



DRUID Working Paper No. 06-7

China's Innovation System and the Move Toward Harmonious
Growth and Endogenous Innovation

By

Shulin Gu and Bengt-Åke Lundvall

Danish Research Unit for Industrial Dynamics

www.druid.dk



China's Innovation System and the Move Toward Harmonious Growth and Endogenous Innovation

Shulin Gu

Tsing Hua University
China

Bengt-Åke Lundvall

Aalborg University
Department of Business Studies
Fibigerstræde 4, DK-Aalborg Ø
E-mail: bal@business.aau.dk

Abstract:

Observers around the world are impressed by the rapid growth of China's economy. 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'. This paper attempts 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. On the basis of the analysis the authors propose that it is possible to link together the two key concepts 'endogenous innovation' and 'harmonious development' by focusing innovation and development efforts in China on domestic needs, including social needs, rather than a one-sided focus on export-promotion and commodity production.

Key words: China, economic growth, R&D, innovation systems

JEL Codes: O32, O11

ISBN 87-7873-197-6

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 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 toward decentralization, privatization and openness around 1980 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 with 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 eighties 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. But 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 the 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 labor and in the interaction between users and producers of knowledge and innovation that was behind the reforms of the eighties 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. The transition of China's economy

How to explain the extra-ordinary growth performance of China? What are the unique features of the 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 economic performance of the two periods, we use the data summarized by A. Maddison (Maddison 1998) depicted in Table 1 and Figures 1 and 2.

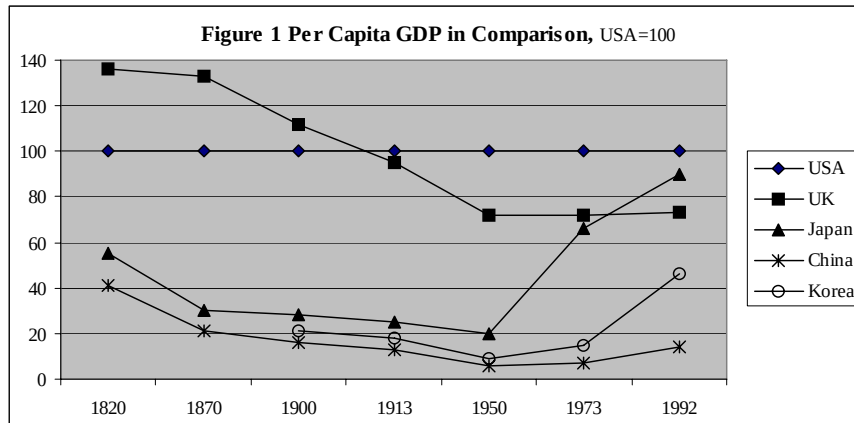
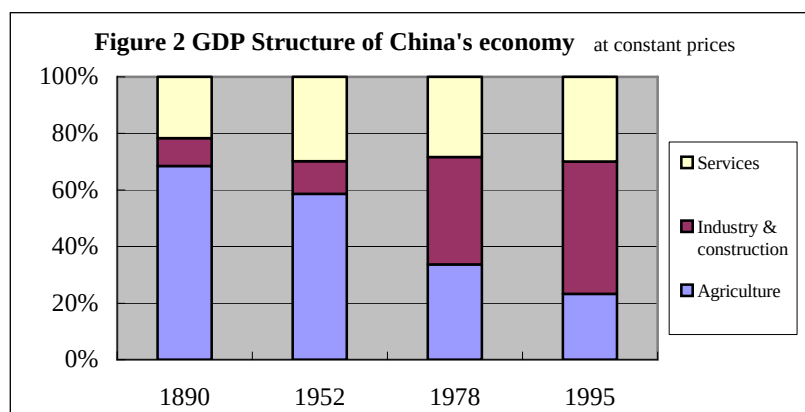


Table 1: Growth of China's economy 1890-1995 (At constant prices)

	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



Source: Maddison 1998: 56, Tables 3.1 and 3.2

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 “post-industrialization” that took place after WWII in developed and most less developed countries. As a result, China ends up being highly “industrialized” by the end of the century. In 2003, the GDP structure of China is 12.5, 46 and 41.5 in terms of percentage for the primary, secondary and tertiary industry respectively. The growth in manufacturing and the relative shrinkage of agriculture went on also in the 1990s, and the value added-share of the service sectors remained almost unchanged until the second half of the 1990s.

But as we shall see below the economic structure looks quite different when the focus is upon employment rather than value added. The proportion of the labor 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 else a very high rate of accumulation of fixed capital accompanied by high rates of growth in labor productivity.

Behind the high growth rates and the 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 aiming at respectively decentralization and privatization (Wu 2003, Chapter 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 nation-wide reforms formalized the relationships and introduced more transparent and coherent rules. This was the period when reforms of taxation, banking system and governance structure of state-owned enterprises—i.e. “corporatization” of previously state-ownership - were initiated. Actually this dynamic of policy learning where experiences from local and regional experimentation were gradually diffused at the national level has been one major characteristic of the reform period.

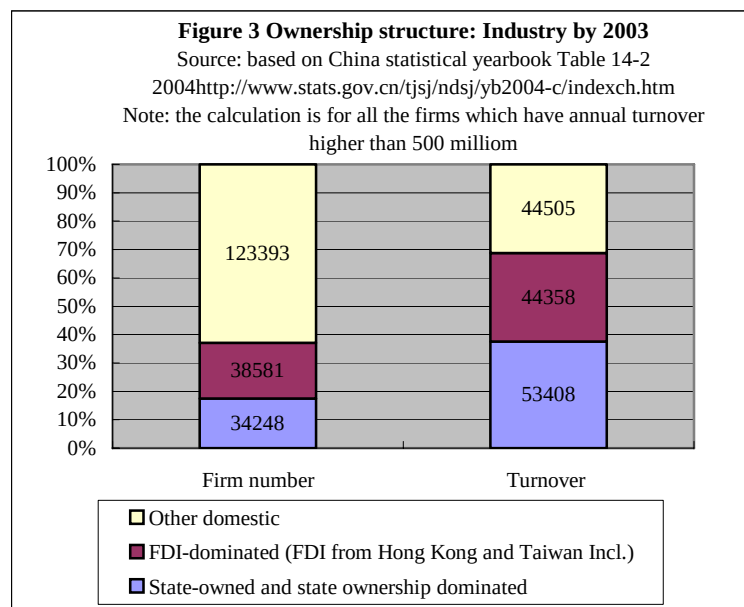
The second line of action loosened the restrictions first for township and village enterprises in the early 1980s and later also for private initiatives in the mid-1990s. It included the creation of “Special Economic Zones” for FDI related investment with various favorable regulations. In provinces like 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 (Wang, XU *et al* and BAO *et al* in this issue).

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

“Diaspora networks” played an important part in re-enforcing the rapid capital accumulation from foreign investment (Kuznetsov, this issue). Throughout the 1980s, the opening to FDI and international trade attracted partners mainly from the Greater China area—Hong Kong, Taiwan Province, Singapore, and overseas Chinese from other continents. It was not until the second half of the 1990s that multinational companies from North America and West Europe came in on a large scale. And still, by 2003, Hong Kong, together with Taiwan, remains the first and primary source of FDI, holding about half of the total FDI in China. The fact that the 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 below, by 2003, each of the three types of ownership—the state-owned, FDI related and other domestic - were responsible for roughly one third of output.



It is important to note that a big share of the firms belonging to the category of “other domestic” enterprises primarily reflects rapid growth in the 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 for industrialization in many regions in China outnumber both the domestic private and the state-owned firms; they underwent a transformation from collective ownership to become private owned since the mid-1990s.

Export led growth

International trade was initially pushed by favorable policies and gradually pulled by

FDI and intra-trade in Global Value Chain. 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).

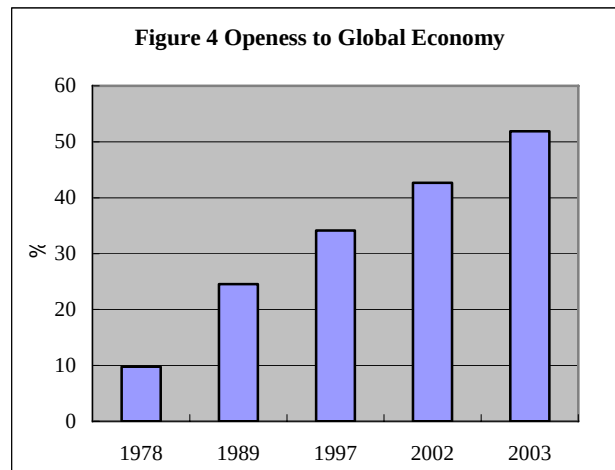
Table 2 Openness of China to the Global Economy

	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

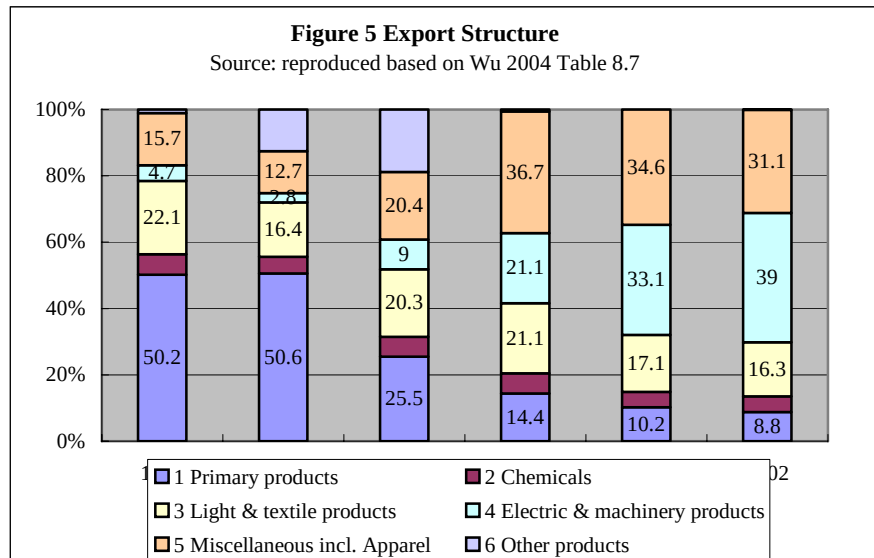
Source (for Table 2 and Figure 4): based on China Statistical Yearbook 2004;

<http://www.stats.gov.cn/tjsj/ndsj/yb2004-c/indexch.htm>,

<http://www.stats.gov.cn/tjdt/zygg/P020060109431083446682.doc>



Export structure has been upgraded (Figure 5). The share of primary products, such as foodstuff, agricultural products and mineral fuels, have 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. But light and textile products and apparel increased considerably as well.



Beyond quantitative growth, qualitative or structural change has been radical. It is useful to make a distinction between global production chains that are driven mainly by demand factors—buyer driven chains, and those driven mainly by supply factors—producer driven chains (Gereffi 1999, UNIDO 2002). In the products of “buyer-driven” chains such as apparel, footwear and toys, contained 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 businessmen play roles as relational coordinators. Many of these goods are produced in factories owned by Taiwanese or Hong Kong investors; some are produced in Chinese owned firms but produced in sub-contracting relationships (see Zheng paper this issue).

In the “producer driven” industries such as computer and IT products which are included in category 4 in Figure 5, exports are mainly manufactured in factories owned by Western and Taiwanese investors. For 2003 it is 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 of the innovation system of China characterized by easy access to foreign technology while weak in local and domestic clustering. We will turn to this

point in sections 3 and 4.

Domestic demand and investment

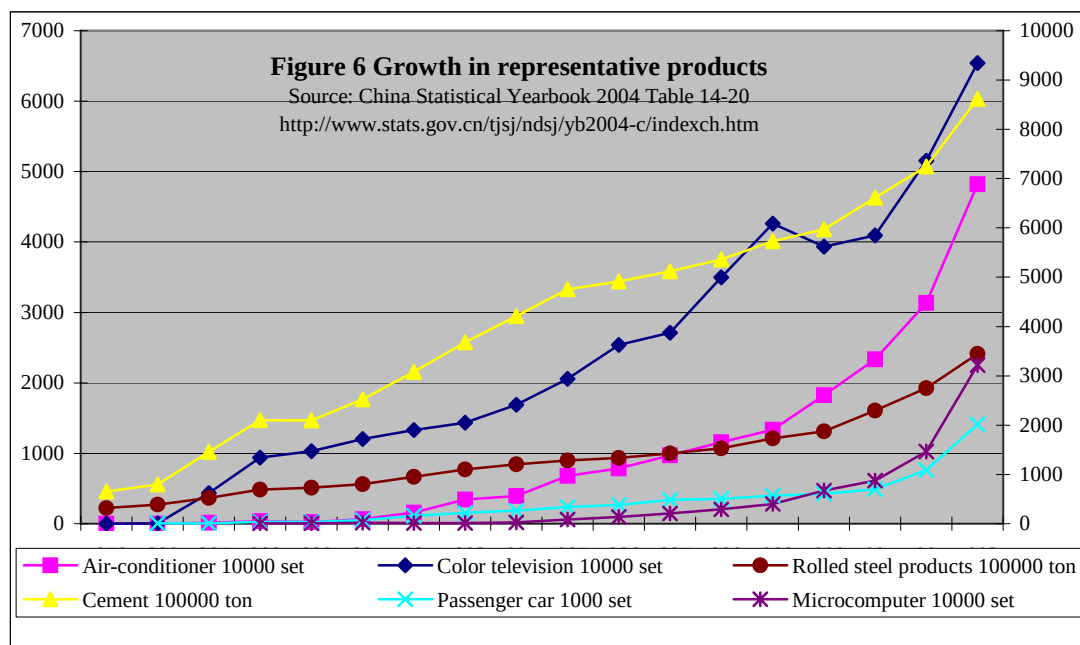
The domestic market has also played a role for the development in the period. Domestic demand experienced at least two rounds of surge and growth. The first round appeared through the 1980s and the first half of the 1990s, and it was led by household durables and necessities, as illustrated by color televisions in Table 3 and Figure 6. The centrally planned economy had left huge areas of shortage in consumer goods industries. The combination of bureaucratic decentralization and incremental reforms stimulated investment in the supply capacity of these industries.

The second round 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 rounds stimulated demand for them. The second period of demand-led growth had strong weight of large-scale activities such as construction and car production, which consume them in great quantities, hence one sees accelerated growth in the latter years. To expand production capacity a very high rate of growth in investment was necessary.

The second surge of 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 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 in stimulating “domestic demand” in consumption. It created loans for individual housing and car consumers at reduced interest rates.

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



Source (for Table 3 and Figure 6): China Statistical Yearbook 2004;

<http://www.stats.gov.cn/tjsj/ndsj/yb2004-c/indexch.htm>.

A unique pattern of economic growth

In 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).

The reforms that were initiated more than 25 years ago unleashed restrained material needs. It was explicitly argued that getting some concentration of wealth among the few was a first step toward making everybody better off; this made the strife 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 their 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 emanating primarily from overseas Chinese investors and later on from wider sources should be added to this as 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 in purely foreign-owned enterprises to the locality. Building infrastructure and supplying cheap labor, energy and land has become a key concern 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 the local administration is less popular than the central government among Chinese citizens (Saich 2004).

The dynamics of reform has also been driven by the competition between localities to offer the most attractive framework conditions. This sometimes takes the form of

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 the high speed of growth is now confronted with barriers for further growth. Some of these are external and refer to potential trade conflicts. Others reflect domestic problems with social and ecological sustainability. There are indications of serious weaknesses of the innovation system. The call for 'harmonious development' may be interpreted as an attempt to give new direction to the recognized unsustainable growth patterns.

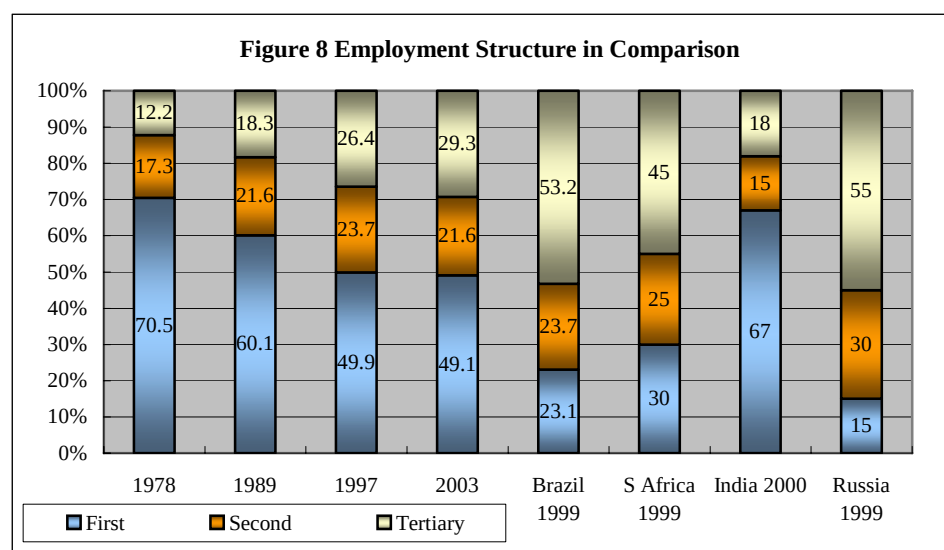
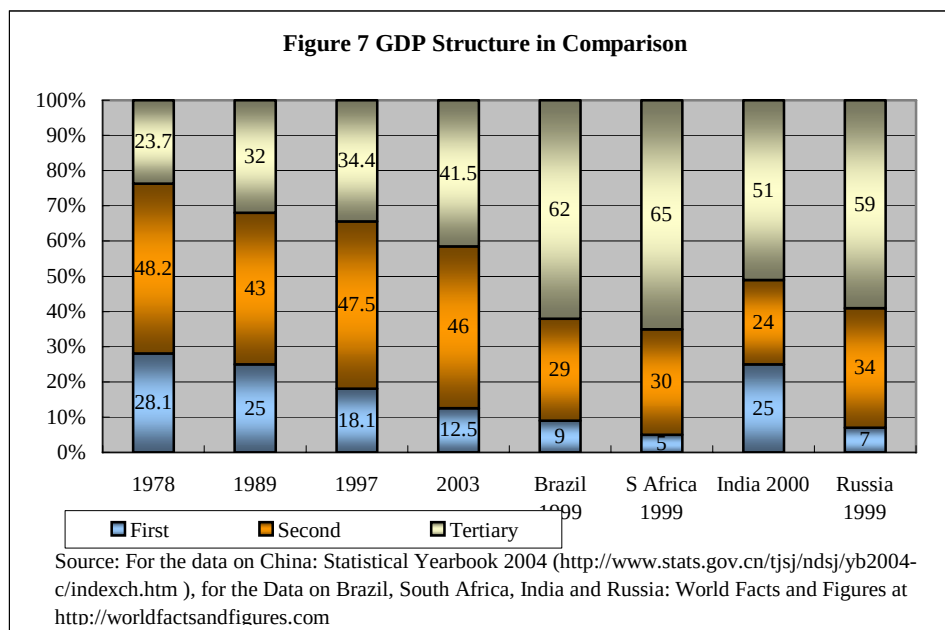
Remarkable global impact and trade disputes.

China's economic growth has had a very visible impact on the global economy. When China's exports and imports grow with double digit rates it makes a major difference for the rest of the world. The impact upon other countries' trade balances is such that there is an upper limit for how far the trade surplus can be increased without triggering trade quotas or other forms of retaliation. The current trend of massive penetration into global markets may not be lasting much longer.

"Job less growth"

In terms of GDP structure (Figure 7 and Figure 8 compare China with four big developing or transition economies: Brazil, South Africa, India and Russia) China appears to be overwhelmingly "industrialized". However, China is faced with the challenge from "job-less growth" in the manufacturing sector. Figure 8 shows that in terms of employment structure China appears as an agricultural economy, half of the labor remains in this sector. Only India has a bigger proportion of the labor force in agriculture. Combining the two sets of data it is obvious that China is characterized by high and rapidly growing capital labor-ratio in the manufacturing sector. While there is net job creation in the first years of the reform period, the increase of employment

slowed down in the 1980s and stagnated since the 1990s.



This displacement of employment exacerbates the “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 twenty years of being the origin of manufactured goods “made-in-China”, China’s economy has not been able to embark upon the track of competence upgrading. This contrasts with the catch-up history of the US and Japan where “made-in-US” and “made-in-Japan” were preludes to the two countries, within a time span of one generation, reaching the world frontier in terms innovativeness and competitiveness. China remains specialized in low value-added products with profit margins trapped at 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 the 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?

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

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

3. The Transformation of China's Innovation System

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

The attempt to re-configure the user-producer relationships

China has an old civilization and historically she has made important contributions to global science and technology (such as compass, gunpowder and paper). In the older history of China, however, science and technology as it evolved in Western Europe was not regarded as important or as carrying social status. While the heritage from Con Fu Tse gave high prestige to the intellectuals, it was to intellectuals 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 started to be organized in the 1920s to 1930s, China could only begin the process of institutionalization of modern science and technology nationwide in the

1950s.

The R&D system established in the first period of development was designed in accordance with the centrally planned regime. One prominent feature was the huge size that was a reflection of the Marxist idea of science as a societal force of production and also a result of the self-reliance development strategy in the centrally planned period (see Table 4).

The second feature was the separation of industrial R&D centers from productive enterprise users. The centrally planned regime had introduced particular mechanisms to link up R&D activity with production: All the R&D institutes, except those belonging to the Chinese Academy of Sciences (which was assigned to be 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 the responsibility for planned production tasks as well. They were hence 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 centers and enterprises, and separation of firms from innovative activities was common for all the former centrally planned economies.² The organizational separation between innovation and production blocked the system from vital and intimate interactions between producers and users, which are 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 apt at “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

² See Granick 1967 for former Soviet Union and for more general discussion see Hanson and Pavitt 1987.

127-135). The low degree of *effectiveness* of the centrally planned institutional settings was well acknowledged at the end of the 1970s. This became one important motive for the launch of reforms.

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>

The crucial event for the R&D system reform came in 1985, slightly lagged to the agricultural and industrial reforms, which were started in 1978 and 1984 respectively. A 1985 Decision made by the Central Committee of the Communist Party of China initiated the reforms in Science and Technology System Management. The central theme for the 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 indispensable.

The size and complexity of the S&T-system made reform crucial for the success of economic growth--By 1980 there were 4,690 research institutes affiliated to administration bodies higher than the “county” level, i.e. to central, provincial, and regional/city governments, with some additional 3000 institutes at the county level, the lowest level of the nation’s administration hierarchy with 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 the following:

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).

The adaptive policy process and the recombination of competences

For reforming the S&T system, a two-pronged policy was designed. On the one hand, “technology markets” were established to function as distributive institution for R&D outputs (Decision: Section III). On the other hand excellence-based allocation mechanisms were introduced for the allocation of public R&D funds (Decision: Section II). In order for R&D institutes to be able to respond to opportunities arising at the market place, some degree of autonomy, in terms of hiring personnel, engaging in contracted project, 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, the previously publicly funded R&D institutes would move to serve their clients via regular and multiple linkages.³

The actual process of S&T system reform, as the reforms of the over all economic system, unfolded through trial and error and entailed continuous adjustment of policies (Gu 1999 Part I). *The technology market solution*, central in the initial design, was soon recognized as being difficult to realize in its original form. The 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 when writing and implementing contracts. As a response, in 1987 reform policy began to promote *merger of R&D institutes* into existing enterprises or enterprise groups. The merger process was also difficult to realize, however. Huge gaps between the merging parties, from differences in work culture and administrative affiliations, were hard to overcome immediately.

In the next year (1988) the Torch Programme was launched to encourage something like *spin-off enterprises*—called *NTEs* (New Technology Enterprises), from existing R&D institutes and universities. Local governments contributed to investment in infrastructure and supporting institutions for the New and High-Tech Industry Zones that became incubation bases for the NTE-startups. Scientists and engineers, often with support from their parent institutions, went into commercial application of their inventions and expertise by means of the creation of NTEs. And by the early 1990s,

³ Note that the Decision recognized the diversity of R&D institutes in terms of their 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 to be complete in a time span of five years. Consequently by 1991, the 2,000 plus, out of the 4,000 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 200 m), or about one tenth of the overall government S&T budget in 1985.

reform policy included another solution to change *individual R&D institutes into production entities*. This, as well, was an adaptation to an actual evolution already realized by many industrial R&D institutes.

At the end of the 1990s, the reforms came to a kind of conclusion. In 1999 an official decision pointed to the need to clarify the actual character of the previously government-run industrial technology R&D institutes. By 2001,⁴ as a stage of the clarification, some 1,200 industrial technology R&D institutes have re-registered their business type. Of them more than 300 were *merger* cases, these institutes have canceled their independent position and become a part of an enterprise. 600 plus have changed to become *profitable firms* in themselves. A few have entered into a university. Table 5 indicates the changed structure of R&D performers. In 2000 the proportion of R&D performed by “enterprises” leaped up abruptly (see line 3, Table 5) largely because a number of previous R&D institutes became registered enterprises or part of existing enterprises. Table 4 also depicts the scope of *technology market* and *spin-offs*, both grew steadily over time (lines 1 and 2), illustrating the complementary effects of various transformation means. Lines 4 and 5 and 3 show a changed structure in technology sources. China, not so long ago nearly closed to international exchange in technology and knowledge, has become a widely open innovation system, with enormous inflows of technology in forms of international capital goods and FDI.

⁴ See: http://www.sts.org.cn/report_3/documents/2002/0207.htm

Table 5 Selective indicators to changes of the China NIS

(All the 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

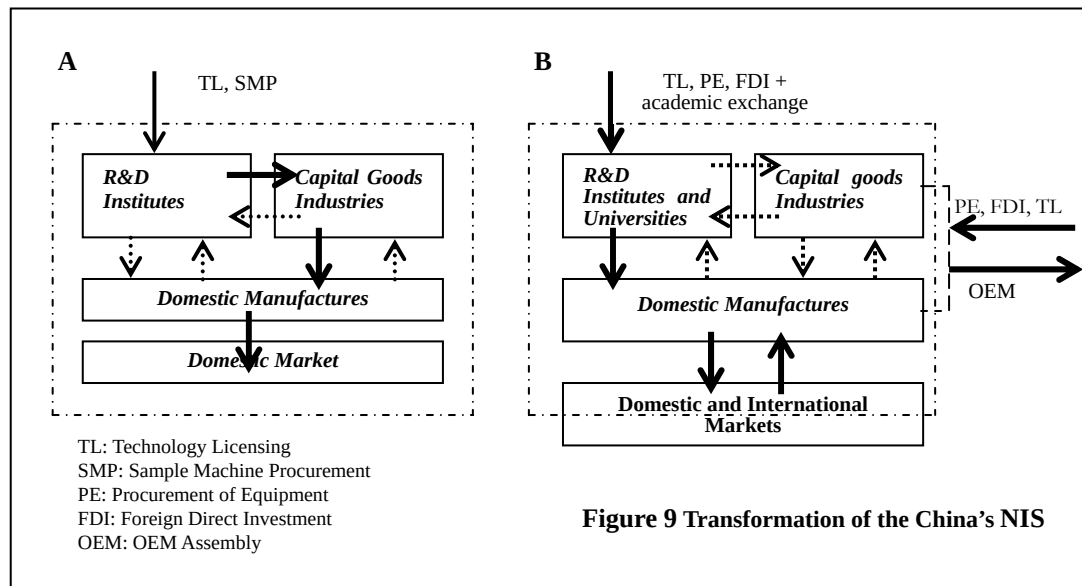
Sources: China Statistical Year Book on Science and Technology various issues; <http://www.most.gov.cn>;<http://www.stats.gov.cn/ndsj/zgnj/2000/Q05c.htm> http://www.moftec.gov.cn/article/200303/20030300072333_1.xml;http://www.sts.org.cn/REPORT_3/documents/2002/0220.htm; http://www.sts.org.cn/REPORT_3/documents/2002/02hdb01.htm

Adaptive policy evolving through trial and error characterizes “gradual reforms” in the whole process of economic transition in China. 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 the feed-back information on the impact could preserve the feasibility for success of any radical social innovation program (Metcalf 1995, Gu and Lundvall 2006).

A review of the transformation of the innovation system

On the basis of the discussion above, Figure 7 illuminates the National Innovation System of China as it looked before (part A) and after (part B) the transformation. It embraces (1) *innovation actors*—R&D institutes, capital goods industries they provide embodied technology as the means 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); and (3) *interactive relationships* between actors and with domestic and international markets, we use arrows with different line boldness to illustrate the intensity of the various links. It

gives a first impression of what significant changes that the transformation has brought into the system.



The transformation was constructive in safeguarding and recombining technological capabilities in the context of market reform and opening to the global economy. It has supported the rapid growth in the economy as a whole. For example, a number of NTEs like Huawei, Datang and Linovo, grew to become key ICT enterprises and this led to a fundamental restructuring of China's ICT industry (Gu and Steinmueller 1996/2000). The achievements are especially impressive when comparing with Russia where scientific and technological capabilities were destroyed on a huge scale. It nonetheless leaves the system with some prominent weakness.

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

First of all, the resulted system developed weaker domestic links and interactions than international links, although the mastery of the latter links remains rather passive dominated by the import of foreign technology embodied in machinery and other process equipment. The *capital goods industry* has not played a role as innovation center for the whole economy by providing appropriately advanced production means for various users; they were instead largely integrated into the 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 2003). In general *potential local or domestic links along and between value chains* have been slow developed and hard to expand. Small firms in traditional manufacturing sectors, and agriculture and rural development have received inadequate support from national and regional technological infrastructure, showing a *separation between the modern and the traditional part* of the system (Tylecote, this issue).

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 markets for technologies for existing R&D institutes and existing enterprises was not realized. Instead other unforeseen adaptations ‘saved’ the reform. A general tendency was *vertical integration of R&D and design with production activities* - either through merger into enterprises or through the 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 complete during the market reforms. This 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 labor for R&D institutes inherited from the centrally planned system in which they had already been involved in many “down-stream” activities.⁵ Weak absorptive capacity and less developed social capital were other reasons for the difficulties to establish markets for technology.

The phenomenon of factories that integrated vertically within themselves all stages in the production process were common in all centrally planned economies (Granick 1967). Kornai (1980) explained this with a combination of the factories’ hunger for investment and the paternalistic relation with the planning authority. The *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 that was given high priority before the reform.

4. Problems, debates and challenges

By the second half of the 1990s, symptoms increasingly indicated that the development dynamics created by reforms was about to be exhausted and negative sides of the growth model came more 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”.⁶ However there has not been much change in economic policy and in the orientation of

⁵ 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” “diffusion and technical services”. The locally affiliated R&D institutes went even downward further. Similar phenomenon was observed in other centrally planned systems to a less extent.

⁶ For the full document, refer to http://www.most.gov.cn/t_a3_zcfgytzgg_a.jsp

development, except “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 now has decided to make “endogenous innovation” and “harmonious development” key components of a renewal of the development strategy. In this section we analyze the problems and introduce the policy debate around “endogenous innovation”. Starting from the innovation system perspective and taking into account the historical transition of the system 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”⁷ 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 adjustment of development strategy which should be economizing material inputs, upgrading economic structure and innovative capability, be friendly to environmental protection, balance between urban and rural development and between the development in east, middle and west regions, and maintaining job creation and social equality (CCCPC 2005). The key for realizing the new strategy is endogenous innovation (*zi-zhu-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 the decision may be considered as

⁷ There are different English translations of the Chinese term *zi-zhu-chuang-xin*, here we use “endogenous innovation”. “Independent innovation” appears quite often in English version of Chinese media report, to which we tend to disagree, for it causes misleading. In the China’s context put an adjective “*zi-zhu*” to “innovation” is for an emphasis that strategically China has to be proactive to do something new but not passively stay with existed and imported technologies. Readers are better to understand the fashionable Chinese term *zi-zhu-chuang-xin* simply as “innovation”.

a follow-up of earlier long-lasting debates.⁸ *One of the focal points* 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 aiming at catch-up and leapfrogging. *Another focus* of the debates relates to the buy-or-make question of technology. Here one opinion insists on the necessity to increase investment in domestic R&D so as to develop competence in core technologies and technological capabilities, national brands and to build independent capabilities in relation to defense, health care and other national specific needs. The opposite opinion argues in favor of buying/borrowing technologies from abroad; it claims that high R&D-investment has yet brought advantages neither for the country nor for enterprises. *The third focus* is upon policies for FDI. Whether, and to what extent does FDI contribute to technology acquisition and upgrading? Were the policies aiming at attracting FDI by opening the huge domestic market successful? Should the favorable treatment for FDI continue or should regulatory conditions be identical for domestic and FDI-related businesses?

The debates have thus raised several different issues and 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 a centrally planned regime. Nonetheless, the current debates may be understood as recognition that free markets alone have their limits when it comes to guide social and economic transition and development.

Endogenous innovation as strategic notion towards innovation driven growth and learning-based economic development

In order to clarify the current debates, we believe it is necessary to put on top of the debates the central theme “how to embark on innovation driven growth and learning-based economic development”. Otherwise many of the debates might go nowhere.

⁸ The following discussion based on various sources from media reports and from personal exchanges.

For example, borrowing technology and domestic development of technology are both important; they actually are complementary in most real innovation process. 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 re-enforce the tendency that R&D organizations 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 the China's economy and innovation system encountered; 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 to work in such a way that it contributes to economic growth and harmonious development. This is actually what the China's government 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 the division of labor grow and become more complex, and the mastery of knowledge generation and application increasingly sophisticated, goes back to Adam Smith, and has been discussed widely by economic historians (e.g. Madisson 1991, Fei & Ranis 1997, Hayami 1997). Human learning, which takes place by doing and through science-based innovation, is the most important source for economic growth that involves the deepening of the division of labor and increase in scale economies as well as dynamic effects (North 1996, Lundvall and Johnson 1994). In the current

context of global competition, deregulation and radical technical change the dynamic effects become increasingly important. The acceleration of the rate of change implies that the speed of learning becomes increasingly important for the competitiveness of firms 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 shows that development in the context of globalizing learning economy has made it very essential to facilitate the learning pace and intensity.

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 centers that transform local experiences and laboratory experiments into more general knowledge and diffuse it through training and publications. But learning also takes place in production and consumption. Producer learning results in productivity growth. Consumer learning results in change in the composition of final demand (Pasinetti 1981). Learning by using refers to how users of complex systems or advanced process equipment become more proficient as they experience and solve problems (Rosenberg 1982).

However, the 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 labor. More fundamentally, ‘learning by interacting’ generalizes and spreads the initially local learning consequences throughout the whole economy, in the form of new machinery, new components or new software-systems embodied knowledge, and tacit and human embedded competences and business solutions (Lundvall 2006).

How a system gets interactive learning to work 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,

which we call “organized market” (Lundvall 1985). Perfect competition with arm’s length and anonymous relationship between customer and seller cannot support product innovation. Vertically integrated firms also excludes product innovation and an economic structure dominated by such firms would make an economy less rich in terms of learning experiences and also more rigid and therefore quite vulnerable to market turbulences (Lundvall 2006, Richardson 2002).

Learning takes place through user producer interaction where, for instance, one producer of machinery absorbs information about user experiences from many diverse users. The interaction at this level may be seen as an important dynamo for innovation driven economic growth. Different from conventional thoughts, 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 constitutes 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 be able 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 borders (Woolcock 1998). Social capital may in this connection be defined as ‘the willingness and capability of citizens and organizations to make commitments to each other, collaborate 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 an innovation policy aiming at endogenous innovation. From the NIS-perspective the promotion of endogenous innovation needs to be built upon an

understanding of the two major themes: *interactive learning* and *system efficiency*.

The policy discussion in the following sections will draw upon the ideas developed above. We see some of the major challenges for the 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 that emanate from the current trajectory of economic growth. At the end of section 3 we 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 that responds to these problems and weaknesses and take into account the global context.

Address domestic needs

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

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 the development of industrial competence and qualified demand, using a pragmatic mixture of market and administrative

governance.⁹

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 market demand in the international market and to human well-being. In short, addressing domestic needs is a necessary ground for “peaceful development” and harmonious development.

Engage in product innovation and improve engineering capability

At the level of the single firm product innovation addresses new needs in the market and therefore it may be seen as an important way to make the market grow. Process innovation, on the other hand, improves the efficiency of the production process. Both types of innovations are important for the 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. It enriches the division of labor and it opens larger space 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 labor reserves and jobless growth in its most dynamic sector.

Jobless growth results partly from lack of product innovation, and partly from weak engineering capability. The weak engineering capability is reflected in the massive import of means of production such as machinery and in weak 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 that can be used by domestic firms would certainly promote endogenous innovation through the stimuli

⁹ 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 the government programs appear as part of health and space related programs, not as industrial policy.

for interaction at the core of the innovation system that it represents.

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

Building user competences and institutions supporting the competence of SME's

Since user-producer interaction is crucial for the success of innovation it is not sufficient to merely promote the competence and knowledge creation of suppliers. One important reason why the 1985 reform did not succeed in building markets for science and technology was that the potential users did not have the competence to absorb advanced knowledge. This is why the dominant pattern was vertical integration and knowledge producers going 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 the building of 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-organized initiatives with the task of diffusing technical

innovations and good organizational practice may be supported by the public sector. Such firms have the needs for non-expensive access to technological service and knowledge institutions. Especially in periods with unemployment among graduates, engineers and scientists it might be considered to give such firms public support 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 main responsibility for basic research became strongly involved in commercial activities. With the improvement of the level of competences at the level of firms, universities and public R&D-centers should redefine their roles and withdraw gradually from downstream commercial activities that are not easily combined with the search for excellency in science and technology.

Improvement of public funds management, and the 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.¹⁰ In the more global knowledge society it is important, as well, to combine that with participating in international academic communities and to expose the 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 organization

There are different forms of governance, and the degrees to which people tolerate

¹⁰ A stronger element of practical experience and a more problem oriented learning methods in 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 life-long learning to these categories. But the most important change would be coming from the increased hiring of academic personnel by the enterprises.

social gaps differ also among the rich countries. Some advanced rich countries operate with wide social gaps while others are more egalitarian. The first group includes the US and the UK 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 active part in innovation as well as in the sharing of the benefits that innovation creates.

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

Improving education and stimulating the mobility of skilled labor

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. In order to enhance user competence and facilitate interaction between users and producers, improvement of education and training is one of the basic means. Universal secondary education in poor rural areas is a way to prepare residents for participation in knowledge and skill-intensive agricultural and related activities or for becoming members of new generations of urban residents.

The education system has to be modified in terms of curricular design and pedagogical methods in order to promote the problem solving capacity of students. Increasingly interaction will depend upon experts who are both creative and co-operative. Elite education needs to be complemented with universal and life-long continuous education for the strategy of endogenous innovation and harmonious development.

But not all competences emanate from formal education and training. With rapid

change the learning that takes place at work becomes more and more important. Stimulating the diffusion of 'learning organization' practices among enterprises is fundamental both for stimulating endogenous innovation and for the on-going upgrading of skills of the workforce.

The mobility of people across organizational borders shape social connections and interaction. Enterprise employees and managers with a university educational background will be the ones that have the least difficulties to establish collaboration with researchers at universities. Therefore schemes that make it attractive to move back and forth between academia and the enterprise sector may be seen as 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 that contain tacit knowledge (Cooke and Morgan 1998). The local and regional dimension has become crucial for growth through reforms of bureaucratic decentralization. But the development toward learning regions has been less impressive. There is a need for a new incentive structure and for policy capacity building at the 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.

Social capital and endogenous innovation

In sum, endogenous innovation and harmonious development require are a new set of efforts rather different from those made in the 1980s and 1990s. It involves reforms of the institutions that support markets and make contracts trustworthy but it also involves broader social changes that support the interaction among economic agents.

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

One way to illustrate the task of promoting endogenous innovation and harmonious development is to present it in terms of four types of capital – see table 6:

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

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

Production capital can be easily produced and reproduced. The same is true for intellectual capital. But production capital loses much of its use value when natural capital is eroded - once the land and the drinking water have been polluted it is immensely expensive to clean it up. Intellectual capital is created through interactive learning and it will depend strongly on social capital. In a society, where people trust the institutions and each other and are ready to co-operate willingly also 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 a 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 makes the innovation system work smoothly.

5. Conclusion

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

These challenges and weaknesses are reflected in the new political signals giving priority to the concepts 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 the historical starting point is different than it was in 1985 but the basic perspective for reform with focus upon 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 users of technology is a key to success. Enhancing the knowledge base of strategic sectors producing process equipment and knowledge intensive business services for the market is another important element. Investing in ‘social capital’ – designing institutions so that citizens become more ready to collaborate and learn from each other is a way to promote endogenous innovation.

Many aspects of both the success and the problems that China’s experience contains are unforeseen in previous catch-up history and in existing theories. This is true for the limits for export-led development strategy, the inadequacy of manufactured export 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 means that China embarks 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 succeeds in pursuing harmonious development it will become clear that it does not represent any threat to other countries. For those who hope China to offer a unique successful experience, we need to point out that the actual process of adjustment unavoidably will involve uncertainties and setbacks. We wish that innovation studies may serve an instrumental and positive role, and certainly innovation studies can learn a lot from the transition that China will undergo in the coming years.

Literature:

- Archibugi, D. and Lundvall, B.-Å. (Eds.) 2001: *Europe in the Globalising Learning Economy*, Oxford University Press, Oxford 2001
- Baldwin, Carliss Y. and Kim B. Clark 1997: Managing in an age of modularity, *Harvard Business Review*, Sept/Oct 1997
- China Science and Technology indicator-1988 (in Chinese), Center for Science and Technology for Development of China and the Information Center, State Science and Technology Commission, 1990
- China Statistical Yearbook 2004, accessible at <http://www.stats.gov.cn/tjsj/ndsj/yb2004-c/indexch.htm>, in 2005 the China's government has adjusted statistical date. The adjustment is accessible at <http://www.stats.gov.cn/tjdt/zygg/P020060109431083446682.doc>
- China Statistical Yearbook on Science and Technology, various issues
- Cooke, Philip and Kevin Morgan 1998: Evolutionary Processes and Regional Practices in Cooke, Philip and Kevin Morgan: *The Associational Economy*, Chapter 8, Oxford University Press 1998
- David, Paul A. 2003: The Economic Logic of "Open Science" and the Balance between Private Property Rights and the Public Domain in Scientific Data and Information: A Primer, *Stanford Institute for Economic Policy Research SIEPR Discussion Paper* No. 02-30
- Dodgson, Mark, David Gann and Ammon Salter: *Think, play, Do, Technology, Innovation and Organization*, Oxford University Press 2005
- Dosi, Giovanni 1982: Technological paradigms and technological trajectories *Research Policy* 11 (1982)
- Fei, John C. and Gustav Ranis 1997: *Growth and Development From an Evolutionary Perspective*, Blackwell Publishers, Malden USA and Oxford UK, 1997
- Freeman, Chris 1987: *Technology Policy and Economic Performance: lessons from Japan*, London, Pinter, 1987
- Gereffi, Gary 1999: International Trade and Industrial Upgrading in the Apparel Commodity Chain *Journal of International Economics* 48 (1999) 37–70
- Granick, David 1967: *Soviet Metal-Fabricating and Economic Development, Practice versus Policy*, The University of Wisconsin Press, Madison, Milwaukee and London 1967
- Gu, Shulin 1999: *China's Industrial Technology, Market Reform and Organizational Change*, Routledge in association with the UNU Press, London and New York, 1999
- Gu, Shulin and Bengt-Åke Lundvall 2006: Policy learning as a key process in the transformation of the Chinese Innovation Systems, in Bengt-Åke Lundvall, Patarapong Intarakumnerd, and Jan Vang (eds): *Asian innovation systems in transition*, Edward Elgar Publishing Ltd, 2006
- Gu, Shulin and W. Edward Steinmueller 1996/2000: National Innovation Systems and the Innovative Recombination of Technological Capability in Economic Transition in China: Getting Access to the Information Revolution, *UNU/INTECH Discussion Paper* 2002-3, Maastricht
- Hanson, Philip and Keith Pavitt 1987: *The Comparative Economics of Research Development and Innovation in East and West: a Survey*, Harwood Academic Publishers, Chur, London, Paris, New York, Melbourne, 1987
- Hayami, Yujiro 1997: *Development Economics, from the Poverty to the Wealth of Nations*, Oxford

- University Press, Oxford, 1997
- Langlois, Richard N.: The Vanishing Hand: the Changing Dynamics of Industrial Capitalism, *Industrial and Corporate Change* 12(2): 351-385 (April 2003)
- ILO 2003: *Rediscovering the cooperative advantage: Poverty reduction through self-help* By Johnston Birchall, Cooperative Branch, International Labour Office, Geneva 2003
- Kline, Steven J. and Nathan Rosenberg An Overview of Innovation, in Ralph Landau and Nathan Rosenberg (eds.): *The Positive Sum Strategy, Harnessing Technology for Economic Growth*, National Academy Press, Washington, D.C. 1986
- Konai, Janos 1980: *Economics of Shortage*, North-Holland Publishing Company, 1980
- Langlois, Richard N. 2003: The Vanishing Hand: the Changing Dynamics of Industrial Capitalism, *Industrial and Corporate Change* 12(2): 351-385 (April 2003)
- Lewis, W. Arthur 1955 (ninth printing, 1970): *Theory of Economic Growth*, George Allen & Unwin Ltd, London 1955
- Lundvall, B.-Å., 2006: Interactive learning, social capital and economic performance', in Foray, D. and Kahin, B. (eds.): *Advancing Knowledge and the Knowledge Economy*, Boston, Harvard University Press.
- Lundvall, Bengt-Åke (ed.) 1992: *National Systems of Innovation*, Pinter, London 1992
- Lundvall, B.-Å 1988 Innovation as Interactive Process: From User-producer Interaction to the national System of Innovation, in Dosi, Freeman, Nelson, Silverberg and Soete (eds.) *Technical Change and Economic Theory*, Chapter 17, Pinter Publishers, London and New York, 349-69
- Lundvall, B.-Å. 1985: *Product Innovation and User-Producer Interaction*, Aalborg, Aalborg University Press.
- Lundvall, B.-Å. (1992), Explaining Inter-firm Cooperation and Innovation - Limits of the Transaction Cost Approach, in Grabher, G., (ed.), *The Embedded Firm: On the Socioeconomics of Industrial Networks*, London, Routledge.
- Lundvall, B.-Å and Johnson, B. 1994: 'The learning economy', *Journal of Industry Studies*, Vol. 1, No. 2, December 1994, 23-42
- Lundvall, B.-Å. and Borrás, S. 1998: *The Globalising Learning Economy: Implications for Innovation Policy*, Bruxelles, DG XII-TSER, the European Commission
- Maddison, Angus 1998: *Chinese Economic Performance in the Long Run*, OECD Paris 1998
- Maddison, Angus 1991: *Dynamic Forces in Capitalist Development, A long-run Comparative View* Oxford University Press, Oxford, New York, 1991
- Metcalfe, J.S. 1995: The Economic Foundations of Technology Policy: Equilibrium and Evolutionary Perspectives, in Paul Stoneman (ed.): *Handbook of the Economics of Innovation and Technological Change*, Blackwell, Oxford UK and Cambridge USA 1995: 409-512
- National Statistical Bureau 1990: *zhongguo kexue jishu sishi nian (Statistics on Science and Technology of China 1949-1989)*, zhongguo tongji chubanshe (Statistics Publishing House of China).
- Nelson, Richard R. 2004: The market economy, and the scientific commons, *Research Policy* 33 (2004) 455-471

- Nelson, Richard R. (ed.) 1993: *National Innovation Systems: A comparative analysis*, New York and Oxford, Oxford University Press, 1993
- Nelson, Richard R. and Sidney G. Winter 1982: *An Evolutionary Theory of Economic Change*, Cambridge, Mass. and London, The Belknap Press of Harvard University Press, 1982
- North, D. 1996: Organizations, institutions and market competition, *working paper*, Washington University, St Louis.
- Pasinetti, L. 1981: *Structural Change and Economic Growth*, Cambridge, Cambridge University Press
- Piñata, Mario 2005: Chapter 21 Innovation and Employment, in Fagerberg, J., D.C. Mowery and R.R. Nelson (eds.): *The Oxford Handbook of Innovation*, Oxford University Press, Oxford, New York 2005
- Qian, Y. and Weingast, B.R., 1996. China's Transition to Markets: Market-Preserving Federalism, Chinese Style, *Journal of Policy Reform*, 1 (2), 149-185.
- Richardson, G.B. 2002: The organisation of industry revisited, *Druid working paper* no. 02-15.
- Rosenberg, N. 1982: *Inside the black box: Technology and economics*, Cambridge, Cambridge University Press.
- Saich, A. 2004: *The Governance and Politics of China*, Second Edition. Palgrave Macmillan, 2004.
- Saxenian, AnnaLee 1996: Inside-Out: Regional Networks and Industrial Adaptation in Silicon Valley and Route 128, in *Cityscape: A Journal of Policy Development and Research*, 2 (2), May, 1996, 41-60
- Tomlinson, M. 2001: A new role for business services in economic growth, in Archibugi, D. and Lundvall, B.-Å. (Eds), *Europe in the Globalising Learning Economy*, Oxford University Press Oxford, 2001
- UNIDO 2002: Industrial Development Report 2002-3
- von Hippel, E. 1994: *The Source of Innovation*, Oxford University Press, Oxford 1994
- von Hippel E. and M. Tyre 1995: How learning by doing is done: Problem identification and novel process equipment, *Research Policy*, vol. 24, no. 5.
- Woolcock, M., 1998: Social capital and economic development: Toward a theoretical synthesis and policy framework, *Theory and Society*, 27 (2), 151–207
- Christensen, J.L. and Lundvall, B.-Å. (eds.) 2004: *Product Innovation, Interactive Learning and Economic Performance*, Amsterdam, Elsevier.
- Wu, Jinglian 2003: dangdai zhongguo jingji gaige (*China's Economic Reform, in Chinese*), Shanghai yuangong chubanshe (Shanghai Far East Publisher), 2003
- White Paper No. 1: State Science and Technology Commission (SSTC): *zhongguo kexue jishu zhengce zhinan 1986, kexue jishu baipishu di'yihao (Guide to China's Science and Technology Policy for 1986)*, "White Paper on Science and Technology No. 1), 1987
- Zhao Ziyang 1985: Speech to the National Working Conference of Science and Technology (6 March 1985, in White Paper No. 1: 293-297)