

**Regional Differences and Ownership Roles
in the R&D and Innovation Activities of
Chinese Industrial Enterprises**

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Regional Differences and Ownership Roles in the R&D and Innovation Activities of Chinese Industrial Enterprises*

Abstract

China is emerging as one major R&D business interest as the global R&D operations started to expand their geographic reach to selected destinations. The fast paced growth in both the domestic and foreign investment in R&D is often interpreted as China's domination in the global technological competition. This paper investigates the regional differences and ownership pattern of technology and innovation in China's industrial enterprises. Our results illustrate the increasing importance of R&D expenditures as a driving force for generating innovation in China. However, the provinces of Jiangsu, Guangdong, Shandong, Zhejiang, Anhui and Shanghai are found to dominate in the R&D expenditures, number of inventions, new product development expenditures, sales revenue and export of new product for Chinese industrial enterprises. It is also be observed that the share of domestically-owned enterprises remains prominent in the criteria like R&D expenditures, inventions, new product development, expenditure on new product development and sales revenue in China. (Words: 152)

Keywords: *Science-Technology-Innovation, Regional Variation, R&D Behavior, Ownership Status Differences, China.*

Advancements in science and technology have long been regarded as an important driver of productivity growth, whereas innovations are generally perceived as the use of technological invention in the development of new products or new process used in their manufacturing. The roles of science-technology-innovation (STI), however, remain as a key driver of economic growth in an economy that is catering to sustainable growth. It is further argued that capabilities in STI remain fundamental for the social progress, viz., health, education and infrastructure systems in developing countries. In recent years, the industrial enterprises of China have undergone massive changes in every growth and transformational indicators. According to the recent Statistical Communiqué of the People's Republic of China on the 2014 National Economic and Social Development, the size of China's high technology manufacturing has expanded constantly with rising research and development (R&D) expenditures. Along with the R&D expenditures or number of patents, indicators like the number of new products development, their sales revenue or export growth have often been highlighted to evaluate the STI performances in China. These developments have led to substantial improvements in the innovation capacity and expanding exports of new products from China. The previous empirical analysis has clearly emphasized on the

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improving performance and capabilities of research and innovation in China over the recent past (Bruche 2009).

The Chinese economy is further characterized by considerable regional variations, such as between the coastal and inland or between the eastern and western provinces. It is often claimed that there are great differences in the formulation, implementation and developments of STI policies in the country. However, very few studies have so far been conducted to determine the nature and extent of differences in the R&D expenditures and patents development across the Chinese provinces. Finally, the Chinese government has also encouraged foreign R&D investment in China by offering a range of preferential policies that include tax rebates, construction loans, access to modern facilities and other incentives. In that connection, the behavioral pattern of foreign funded industrial enterprises vis-à-vis the domestic funded companies has assumed crucial importance in the respect of China's STI developments.

In this background, the objective of this paper is set to examine the aspects of R&D and new product development (innovation) in the Chinese industrial enterprises. We focus on the provincial differences in the R&D and innovation of the Chinese industrial enterprises, and subsequently study the relative performances of enterprises funded by domestic vis-à-vis foreign entities in this respect. The expenditure on R&D, number of R&D projects and number of patent applications are generally considered as standardized indicators of the technology improvements in an industry. On the other hand, the number, sales revenue and exports of new developed products have remained as common measures of industrial innovation. The basic data on the relevant variables for our analysis are derived from the recent information that is provided by the National Bureau of Statistics, China. The plan for the rest of the paper is as follows. We discuss the recent trends in R&D and innovation activities of Chinese industrial enterprises in section 2. Section 3 examines issues on the differences in R&D expenditures and patent development in industrial enterprises across the Chinese provinces. In section 4, we discuss general aspects on the STI behavior of domestic and foreign entities in China. The analyses of our results on the provincial as well as ownership differences are included in section 5. The final section summarizes the findings and infers policy implications.

R&D and Innovation Activities of Chinese Industrial Enterprises

The science and technological developments held a very crucial role in the economic development of People's Republic of China since the beginning of the economic reforms in the late 1970s (OECD 2007; Benner et al. 2012, Liu et al 2017). Subsequently, China made impressive progress to turn its image from imitator to world-leading innovator in manufacturing and established itself as a trendsetter in emerging industries. Several important STI programs were created in China during the mid' 80s, such as the State Key Lab program for laboratories in

1984 supported by the Ministry of Science and Technology, the high-technology research program oriented towards export, the Torch program initiated in 1988 for the establishment of technological parks or the foundation of Natural Science Foundation of China in 1986 (Campbell 2015). The fact that STI remains vital for the Chinese economic development is reflected in the rapid increase of its R&D expenditures (Table 1). The expenditure on R&D grew many times in between the years between 2004 and 2016. The percentage of enterprises having R&D activities or the number of R&D institutions also reveals impressive growth during the same time span. The expenditure on new product development or the number of inventions in force for the industrial enterprises also grew within a small time span. These results convincingly illustrate the increasing importance of R&D expenditures as a driving force for generating innovation in China.

Today, China is recognized as a high technology country perusing aggressive policies for acquiring technically superior foreign enterprises. Further, the Chinese government has invested heavily in science and technology with a policy of indigenous innovation to develop new products and services. The R&D operations have increasingly been relocated from public research institutes to firms in state and non-state sectors to increase China’s general scope of industrial R&D and to contribute to the economy’s technological sovereignty (Liu 2009). In addition, the government has provided substantial funding, in particular to inventive high-technology firms which are supposed to become main drivers of China’s technological trajectory. The rise of China’s STI capabilities can be perceived from the global distribution of industrial R&D expenditures, number of patents or new product development during the recent time period.

Table 1: Summary Statistics: STI Activities of Chinese Industrial Enterprises.

| Year | R&D Expenditure (100 million Yuan) | Percentage of Enterprises having R&D Activities | Number of R&D Institutions | Expenditure on New Product Development (100 million Yuan) | Number of Inventions in Force |
|------|------------------------------------|---|----------------------------|---|-------------------------------|
| 2004 | 1104.5 | 6.2 | 17555 | 965.7 | 30315 |
| 2009 | 3775.7 | 8.5 | 29879 | 4482.0 | 118245 |
| 2014 | 9254.3 | 16.9 | 57199 | 10123 | 448885 |
| 2015 | 10013.9 | 19.2 | 62954 | 10270.8 | 573765 |
| 2016 | 10944.7 | 23.0 | 72963 | 11766.3 | 769847 |

Note: Derived from National Bureau of Statistics, China data.

Regional Differences

The regional disparity in China attracted a considerable amount of attention whereby the literature has identified the existence of strong geographical patterns in inequality in the country.

It is maintained that the east coast has gained momentum from the decentralization of regional policies in China that aimed for prioritizing development in certain provinces of China. As part of its economic reforms and opening-up policy during 1980-1984, China established Special Economic Zones (SEZs) in Shantou, Shenzhen, and Zhuhai in Guangdong province and Xiamen in Fujian province and designated the entire island province of Hainan as SEZ. In 1984, China opened 14 other coastal cities to overseas investment. Beginning in 1985, the central government expanded the coastal area by establishing the following open economic zones surrounding Beijing, Tianjin, Shandong and Guangxi. In 1990, the Chinese government opened the Pudong New Zone in Shanghai to overseas investment. Since 1992, 15 free-trade zones, 32 state-level economic and technological development zones, and 53 new and high-tech industrial development zones have been established in large and medium-sized cities. The formation of SEZ, where foreign and domestic trade and investment can be conducted without the authorization of the Chinese central government, generated an economic management system in specific provinces that is more attractive for foreign and domestic firms to do business in comparison to the rest of mainland China. It facilitated the market liberalization and boosted its exporting sectors by attracting the foreign direct investments (FDI) into those regions.

The previous analysis on the subject of STI activities in China have found that the growth in R&D activities has mainly been driven by technological factors, high human resource aspects or market factors. Accordingly, the role of provincial governments in the Chinese STI policy has assumed importance as the spending on R&D programs mostly took place at the subnational level (Springut et al. 2011). Using a panel data-set from 31 regions, Yang and Khalil (2015) have found that the R&D manpower and investments, stock of students at higher education level, and public education expenditure can significantly explain the variations in cross-regional innovation output of China. The provincial governments in China have been raising the R&D investments and increased the spending share in GDP to achieve higher regional growth rates. As a result, provinces like Guangdong, Beijing, Shanghai, Jiangsu or Shandong emerged as preferred destinations for R&D investments (both domestic and foreign) for varied reasons. The previous studies have also focused on the roles of provincial government's innovations policies for identifying the regional disparities in STI activities. While the Shanghai province has already become one of the most concentrated centers of foreign R&D in China, provinces like Jiangsu, Guangdong, Shandong or Zhejiang are soon becoming the

new centers of foreign R&D investments. While most of the foreign R&D in China has adapted to function according to the local markets, they also cater to a larger global market. It therefore follows that the the research and knowledge creating capacities of the provincial governments determined the innovation development at the regional level. The provincial governments also implemented several policies to improve higher education and fundamental research levels and to strengthen knowledge creation capability.

Ownership Differences

Given that firms are driven by different motives for foreign investment, they often pursue more than one goal while getting engaged in foreign R&D investments. The literature has so far provided various hypotheses on the technological behavior of multinational companies. That is, the firms may undertake foreign R&D investments for technology sourcing, viz., to profit from the knowledge that is available at specific foreign locations. On the other hand, the R&D internationalization hypothesis views firm's R&D activities as attempt to accessing local talent at lower costs. The globalization of R&D has made rapid progress among the top multinational corporations. A first important regional or country level driver for the R&D internationalization decisions is the income per capita income and market size of the host country. The size of the Chinese market has remained a strong factor behind the company decisions to extend their R&D operations in the country. The emergence of a skilled workforce and the quality of education systems in the host country has also been found to be an important attractor of foreign R&D (Thursby and Thursby 2006, European Commission 2010). The foreign companies therefore strategically positioned the R&D activities to take advantage of the skilled scientists and engineers and also cheap labor and production costs in China. Thus, the large and increasingly sophisticated talent pool remained as another reason behind the rapid expansion of R&D outfits in the country. It has been observed that several foreign firms run their R&D operations in China based on the locally hired manpower that works cheaper with a better understanding of local tastes and preferences. Several companies took the advantages of hiring the *haigui* (persons who pursued higher education abroad and came back to work in China). In fact, the objective of refocusing research institutions and improve their quality in China were taken up by reversing the brain drain and make the returnees fill the research labs of transnational corporations. On the other hand, the State Council launched the National Plan for Science and Technology Talent Development (2010-20) with the objective of strengthening the domestic component of talent for R&D in various economic sectors.

A major explanation for the expanding foreign investment opportunities in China lies in the country's growing demand for consumption-related products and services. On the other hand, the free trade deals with partner countries or the

market channels created by the Belt and Road Initiative also helped the consolidation of research and innovation hubs in China. The policies of the host country or the region also shape the R&D internationalization decisions of firms. It may be pointed out that the Chinese government launched a series of initiatives over the past few years to foster and support R&D programs in the country. Thus, while other economies use the non-discriminative tax regime, the Chinese government offers preferential tax rates for R&D activities. The tax incentive measures that are used to attract more foreign R&D to China are based on a variety of channels, viz., R&D super deduction, value-added tax, etc. In addition to the tax incentive programs, other programs such as, High and New Technology Enterprise (HNTE) status, Technology Advanced Service Enterprise (TASE) program or Strategic and Emerging Industries (SEI) program were initiated to promote innovation for both domestic and foreign enterprises.

Results

The provincial shares of R&D expenditures in the Chinese industrial enterprises during 2016 are provided in Figure 1. It can be observed that the provinces of Jiangsu, Guangdong, Shandong, Zhejiang and Shanghai occupy the top five positions in the R&D expenditures of the country. The converged nature of R&D expenditures is also evident in the fact that the five provinces together constitute more than 55 per cent of the total R&D expenditures of China. Further, the provincial shares of Jiangsu, Guangdong and Shandong remain much ahead of the other provinces. In Figure 2, we provide information on the provincial shares of number of inventions in Chinese industrial enterprises, where it can be witnessed that Guangdong, Jiangsu, Shandong, Anhui and Zhejiang held the top five positions in the number of inventions. It is also noticed that Guangdong alone represented about one-third of the inventions, and the combined share of the three provinces Guangdong, Jiangsu and Shandong formed more than half of the national inventions in industrial enterprises.

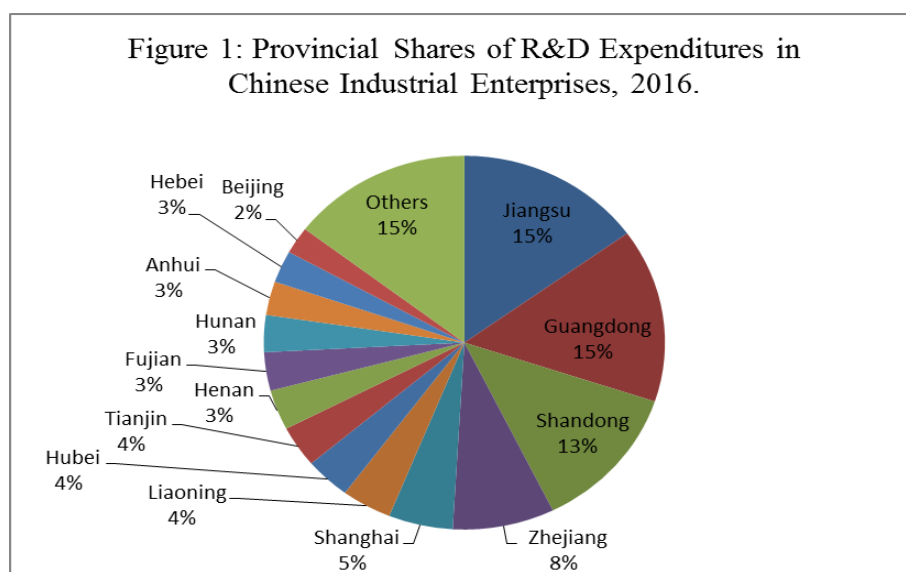
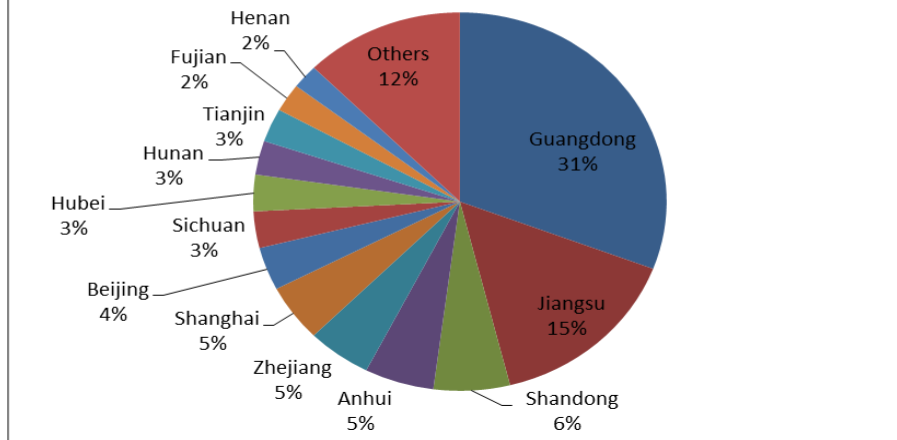


Figure 2: Provincial Shares of Number of Inventions in Chinese Industrial Enterprises, 2016.



The provincial shares of new product development expenditures in Chinese industrial enterprises during 2016 are forwarded in Figure 3. It can be noticed that the provinces of Guangdong, Jiangsu, Shandong, Zhejiang and Shanghai dominate in the top five positions and together constitute more than 60 per cent of the new product development expenditures in the country. Further, the dominance of Guangdong, Jiangsu and Shandong remains prominent so that these three provinces constitute almost half of the new product development expenditures of the Chinese industrial enterprises. In Figure 4, the evidence on the provincial shares of sales revenue from new products in Chinese industrial enterprises are furnished, and it can be seen that Guangdong, Jiangsu, Zhejiang, Shandong and Shanghai maintain the top five positions in the shares of sales revenue from new products. The congregated character of the industrial enterprise's sales revenue from new products is well supported by the data that indicates a share of 58 percent for these five provinces in China. Further, it is just the two provinces of Guangdong and Jiangsu that together represented almost one-third of the industrial enterprise's sales revenue from new products in the nation.

Figure 3: Provincial Shares of New Product Development Expenditures in Chinese Industrial Enterprises, 2016.

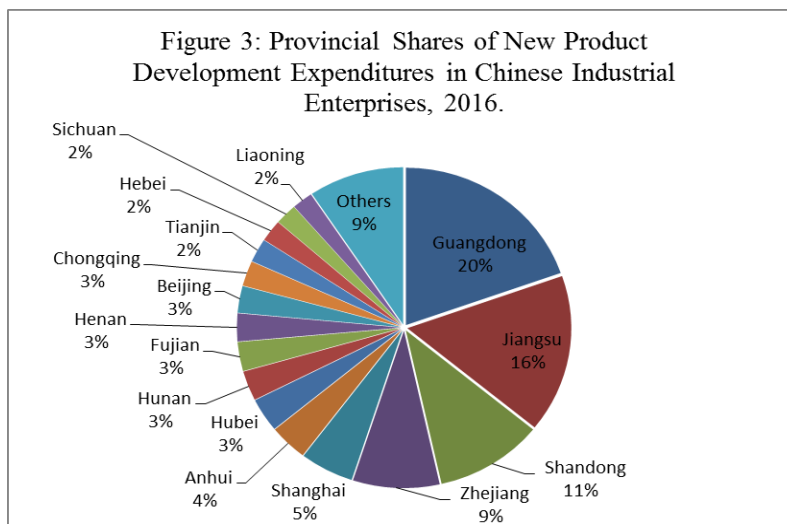
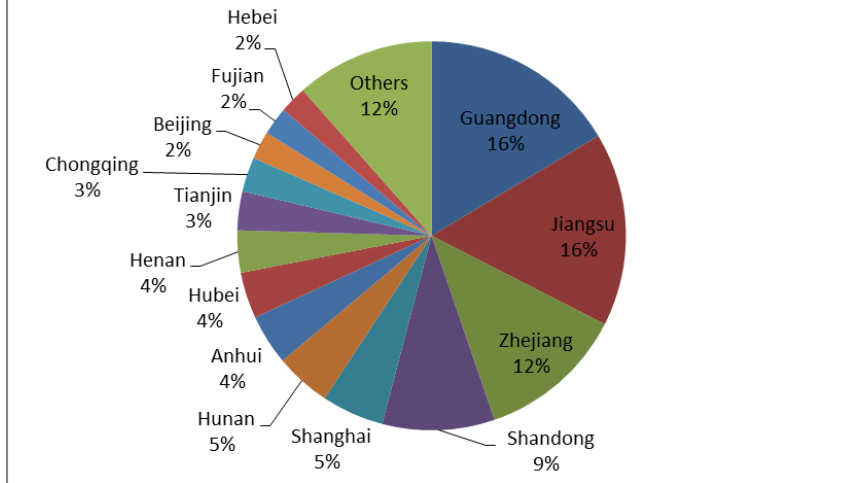
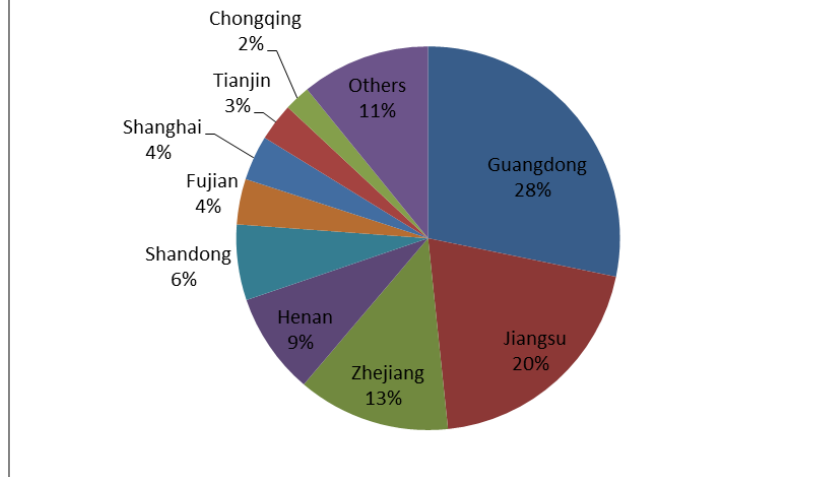


Figure 4: Provincial Shares of Sales Revenue from New Products in Chinese Industrial Enterprises, 2016.



Successively, Figure 5 illustrates the provincial shares of new product exports of industrial enterprises in the nation, where it can be perceived that Guangdong, Jiangsu, Zhejiang, Henan and Shandong retained the top five positions in the exports of new industrial product in China. The strengthening of the new industrial product export from China can be easily detected in the provincial shares that show a combined share of almost 75 percent for these five provinces in China. Further, the two provinces of Guangdong and Jiangsu occupied almost half of the national export of new industrial products.

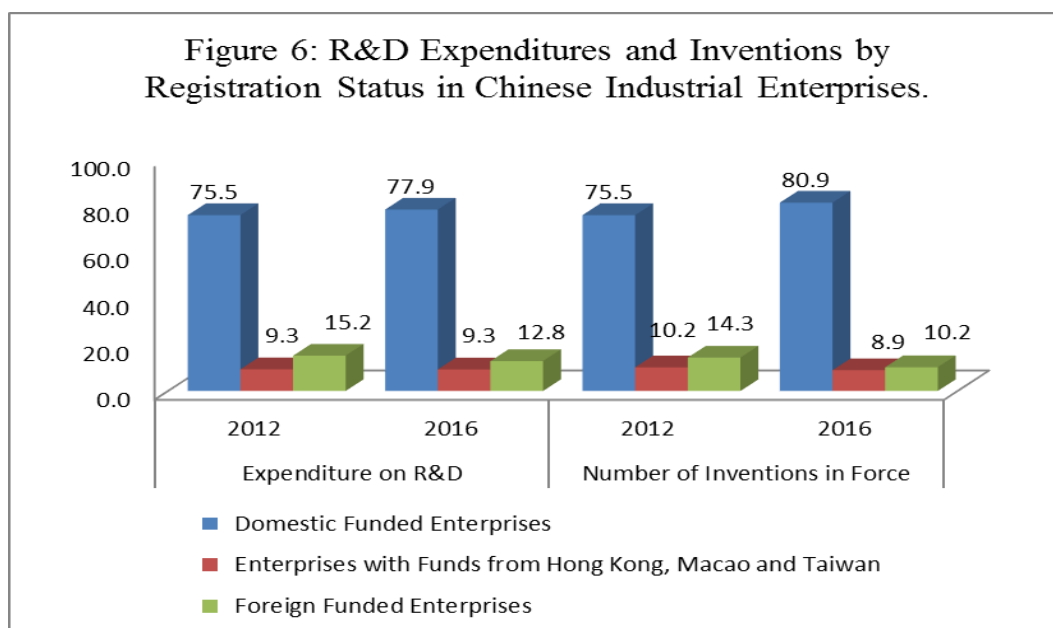
Figure 5: Provincial Shares of New Product Exports in Chinese Industrial Enterprises, 2016.

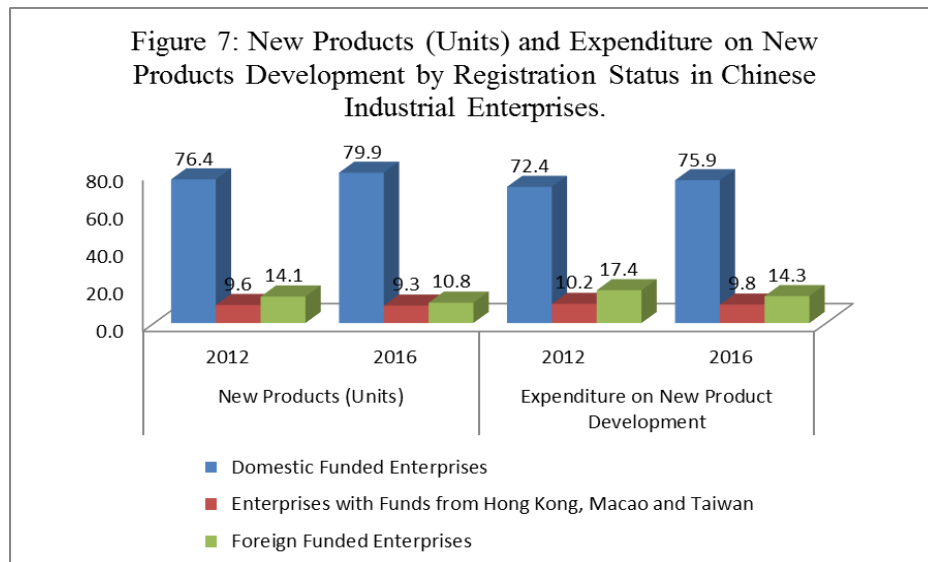


Consequently, we also analyze the STI behavior of Chinese industrial enterprises, when they are segregated over ownership of three types, viz., domestic funded enterprises, foreign funded enterprises and enterprises funded by Hong Kong, Taiwan and Macau (HTM). The previous research has also pointed out that geographical proximity between the host and home country leads to higher levels of cross-border R&D investments. It may be noted that Taiwan and Hong Kong

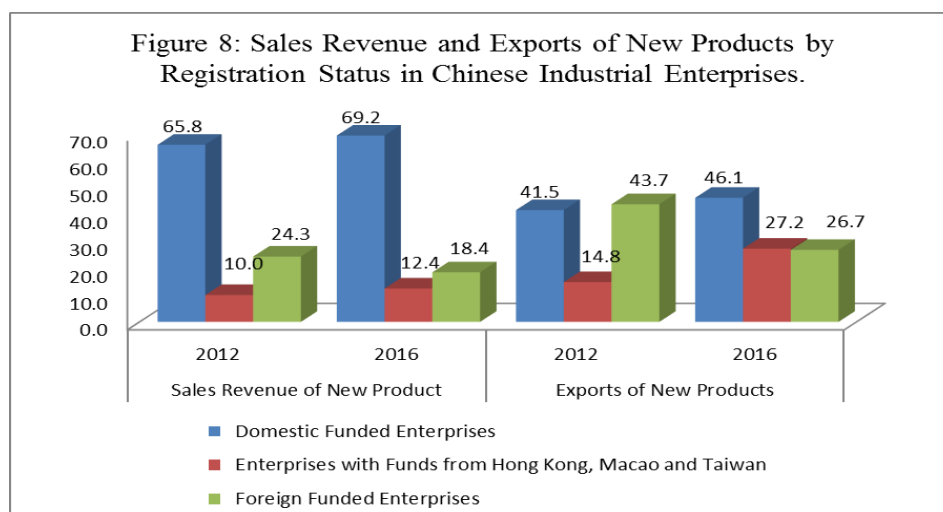
accumulated a substantial stock of direct investment in the mainland during the 1980s, thereby making China as the largest recipient of the FDI outside the OECD area. According to Chinese statistics, the United States and Japan remained the other two major investors in China.

In Figure 6, we have provided information on the R&D expenditure and number of new products for the three different ownership types (or registration status) of Chinese industrial enterprises during the years 2012 and 2016. It can be observed that the share of domestically owned enterprises remained prominent, i.e., almost three-fourths of the total R&D expenditures in the Chinese industrial enterprises. Furthermore, the share of domestically owned enterprises can be found to have increased at the cost of foreign funded enterprises in between the years 2012 and 2016, while the share of HTM funded enterprises remained unchanged during the same period. As concerns the number of inventions, it can be seen that the share of domestically owned enterprises remained about three-fourths of the total number of inventions in the industrial enterprises of China. Moreover, the share of domestically owned enterprises in industrial inventions can be found to have increased at the cost of both foreign and HTM funded enterprises during the years between 2012 and 2016. The information on the number of new products developed as well as the expenditures on new products development are furnished for the three different ownership types of industrial enterprises in Figure 7. It can be noticed that the share of domestically owned enterprises remained almost three-fourths of the total number of new products developed as well as the expenditures on new products development in Chinese industrial enterprises. Further, while the share of domestically owned enterprises can be found to have increased, the share of foreign funded enterprises in both the new product development and associated expenditures declined during the years between 2012 and 2016.





Finally, figure 8 provides data on the sales revenue and exports of new products by the registration status in between the years 2012 and 2016. It can be witnessed that the firms with domestic registration comprised the major share of total sales revenue and exports of Chinese industrial enterprises. Further, the share of domestically owned and HTM funded enterprises can be found to have increased at the cost of foreign funded enterprises in the sales revenue of new products from 2012 to 2016. The share of domestically owned enterprises also increased in the export of new products during this period. However, while the share of HTM funded enterprises can be found to have registered an impressive rise in the export of new products, the same for the foreign funded enterprises actually declined sharply during the same period. Overall, it can be observed that the share of domestic industrial enterprises remains very prominent in the criteria like R&D expenditures, inventions, new product development, expenditure on new product development and sales revenue in China. It is only in the case of export of new products that the shares of firms with domestic, foreign and HTM registration status remained somewhat evenly distributed, although firms with domestic registration dominate in the share.



Conclusions

Along with the opening of markets and economic reform of the 1990s that brought a period of sustained economic growth in the People's Republic of China, the country has correspondingly begun to assume its influential role in the globalization of research and development activities. The previous analyses have claimed that the vast domestic market and the growing export market, as well as its large pool of skilled labor are the major drivers for R&D progress in China. According to the recent PRC communiqués, the government carried the intention to encourage foreign R&D investment in China, particularly in information technology-related industries, by offering a range of preferential policies that include tax rebates, construction loans, access to modern facilities, and other incentives. The government also used the attraction of China's enormous market-size to influence the technology transfer from abroad. These policies reflected the government's shift towards incentivizing research and innovation in certain industries where the government desired to see greater innovation. At the present day, the Chinese scientific and technological development is surging forward at a remarkable rate, and a comprehensive national innovation strategy was taken up in 2016 for turning the country into an S&T powerhouse by 2050 (Cao and Suttmeier 2017). In this backdrop, this paper had the objective of examining the provincial geography as well as ownership pattern of STI activities in the Chinese industrial enterprises.

Our results reveal that China has considerably increased its research and innovation capability as reflected in the significant rise of its R&D expenditures and efforts. However, the provinces of Jiangsu, Guangdong, Shandong, Zhejiang, Anhui and Shanghai dominate in the R&D expenditures, number of inventions, new product development expenditures, sales revenue from new products and export of new product from the Chinese industrial enterprises. It is also observed that the share of domestically owned enterprises remained prominent in the total R&D expenditures, number of inventions, number of new products developed, expenditures on new products development, sales revenue and exports of new products in the Chinese industrial segment. It is only in the case of export of new products that the shares of firms with domestic, foreign and HTM registration status remained somewhat evenly distributed, although firms with domestic registration dominated in the share.

The innovative capacities of Chinese companies are high as they are continuously designing new products to fill the consumer needs with better products and services. A study by McKinsey & Company (2015) has argued that China has the potential to absorb and adapt the global technologies and knowledge and evolve into an innovation leader. It in fact claims that the China effect on innovation will be felt around the world in the next ten years the as more companies use China as a location for low-cost and rapid innovation. Our results pointed out that the

foreign firms contributed lesser R&D resource than China's domestic enterprises, which may implicate that foreign R&D activities remained more active in the high-technology industries and not in the labor intensive industries. As China is shifting its focus to attract more foreign investment in high-end manufacturing and environment-friendly products, the multinational companies have made additional investments to set up research and service-based businesses for the Chinese market. A proper understanding of the STI's nature and activities and a careful evaluation on the ownership pattern of domestic versus foreign funded research and innovations in Chinese industrial enterprises could help the policymakers devising appropriate policies that can serve both the international relations and economic interests for China.

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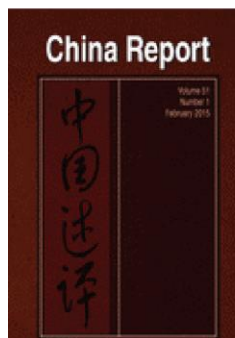


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