder of NEUSOFT, in Liaoning.

In China, the status of professors does not prevent them from starting firms or owning intellectual property. However, the national evaluation system for professors does not cover technology transfer. Basic research projects funded by S&T programmes carry greater weight than research for firms in formal and informal evaluations of professors. As in most countries, the university culture accords greater prestige to basic than to applied research. While this may serve as a mild disincentive for professors to engage with firms, professors do have some financial and other incentives to do so. There are in fact more barriers to engaging in research with firms or to owning intellectual property in several OECD countries than in China. Relations between research universities and small high-technology firms appear to be relatively open. Because many of these firms are started by professors or former students, informal networks play an important role. Universities can host an incubator or science park in which firms have easy access to university contacts. Moreover, the universities may have a financial stake in companies or in technologies used by the company.

Intellectual property rights are a clear structural barrier to collaboration across RIS actors, more for foreign than for domestic firms. All provincial actors cited the relationship between universities and MNEs as a key challenge for their innovation systems, in large part owing to IPR concerns. This does not prevent MNEs from establishing their own R&D centres in China, often a country in which their investment is expanding. For example, by 2003, the Zhongguancun Science Park included 54 MNE R&D centres which are in some cases part of those firms' global R&D activities (Zhu and Tann, 2005). Shanghai's Zhanjiang High Technology Park has also attracted several very prominent MNE R&D centres in biopharmaceuticals. For domestic firms, some actors consider IPR a possible impediment, in part because it is easier for universities to pursue firms for breach of contract than for firms to do so. Others indicate that they have now learned how to manage IPR issues in these collaborations and that it is no longer a problem.

In China, IPR is not only a national issue, as regional actors can play a role in improving the IPR regime in their area to support innovation. Shanghai is known for having one of the strongest IPR environments in China. Since the 1990s, a working group of 15 departments at the municipal level meets on IPR issues. The courts and the People's Congress (legislative branch) also participate. They can exchange views and identify gaps. Different departments implement and manage issues in their own areas of competence. Shanghai also manages information on IP disputes via the Internet to improve access and transparency.

In China, unlike OECD countries generally, SOEs are major actors. They are not homogenous in terms of technological upgrading and R&D investment. Large SOEs usually have in-house research institutes and are therefore leading actors in the local innovation system. For instance, in Shanghai, a research institute at one of the most prominent former SOEs has direct links with a local university for each project it considers. In Liaoning and Sichuan, many SOEs have low productivity levels and therefore poor financial situations; this hinders investment in R&D and makes technological catch-up impossible. Ji Xiaonan, Chairman of Council of Large Enterprises, SASAC, stated in November 2005, "there is a great gap between Chinese SOEs' input in research and technology and enterprises in developed countries…China's large SOEs spent RMB 5.67 billion [approximately EUR 567 million] on introducing technology, but only RMB 360 million on absorbing technology in 2003… The general technical level of SOEs is relatively low and the efficiency of technological innovation needs to be enhanced."

Several officials interviewed reported the lack of skilled R&D personnel, the problem of corporate culture, and the lack of motivation for R&D in SOEs. There are disincentives for top managers, who are often appointed for short periods of time, because their evaluation is based in large part on profits, yet the benefits of R&D investment often require a longer time horizon. Recently, the relevant performance criterion was revised to incorporate R&D investment. Provincial governments are also taking action with their SOEs to encourage more R&D investment.

The financial environment for supporting innovation, which varies by province, is a greater barrier for actors in China's RIS than in OECD countries. When regional actors speak of venture capital, they usually mean public sources. For small firms, access to bank loans was repeatedly cited as a major barrier to investment in innovation and overall development. Nevertheless, Shanghai reports an active private venture capital community of over 200 for the biotechnology industry, for example. Weaknesses in the financial environment may also explain the lesser economic impact of certain investments in innovation.

7.5.2.6. Mismatches and complementarity among actors

Regional actors in China reported a clear mismatch between the focus of research and the efficiency of investment in R&D for commercialisation. For example, enterprises want mature technologies and reliability and are interested in products, while universities work on specific aspects of a technology, even if in an application context. Because Shanghai's plan explicitly recognises the importance of cross-sectoral projects in support of a particular technology, one of its five areas of S&T focus is interdisciplinary research. An explicit goal of the Sichuan University science park is to bring together different technologies to develop products rather than aspects of a technology. This orientation is also critical for bringing together different technologies, which is much harder to do in the context of the technology- or sector-specific research approaches that are more common in universities. OECD countries have some interesting examples of programmes that support work on a product level. In Sweden, national programmes have supported clusters. A packaging cluster brought together four different specialty areas: pulp and paper, design, ICT, surface technology.

Firms differ in terms of their propensity to collaborate with research institutes and universities for S&T outsourcing. Domestic shareholding companies and SOEs actively outsource S&T. Foreign-owned firms outsource little S&T to Chinese actors but do outsource to other international actors. Compared with OECD countries, there is less collaboration in China. In Japan, more than half of R&D firms conduct joint research with universities; in China in 2002, the share was between 20 and 35% depending on the type of outsourced S&T activities (Motohashi and Yun, 2007).

Another area in which interaction with universities could be improved is the orientation of education for training future workers. In Shanghai, where there is a strong presence of MNEs, the municipal government surveyed them for their opinion on how well universities prepare students for working in their firms. The MNEs stated that the educational system placed too much emphasis on successful exam taking and not enough on practical experience working in laboratories and using equipment, so that they have to invest in training such students to be operational.

At the regional level, the system of local technical universities seems generally to be insufficiently used to support innovation in some areas. Much of the focus in S&T plans is on more sophisticated high-technology research and firms. The technology transfer needs of less advanced firms in urban and more peripheral areas are also important. In OECD countries, polytechnics, *Fachhochschule* and colleges generally play this role. These institutions are often less intimidating to SMEs than leading universities and can bring companies and services together, encourage technology transfer and information exchange and provide consulting services directly (OECD, 2006a).

7.6. Key findings and recommendations

The regional impact of S&T policy warrants consideration by both national and provincial policy makers given the link with economic development and the country's marked regional disparities.

Growing disparities across China in terms of S&T and innovation capacity underscore the importance of a regional perspective in S&T policy. Provinces on the east coast and the five municipalities with provincial status perform better than provinces in central and western China. Moreover, the correlation between the level of S&T inputs and outputs and GDP per capita makes investment in S&T a key component of the country's economic development. Given the size and diversity of many provinces, the same may hold true at the provincial level. However, there is a lack of explicit identification of the diverse functional regions that comprise provinces; municipal-level S&T plans only partially serve this purpose. *It is suggested that the sharing of responsibility and funding levels across levels of government with regard to S&T policy should be reviewed so as to adapt the nature of support to their respective comparative advantages.*

This chapter shows the impact of the legacy of the planned economy on S&T policy. This is true for the institutional framework, enterprises and, to some extent, business culture and the way RIS principles are put into practice. If the planning system enables a certain level of coherence in terms of strategic planning, the unclear division of labour among actors at the provincial level and between the provincial level and the sub-provincial levels seems to result in less coherent implementation, particularly in light of the competition among actors across levels of government.

The generally parallel structures of government at the national, provincial and sub-provincial levels result in a division of labour that does not always fit the respective comparative advantages of the various levels. This is reflected in the lack of strategic thinking about the roles of different levels of government. For example, all levels fund S&T projects at national, provincial, municipal and even county levels. In fact, S&T funding by sub-provincial actors may exceed provincial level budgets. In OECD countries it is highly unusual for the local level (municipality or county) to be responsible for a notable share of S&T spending. *It would be good if co-ordination efforts in support of innovation and regional development were strengthened.*

Cross-sectoral co-ordination problems are exacerbated by the different "silos" at the national level and can lead to a waste of resources. The recently introduced "co-ordination agreements" are meant to respond to this problem but their leverage power appears insufficient. *Nascent efforts to encourage actors to engage in an innovation system should be bolstered; the public sector can play a catalytic role at this stage of development.*

Past efforts to attract investment into special zones have had some success in co-locating firms, as have the development of science parks. Yet, only relatively recently have the issues of network building and cross-fertilisation become more prominent. Chinese policy makers have integrated the main RIS ideas into policy discourse and strategy; the 11th S&T Plan promotes private-sector-driven R&D and increased links between universities, research institutes and firms. Regional strategies mirror these national strategic orientations and objectives, as exemplified, for instance, by the recent creation of "platform departments" in provincial offices of science and technology.

In OECD countries private actors often are initiators in the innovation system, but in China the public sector plays the role of key initiator in most provinces. The lack of a strong organic culture of co-operation among economic actors makes this role even more important. In terms of policies, there appear to be few formal barriers preventing researchers from engaging with private industry and universities have considerable freedom to work with the private sector. Many high-technology start-ups are affiliated with a university or have informal ties via students and professors. The links between foreign firms and Chinese universities are, however, underdeveloped. From a regional development perspective, more use could be made of regional technical universities as support for local small firms with limited access to business support services and finance, especially in China's non-core regions.

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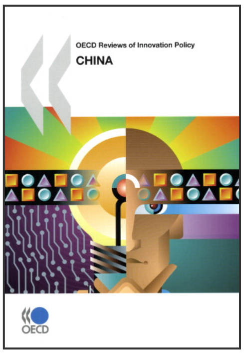
Table of Contents

Abbreviations and Acronyms

CAE	Chinese Academy of Engineering
CAS	Chinese Academy of Sciences
CVCF	Corporate Venture Capital Firm
FDI	Foreign Direct Investment
FVCF	Foreign Venture Capital Firm
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on Research and Development
GPA	Government Procurement Agreement
GVCF	Government Venture Capital Firm
HRST	Human Resources in Science and Technology
ICT	Information and Communication Technology
IPR	Intellectual Property Rights
ISR	Industry-Science Relationship
IT	Information Technology
MII	Ministry of Information Industry
MNE	Multinational Enterprise
MOA	Ministry of Agriculture
MOC	Ministry of Commerce
MOE	Ministry of Education
MOF	Ministry of Finance
MOP	Ministry of Personnel
MOST	Ministry of Science and Technology
NCSTE	National Centre for S&T Evaluation
NDRC	National Development and Reform Commission
NIS	National Innovation System
NSFC	National Natural Science Foundation of China
OECD	Organisation for Economic Co-operation and Development
PCT	Patent Cooperation Treaty

PPP	Purchasing Power Parity
P/PP	Public/Private Partnership
PRO	Public Research Organisation
R&D	Research and Development
RMB	Chinese Yuan
S&T	Science and Technology
SCI	Science Citation Index
SIPO	State Office of Intellectual Property
SIPIVT	Suzhou Industrial Park Institute of Vocational Technology
SMEs	Small and Medium-sized Enterprises
SOE	State-Owned Enterprise
STIP	Science and Technology Industrial Park
TBI	Technology Business Incubator
TRIPS	Trade-Related Aspects of Intellectual Property Rights
UVCF	University-backed Venture Capital Firm
VC	Venture Capital
VCF	Venture Capital Firm
WTO	World Trade Organization



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