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TRENDS AND PROSPECTS IN CHINA'S R&D SECTOR

by

Yanrui Wu

Business School
University of Western Australia

DISCUSSION PAPER 12.16

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Yanrui Wu
UWA Business School
University of Western Australia

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Abstract: This paper presents a critical review of trends and prospects in China's research and development (R&D). Specifically it discusses the main achievements and the role of major players in China's R&D sector. It also highlights the potential challenges which Chinese policy makers have to face in the future.

Key words: China, R&D intensity, Chinese economy

Supported by a booming economy, China has made considerable progress in science and technology in recent decades (OECD 2009). In particular China has become a leading investor in research and development (R&D). If the current growth momentum is maintained, China could be transformed from the world's manufacturing powerhouse to a technological superpower (Sigurdson et al. 2005). This change would have important implications for the rest of the world, especially China's neighbours including Australia. The objective of this paper is to present a critical review of China's research and development (R&D) and hence draw policy implications for China's R&D sector in the near future.

1. Trends in China's R&D Activities

Severe environmental damages at home and an increasing awareness of global climate changes have forced policy makers to re-chart the growth course of the Chinese economy. For this purpose, China's State Council released a major policy document in 2006 to guide the country's science and technology development in the coming decades. The development goal is to make China an innovation-oriented society by the year 2020 and a world leading innovator in the longer term (State Council 2006). The new development strategy was further emphasised in China's 12th Five-Year Programme (FYP) 2011-2015. According to the official policy statement, coastal China will be transformed from the "world factory" to a R&D hub, high-end manufacturing and services (State Council 2011). The 12th

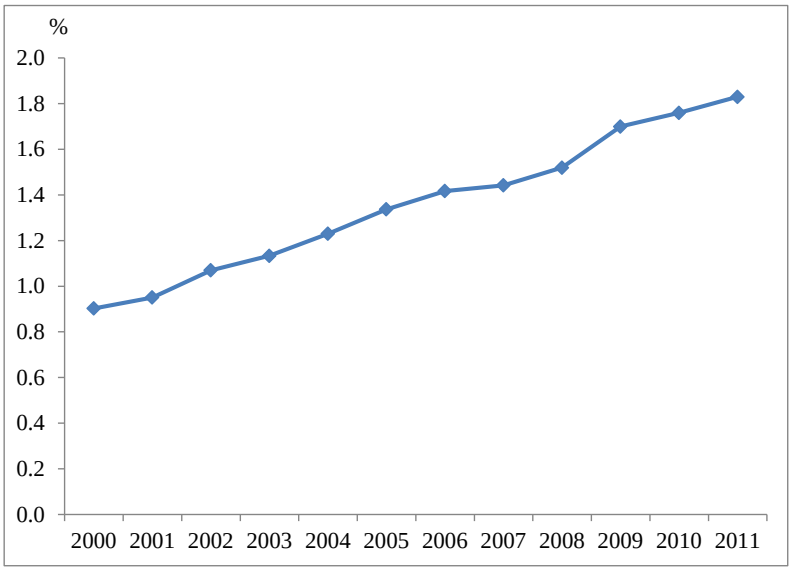
FYP designates seven strategic emerging industries (SEI) as the drivers for China's future economic development.

In fact, China's investment in R&D has maintained a steady rate of growth for decades. In recent years, this growth was boosted by the new development policies. For example, during the period 2001-2011, the average growth rate of R&D investment reached 17.8% per annum which almost doubled the growth rate of China's GDP over the same period.[1] Among the world's major spenders in R&D, China was ranked number two in 2010 with a total spending of US$178 billion, only behind that of the United States (with a total spending of US$403 billion in purchasing power parity (PPP) terms). China also has the largest R&D research team with a total of about 2.9 million full time equivalent (FTE) researchers in 2011 which was double the United States figure.[2]

R&D expenditure as a proportion of the country's GDP (i.e. R&D intensity) has risen from 0.90% in 2000 to 1.83% in 2011 as shown in Figure 1. This puts China on par with countries such as Belgium, Canada, the Netherlands and the UK. Though China's R&D intensity is still behind those of major players such as the

[1] This growth rate is based on the author's own calculation using data from the NBS (various years, 2012a).
[2] The Chinese R&D personnel data are drawn from the NBS (2012a). US R&D personnel statistics are calculated using information obtained from the OECD online database (www.oecd.org). It is noted that there may be accounting inconsistencies between the two data sources. The R&D expenditure figures are also drawn from the OECD online database.

United States (2.79%), Germany (2.82%) and Japan (3.44%), it is well ahead of other large developing economies such as India (0.80%) and Brazil (1.10%).[3] According to China's 12th FYP, the country's R&D intensity is to reach 2.20% in 2015 and 2.50% in 2020. Given the current growth trend, these targets are feasible.



Notes and sources: NBS (various years, 2012a). R&D intensity is defined as the ratio (%) of R&D expenditure over GDP.

Figure 1 R&D Intensity in China, 2000-2011

The increased effort in R&D has boosted China's innovation capacity. For example, the number of invention patents granted in China doubled during the period of 2006-2011 rising from 57,786 to 172,000 items (Table 1). In particular, the share of locally owned inventions increased significantly. Apart from the current R&D personnel, there are also about 11.4 million undergraduate students

[3] Data are drawn from YST (various years).

and 0.8 million postgraduate students who are studying sciences, engineering and medicine in Chinese universities (YST various years). Over 285,000 Chinese students are also studying overseas.[4] These students will potentially add to the pool of R&D researchers and hence further strengthen China' innovation capacity in the coming years.

Table 1 Granted Invention Patents, 2006-2011

Year	Total (pieces)	Domestic (pieces)	% of domestic over the total
2006	57786	25077	43.4
2007	67948	31945	47.0
2008	93706	46590	49.7
2009	128489	65391	50.9
2010	135110	79767	59.0
2011	172000	n.a.	n.a.

Sources: NBS (2012b, various years) and YST(various years).

2. The Role of the Business Sector in China's R&D

Associated with the expansion in China's R&D capacity is the important role of the business sector including private businesses. Since the mid-1990s, Chinese business enterprises have become the leading players in the country's R&D activities. In 1997, Chinese firms together accounted for 42.9% of the country's

[4] This number is reported in NBS (various years). It may include government-sponsored students only. In reality, there may be more than one million Chinese students studying overseas.

R&D spending. However, this figure rose to 60.3% in 2000, 68.4% in 2005 and 73.4% in 2010 (STS 2010 and 2011). It is now in line with the likes of Japan (78.5%), South Korea (75.4%), Sweden (70.5%), Switzerland (73.5%), and the United States (72.6%).[5]

The firms' increased role in R&D is also reflected in the changing share of patents applied by and granted to the enterprise sector over the national total. For example, the share of invention patent applications by firms over the national total increased from 52.7% in 2000 to 64.7% in 2005 and further to 69.2% in 2010.[6] Large and medium-sized enterprises (LMEs) – which account for 10 per cent of all firms undertake 77% of total R&D expenditure and 68% of all invention patent applications.[7]

In terms of ownership, domestic firms were responsible for about 74% of R&D expenditure in 2010 with the rest being undertaken by firms with funds from Hong Kong, Macao and Taiwan (HMT, 9 per cent) and other foreign-invested firms (17 per cent). These shares are inconsistent with the market shares of the three types of firms in the country (see Table 2). For example, foreign-invested firms,

[5] These are 2008 statistics reported in YST (various years).
[6] Those share figures are drawn from STS (various years). Chinese patents are officially classified into three categories, namely, invention, design and utility patents.
[7] The invention patent application share is based on the second National R&D Census conducted in 2010 and reported in YST (various years).

particularly those owned or controlled by investors from HMT, tend to spend proportionately less on R&D. The HMT-invested firms are highly concentrated in some areas within the Pearl River Delta region. Thus achieving growth through innovation in those areas is very challenging. In the aftermath of the US sub-prime credit crisis, those regions have been hard hit and will probably need fundamental changes in industrial policies so that innovation efforts can be boosted.

Table 2 R&D Spending Shares (%) by Ownership, 2010

Ownership	R&D spending	Employment	Profits
Domestic firms			
State	19	16	14
Private	10	17	15
Share-holding	18	10	16
Limited liability	24	19	19
Others	3	3	3
Offshore firms			
HMT	9	16	11
OECD	17	19	22

Notes and sources: The statistics in this table are calculated using information from YST (various years).

State-owned enterprises (SOEs) spend relatively more on R&D (Table 2). In contrast, domestic privately owned firms were less keen on investing in R&D activities. This situation may be the result of government policies or inherited from the pre-reform system in which SOEs were the key players. These findings were also reported in an empirical study using firm-level data by Wu (2012). The same

study also showed that a high level of liability or debt burden is detrimental to innovation and that firms with heavy debts are less likely to invest in R&D or be persistent innovators if they do invest in innovation. These firms' R&D intensity is also likely to be lower. This was also observed in other economies such as Japan (Ogawa 2007). Therefore, reducing company debt is vital for improvement in innovation.

3. R&D by Sector

There are however considerable variations across the industrial sub-sectors in the Chinese economy. The top 10 sectors with the largest R&D spending in 2010 (these sectors are listed in Table 3) accounted for about 78.9% of total R&D spending within all sectors. In particular, the top four sectors have a combined share of more than 50%. On average, these top players spend much more on R&D activities than other industrial sub-sectors. However, if the intensity is defined as the ratio of R&D spending over total revenue, three of the top spenders fall behind the industrial average. Thus there is still scope for growth in some sectors.

As expected, the top 10 sectors cover most of the so-called high technology (high-tech) industries, namely pharmaceuticals, medical equipment, computer, electronic and communication equipment, and aerospace. China has done exceptionally well in the export of high-tech products. In 2006, the country became the world's

largest exporter of high-tech products. In 2009, the value of China's high-tech exports amounted to US$348 billion which was greater than the combined value (US$284 billion) of high-tech exports from Germany and the United States, or the world's second and third largest exporters of high-tech products, respectively. In 2010, China's exports of high-tech products further increased to US$492 billion. However, about 79% of the high-tech product exports were associated with China's processing trade which is overwhelmingly dependent upon imported materials.[8]

Table 3 R&D Spending by the Top 10 Industrial Sectors

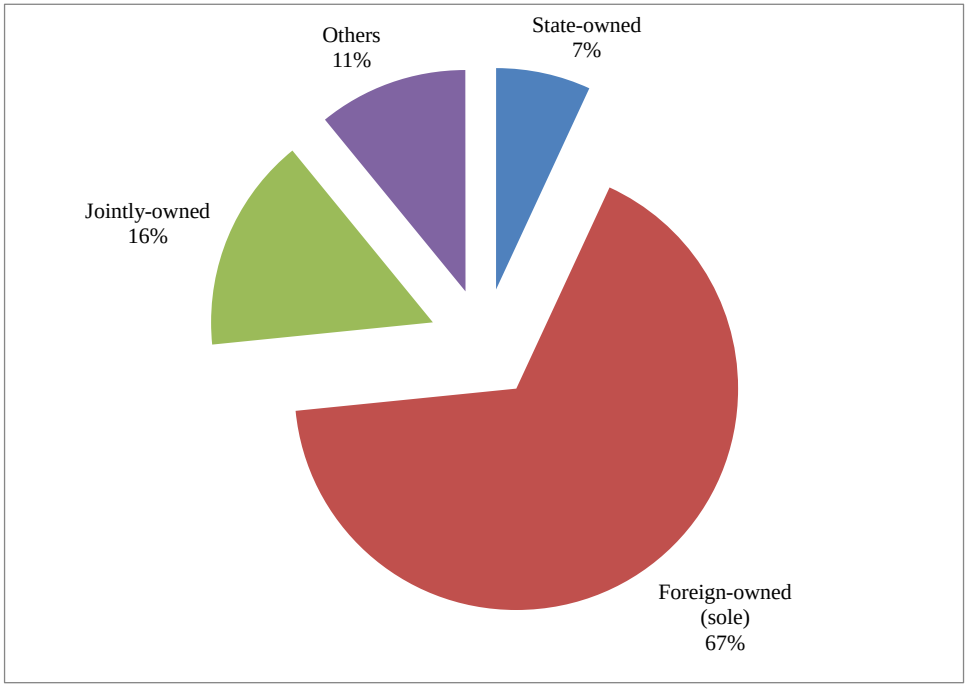
Industrial sectors	Spending shares (%)	Spending/ Profits (%)	Spending/ Revenue (%)
Computers, communication etc	17.1	27.95	1.42
Transport equipment	14.5	14.45	1.31
Electrical equipment	10.6	19.83	1.59
Ferrous metals	10.0	24.00	0.88
Chemicals	6.2	13.84	1.02
General purpose machinery	5.9	18.24	1.59
Special purpose machinery	5.8	22.23	2.04
Pharmaceuticals	3.1	14.06	1.82
Non-ferrous metals	3.0	12.36	0.68
Coal mining and washing	2.7	4.06	0.63
Sub-sector average		17.10	1.30
Overall average		11.75	0.93

Notes and sources: The statistics refer to large and medium enterprises only and are drawn from YST (various years). The "average" is the un-weighted mean of relevant groups.

[8] In this paragraph, the 2009 statistics are drawn from the World Bank (2011) and the 2010 data are sourced from MST (2011).

Furthermore, China's processing trade is dominated by foreign-invested firms. As a result, solely foreign-invested firms accounted for 67% of China's high-tech exports in 2010 with an additional 16% being exported by Sino-foreign joint ventures (Figure 2). As foreign-owned firms are minor R&D players in China, China's success in high-tech product exports is not driven by indigenous innovation. Researchers have provided further evidence at the micro level to show that China has been very successful in attracting foreign high-tech enterprises and promoting exports but the country's domestic firms are still not competitive in the high-tech product market (Fu et al. 2012). Thus it is cheap labour rather than innovation that is the key to the growth of China's high-tech product exports.

Even within the high-tech product sectors, considerable differences exist. Two sectors (electronic and communication equipment, and computers and office equipment), in particular, accounted for 71% of total R&D spending and 94% of the total value of exports in the high-tech product sectors in 2010. In addition, high-tech businesses are mainly located in the coastal areas which have a 96% share of the export value and 84% of the R&D spending in the high-tech product sectors (YST various years).



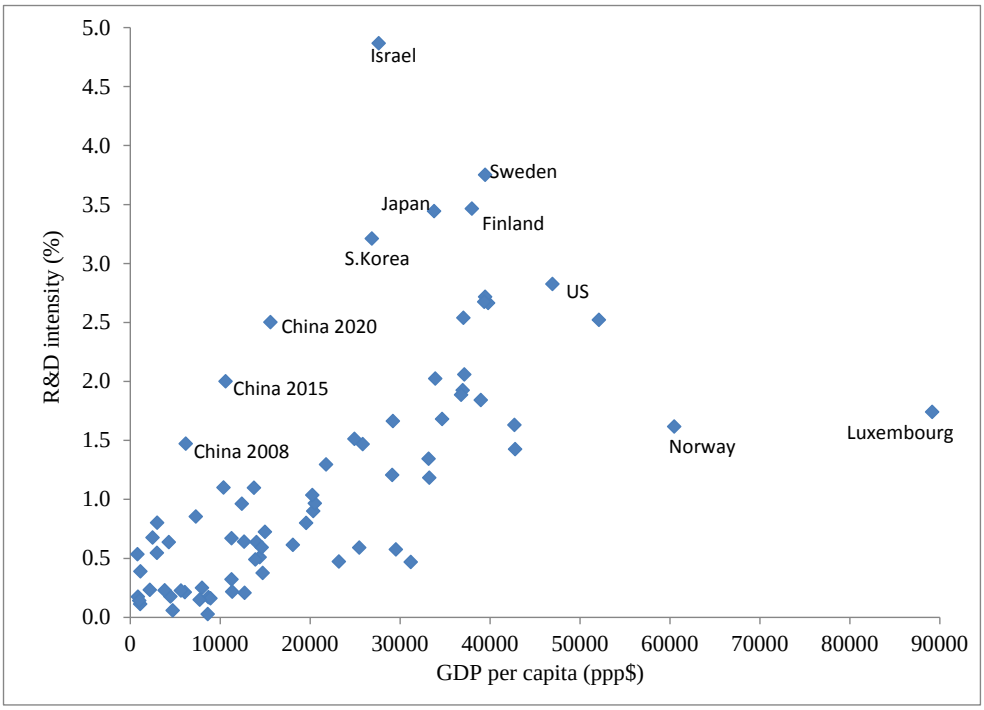
Notes and Sources: The raw data are drawn from MST (2011).

Figure 2 High-tech Product Exports by Ownership, 2010

4. Outlook and Challenges

With robust economic growth and strong government support, China's investment in R&D as well as innovation capacity is set to expand. From an international perspective, it seems that China's R&D spending pattern is to follow those of Japan and South Korea (Figure 3). Given the size of the Chinese economy, it can be anticipated that the country will become a technology leader in the world. Therefore, it can be concluded that within decades, China could become a modern

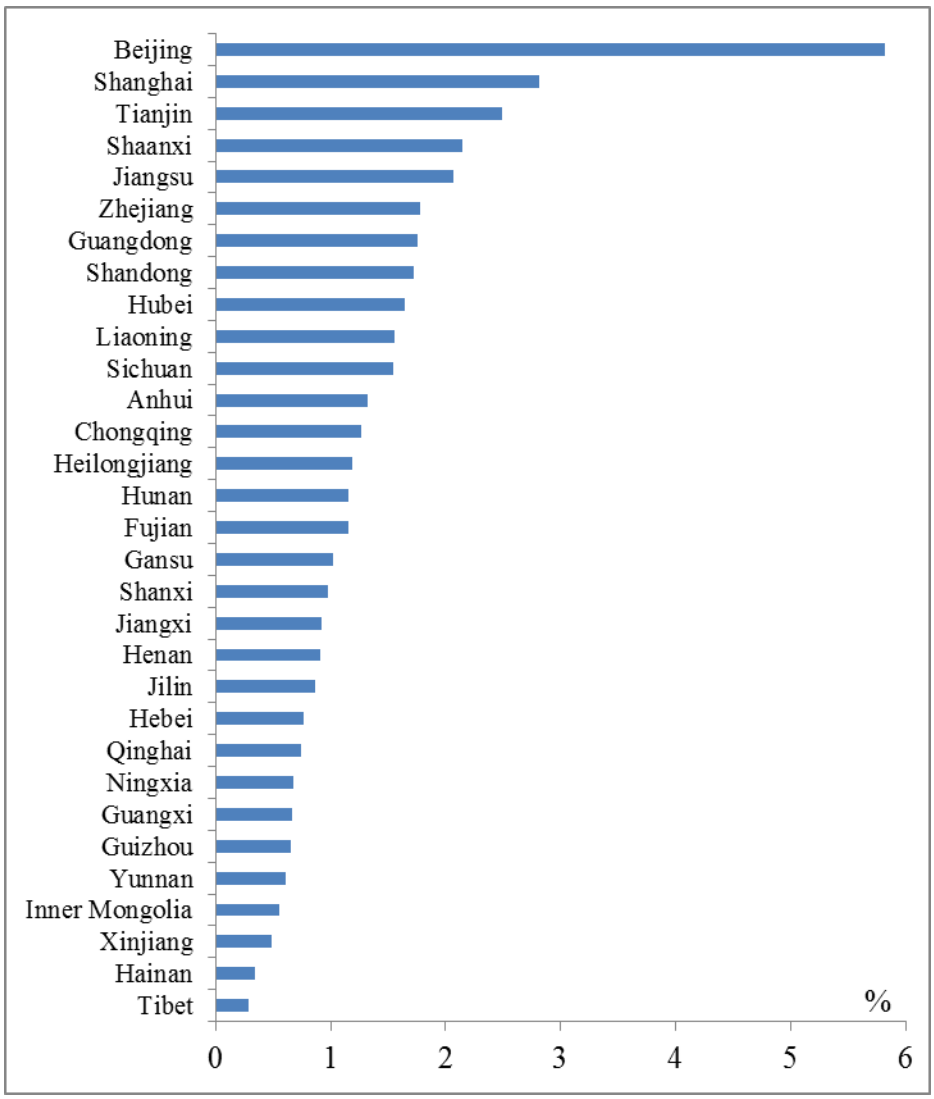
and creative high-income society as advocated in the World Bank's China 2030 Report released on 27 February 2012.



Note and source: The raw data are drawn from the World Bank (2011).

Figure 3 R&D Intensity and GDP Per Capita in Selected Economies, 2008

However, several challenges will affect the sustainability of China's current growth momentum. First, there is huge disparity across the Chinese regions. Among the 31 administrative regions in China, the R&D intensity varies from less than 0.5% in three regions to more than two per cent in five regions in 2010 (Figure 4). This gap adds to the broad regional inequality which is now a major social issue faced by policy makers in the country.



Notes and sources: R&D intensity is defined as the ratio (%) of R&D expenditure over gross regional product (GRD) which is calculated using data from NBS (various years).

Figure 4 R&D Intensity in Chinese Regions, 2010

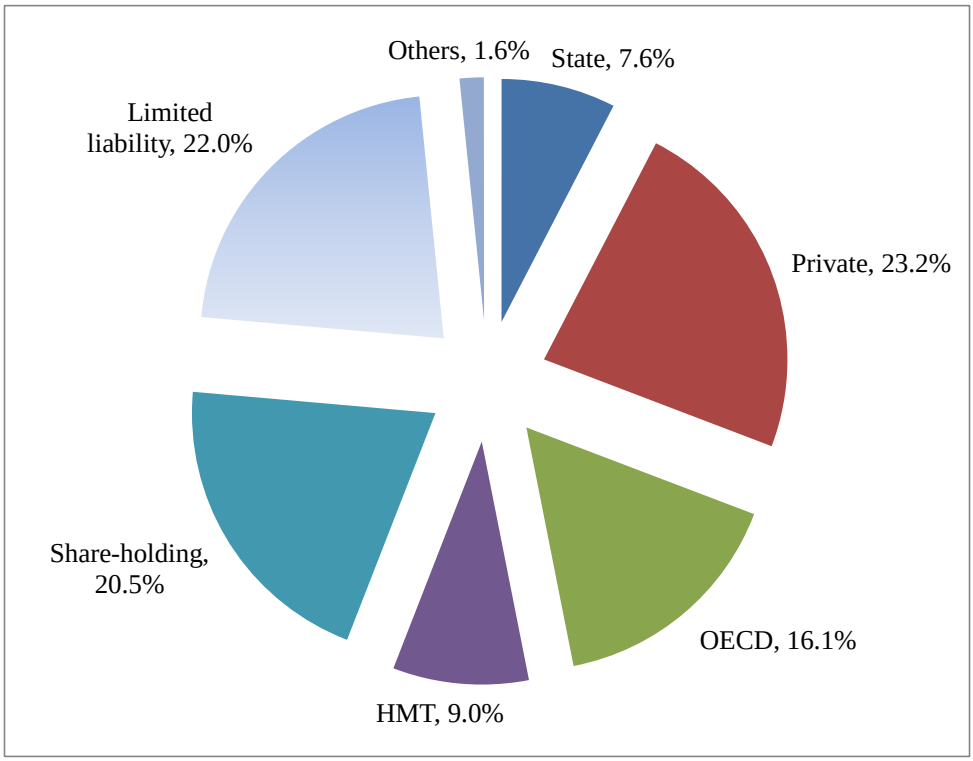
Second, the structure and hence quality of China's R&D has changed in recent years. The combined share of basic and applied research expenditure over total R&D spending declined from 32% in 1995 to 17% in 2010 while this figure is

around 50% in major developed economies (OECD 2009, YST various years). Thus, the expanded role of Chinese enterprises may have led to the rapid growth of market-driven R&D investment. The challenge ahead for policy makers is then to ensure that the market-oriented R&D activities would not grow at the expense of long-term innovation capacity building in the country.

Third, while the SOEs have invested proportionately more in R&D, it seems that their investment is less efficient. Figure 5 illustrates that private firms have the largest share of invention patent applications though their investment is relatively small (see Table 2). Therefore future policies should aim to provide more incentives for private firms and encourage them to invest more in R&D and promote efficiency improvements in the SOE sectors. This view was also expressed in the World Bank's China 2030 Report. While large and medium firms are important players in China's R&D sector, small enterprises could have the advantage of being potent and flexible in some fields of innovation, and hence should be encouraged to be more active in innovation (Tong and Zhu 2009).

Fourth, labour compensation as a proportion of total R&D costs in China was about 21% in 2007 and 24% in 2010 (YST various years). It is much lower than the OECD average of about 50% (OECD 2009). Therefore China still enjoys considerable advantage in labour costs. However, low labour compensation could

also make Chinese institutions less attractive in the internationally competitive labour market.



Notes and sources: The raw data are based on the second National R&D Census conducted in 2010 and reported in YST (various years).

Figure 5 Shares of Invention Patent Applications

Finally, the protection of intellectual property rights (IPRs) is vital for R&D activities. Though China has made rapid progress and noteworthy achievements in IPR law reforms in the past decades, foreign investors are still concerned about China's enforcement of IPR regulations and laws. The lack of protection of IPRs is detrimental to indigenous innovation too. Thus, more efforts should be made to

promote IPR knowledge and awareness in the society, and enforce the related laws and regulations stringently.

5. Conclusions

In summary, China has achieved considerably in the R&D sector in terms of investment, capacity building and outcome. Growth in this sector has been particularly strong in recent years due to the support of government policies. China's economic power continues to expand and is expected to overtake the United States to become the world's largest economy in a decade. There is no doubt that China's R&D sector will grow. There are however some challenges ahead.

The business sector dominates China's R&D field with an investment share of over 70%. This phenomenon is reshaping the structure of China's R&D activities. The challenge to policy makers is to ensure that the quality of R&D and hence long term capacity building would not be compromised due to the expansion of the market-oriented activities. SOEs are still major investors in R&D but they suffer from poor efficiency performance. The immediate concern is how to improve efficiency in the SOEs. In the long run, the role of private businesses in R&D should be strengthened. Chinese policy makers will also face challenges in

reducing regional inequality and retaining skilled R&D researchers in an internationally competitive market.

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