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INTRODUCTION

China's innovation system and the move towards harmonious growth and endogenous innovation

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1. INTRODUCTION

Observers around the world are impressed by the rapid growth of China's economy, some with hope and others with fear. Some hope that China will offer the unique experience of successful economic growth and catch-up under the new World Trade Organization (WTO) regime; some see the rise of China as a threat to the current world order and to the powers that currently dominate the world in terms of economy, technology and politics.

While outside observers tend to focus on the success story of unprecedented growth, policy documents and recent domestic debates in China have pointed to the need for a shift in the growth trajectory, with stronger emphasis on 'endogenous innovation' and 'harmonious development'. In this paper we make an attempt to capture the current characteristics of China's production and innovation system; how they were shaped by history and what major challenges they raise for the future.

In Section 2 we present data on China's post-war growth experience. We show how the shift in policy around 1980 toward decentralization, privatization and openness established an institutional setting that, together with other factors such as the presence of a wide 'Chinese Diaspora', has resulted in extremely high rates of capital accumulation, especially in manufacturing. The section ends by pointing to some inherent contradictions in the current growth pattern.

In Section 3, we take a closer look at how the policy shift in the '80s affected the institutional framework shaping R&D activities in particular, and learning and innovation in general. The attempt to break down the barrier between the science and technology infrastructure on the one hand and the production sphere on the other was highly successful, as compared to the development in the former Soviet Union. However, the original intentions were not fully realized. Rather than establishing markets for science and technology, the reforms led knowledge producers to

engage in mergers or forward vertical integration and they became, to a large extent, involved in production activities.

Referring back to analysis of the sustainability of the growth model and the unfinished reform of the innovation system, Section 4 introduces the recent decision by China's government to promote endogenous innovation and harmonious development. Applying the innovation system perspective, we argue that these broadly defined objectives can be realized only through a strategic adjustment towards 'innovation driven growth and learning based development' and we discuss what important policy elements such a strategic adjustment needs to encompass.

In Section 5, we conclude that imperfections, in the division of labour and in the interaction between users and producers of knowledge and innovation behind the reforms of the '80s, remain central concerns. In order to raise the long-term efficiency of the massive accumulation of production capital, it is necessary to promote the formation of social capital and to be more considerate when exploiting natural capital.

2. Transition of China's economy

How do we explain the extraordinary growth performance of China? What are the unique features of its production system? In this section, we will see how the development paths of the past define the strengths and weaknesses of the national production systems, as well as the bottlenecks and challenges that confront China today.

It is useful to distinguish between two periods in China in the second half of the 20th century. The crucial shift takes place in 1978 when DENG Xiaoping took over the political leadership after Chairman MAO and initiated economic reform and the opening of the economy to international trade. The first was a period of development under a centrally planned economic regime and the second a period with market-oriented reforms and economic transition. To characterize the economic performance of the two periods, we use data summarized by Angus Maddison (1998) depicted in Table 1 and Figures 1 and 2.

At the time of the revolution, the economy was still dominated by agriculture; in 1952 about 60 percent of GDP was generated by the agricultural (primary) sector, as shown in Figure 2. Both the first and the second period were dominated by industrialization, rather than the 'post-industrialization' that took place after WWII in developed and most less developed countries. As a result, China was highly 'industrialized' by the end of the century. In 2003, its GDP structure was 12.5 per cent primary, 46 per cent secondary and 41.5 per cent tertiary. The growth in manufacturing and the relative shrinkage of agriculture continued in the 1990s, and the value added-share of the service sectors remained almost unchanged until the late 1990s.

Table 1: Growth of China's economy 1890–1995 (At constant prices)

	1890–1952	1952–1978	1978–1995	1952–1995
Farming, Fishery & Forestry	0.3	2.2	5.1	3.4
Industry	1.7	9.6	8.5	9.2
Construction	1.6	7.2	11.1	8.7
Transport & Communications	0.9	6.0	10.0	7.6
Commerce & Restaurants	0.8	3.3	9.9	5.9
Other Services (incl. Government)	1.1	4.2	6.7	5.2
GDP	0.6	4.4	7.5	5.6
Per Capita GDP	0.0	2.3	6.0	3.8
Export Volume	1.6	6.4	13.5	9.2

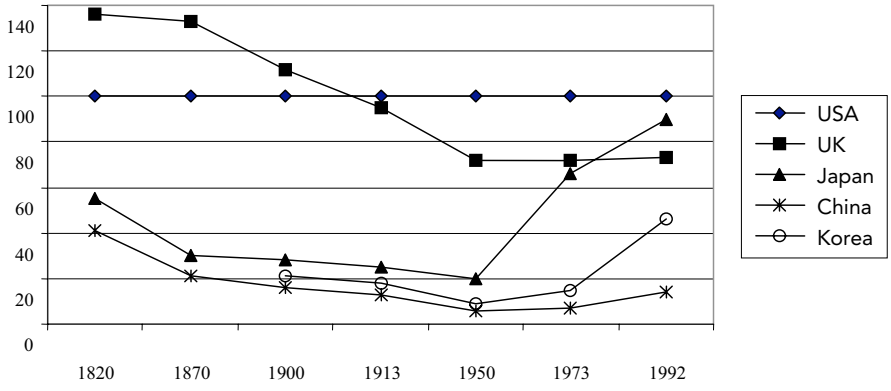

FIGURE 1: PER CAPITA GDP IN COMPARISON, USA=100

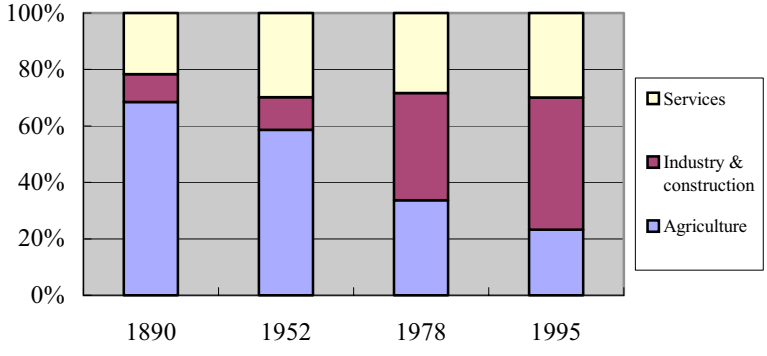

FIGURE 2: GDP STRUCTURE OF CHINA'S ECONOMY AT CONSTANT PRICES

Source: Maddison 1998: 56, Tables 3.1 and 3.2

As we shall see below, however, the economic structure looks quite different when the focus is employment rather than value-added. The proportion of the labour force working in agriculture remains as high as 50% in the beginning of the new millennium. The growth in manufacturing value-added reflects more than anything a very high rate of accumulation of fixed capital accompanied by high rates of growth in labour productivity.

Behind high growth rates and restructuring of the economy in the second period lie extraordinary rates of savings and capital accumulation. In order to understand how these could be realized in a poor country like China, it is necessary to look at the institutional changes that took place with the shift in the political climate.

Reforms and development performance in the 1980s and 1990s

The policies transforming the economy from a centrally planned towards a market-oriented regime may be seen as following two parallel and mutually reinforcing lines of action, aimed at decentralization and privatization (Wu 2003: Ch. 2).

The first line of action, 'bureaucratic decentralization', began with increasing the autonomy of firms in decision-making on production planning, investment and acquisition of technology, marketing, pricing and personnel and with more autonomy to local governments in financial, budgetary and administrative issues. Initially, decentralization was based on ad hoc negotiations in individual cases. It was not until the mid-1990s, that nationwide reforms formalized

the relationships and introduced more transparent and coherent rules. This was the period when reforms in taxation, the banking system and governance structure of state-owned enterprises – 'corporatization' of previous state ownership – were initiated. This policy learning dynamic, where experiences from local and regional experimentation were gradually diffused at the national level, has been one major characteristic of the reform period.

The second line of action loosened restrictions first for township and village enterprises in the early 1980s and later for private initiatives in the mid-1990s. It included the creation of 'Special Economic Zones' for FDI-related investment with various favorable regulations. In provinces like Zhejiang, this led to private initiatives by entrepreneurs. Here limited arable land, poor mineral deposits, high population density and little accumulation in modern industry, in combination with local historical experience in commercial activities, led to the start-up of private firms based on small family workshops (Xu, Chen and Bao (2006): this issue pp. 144–52; and Bao, Zu and Gu (2006): this issue pp. 153–59).

But most importantly it gave local governments greater opportunities to engage in initiatives promoting local accumulation of capital. They did so by establishing and expanding Township and Village Enterprises (TVEs) sometimes owned by the local governments, sometimes representing joint enterprises with private capital or through initiatives which attracted private capital from local, national or international sources.

'Diaspora networks' played an important part in re-enforcing rapid capital accumulation from foreign investment (Kuznetsov (2006): this issue pp. 45–61). Throughout the '80s, the opening to FDI and international trade attracted partners mainly from the Greater China area – Hong Kong, Chinese Taipei, Singapore, and overseas Chinese from other continents. It was not until the second half of the '90s that multinational companies from North America and West Europe came into China on a large scale. Hong Kong, together with Taiwan, remains the first and primary source of FDI, holding about half of China's total FDI. The fact that members of the Diaspora could communicate directly with local authorities reduced investor uncertainties.

The second line of action, also called 'incremental reform', opened up new spaces for economic activities outside the entities inherited from the central planning era. As a result, the ownership structure of industrial enterprises changed rapidly. As can be seen from Figure 3, by 2003, each of the three types of ownership – state-owned, FDI-related and other domestic – were responsible for roughly one-third of output.

It is important to note that a large proportion of firms belonging to the category of 'other domestic' enterprise primarily reflects the rapid growth in number and size of township and village firms over which local governments have some influence. The township and village enterprises – that played a major role in industrialization in many regions in China – outnumber both domestic private and state-owned firms undergoing a transformation from collective to private ownership in the mid-1990s.

Export-led growth

International trade was initially pushed by favourable policies and gradually pulled by FDI and intra-trade within global value chains. Today China's economy has reached a much higher level of openness than all other large economies in the world, developed or developing (Table 2 and Figure 4).

Export structures have been upgraded (Figure 5). The share of primary products, such as foodstuffs, agricultural products and mineral fuels, has been reduced from half of the total in 1980 to less than 10 percent by 2002, while the share of manufactured goods increased to more than 90 percent. In manufactured exports, electric and machinery products, including electronic products, demonstrated the fastest growth rate, although light and textile products and apparel also increased considerably.

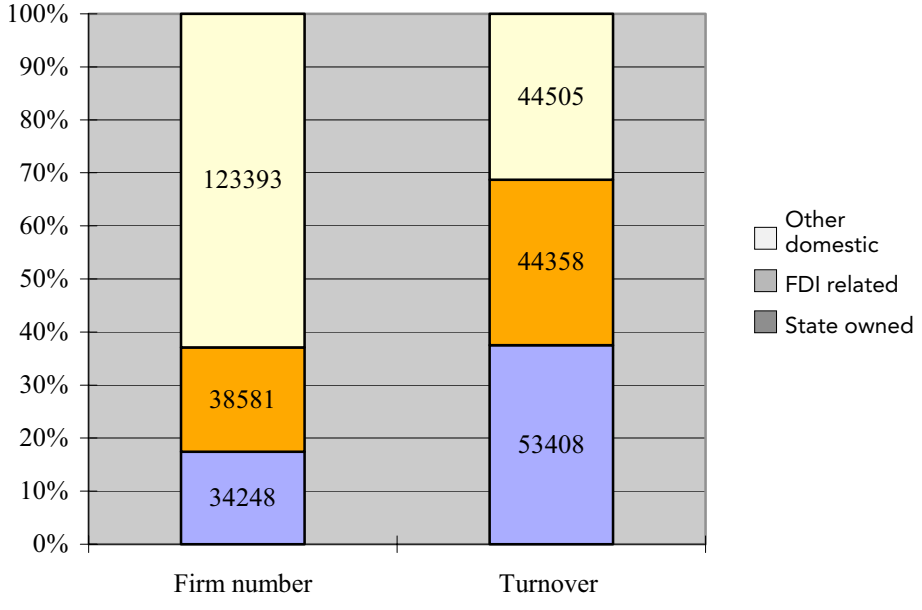

FIGURE 3: OWNERSHIP STRUCTURE: INDUSTRY BY 2003

Source: based on China statistical yearbook Table 14-2 2004http://www.stats.gov.cn/tjsj/ndsj/yb2004-c/indexch.htm
Note: the calculation is for all the firms which have annual turnover higher than 500 million

TABLE 2: OPENNESS OF CHINA TO THE GLOBAL ECONOMY

	1978	1989	1997	2002	2003
GDP (¥100 million)	3624.1	16917.8	78973	120333	135823
Sum import and export (¥100 million)	355.0	4156.0	26967.2	51378.2	70483.5

Source (for Table 2 and Figure 4): based on *China Statistical Yearbook 2004*; http://www.stats.gov.cn/tjsj/ndsj/yb2004-c/indexch.htm, http://www.stats.gov.cn/tjdt/zygg/P020060109431083446682.doc.

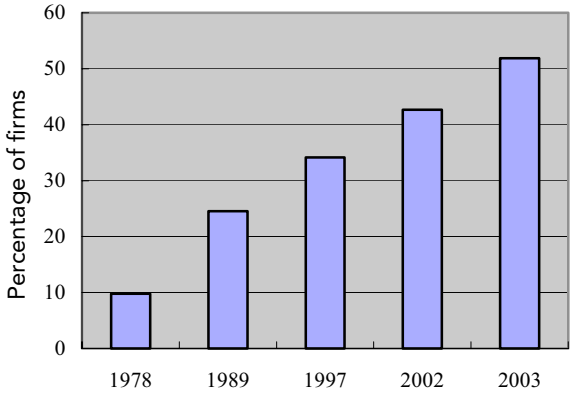

FIGURE 4: OPENNESS TO GLOBAL ECONOMY

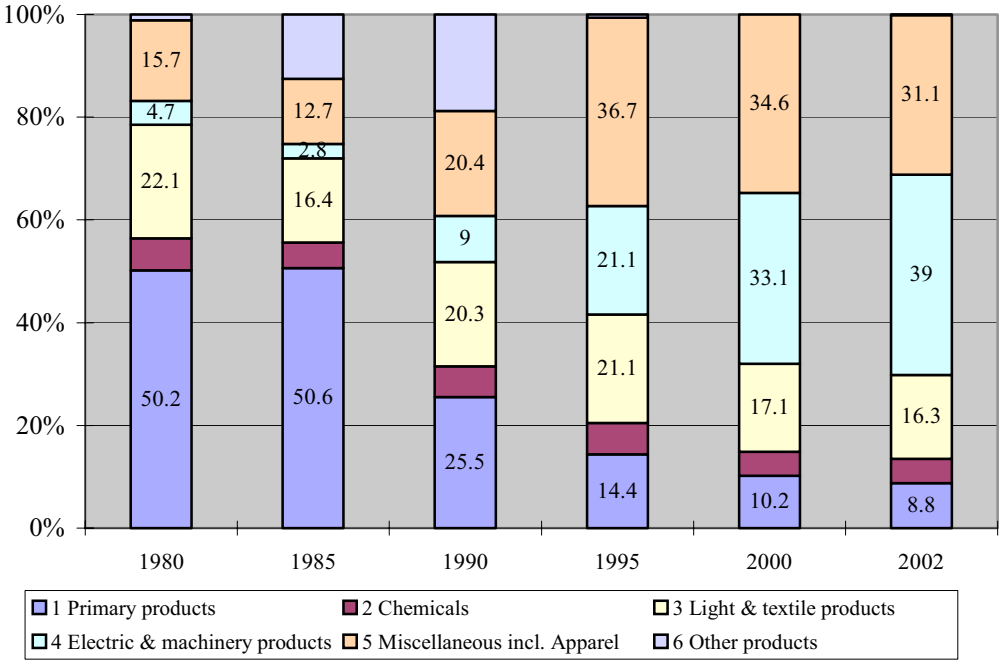

FIGURE 5: EXPORT STRUCTURE

Source: Reproduced based on Wu (2004) Table 8.7

Beyond quantitative growth, qualitative or structural change has been radical. It is useful to make a distinction between global production chains driven mainly by demand factors – buyer-driven chains and those driven mainly by supply factors – and producer-driven chains (Gereffi 1999; UNIDO 2002). For products of buyer-driven chains such as apparel, footwear and toys (included in Category 3 and partly in Category 5 in Figure 5), China has become the preferred manufacturing location of a global 'Triangle relationship. The consumption sites are largely in North America and West Europe while Hong Kong and Taiwanese businesses play a role as relational coordinators. Many of these goods are produced in factories owned by Taiwanese or Hong Kong investors, and some are produced in Chinese-owned firms but produced in sub-contracting relationships (Zheng Y and Sheng S (2006): this issue pp.120–27).

In the producer-driven industries such as computer and IT products (included in Category 4, Figure 5), exports are mainly manufactured in factories owned by Western and Taiwanese investors. For 2003 it was reported that 61.9 percent of high-tech export was produced by fully foreign-owned and 21.4 percent by partly foreign-owned firms; altogether FDI-related manufacturing produced more than 80 percent of high-tech export from China (China S&T Indicators 2004). This reflects overall trends in China's innovation system characterized by easy access to foreign technology, while remaining weak in local and domestic clustering. We discuss this point in Sections 3 and 4.

Domestic demand and investment

The domestic market has also played a role in development during this period. Domestic demand experienced at least two rounds of surge and growth, the first through the 1980s and early '90s, led by household durables and necessities, as illustrated by color televisions in Table 3 and Figure 6. The centrally planned economy had left huge shortages in consumer goods industries. The combination of bureaucratic decentraliza-

TABLE 3: GROWTH IN REPRESENTATIVE PRODUCTS

Year	Air-conditioner 10000 set	Color television 10000 set	Rolled steel products 10000 ton	Cement 10000 ton	Passenger car 10000 set	Microcomputer 10000 set
1978	0.02	0.38	2208.00	6524.00		
1980	1.32	3.21	2716.00	7986.00	0.54	
1985	12.35	435.28	3693.00	14595.00	0.90	
1989	37.47	940.02	4859.00	21029.00	3.58	7.54
1990	24.07	1033.04	5153.00	20971.00	3.50	8.21
1991	63.03	1205.06	5638.00	25261.00	6.87	16.25
1992	158.03	1333.08	6697.00	30822.00	16.17	12.62
1993	346.41	1435.76	7716.00	36788.00	22.29	14.66
1994	393.42	1689.15	8428.00	42118.00	26.87	24.57
1995	682.56	2057.74	8979.80	47560.59	33.70	83.57
1996	786.21	2537.60	9338.02	49118.90	38.29	138.83
1997	974.01	2711.33	9978.93	51173.80	48.60	206.55
1998	1156.87	3497.00	10737.80	53600.00	50.71	291.40
1999	1337.64	4262.00	12109.78	57300.00	57.10	405.00
2000	1826.67	3936.00	13146.00	59700.00	60.70	672.00
2001	2333.64	4093.70	16067.61	66103.99	70.36	877.65
2002	3135.11	5155.00	19251.59	72500.00	109.20	1463.51
2003	4820.86	6541.40	24108.01	86208.11	202.01	3216.70

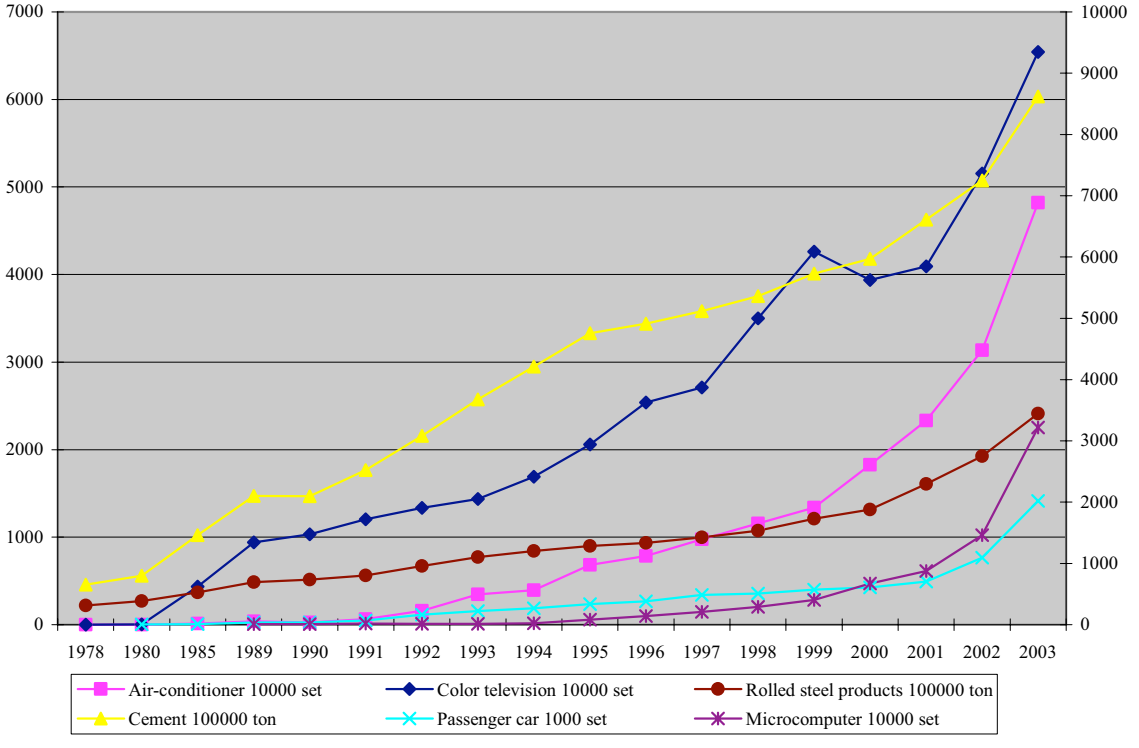

FIGURE 6: GROWTH IN REPRESENTATIVE PRODUCTS

Source (for Table 3 and Figure 6): *China Statistical Yearbook 2004*; http://www.stats.gov.cn/tjsj/ndsj/yb2004-c/indexch.htm

tion and incremental reforms stimulated investment in the supply capacity of these industries.

The second surge begun around 1999 and was focused on real estate, passenger cars and personal computers and telecommunications, as illustrated by microcomputers and passenger cars in Table 3 and Figure 6. Cement and rolled steel products are intermediate products and both surges stimulated demand, although the second period of demand-led growth (strongly weighted towards large-scale activities such as construction and car production, which consume those products in great quantities) explains the accelerated growth of the latter years. To expand production capacity a very high rate of growth in investment was necessary.

This second surge in manufacturing was more directly induced by central monetary and industrial policies. In order to cope with the stagnation and deflation that appeared in 1998–1999, diagnosed as being caused by lack of effective demand, the government engaged in 'active fiscal policies' to increase public investment in highways, telecommunications and power generation stations. The banking system was also engaged to stimulate 'domestic demand' in consumption. It created loans for individual housing and car consumers at reduced interest rates.

A unique pattern of economic growth

For about a quarter of a century, China's economy has been characterised by high rates of economic growth and capital accumulation. Some of the mechanisms behind that growth pattern are unique while some have parallels with the institutional set up that promoted capital accumulation in England in the 18th century (Qian 1996).

Reforms initiated more than 25 years ago unleashed restrained material needs. It was explicitly argued that some concentration of wealth among the few was a first step toward making everybody better off; making the strive for material wealth ideologically legitimate. Slumbering entrepreneurship was awoken to engage in production and trade both within and outside the public sector.

> *The most important driver behind capital investment and economic growth was a specific local fusion of political and economic interests.*

Local authorities and local entrepreneurs were able to promote simultaneously their political career and own economic interests by stimulating industrial growth in their region, province, town or village. Most of the extra income created remained under local control and the incentives to reinvest the surplus were strong.

Foreign direct investment, initially emanating primarily from overseas Chinese investors and subsequently from wider sources, is also an important factor. Joint ventures offer good opportunities for public and private rewards for local policy makers. The same is true for attracting direct investment of purely foreign-owned enterprises to the locality. Building infrastructure and supplying cheap labour, energy and land are now key concerns for local administrators. This mixture of political and economic interests constitutes a new kind of concentration of power at the local level, not always balanced by local political democracy and local rule of law, and it may explain why local administration is less popular than the central government among Chinese citizens (Saich 2004).

The dynamics of reform have also been driven by competition between localities to provide the most attractive framework conditions, sometimes by offering cheap resources and lax regulations in relation to environment and workers' safety. But there are also examples of forward-looking ideas developed locally and then spread nation-wide.

Limits to growth

The development trajectory behind this high speed growth is now confronted with barriers for further growth. Some of these are external and refer to potential trade conflicts. Others reflect domestic problems regarding social and ecologi-

cal sustainability. There are indications of serious weaknesses in the innovation system and the call for 'harmonious development' may be interpreted as an attempt to give new direction to recognized unsustainable growth patterns.

Remarkable global impact and trade disputes

China's economic growth has had a very visible impact on the global economy. With China's exports and imports growing at double digit rates, the impact upon other countries' trade balances is significant; an upper limit for China's trade surplus may have to be set before trade quotas or other forms of retaliation are triggered. The current trend of massive penetration into global markets may not last much longer.

'Jobless growth'

In terms of GDP structure (Figure 7 and Figure 8 compare China with four big developing or transitional economies: Brazil, South Africa,

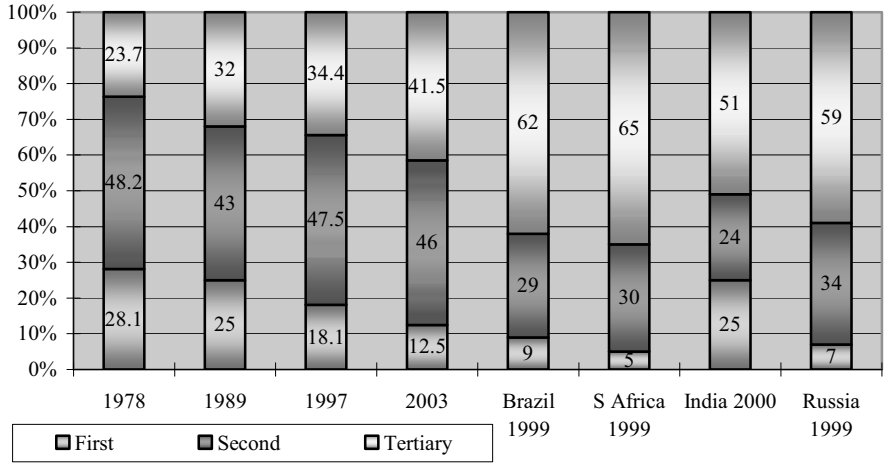

FIGURE 7: GDP STRUCTURE IN COMPARISON

Source: For the data on China: *Statistical Yearbook 2004* (http://www.stats.gov.cn/tjsj/ndsj/yb2004-c/indexch.htm), for the Data on Brazil, South Africa, India and Russia: *World Facts and Figures* at http://worldfactsandfigures.com

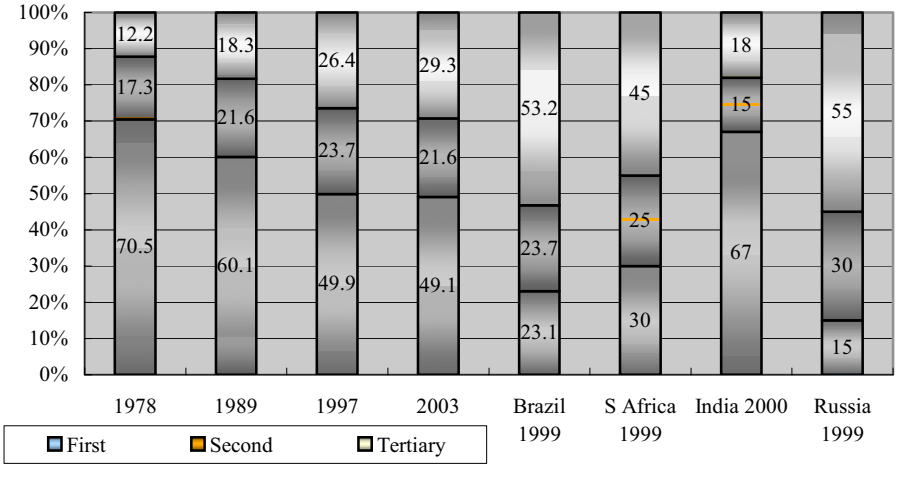

FIGURE 8: EMPLOYMENT STRUCTURE IN COMPARISON

India and Russia) China appears to be overwhelmingly 'industrialized'. However, China is faced with the challenge of 'jobless growth' in the manufacturing sector. Figure 8 shows that, in terms of employment structure, China appears as an agricultural economy, half of its labour remaining in this sector. Only India has a bigger proportion of the labour force in agriculture. Combining the two sets of data, it is obvious that China is characterized by high and rapidly growing capital–labour ratio in the manufacturing sector. While there was net job creation in the first years of the reform period, the increase in employment slowed in the 1980s and has stagnated since the 1990s.

This displacement of employment exacerbates 'structural unemployment' (Lewis 1955). Jobless growth, in addition to inequality in wealth distribution and redistribution, entails social instability and endangers sustainable development.

Widening income gaps and negative environmental externalities

Gaps between the urban and the rural, between regions, and between the rich and poor in the same region are widening. Working conditions and workers' safety have been largely neglected. Negative externalities also include environmental degradation such as pollution of air and water and exploitation and wasteful use of other non-renewable resources. The current development mode entails intense consumption of non-renewable raw materials and energy sources. Especially when these inputs are under the control of local groups with vested interests, there may be a tendency to set prices too low and to be lax in terms of safety regulations.

Slow pace in competence and competitiveness upgrading

The industrialization process has not resulted in building a widespread and robust indigenous innovation capability in Chinese firms. After 20 years as the origin of manufactured goods 'made-in-China', China's economy has not been able to embark upon the competence upgrading track. This contrasts with the catch-up history of the United States and Japan where 'made-in-USA' and 'made-in-Japan' were preludes to those countries, within one generation, reaching a world frontier in innovativeness and competitiveness. China remains specialized in low value-added products with profit margins trapped at a meager 2–5 percent, or in some areas even lower.[1]

Recent policy documents and the general debate have pointed to these problems and contradictions, and to the need for a shift in development strategy with stronger emphasis on 'harmonious development' and 'endogenous innovation'. What adjustments of the development strategy are needed to realize the intentions signaled by these concepts?

Before discussing this issue in Section 4, it is necessary to analyze the innovation system reform that accompanied decentralization and privatization. Analysis of reform and its outcome points to weaknesses in the current innovation system, which helps us to specify the reforms required to make innovation endogenous and for it to contribute to harmonious development. We will argue that efforts to stimulate endogenous innovation may go hand in hand with promoting harmonious development.

3. Transformation of China's Innovation System

We now turn to the transformation of the innovation system in China, in the context of market-oriented economic reform. It is interesting to note that motivation for reform of the R&D-system initiated in 1985 was 'highly systemic' in the sense that the focus was on re-shaping the division of labour and the interaction between producers and users of knowledge and innovation. As we shall see, problems remaining after the reform can also be defined as 'highly systemic'. The fundamental weakness of the system, having a negative impact both on absorption of foreign technology and on domestic innovation, has to

do with an economic structure that does not support learning by interaction in organized markets.

Attempt to reconfigure user–producer relationships

China has an old civilization and historically has made important contributions to global science and technology (such as the compass, gunpowder and paper). In China's older history, however, science and technology as it evolved in Western Europe was not regarded as important or as carrying social status. While Confucious' heritage gave high prestige to intellectuals, it was to those engaged in humanistic science and in political and administrative affairs. Scientific and technological knowledge was seen as based upon practical experience, rather than as a modern type of scholarship. Whereas Research and Development (R&D) establishments commenced elsewhere throughout the 1920s and '30s, China only began the process of nationwide institutionalization of modern science and technology in 1950.

The R&D system established in the first period of development was designed in accordance with the centrally planned regime. One prominent feature was its huge size, a reflection of the Marxist idea of science as a societal force of pro-

TABLE 4: CHINA'S INVESTMENT IN R&D

Year	Percentage of R&D Expenditure Based on National Income	Year	Percentage of R&D Expenditure Based on GDP
1953	0.1	1978	1.5 (1.8 of national income)
1954	0.2	1979	1.5
1955	0.3	1980	1.5
1956	0.6	1981	1.3
1957	0.6	1982	1.3
1958	1.0	1983	1.4
1959	1.6	1984	1.4
1960	2.8	1985	1.2
1961	2.0	1986	1.3
1962	1.5	1987	1.0
1963	1.9	1988	0.8
1964	2.1	1989	0.8
1965	2.0	1990	0.8
1966	1.6	1991	0.8
1967	1.0	1992	0.7
1968	1.0	1993	0.7
1969	1.5	1994	0.7
1970	1.6	1995	0.6
1971	1.8	1996	0.6
1972	1.7	1997	0.6
1973	1.5	1998	0.7
1974	1.5	1999	0.8
1975	1.6	2000	1.0
1976	1.6	2001	1.1
1977	1.6	2002	1.2
1978	1.8 (1.5 of GDP)	2003	1.3

Sources: *China Statistical Yearbook on Science and Technology* various issues; National Statistics Bureau 1990: 207, and http://www.sts.org.cn/KJNEW/maintitle/MainTitle.htm.

duction, and also a result of the self-reliance development strategy in that centrally planned period (Table 4).

The second feature was the separation of industrial R&D centres from productive enterprises. The centrally planned regime introduced mechanisms to link R&D activity with production: All R&D institutes, except those belonging to the Chinese Academy of Sciences (assigned as the national top organization for comprehensive natural and engineering science) were organized under the jurisdiction of sector specific ministries or bureaus, independently outside enterprises. The ministries or bureaus took responsibility for planned production tasks as well. They were therefore in command of both R&D and production (Gu 1999: 151–176).

It is interesting to note that this model of specialization according to product category, both for R&D centres and enterprises, and separation of firms from innovative activities, was common for all former centrally planned economies (Granick 1967 – for former Soviet Union; Hanson and Pavitt 1987 – for more general discussion).

Organizational separation between innovation and production blocked the system of vital and intimate interactions between producers and users, which was important especially for innovation in sophisticated producer goods technology (von Hippel 1994; Kline and Rosenberg 1986; Lundvall 1988).

The institutional setting was reflected in innovation characteristics. For example, the machinery industry of China was strong in 'general purpose' machinery, and weak in technologies fulfilling particular machining tasks since these could only be developed through interactive learning and close producer–user communications (Gu 1999: 127–135). The low degree of *effectiveness* of the centrally planned institutional settings was well acknowledged at the end of the 1970s. This became an important motive for the launch of reforms.

The crucial event for R&D system reform came in 1985, lagging slightly behind agricultural and industrial reforms which started in 1978 and 1984 respectively. A 1985 Decision of the Central Committee of the Communist Party of China initiated reforms in Science and Technology System Management. The central theme for reform was to rearrange the relationship between knowledge producers and users and their relationships with the government. In a context where demand, supply and coordination factors were changing, reform of the S&T system was seen as essential.

The size and complexity of the S&T system made reform crucial for economic growth. By 1980 there were 4,690 research institutes affiliated to administration bodies higher than 'county' level, i.e. to central, provincial and regional/city governments, with some additional 3000 institutes at county level, the lowest level of the nation's administration hierarchy with an independent budget (White Paper No. 1: 232, 235). 323,000 scientists and engineers worked in these institutes. The then Prime Minister Mr. Zhao Ziyang interpreted the reform as follows:

> The current science and technology institution in our country has evolved over the years under special historical situations. The advantages embodied in this system manifested themselves in concerted efforts to tackle major scientific and technological projects, which were achieved with great success. However, there is growing evidence to show that the system can no longer accommodate the situation in the four modernizations programme, which depends heavily on scientific and technological progress. One of the glaring drawbacks of this system is the disconnection of science and technology from production, a problem, which is a source of great concern for all of us …
>
> By their very nature, there is an organic linkage between scientific research and production. For this linkage a horizontal, regular, many-leveled and many-sided channel should be provided. The management system as practiced until now has actually clogged this direct

> linkage, so that research institutes were only responsible to the leading departments above, in a vertical relationship, with no channels for interaction with the society as a whole or for providing consultancy services to production units. This is the root cause of the inability of our scientific research to meet our production needs over the years.... This state of affairs can hardly be altered if we confine ourselves to the beaten track. The way out lies in a reform.
>
> (Zhao Ziyang 1985)

Adaptive policy process and the recombination of competences

To reform the S&T system, a two-pronged policy was designed. On the one hand, 'technology markets' were established to function as distributive institutions for R&D outputs (Decision: Section III). On the other hand, excellence-based allocation mechanisms were introduced for allocation of public R&D funds (Decision: Section II). In order for R&D institutes to be able to respond to opportunities in the market place, some degree of autonomy, in terms of hiring personnel, engaging in contracted projects, and acceptance and use of contractual fees, were assigned (Decision: Section VII). At the same time subsidies from the government were gradually reduced (Decision: Sections I and II). It was expected that by push and pull, previously publicly funded R&D institutes would move to serve their clients via regular and multiple linkages.[2]

The actual process of S&T system reform, as with reforms of the overall economic system, unfolded through trial and error and entailed continuous policy adjustment (Gu 1999). *The technology market solution*, central to the initial design, was soon recognized as being difficult to realize in its original form. Users were not capable of absorbing transferred technology, and the market was too small to secure R&D institutes with enough earnings. Buyers and sellers experienced serious uncertainty in assessing the use value of technology, giving rise to disputes during the writing and implementing of contracts. In response, in 1987, reform policy began to promote the *merger of R&D institutes* into existing enterprises or enterprise groups. The merger process was however not easy to realize. Huge gaps between the merging parties, from differences in work culture and administrative affiliations, were difficult to overcome immediately.

In 1988, the Torch Programme was launched to encourage organizations akin to *spin-off enterprises* – called New Technology Enterprises (NTEs) – from existing R&D institutes and universities. Local governments contributed to investment in infrastructure and supporting institutions for New and High-Tech Industry Zones that became incubation bases for NTE-startups. Scientists and engineers, often with support from their parent institutions, sought commercial application of their inventions and expertise by means of the NTEs. By the early 1990s, reform policy included a solution to change *individual R&D institutes into production entities*. This was also an adaptation of the actual evolution already realized by many industrial R&D institutes.

The reforms came to a form of conclusion when, in 1999, an official decision pointed to the need to clarify the actual character of previously government-run industrial technology R&D institutes. By 2001 some 1,200 industrial technology R&D institutes had re-registered their business type.[3] Of them more than 300 were *merger* cases, having cancelled their independent position and become part of an enterprise. Six-hundred plus became *profitable firms* and a few joined universities. Table 5 indicates the changed structure of R&D performers. In 2000 the proportion of R&D performed by 'enterprises' leaped abruptly (Table 5: Line 3) largely because many R&D institutes registered as enterprises or part of existing enterprises. Table 4 also depicts the scope of *technology market* and *spin-offs*, growing steadily over time (Lines 1 and 2), and illustrating the complementary effects of various transformation means. Lines 3, 4 and 5 show the changed structure in technology

Table 5: Selective indicators to changes of the China NIS (All measures at current price)

	1985	1990	1995	2000
(1) **Technology Market**				
Contract fees (RMB Billion)	2.30	7.51	26.83	65.07
(2) **Spin-offs**				
Number of NTEs	–	1,690	12,937	20,796
Annual turnover (RMB Billion)	–	5.94	151.2	920.9
Export (USD Billion)	–	0.69 (RMB Billion)	1.55	13.81
(3) **Domestic R&D expenditure** (RMB Billion)	6.74 (1987)	12.54	34.87	89.57
in which Enterprises (%)	29.3	n.a.	43.7	60.0
Independent R&D institutes (%)	54.7	n.a.	42.1	28.8
Universities (%)	15.9	n.a.	12.1	8.6
(4) **Import of capital goods** (USD Billion)	16.24	16.85	52.64	69.45 (1999)
(5) **FDI** (USD Billion)	1.96	3.49	37.52	40.72

Sources: *China Statistical Year Book on Science and Technology* various issues; http://www.most.gov.cn; http://www.stats.gov.cn/ndsj/zgnj/2000/Q05c.htm; http://www.moftec.gov.cn/article/200303/20030300072333_1.xml; http://www.sts.org.cn/REPORT_3/documents/2002/0220.htm; http://www.sts.org.cn/REPORT_3/documents/2002/02hdb01.htm

sources. China, not so long ago almost closed to international exchange in technology and knowledge, has developed a widely open innovation system, with enormous inflows of technology in forms of international capital goods and FDI.

Adaptive policy, evolving through trial and error, characterizes 'gradual reforms' in the whole process of China's economic transition. The great uncertainties associated with foreseeing the impact of major political reform made adaptive policy learning necessary. Only policy-making that was responsive and adaptive to feedback on reform impacts could preserve the feasibility for success of any radical social innovation program (Metcalfe 1995; Gu and Lundvall 2006).

Review of the transformation of the innovation system

On the basis of discussion above, Figure 9 illustrates China's National Innovation System as it looked before (Part A) and after (Part B) the transformation, embracing:

1. *innovation actors* – R&D institutes, capital goods industries that embodied technology for user sectors, domestic end-product manufacturers;
2. *inflows of technology* – by means of technology licensing (TL), sample machine procurement (SMP), equipment procurement (PE), foreign direct investment (FDI) and original equipment manufacturing (OEM);
3. *interactive relationships* between actors and with domestic and international markets. Arrows with different line boldness illustrate the intensity of various links and provide an impression of the significant changes transformation has brought into the system.

The transformation was constructive in safeguarding and recombining technological capabilities in the context of market reform. It not only opened China to the global economy but supported rapid economic growth as a whole. For example, a number of NTEs like Huawei, Datang and Linovo grew into key ICT enterprises, leading to a fundamental restructuring of China's ICT industry (Gu and Steinmueller 1996/2000). The achievements are especially

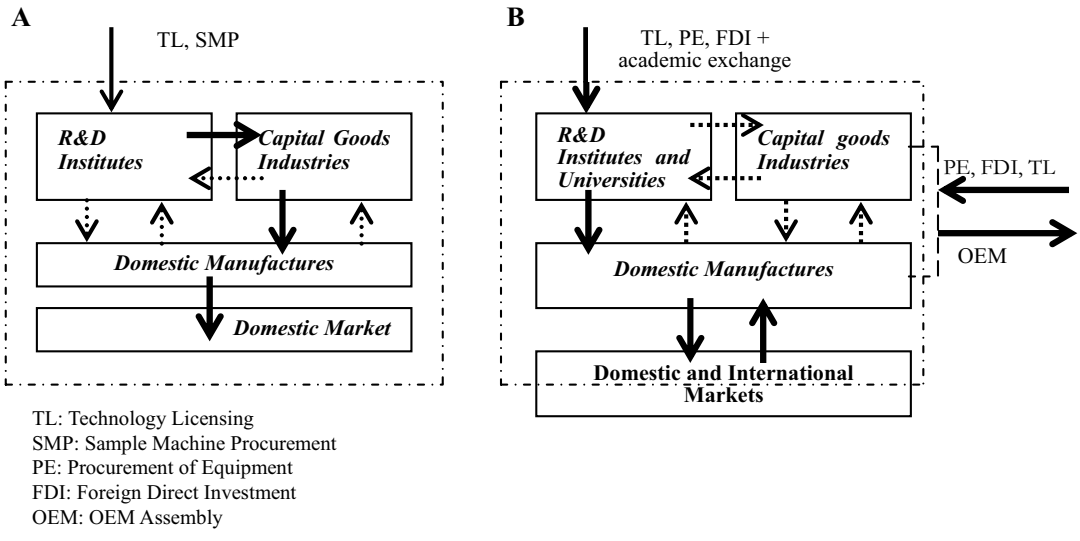

FIGURE 9: TRANSFORMATION OF THE CHINA'S NIS

impressive when compared with Russia where scientific and technological capabilities were destroyed on a huge scale. Nonetheless, the system still has some prominent weaknesses.

Easy access to foreign technology while remaining weak in local and domestic clustering

Firstly, the system resulted in weaker domestic links and interactions, although mastery of international links remained passive, dominated by import of the foreign technology embodied in machinery and other process equipment. The *capital goods industry* has not played a role as an innovation centre for the whole economy by providing appropriately advanced production means for various users; they were instead largely integrated into respective global value chains. Many regions of China, for which the autonomy of policy decision-making was strengthened during the market reform, are weak in *geographical proximity-based clustering or networking* even when there is some firm agglomeration (Wang and Tong 2000). In general *potential local or domestic links along and between value chains* have been slow to develop and hard to expand. Small firms in traditional manufacturing sectors, and agriculture and rural development, have received inadequate support from the national and regional technological infrastructures, showing a *separation between the modern and traditional parts* of the system (Tylecote (2006): this issue pp. 62–83).

Missing technological infrastructure and supportive institutional development

Second, the transformation ignored the development of technological infrastructure and supportive institutions. The remarkable aspect of the reform is that the initial intention – to establish technology markets for existing R&D institutes and existing enterprises – was not realized. Instead unforeseen adaptations 'saved' the reform. A general tendency was for *vertical integration of R&D and design with production activities*, either through merger into enterprises or through establishment of downstream production. This was true not only for R&D institutes for industrial technology, but also for institutes engaged in health and agricultural R&D, and even for universities. As a result, the reconfiguration of the scientific and technological infrastructure was not

completed during the market reforms, which has resulted in a weak capability to provide S&T inputs and supportive services to innovation in firms; a capability that is fundamentally important for knowledge-based growth (Nelson 2004; David 2003).

There were several reasons for the drive toward vertical integration. One reason was the peculiar pattern of division of labour for R&D institutes inherited from the centrally planned system in which they had already been involved in many 'down-stream' activities.[4] Weak absorptive capacity and less developed social capital were other reasons for the difficulties in establishing technology markets.

The phenomenon of factories integrating vertically at all stages in their production process was common in centrally planned economies (Granick 1967). Kornai (1980) explained this as a combination of the factories' hunger for investment and paternalistic relations with the planning authority. *Vertically integrated factories were left almost untouched* by the market reforms, and this obstructed networking in the core part of the economy. Vertically integrated enterprises survived, mainly in what had been seen as strategic sectors, and especially in the machinery industry which was given high priority before the reform.

4. Problems, debates and challenges

By the end of 1990, symptoms increasingly indicated that the development dynamics created by reforms were about to be exhausted and negative sides of the growth model came into focus. The accession to WTO added to the need for China to move into a new period of economic and NIS transition. This was the background for the 1999 Decision by the Communist Party and the State Council, where it declared the need for 'enhancing technological innovation, developing high technologies and promoting commercial production of S&T achievements' (White Paper No. 1 1985: 238).[5] However there has not been much change in economic policy and in the orientation of development, except in 'active fiscal policies' which targeted material infrastructure construction and a considerable increase in public investment in R&D.

With the further accumulation of problems, the government has now decided to make 'endogenous innovation' and 'harmonious development' key components of its renewal of the development strategy. In this section, we analyze the problems and introduce policy debate around 'endogenous innovation'. Starting from the innovation system perspective and taking into account its historical transition, we propose an interpretation of endogenous innovation where it is understood as a move toward innovation-driven growth and learning-based economic development.

Endogenous innovation[6] and policy debates

In October 2005, the Communist Party Central Committee and China's Government stipulated the Guiding Vision for the 11th National Economic and Social Development Program (2006–2010). It emphasizes the importance of a development strategy which economizes on material inputs; upgrades economic structures and innovative capabilities; considers environmental protection; balances urban and rural development and that between eastern, middle and western regions; and maintains job creation and social equality (CCCPC 2005). The key for realizing the new strategy is endogenous innovation (*zizhu-chuang-xin*) and continuous reforms to build harmonious development. One can see that the new strategic vision accommodates several of the problems discussed above.

Policy debates on endogenous innovation following this decision may be considered as follow-up on earlier long-lasting debates.[7] A first focus concerns the theoretical rationale for alternative development strategies – whether the strategy should be based on comparative advantages, or if it should involve strategic industrial policy aimed at catch-up and leapfrogging. Another debate

focus relates to the buy-or-make question of technology. Here, one opinion insists on the necessity of increasing investment in domestic R&D so as to develop national brands, competence in core technologies and technological capabilities, and to build independent capabilities in relation to defense, health care and other national specific needs. The opposing view argues in favor of buying/borrowing technologies from abroad, claiming that high R&D investment to date has brought advantages for neither the country nor enterprises. A third focus is on FDI policies. Whether, and to what extent does FDI contribute to technology acquisition and upgrade? Were policies successful that aimed at attracting FDI by opening the huge domestic market? Should favorable treatment for FDIs continue or should regulatory conditions be identical for domestic and FDI-related businesses?

The several different issues of the debate have not always been clearly focused. The emphasis on promoting free market and trade liberalization in policy spheres was, to some extent, unavoidable in a period when China was engaged in economic and social transition away from its centrally planned regime. Nonetheless, current debate recognises that free markets alone have their limits when it comes to guiding social and economic transition and development.

Endogenous innovation as a strategic element of innovation-driven growth and learning-based economic development

In order to clarify the current debates, we believe it is necessary to elevate the central theme: 'how to embark on innovation-driven growth and learning-based economic development'. Otherwise much of the debate might go nowhere.

For example, purchasing technology from overseas and domestic development of technology are both important; they are complementary in most innovation processes. To see policies that encourage domestic firms' innovation as conflicting with policies that aim to acquire foreign technologies would be misleading. Comparative advantages are necessary reference points for operational planning, while strategic planning needs to consider how existing comparative advantages can be renewed and upgraded. To promote endogenous innovation, a conventional and simplistic response would be to invest more in science and technology, and reinforce the tendency of R&D organizations to move into downstream activities. It is highly questionable if such an effort would make any major difference and overcome the weakness in competence upgrading at the firm level and in internal clustering and dynamics.

The crucial question is how to overcome the weaknesses encountered by the Chinese economy and innovation system; and for this it is essential to define endogenous innovation as a strategy for innovation-driven growth and learning-based development. We believe that the fundamental challenge is still to make the innovation system as a whole work in such a way that it contributes to economic growth and harmonious development. This is actually what the Chinese Government's Guiding Vision for the 11th National Economic and Social Development Program (2006–2010) declares.

Reconfiguring innovation systems in the context of the globalizing learning economy

The idea that economic development is a process where the degree of specialization and division of labour grows and become more complex, and mastery of knowledge generation and application becomes increasingly sophisticated, goes back to Adam Smith, and has been discussed widely by economic historians (Madisson 1991; Fei & Ranis 1997; Hayami 1997). Human learning, which takes place by doing and through science-based innovation, is the most important source of economic growth and involves the deepening of the division of labour and increasing scale economies as well as dynamic effects (North 1996; Lundvall and Johnson 1994). In the cur-

rent context of global competition, deregulation and radical technical change, the dynamic effects become increasingly important. Acceleration of the rate of change implies that the speed of learning become increasingly important for firms' competitiveness and national systems. One of the authors has referred to this change in context as 'a globalizing learning economy' (Lundvall and Borras 1998; Archibugi and Lundvall 2002). China's experience has shown that, to facilitate a rapid learning pace and intensify development, a globalizing learning economy is essential.

One of the major focuses of the innovation system perspective (Nelson and Winter 1982; Freeman 1987; Lundvall 1992; Nelson 1993) *is about how an innovation system generalizes and diffuses knowledge through learning.* Learning takes place in specialized R&D centres that transform local experiences and laboratory experiments into more general knowledge, diffused through training and publication. But learning also takes place in production and consumption. Producer learning does result in productivity growth and consumer learning can alter the composition of final demand (Pasinetti 1981). Learning by using enables users of complex systems or advanced process equipment to become more proficient as they experience and solve problems (Rosenberg 1982).

However, development of new products and processes, especially capital goods and sophisticated devices, has to involve an interaction and information exchange between users and producers (Lundvall 1985). *Interactive learning* is pervasive in a modern economy, which is characteristic of sophisticated patterns in division of labour. More fundamentally, 'learning by interacting' generalizes and spreads initial, local learning consequences throughout the whole economy, in the form of new machinery, new components or new software-systems embodying knowledge, and tacit and human-embedded competences and business solutions (Lundvall 2006).

How a system becomes interactive and works well is crucial for innovation and development performance of a national economy. *Interactive learning is carried out in a hybrid structure of governance* consisting of markets, organizations and networks, called 'organized markets' (Lundvall 1985). Perfect competition at arm's length, with anonymous relationships between customers and sellers, cannot support product innovation. Vertically integrated firms also exclude product innovation and an economic structure dominated by such firms would make an economy less rich in terms of learning experiences, as well as more rigid and therefore quite vulnerable to market turbulence (Lundvall 2006; Richardson 2002).

Learning takes place through user–producer interaction when, for instance, a producer of machinery absorbs information about user experiences from many diverse users. Interaction at this level may be seen as an important dynamo for innovation-driven economic growth. Different from conventional thought, the perspective of interactive learning points to the *importance of the structure of the production and innovation* system: the absence of a strong domestic capital goods sector would constitute a serious handicap for the innovation system. Similar considerations apply to *knowledge intensive business services*. Today such services play an increasingly important role for economic growth. While it is necessary for production enterprises to have in house R&D-activities in order to absorb knowledge from the outside, having access to knowledge intensive business services is a great advantage. Empirical studies from different countries show that firms that outsource the production of such services experience rapid productivity growth (Tomlinson 2001).

Network formation is crucial for the improvement of interactive learning by augmenting and mediating 'complementary' but not 'similar' innovative activities (Saxenian 1996; Baldwin and Clark 1997; Langlois 2003). *Social capital* supports networking and interactive learning across organizational boarders (Woolcock 1998) and may, in this connection, be defined as 'the willingness and capability of citizens and organizations to make commitments to each other, col-

laborate with each other and trust each other in processes of exchange and interactive learning.'

The above paragraphs illustrate the importance of applying a systemic perspective when designing a policy aimed at endogenous innovation. From the NIS-perspective the promotion of endogenous innovation needs to be built upon an understanding of two major themes: *interactive learning and system efficiency.*

The policy discussion in the following sections draws on ideas developed above. We see some of the major challenges for reform of China's innovation system as having to do with a need to reconfigure user–producer relationships and to stimulate new forms for user–producer interaction in the context of innovation.

Innovation policies to overcome the limits to growth and foster endogenous innovation and harmonious development

At the end of Section 2, we listed a number of problems from China's current trajectory of economic growth. Section 3 pointed to weaknesses of the current innovation system. In what follows we will, from the innovation system perspective, briefly present some ideas for the next transition of the innovation system to respond to these problems and weaknesses and to take the global context into account.

Address domestic needs

An inexorable factor for innovation is demand characteristics; requiring both incentives and demand information. China's enterprises should not miss the rich domestic market resources, reflecting heterogeneous regional, habitual and cultural variation in needs, both advanced and basic. A general shift toward home markets would also reduce international trade friction.

One way to promote harmonious and sustained development is to direct innovation activities toward domestic social and ecological needs such as health services, education, transport, energy and environment. China has the necessary planning capacity to coordinate R&D and to develop industrial competence and qualified demand, using a pragmatic mixture of market and administrative governance.[8]

To respond to the demands emerging domestically would open ways to stimulate and nurture novel ideas for endogenous innovation. In the longer run that would eventually make it possible for China to contribute both to international market demands and to human well-being. In short, addressing domestic needs is a necessary ground for 'peaceful' and harmonious development.

Engage in product innovation and improve engineering capability

At the level of a single firm, product innovation addresses new market needs and is therefore an important factor in market growth. Process innovation, on the other hand, improves the efficiency of the production process. Both types of innovations are important for survival of the firm. But for the innovation system as a whole, product innovation may be more efficient in promoting innovation-driven growth and job creation because it enriches the division of labour and provides greater opportunities for interactive learning. While product innovation creates jobs, process innovation alone tends to reduce jobs (Pianta 2005). This distinction is especially important in an economy with big labour reserves and jobless growth in its most dynamic sector.

Jobless growth results partly from lack of product innovation, and partly from a weak engineering capability, reflected in the massive import of production means such as machinery and poor indigenous provision. Engineering capability is the ability to implement and realize innovation based upon innovative ideas, which in themselves are experiencing dramatic change and improvement (Dodgson, Gann and Salter 2005). Policies that stimulate domestic firms to develop new products, in the form of new process equipment for use by domestic firms, would certainly promote endogenous innovation

through stimuli for interaction at the core of the system it represents.

Product innovation takes place also in the form of new services and increasingly the knowledge intensive business services that have become strategic parts of the innovation system (Tomlinson 2001). They interact with many users who profit from development of more efficient services that embody the requirements of those diverse users. From a strategic perspective, building a strong and dynamic business services sector may be a necessary step toward innovation-driven growth in China. Growth in this sector has until recently been slow and there is also great potential for job creation here.

Building user competences and institutions supporting SME competence

Since user–producer interaction is crucial for the success of innovation, it is not sufficient merely to promote supplier competence and knowledge creation. One important reason why the 1985 reform did not succeed in building markets for science and technology was that the potential users had no competence to absorb advanced knowledge. This is why the dominant pattern became vertical integration and knowledge producers moved into production. To improve interactive learning, user competence is as important as the competence of the producer, and in China this constitutes a major bottleneck for learning and innovation.

Competence refers to scientific capabilities as well as to the capacity to engage in learning by doing and organizational learning. To promote scientific capabilities, incentives for enterprises to engage in R&D-activities may be combined with incentives to hire highly educated personnel. To stimulate the diffusion of organizational learning among firms, a combination of benchmarking good practice in terms of organizational and inter-organizational learning may be combined with competence-based selection and job rotation among top managers.

For small and medium-sized firms in traditional sectors, including agro-food business, specific institutes and self-organizing initiatives with the task of diffusing technical innovations and good organizational practice may be supported by the public sector. Such firms have a need for inexpensive access to technological services and knowledge institutions. Especially in periods of unemployment for graduate engineers and scientists, public support might be considered for such firms to hire their first engineer/graduate.

Develop a responsive science and engineering base

The 1985 reform resulted in a structure where universities and other institutions with responsibilities for basic research were strongly involved in commercial activities. With improvement of competency levels within firms, universities and public R&D centres should redefine their roles and withdraw gradually from downstream commercial activities that are not easily combined with the search for excellence in science and technology.

Improvement of public funds management, and development of scientific community-based academic evaluation, would largely increase the efficiency of knowledge production. Such a shift may actually be combined with a more intense communication with industry, both in research and in higher education.[9] In a greater global knowledge society, it is also important to participate in international academic communities and to expose academic research to international competition. Such changes would certainly increase the rate of return from the increased investment in R&D that the Chinese Government is beginning to implement.

Develop new forms of participatory governance of economic organizations

There are different forms of governance, and the degree to which people tolerate social gaps differs even in wealthy nations. Some advanced coun-

tries operate with wide social gaps while others are more egalitarian. The first group includes the United States and United Kingdom where ordinary people are less participatory; they are expected to adapt passively to new technologies. The second group includes the small European welfare states where ordinary workers take an active part in innovation as well as sharing in the benefits that innovation creates.

In China, one way to stimulate participation in change processes is to establish cooperative ownership of firms. This might be especially relevant for densely populated agricultural regions. The International Labour Office (ILO 2003) calls for rediscovery of the cooperative advantage to reduce poverty, warning at the same time that people have to learn lessons from negative experiences of the past. One lesson is to let cooperatives grow through self-organization and learning; another is to support development of the qualifications of leaders and participants.

Improving education and stimulating the mobility of skilled labour

The most fundamental and dynamic resource in the innovation system is people. Every single person is a potential user and producer of technology and knowledge.

> *One of the basic means of enhancing user competence and facilitating interaction between users and producers is improvement of education and training.*

Universal secondary education in poor rural areas would prepare residents for participation in knowledge and skill-intensive agricultural and related activities, or to join the new generation of urban residents.

The curricula design and pedagogical methods of the education system must be modified to promote the problem-solving capacity of students. Increasingly interaction will depend upon experts who are creative and co-operative. Elite education needs to be complemented with universal and life-long continuous education as a strategy of endogenous innovation and harmonious development.

But not all competencies emanate from formal education and training. With rapid change the learning that takes place at work ill become more and more important. Stimulating diffusion of 'learning organization' practices among enterprises is fundamental for endogenous innovation and for the ongoing upgrade of skills in the workforce.

The mobility of people across organizational borders shapes social connections and interaction. Enterprise employees and managers with a university education will have the least difficulty establishing collaboration with university researchers. Therefore schemes that make it attractive to move back and forth between academia and the enterprise sector may be especially important.

Develop networking and learning regions

Regions can be springboards for endogenous innovation, if they develop and exploit specialized strengths based on firm networks with tacit knowledge (Cooke and Morgan 1998). The local and regional dimension has become crucial for growth in China through reforms leading to bureaucratic decentralization, but development of learning regions has been less impressive. There is a need for a new incentive structure and for policy capacity-building at a regional and local level. Reform should aim at rewarding innovative solutions that promote networking and save scarce resources.

There is also a need to give central government a stronger role in the redistribution of wealth between provinces and regions. Central government could also play a more important role as promoter of regional policy and managerial learning within the regions.

Social capital and endogenous innovation

In summary, endogenous innovation and harmo-

nious development require a new set of efforts, rather different from those of the 1980s and 1990s. It will involve reform of institutions that support markets and make contracts trustworthy but must also involve broader social changes to support the interaction between economic agents.

Corruption and irregularities in the use of legal systems undermine trust and thereby undermine a critical prerequisite for interactive learning across organizational borders. Innovation, because of its inherently uncertain character, is especially vulnerable to lack of trust. To foster the rule of law and a competent and honest public administration is therefore an integral element of any strategy for innovation and learning-based development. In the current context, fostering good governance, especially at the local and enterprise level, may be a key to enhancing innovation.

One way to illustrate the promotion of endogenous innovation and harmonious development is to present it in terms of four types of capital (Table 6).

Production capital can be relatively easily produced and reproduced. The same is true for intellectual capital. But production capital loses much of its user value when natural capital is eroded – once the land and drinking water are polluted, it is immensely expensive to clean it up. Intellectual capital is created through interactive learning and depends strongly on social capital. In a society where people trust institutions and each other, and are ready to co-operate willingly even outside the most narrow group, learning will flourish.

Endogenous innovation and harmonious development implies a growth model that gives attention not only to production capital and intellectual capital. Avoiding the degradation of natural capital must be a key element in any strategy favoring harmonious development. Stimulating the formation of social capital is a key to long-term success in promoting endogenous innovation. Social capital is the basis for interactive learning and therefore the lubrication that will make the innovation system work smoothly.

5. Conclusion

In this paper, we have analysed the forces behind China's rapid growth. We have shown that pragmatic policies and policy learning have been central to its success. We have also identified challenges posed by its growth pattern and remaining weaknesses in its innovation system.

These challenges and weaknesses are reflected in the new political signals giving priority to concepts of endogenous innovation and harmonious development. Building upon the historical experience, we argue that the best way to interpret these concepts is to see them as signalling innovation-driven economic growth and learning-based economic development.

The global context and historical starting point is different than it was in 1985 but the basic perspective for reform, with its focus on interaction between users and producers of knowledge and technology, remains pertinent when designing the next major transition. Strengthening domestic demand and the competence of domestic technology users is a key to success. Enhancing the knowledge base of strategic sectors producing processing equipment and knowledge-intensive business services for the market is another important element. Investing in social capital – designing institutions so that

Table 6: Resources fundamental for economic growth – combining tangible and reproducible dimensions

	Easily reproducible resources	Less reproducible resources
Tangible resources	Production capital	Natural capital
Intangible resources	Intellectual capital	Social capital

citizens more readily collaborate and learn from each other – is a way to promote endogenous innovation.

Many aspects of the successes and problems that China has experienced were unforeseen in its previous catch-up history and in its existing theories of economic development. This is true for the limits of export-led development strategies, the inadequacy of manufactured exports in spreading learning effects, the extreme rate of substitution of capital for labour, and the severe structural unemployment phenomenon. The response to these accumulated challenges sees China embark on a new development strategy characterized by endogenous innovation and harmonious development, which we have interpreted as a strategy of innovation-driven growth and learning-based development.

As China pursues harmonious development, it will become clear that it represents no economic threat to other countries. For those who wish China a uniquely successful experience, we must point out that the actual process of adjustment will unavoidably involve uncertainties and setbacks. We trust that innovation studies can serve an instrumental and positive role, and believe that these studies can also learn from China's transition in future years.

Endnotes

1 Low profitability of commodities made in China is common knowledge, although the 2–5 percent is a rough estimation. For example, the TV industry, which has a well developed competitive advantage, has rather thin profit margins because key components for final products are imported from Japan, Korea and Taiwan. It is reported that in 2005 average net profit of the TV industry was as low as or less than 3 percent, and for some firms it was lower than 1 percent, even though the industry had introduced flat panel TV sets a year ago and these were expected to improve the industry's profitability record (*Shangwu shoukan* (*Business Watch Magazine*) 28 October 2005). Ninbo City, Zhejiang province, is an important export-manufacturing base. It exported US$12 billion of products such as clothing, cigarette lighters and air-conditioners in 2003. Possessing weak negotiating capacity with international buyers and being engaged in the low end of value chains, the exporting firms had net profits of around 10 percent with some lower than 5 percent. (*IT jingli shijie* (*CEO & CIO China*) 9 November 2004).

2 Note that the Decision recognized the diversity of R&D institutes in terms of function. It divided them into 'technology development type', 'basic research type', and 'public welfare and infrastructure services type'. The reduction of public funds was mainly applied to the technology development type and it was done gradually for completion over five years. Consequently by 1991, the 2000 plus, out of 4000 in total, technology development institutes had had their public 'operation fees' entirely or partly cut. Roughly the sum of the reduction accounted to slightly less than RMB 1 billion (or USD 200m), or about one-tenth of the overall government S&T budget in 1985.

3 See: http://www.sts.org.cn/report_3/documents/2002/0207.htm.

4 Data show that in 1985 the centrally affiliated R&D institutes engaged mainly in 'experiment development' and 'design and production engineering'. According to international standards. half of their works were not 'R&D' but downstream innovation-related activities such as 'design and production engineering' and 'diffusion and technical services'. Locally affiliated R&D institutes went downward even further, and to a lesser extent, similar phenomenon were observed in other centrally planned systems.

5 For the full document, refer to http://www.most.gov.cn/t_a3_zcfgytzgg_a.jsp.

6 There are different English translations of the Chinese term *zi-zhu-chuang-xin*; here we use 'endogenous innovation'.We tend to disagree with 'independent innovation' which appears quite often in English versions of Chinese media reports, as it is misleading. In Chinese to put an adjective '*zi-zhu*' to 'innovation' is to emphasize that strategically China has to be proactive to do something new and not passively remain with existing and imported technologies. Readers should better understand the fashionable Chinese term *zi-zhu-chuang-xin* simply as 'innovation'.

7 The discussion is based on various sources from media reports and personal exchanges.

8 It is interesting to note that the market economy par excellence, the United States, has a much more active government policy to support science and technology than Japan and Europe. But these policies appear as part of health and space-related programs, not as industrial policy.
9 A stronger element of practical experience and a more problem-oriented learning method in the academic training of scientists, engineers and managers would be a most efficient way to create stronger links between universities and enterprises. The same would be true for more systematic efforts by universities to offer lifelong learning in these categories. But the most important change would come from increased hiring of academic personnel by the enterprises.

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