Industrial Policies and Innovation: Evidence from the Chinese Automotive and Electronics Industries

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Abstract

In this study, we explore how various forms of industrial policies such as government subsidies, state ownership and Special Economic Zones (SEZ) affect financial constraints and innovation at the firm level in two strategically important industries in China, namely the automotive and the electronics industries. We perform empirical analyses using a sample of 492 listed firms from 2006 to 2014. At the same time, we conduct 22 interviews of entrepreneurs, managers, government officials and venture capitalists to add qualitative insight to our analysis. We show that government subsidies play a key role in reducing financial constraints and promoting innovation. However, compared with state-owned enterprises, private firms are more efficient at utilizing subsidies to engage in R&D and invest more proportionately on innovation. In addition, we provide strong evidence that firms located in the SEZ enjoy the premium of regional clustering, are less financially constrained and more effective in innovation. Our findings contain rich policy implication and shed new light on the current debate on industrial policies as well as institutional reforms in China.

JEL classification: O31, O32, O47

Keywords: Subsidies, Industrial Policy, State Ownership, Special Economic Zones, Clustering.

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1. Introduction

Previous studies have examined how financial market developments affect technological innovation (see Hsu et al. (2014) and the references therein). At the same time, the investment in innovations such as Research and Development (R&D) expenses is riddled with asymmetric information problems and lack of collateral value due to the uncertainty involved in R&D activities, which make R&D more susceptible to financing frictions than other investments (Hall, 1992; and Brown et al., 2012). Hence government policies that subsidize commercial R&D are capable of providing low-cost capital to release the financial constraints of high technology firms and certifying firms to private investors as well as addressing the informational asymmetries by knowledgeable government officials (Lerner, 1999).

Empirical studies in the literature generally report a positive correlation between government R&D funding and private R&D effort. In practice, a number of government-industry technology programs are reputed to have had a positive and significant effect on technical progress, economic growth and knowledge spillovers (Rosenberg and Nelson, 1994; Lerner, 1999; Wallsten, 2001; Feldman and Kelley, 2006; and Girma et al., 2007). Nevertheless, there is a predominant focus on the experiences of developed markets on whether government subsidies stimulate innovation, including Wallsten (2001), Stein (2003), and Brown et al. (2012).

Relatively few studies evaluate how financing financial constraints or frictions affect R&D in developing countries that have different institutional structures (Cull et al., 2015). The issue of financial friction is more severe in developing countries due to their under-developed equity market, opaque financial reporting practice, and heavy government involvement in the allocation of resources. These features render financing constraints a more severe hurdle to technology innovation in developing markets (Sadidharan et al., 2015), and allow academic studies in these markets to adopt a rather different perspective compared with those focusing on developed economies.

As the most significant emerging economy, China has attracted notable research interest due to its unprecedented economic growth in the past three decades. China's innovation system has undergone considerable changes in this period of time and its innovation performance has improved remarkably. However, the R&D expenditure as a share of value added remains relatively low compared with other countries (Guariglia and Liu, 2014). In addition, credit allocation in China has been characterized by government intervention and biased towards state-owned enterprises (SOEs) with private firms having to face more severe financial constraints in innovation activities than those in developed countries (Guariglia and Liu, 2014; Cull et al., 2015). To help firms overcome financial constraints in R&D investment and, in particular, to encourage firms to adopt new technologies, China's government has funded R&D activities in some strategic industries.

Despite economists' interest in the interactions between the government and firms in China, the public subsidization of high technology Chinese firms has attracted little scrutiny in the literature. Our study aims to fill in the gap. In our study, we focus on two technology-sensitive industries, namely the automotive industry and the electronics industry, and explore how the relationship between government subsidies and R&D is affected by the presence of firm heterogeneity in ownership structure and location. We select these two industries because both manufacture products consisting of large numbers of different parts and components requiring long supply chains (Motohashi and Yuan, 2010), and both are strategically important to the national economic growth and have been on the receiving ends of heavy government subsidies and support (He and Mu, 2012).

Before and during the process of undertaking the statistical analyses, we engage in a number of interviews of people with expertise on this issue to gain a better understanding of the linkages between government subsidies, state ownership, firm location, and innovation. With a sample of 492 firms over a recent sample period from 2006 to 2014, as well as 22 interviews conducted in 2014 and 2015, our study contributes to the literature in a number of important ways. Our first contribution is to show that government subsidies play a key role in reducing firm financial constraints and stimulating innovative activities at firm level, as the subsidy variable is consistently positive and highly significant across model specifications and in the presence of other controlling variables. At the same time, we provide strong evidence that, although government subsidies is a key factor in promoting R&D, there is a clear difference between firms with different ownership structure in terms of how well the subsidies are taken advantage of.

In particular, we find that for SOEs, the dummy variable which takes the value of 1 should a firm be a local SOE or a central SOE, is significantly negative in eight out of nine model specifications. The negative sign indicates that being SOEs reduces proportional R&D expenditure given other variables and shows that this particular ownership structure exerts a negative impact on the relation between financial constraints and R&D activities. At the same time, when a firm is private, the dummy variable for ownership is consistently positive and significant at the 1% level. This indicates that being a private enterprise is instrumental to firm R&D effort. We also show that the electronics industry, which mainly consists of private enterprises, invest significantly more, in proportion to their size, in innovation compared with their automotive industry implying a strongly willingness to engage in R&D activities.

This interesting pattern has significant policy implication. It suggests that while government subsidies are very important in helping firms develop their innovation and fulfill economic growth potential, the way that subsidies are allocated needs to be carefully planned. As Shleifer (1998) has comprehensively argued, the top priority for government is to maximize social welfare. Government subsidies are intended for a number of social and political objectives in addition to profit maximization. These include promoting export competiveness, production efficiency, employment, and social welfare (Lee et al., 2014). For SOEs, subsidies may be spent in some of these areas instead of or in addition to innovative activities. As the same time, private firms are more efficient and ambitious in taking advantage of government subsidies and engage more aggressively in innovation for growth and profit maximization. The implication for policy makers is that, if innovation and economic growth is their prime objective, private firms are a better choice for granting subsidies.

Our second contribution is derived from firm location and clustering differences. We show that locating a firm in the SEZ adds an additional significant premium in terms of increased innovation and reduced financial constraints. We observe that in terms of firm location, for the automotive industry major firms are scattered around the central and eastern areas of China (see Appendix A for a summary, as well as Authors' interviews in Appendix B). Less geographic concentration in the automotive industry with a large share of state ownership reflects stronger local government protection of this industry (Bai et al., 2008; Authors' interviews No. 1, 2, 3, 15, and 21). In contrast, for the electronics industry, most firms are clustered in eastern China, and among them many are located in the Special Economic Zones (SEZs), areas set up by the government with favorable economic and taxation policies for innovation and networking which ultimately lead to economic growth (Authors' interviews No. 7, 8, 11 and 19). The regional clustering in the electronics industry is likely to benefit from a "cluster premium" due to favorable knowledge generation and diffusion, production, demand conditions, and public R&D subsidization policies (Broekel et al., 2015). Given that the two industries are evidently different from each other in this respect, we separate the full sample by industry and find that the electronics industry clearly benefits from regional clustering with better utilization of public subsidies and reduced financial constraints.

Our findings shed new light on the perennial issue of how government sets its policies for the promotion of innovative activities and economic growth. Our findings suggest that it is imperative that China focus on maximizing the revenues from the more efficient and effective management of its SOEs to achieve the long-run economic benefits to consumers and society. They also suggest that regional clustering, which the electronics industry has taken advantage of and contributes significantly to its current cutting-edge technology capability, can be promoted and adopted in other technology-sensitive sectors including the automotive industry. To facilitate innovation and knowledge diffusion, policies aiming at reducing market fragmentation and local protectionism and promoting national collaborative RD activities need to be better supported. Our results are highly relevant to the current debate that China is having on institutional reform. We argue that it is imperative that the government pay more attention to creating an institutional environment, as well as establish the legal and regulatory framework, that supports private and competitive industries.

The remainder of the paper is structured as follows. Section 2 describes the background of the two strategically important industries under scrutiny in this paper. Section 3 reviews relevant literature, describes interview results, and develops working hypotheses. Section 4 construct economic variables, summarizes data and outlines methodology. In Section 5, we analyze empirical results and discuss their economic significance and policy implications. Finally, Section 6 concludes.

2. Industry background

In our study, we focus on two priority industries that have been on the receiving ends of substantial government support, namely the automotive industry and the electronics industry (He and Mu, 2012; Authors' interviews in Appendix B). It is accepted that China enjoys significant comparative and competitive advantage in both industries, at least in terms of production (Authors' interviews No. 7, 9, 15 and 21). It is fueled in part by massive domestic investment and outsourcing to China by western firms, and benefits from significant economies of scale. On the one hand, these two manufacturing industries offer similar opportunities for domestic firms to advance because technologies were relatively mature and domestic markets are huge and rapidly growing, but domestic firms have only succeeded and rapidly narrowed the gap with multinational in electronics industry (Thun, 2006; Brandt and Thun, 2016; Authors' Interviews No. 1 and 21). On the other, differences in capital requirements, financial constraints, market segmentation of these two industries allow us to identify the key challenges in each sector, and evaluate the role of government subsidies and other industrial policies in shaping the innovation outcomes.

A dynamic automotive industry has been regarded as a key component in industrial achievements in many countries for most of the 20th century, and the industrial ascendancy of a few developed economies have been associated with the growth of large and successful automotive industries. Not surprisingly, China's policy makers are keen to promote automotive industry to achieve rapid industrialization. This is evidenced by the publication of three official industrial policy statements (1994, 2004, and 2009) for the sector within a fifteen year period (Brandt and Thun, 2016). In 1956, the First Automotive Works (FAW) was established and two years later FAW produced its first passenger cars named Hongqi (Red Flag), which were designed for and used by high-ranking government officials. Also in 1958, the Shanghai Automotive Assembly Plant (Shanghai Auto) produced the Phoenix model passenger car; and in 1969, the Second Automotive Works (later renamed Dongfeng) produced the Dongfeng model in 1969. Over time, other automotive companies were also established (Qiu, 2005). However, until about 1975 there was virtually no passenger car production in China, and cars were the privilege of a very small number of high-ranking officials. In total, less than 2000 cars were made in China in the mid-1970s and only some 3000 in the early 1980s, and as late as 2002, the "big three" – FAW, Shanghai Auto, and Dongfeng – contributed to 67% share of the market (Brandt and Thun, 2016).

In 1994, the Chinese government designated a number of industries as 'Pillar Industries' intended to drive the national economy, and the automotive industry was chosen as one of them (Holweg et al., 2008). The automotive industry is related to many other industries including metallurgy, petroleum, chemistry, coal, light industry, electronics and textiles (Authors' interviews No. 14 and 18) as an automobile is composed of more than 10,000 parts and components. Thus, the development of the automotive industry is able to encourage Chinese enterprises in other sectors to specialize and better coordinate their effort. To speed up the development, the Chinese government intervenes extensively, relying on a range of policy instruments, which include the ownership structure of the enterprise system, including direct state ownership and accommodations to FDI, and tax subsidies (Du et al, 2014). China made extensive use of foreign direct investment (FDI) based on the strategy of "trading market access for technology" since 1978 (He and Mu, 2012). Key international joint ventures (IJV) have been established, including the Beijing Jeep in cooperation with AMC/Chrysler

Corporation in 1984, the Shanghai FAW Volkswagen in 1985, the Wuhan Dongfeng Citroen in 1992, the Chongqing Chang'an Ford Mazda in 2001, and the Guangzhou Peugeot in 2002. In 1987, the government's auto industry development plan started to promote concentrations in the industrial structure to reach efficient scales and international standards and, as a result, preferential policies were granted to those big car manufacturers (Qiu, 2005). These IJV were at the center of China's "trading market access for technology" strategy for its passenger vehicle sector (Nam, 2011). Cooperation with foreign automakers helped to bring in capital and relevant technology, but also led to overdependence on foreign technology and inadequate capacity and incentive for independent innovations (Brandt and Thun, 2016; Lu, 2006; He and Mu, 2012; Authors' interviews No. 1, 4, and 21).

For historical and social reasons, until the late 1990s, the automotive industry had seen a strong emphasis on state-owned enterprises (SOEs), whereby the controlling domestic shareholder is the government or government-affiliated units (Authors' interviews No. 1, 2, 3, and 21). By establishing JVs with all the major domestic SOE automakers and controlling branding, design and key technologies, private car manufacturers had been discouraged from the automotive industry and this effectively eliminated domestic competition for most of the last thirty years (Authors' interviews No 1, 2, 3, 5, 8, 9 and 12 in Appendix B). Since the late 1990s, the government started to encourage private investors to enter this industry and Chinese automakers started to design, produce, and market independent brands. To face the challenges emerging in the automotive industry after China's entry to WTO, the National Development and Reform Commission (NDRC) released the New Automotive Industry Policy. The new policy intended to encourage self-reliant product development and local brand development, to encourage independent R&D and production on a large scale for key components and parts, and to foster local suppliers and their international operations (Holweg et al., 2008). The emerging new star in the China's automotive industry, Chery, began with an investment of only 25 million US dollars in 2001 but since then has become the representative of China's self-branded car makers (He and Mu, 2012).

China’s electronics industry was also established from the 1950s. China’s first semiconductor was made as early as 1956, and the Chinese Academy of Science, China’s premiere state lab, built the country’s first integrated circuit (IC) in 1964, only seven years after IC was invented in the Bell Lab in United States (Simon, 1996). Nevertheless political turbulence during the Cultural Revolution disrupted research and development in this industry. When the country reorganized for technological catch-up in the late 1970s, the technological gap between China and the industrialized world had considerably widened (Authors’ interviews No. 4 and 12).

Since the market open-up policy in 1978, China has placed strategic importance on reforming and modernizing its electronics sector. Under the leadership of former Premier Zhu Rongji, the government was fully committed to making this sector an integral part to its national strategic objectives. Furthermore, policies are designed in such a way that direct government involvement in the industry is reduced and government’s role as regulatory authority is strengthened. Accordingly, the electronics industry in China has achieved a comparatively rapid growth and massive technological catch-up during the last thirty years (He and Mu, 2012), while huge differences persist in automotive industry, and appear to be widening (Brandt and Thun, 2016). The advancement in electronics technology is presently among the driving forces of China’s staggering globalization and the rapid growth of the Chinese economy. Notable examples include the following: In 2012, Huawei has overtaken Ericsson to become the world’s largest supplier of telecommunications equipment; in the PC market, the top PC maker in China is Lianxiang with the Lenovo brand; in the color TV market, the market share of domestic brands exceeded that of foreign brands in 1996 with the largest market shares claimed by indigenous manufacturers such as Changhong, TCL and Konka (He and Mu, 2012; Authors’ interviews No. 10 and 13).

Policy initiatives promoting the automotive and electronics industries have been a core of national development strategies in China (Authors’ interviews No. 12 and 22). In particular, to promote technological innovation and achieve national strategic interests, government subsidization is widely provided to companies in these two sectors. The top priorities for government subsidies are in export promotion, technology innovation, large investment projects, support to enable firms to pursue social objectives, and support for ailing firms and job protection (Lee et al., 2014; Authors' interviews No. 5 and 12). The subsidies can be financial, such as the tax rebates and R&D subsidies, or policy-based, such as land preferential policies (Authors' interviews No. 21 and 22).

More recently, a key policy focus is on the structural optimization of the innovation system. For example, during the "Eleventh five-year" period from 2006 and 2010, the Ministry of Science and Technology has added the field of modern transport technology to the "863 Program" and classified new energy vehicles as a major project for subsidization. These include financial support for R&D activities in environmentally friendly automobiles and new energy automobiles, subsidies to public transport service firms that purchase these environmentally friendly automobiles, and to firms that improve the infrastructure to utilize new energy vehicles. To speed up the industrial upgrades and the transformation from traditional to environmentally friendly vehicles, 1.03 billion RMB were provided to auto manufacturers by the end of 2007, and in 2008 an extra 0.3 billion RMB were added. The government subsidies have helped to stimulate the innovation activities in new energy vehicles and successfully fostered a range of new cutting edge technologies (Authors' interviews No. 11, 15 and 21).

3. Literature review and hypotheses development

There is a large and growing literature on the relation between innovative activities, financial constraints, government subsidies, firm ownership and locality. In China, subsidies from the government are an important resource for firms (Lee et al, 2014). To gain a better understanding of the impact of Chinese government subsidies policy and to motivate our hypotheses for the large sample econometric analyses, we carried out 22 interviews of people familiar with this issue (see Appendix B for the list). We discuss the literature review and interview results, as well as the research hypotheses, in this section.

3.1 Innovation and financial constraints

A growing literature is interested in the link between financial constraints and innovation, and the empirical results are rather mixed. A number of studies have assessed the impact of financing constraints on innovative firms in developed economies, including the US, the UK, France, Germany, and Japan. They typically utilize firm-level data and investigate the sensitivity of R&D spending with respect to cash flow and argue that a financially constrained R&D-intensive firm is more likely to suspend and/or discontinue its R&D projects. In an early study, Hall (1992) examines US firms during the sample period from 1973 to 1987 via a dynamic accelerator model and reports a significantly positive relation between R&D expenses and cash flow. More recently, a similar relationship is identified in Himmelberg and Petersen (1994) using a panel of 179 small high-tech companies in the US. Additional empirical support is obtained in Ireland (Lerner and Wulf, 2007) and the Netherlands (Tiwari et al., 2007). Brown and Petersen (2009) point out that the sensitivity of investing cash flow varies over time and tends to stay relatively strong for R&D spending while Brown and Petersen (2011) utilize data in the manufacturing sector in the US from 1970 to 2006 and focus on the relationship between currency holdings and R&D smoothing. They show that when firms are under financing constraints, they prefer to rely on cash reserves rather than R&D investments smoothing.

On the other hand, there is also evidence that individual firms' innovative activities are not subject to financial constraints. For instance, Bhagat and Welch (1995) explore the relationship between operating cash flow and R&D expenditure in developed countries including the US, Canada, Japan, and a number of European countries. They show that the two factors are not significantly correlated. Similarly, Bond et al. (2003) adopt an Error Correction model and argue that for firms in Germany and the UK, cash flow is not essential for R&D investments.

While most of the existing literature focuses on developed markets, the study of Guariglia and Liu (2014) is amongst the first to investigate this relationship in China, a relatively under-research market given its unprecedented economic growth in the past few decades. They explore the extent to which financing constraints affect innovation activities of 120,000 mainly unlisted Chinese firms over the period from 2000 to 2007. Their results indicate that Chinese firms' innovative activities are constrained by the availability of internal finance and this is especially true for private firms which suffer the most from financial constraints, followed by foreign firms, while state-owned and collective enterprises are the least constrained. Related, Cull et al. (2015) also concentrate on the Chinese market and the severity of financial constraints faced by Chinese firms. It examines the role of government connections in reducing financial constraints. Consistent with common reception of this market, the paper indicates that well-connected firms are associated with substantially less severe financial constraints, and that the sensitivity of investment to internal cash flows is higher for firms that report greater obstacles to obtaining external funds.

3.2 Innovation and government subsidies

As the global economy evolves towards a knowledge-based economy driven by rapidly changing technologies and innovation, governments around the world have adopted policy initiatives to improve firms' access to financing and technology infrastructure, and to provide them with regulatory, legal and financial service conducive to entrepreneurship, innovation and growth (Authors' interviews No. 10 and 11). Thus in many countries, industrial policies become an important tool to support development and technology innovation. The elements constituting industrial policy typically include: (1) subsidies; (2) tariff policy, preferential tax treatment, and other forms of protection; (3) the ownership structure of the enterprise system, including direct state ownership and accommodations to FDI; (4) economic planning at the national level; (5) man-power policy broadly defined; (6) regional policy; (7) government procurement policy; and (8) policies regarding research, development and technical training; (9) special economic zone or high technology park, and so on (Carlsson, 1983; Liu et al., 2011; Du et al., 2014; Authors' interviews No. 5, and 12).

It is well established that public sectors of all industrialized countries spend massive amount of budget to subsidize commercial R&D in manufacturing firms (Gonzalez, et al., 2005; Authors' Interview No. 5). Colombo et al. (2013) analyze the effect of public subsidies on firm investment and investment–cash flow sensitivity in a longitudinal sample of 288 Italian unlisted non-venture capital backed owner-managed new-technology-based firms (NTBFs) over a 15-year period from 1994 to 2008. They report indications of reduced financial constraints after receipt of the first public subsidy and support the view that public subsidies can help small NTBFs substantially reduce the financial constraints that bind their investment activity. Meuleman and Maeseneire (2012) argue that knowledgeable government officials may certify firms to private financiers by spending sizeable sums of public money on R&D grants to alleviate debt and equity gaps for small firms' innovation projects. Using a unique Belgian dataset of 1107 approved requests and a control group of denied requests for a specific type of R&D grant, they examine the impact of subsidies on small firms' access to external equity, short term and long term debt financing, and show that obtaining an R&D subsidy sends a positive signal about SME quality and results in better access to long-term debt.

Given the evidence in the literature and interviews of utilizing financial support policies as incentive for firms to engage in innovation activities, either indirectly through tax incentives or directly through subsidies, and given the strategic importance of the automotive and the electronics industries, heavily subsidized, in promoting economic growth in China (Authors' interviews No. 5, 6, 12 and 22), we hypothesize that government subsidies play an important role in relieving financial constraints and promoting innovation in these two industries.

Hypothesis 1. Government subsidies are a key factor in helping reduce financial constraints and promote innovation in the automotive and electronics industries.

3.3 Innovation and state ownership

There is a massive and still growing literature, both theoretical and empirical, that explores the relationship between corporate governance and firm innovative activities. Belloc (2012) offers a recent literature review that explicitly examines the three main channels – corporate ownership, corporate finance, and labour – through which a system of governance affects innovative activities. From a slightly different angle, Ticha (2012) surveys empirical literature on corporate ownership and firm performance captured by profitability, productivity, investment, cost effectiveness, and so forth.

In an influential article by Boardman and Vining (1989), the performance of the 500 large US and European non-industrial enterprises, predominantly private with some state-owned and mixed enterprises, is examined. This comprehensive empirical study suggests that after controlling for a variety of factors, private enterprises perform significantly better than mixed or state-owned enterprises and argues that government's agenda in promoting social and political goals surpasses that in profit maximization.

There is also widespread academic and policy research interest in ownership and firm performance in transition economies like China. Many Chinese firms are distinguished from their East Asian counterparts in terms of the government connections that they enjoy, as they have dominant state ownership and well-focused business domain (Lee and Kang, 2010; Authors' interviews No. 11, 12 and 22). Adopting a detailed categorization of ownership, Choi et al. (2010) empirically test the relation between ownership and firm innovation performance of 548 Chinese firms. The paper shows that the volume of patent registration is most strongly influenced by foreign ownership or affiliation within a business group. Interestingly, the influence of state and institutional ownership on innovative performance is positive but lagged, implying that the state ownership may not be direct factor in promoting innovation but rather a positive signal in providing business and financial connections and offering protection in a relatively weak legal environment.

The Chinese SOEs enjoy privilege in the access to finance and other resources and are springboard for managers to become bureaucrats (Authors' interviews No. 12, 21, and 22). On average, Chinese SOEs receive more subsidies relative to private firms (Lee et al, 2014), but the profitability of SOEs is less affected by the extent of subsidies (Authors' interviews No. 5, 21 and 22). It is widely accepted that there is a close relation between the spheres of SOEs and state administration (Du and Mickiewicz, 2016), and the management of SOEs cares more about their managerial positions and political interests than technology innovation (Authors' Interview No. 11). SOEs can rely on direct links with and influence from the government more easily, particularly in the relatively weak institutional environment of China. Thus subsidies from the government are shared as rents by managers and workers who do not need to be involved heavily in innovation activities (Du and Mickiewicz, 2016; Authors' interviews No. 11 and 22).

This is contrary to private firms, whose primary objective is profit maximization and the fundamental way to achieve this is to engage in R&D to raise productivity and gain comparative advantages (Authors' interviews No. 1 and 21). The private sector has been regarded as an essential driver of sustainable economic development and growth in a knowledge-based economy. Private firms appear to be better at capturing the benefits of networking for innovation. The economic rationale for R&D subsidies to the private sector is widely accepted that when the level of privately financed R&D in the economy is lower than socially desirable, the public funding is able to reduce the price for private investors so that the otherwise too expensive innovation projects are carried out (Hud and Hussinger, 2015; Authors' interviews No. 5 and 21).

In China, for private firms to qualify for subsidies, their research and development expenses must exceed a certain threshold, or their products must be within the high technology fields as stipulated in official guidelines (Lee et al., 2014). Although one of key factors that influences whether private firms receive subsidies is the personal connections (or guanxi) between entrepreneurs and officials, some studies and interviewees confirm that subsidies are positively related to firm value (Lee et al., 2014; Authors interviews No. 5, 12 and 21). Hence, if government chooses to subsidize R&D projects of innovating private companies, the creation of new innovations leading to economic growth is much easier to foster. We therefore hypothesize that compared with SOEs, private firms are better at utilizing subsidies in promoting innovative activities. In addition, because the electronics industry is predominantly consist of private enterprises whereas the automotive industry is mainly consist of SOEs and IJVs (Authors' interviews No. 5 and 21), we hypothesize that the electronics industry invests more in R&D to achieve profit maximization compared with the automotive industry.

H2a. Private firms are better at utilizing subsidies in promoting R&D compared with their state-owned counterparts.

H2b. The electronics industry that is dominated by private firms invests more in R&D than the automotive industry that is dominated by SOEs and IJVs.

3.4 Innovation and regional specialization

Both the automotive and the electronics industries benefit from the "trading market access for technology" strategy in the 1980's. Despite massive government subsidies and preferential policies, however, there are clear differences in terms of technological capability and independent innovation of indigenous Chinese firms between these two industries (He and Mu, 2012; Brandt and Thun, 2016). There are two notable efforts in the literature that rationalize the differences between China's automotive and electronics industries. Lee, Cho, and Jin (2009) adopt a sectorial system of innovation (SSI) framework to analyze the technological catch-up by the Chinese automotive and the mobile phone industries with reference to the technology catch-up in South Korea. Emphasis has been placed on the regime of technologies and knowledge. Related, He and Mu (2012) utilize a revised model of Lee and Lim (2001) in describing firm technological learning and catch-up. They conclude that different market demand, different level of competitiveness on the supply side, and the predominant form of firm ownership structure all directly contribute to the disparity in technological capabilities that exist between the two industries today. In a recent article and from a policy point of view, Brandt and Thun (2016) analyze how government policies in China shape the growth and segmentation of markets and thus the opportunities for industrial upgrading.

Extending the above literature, many of our interviewees argue that market fragmentation and local government protectionism play a significant role in demotivating innovative effort. There is plenty of anecdotal evidence of how government agencies of different provinces protect local IJVs and SOEs and shield them from competing with other automotive companies outside the region (Authors' interviews No. 1, 11, and 21). The market fragmentation is very severe and local governments adopt many trade barriers to hamper other auto manufacturers to enter the local markets as a result of fiscal decentralization and local government wishing to protect its tax base (Bai et al., 2014; Authors' interviews No. 12, 13, 14, 15, 18 and 21).

In contrast, regional distribution of the electronics industry has been increasingly concentrated in the eastern coastal area and by 2004, the eastern part of China had accounted for 94% of the added value of the electronics industry, which reveals a strengthened trend of clustering in the industry, and allows cooperators and competitors locating densely in an area to take advantage of the linkage and spillover effects (Zhao, et al., 2007).

In the literature, there is ample evidence in favour of geographical concentration of firms. Notable examples include Feldman and Florida (1994) which argues that innovation increasingly depends on a geographically defined infrastructure that is capable of mobilizing technical resources, knowledge, and other inputs essential to the innovation process; and Florida and Kenney (1988) conclude that innovation is a product of the underlying social structure and innovation is geographically based. Krugman (1991) also agrees that the regional specialization of industrial activity is an important facet of advanced industrial economies.

One way to benefit from such regional specialization is to set up Special Economic Zones (SEZ), contained geographic regions within a country with more liberal laws and economic policies to encourage domestic- or foreign-invested manufacturing and services for export (Arol, 2013; Wang, 2013). In many countries, they serve as policy means for facilitating trade and financial liberalization, enhancing resource utilization, and promoting economic growth and structure changes (Ge, 1999; Chaudhuri and Yabuuchi, 2010). Such programs have proven to contain great policy relevance as well as offered significant and positive effect on the local economy (Wang, 2013).

In the late 1970s, China's State Council approved small-scale SEZ experiments in four remote southern cities: Shenzhen, Zhuhai and Shantou in Guangdong Province, and Xiamen in Fujian Province. Those SEZs are considered a test base for liberalization of trade, tax and other policies nationwide. The SEZ program generates significant agglomeration economies and increases the technological progress (Wang, 2013;

Authors' interviews No. 7 and 8), and clusters of specialized firms. The infrastructure of China's SEZ consists of sources of knowledge: networks of firms that provide expertise and technical knowledge; concentrations of R&D and skilled researchers and workers that enhance opportunities for innovation by providing knowledge of new scientific discoveries and applications; and business services with expertise in product positioning and intricacies of new product commercialization. At the micro level, the central and local governments use VAT returns, fiscal subsidies, tax incentives and innovation awards to subsidize firms and innovation financing such as venture capital investments is more advanced in the SEZ (Zhang et al., 2014; Authors' interviews No. 5, 12, 21 and 22).

The geographic distribution of product innovations of some manufacturing industries, including the electronics industry, is highly concentrated in China's SEZs (Authors' interviews No. 7 and 8). For instance, Shenzhen has grown into a hub for the telecommunications industry and is headquarter for telecommunications giants such as Huawei, ZTE, and Tencent. In contrast, the spatial dimension of a well-functioning automotive manufacturing and sales market within China is far from satisfactory (Authors' interviews No. 21 and 22). The regional distribution of automotive manufacturers shows few major automotive makers are located in the same provinces (see Appendix A), and China is far from realizing the benefits of its potentially large domestic market for auto manufacturing (Authors' interviews No. 9 17, 18, and 21). Therefore firms in the electronics industry benefit more from SEZ programs than those in auto industry that are scattered in many provinces (Authors' interview No. 7, 8 and 11). Thus we hypothesize:

H3a. Being located in the SEZ yields a premium of regional clustering that makes firms less financially constrained in innovative activities.

H3b. Compared with the automotive industry that suffers from market fragmentation and local protectionism, the electronics industry benefits more from the SEZ programs and engage more efficiently in innovative activities.

4. Data and Methodology

Our data sample contains all firms in the automotive and the electronics industries listed in the Shanghai and the Shenzhen stock exchanges. Most of our quantitative data come from two widely used data vendors in China, namely the Wind Information Co. Ltd and the GTA Information Co. Ltd. Some data, such as firm location, are hand-picked from company annual reports. We use both interim and annual reports to collect data hence the data are semi-annual in frequency. The sample period is from 2006 to 2014.

Additional information on the development of the automotive and electronics industries was collected from interviews to supplement quantitative data. This is particularly helpful for us to understand the mechanism linking financial constraints, government subsidies, and firm location with innovation activities of Chinese companies. Oral testimony is obtained through 22 formal and informal interviews with entrepreneurs, senior managers of companies in the automotive and electronics industries, venture capitalists and government officials, which provide new details as well as narratives of how financial constraints and government subsidies impact the R&D expenses and innovation activities in these two industries in China. Two rounds of interviews were conducted in 2014 and 2015. During the first round from July 2014 and June 2015, we interviewed nine company owners or senior managers, four venture capitalists in related industries and two government officials. We used open-ended questions to gain understanding of the impact of government subsidies on financial constraints and innovation activities.

To obtain more substantive insights into the interactions between financial constraints, government subsidies, location and innovation, we conducted a second round of interviews from September to December 2015 during which we interviewed seven new informants: five owners or senior managers of related companies, one venture capitalist and one government official. We designed our interview protocol to focus on questions regarding the link between innovation and financial activities. All interviews lasted between one to three hours and were conducted in Chinese. Informants were assured of anonymity. Appendix B provides the list of interviewees.

As the current literature suggests different measures of innovation (see, for example, Guariglia and Liu, 2014), we follow Brown et al. (2013) in choosing our innovation proxies as R&D intensity, measured by the firm R&D expenditure scaled by the book value of total assets. Five proxies of financial constraints are used: age, ROE, cash flow, long-term debt, the White and Wu (2006) index (hereafter WW index) and the SA index proposed in Hadlock and Pierce (2010). The first financial constraints measure, age, was the number of years since the firm was listed. Hadlock and Pierce (2010) suggest that age is one of the most significant variables reflecting the existence of financial constraints. A stable stream of cash flow is one of the most important requirements for obtaining bank loans. Therefore, we consider cash flow, defined as the firm cash flow scaled by the book value of total assets, as another financial constraint measure. Our last two financial constraints proxies are the SA index and the WW index. A reasonable concern for using these two as the proxies for financial constraints is their straightforward intuition and easy implementation. Government subsidies refer to R&D subsidies at firm level scaled by the book value of total asset. The definitions of all variables in our empirical analyses and robustness checks are summarized in Appendices C and D.

In Table 1, we provide a breakdown of the distribution of firms in our sample according to industry, ownership, and location. In Panel A, we group firms according to their industries. Out of the 492 firms in the sample, according to the classification in Wind, we divide the automotive industry into automotive and auto part with a total 104 firms, and software and services, hardware manufacturing, and semiconductor and telecommunications under the umbrella of the electronic and telecom industry with a total of 388 firms. In Panel B, we observe that within the 104 automotive firms, 45 are central or local SOEs while 54 are privately owned, showing an almost equal split between these two ownership structures. On the other hand, for the electronics industry, only 77 firms out of the total 388 are SOEs while 272 firms, or 70%, are private. Thus the electronics industry is predominantly privately owned exhibiting a marked difference in terms of ownership composition between the two industries. Panel C shows that only five firms in the automotive industry are located in the SEZs, whereas for the electronics industry 83 firms, roughly 21%, are located in the SEZ.

[Insert Table 1 here]

When we examine the ownership structure and firm location in the automotive industry, we observe that out of the 104 firms in the sample, only 24 firms are passenger vehicle manufacturers. In Appendix B, we report their respective name, ownership, date listed, and location. In these 24 firms, 17 are SOEs and they are scattered in 13 provinces or municipalities directly under the central government. The other seven are private enterprises and scattered in six provinces or municipalities. This information paints a rather fragmented map of the passenger vehicle industry and suggests that local specialization is prevalent in this industry.

We provide descriptive statistics of the variables to be used in the empirical examination and analysis in Table 2. We report these statistics for the entire sample as well as separately for the two industries. The dependent variable, R&D expenses scaled by book value of total assets, is average 0.02 for the full sample. It is average 0.01 for the automotive industry, and higher for the electronics industry at 0.02. As for the independent variables, compared with firms in the automotive industry, those in the electronics industry are on average younger, much more profitable, have less cash flow and less debt as a fraction of the book value of total assets, and receive more government subsidies as a fraction of the book value of total assets. They tend to face much more financial constraints as measured by the SA index and the WW index.

[Insert Table 2 here]

It is well known that the fixed effect estimator is biased when the number of periods of fixed and the GMM (Generalized Method of Moments) procedures have been advocated as a convenient way of dealing with the heterogeneity and endogeneity bias in the literature on dynamic panel data. Following Windmeijer (2005) and Brown and Petersen (2011), we perform the “system” GMM estimator developed for dynamic panel models developed by Arellano and Bond (1991) and Blundell and Bond (1998). It deploys additional instruments obtained by utilizing the orthogonality conditions that exist between the lagged values of the dependent variable and disturbances. This method is robust to the endogeneity problem that explanatory variables may also affect the estimates. Thus the methodology has 1become an important tool in dealing with endogeneity in many empirical analyses.

We estimate the following benchmark specifications for dynamic panel models to explore the relationship between (1) R&D intensity and financial constraints given the impact of government subsidies; (2) R&D intensity and financial constraints given the impact of government subsidies and firm ownership; (3) R&D intensity and financial constraints given the impact of government subsidies and industrial cluster location.

$$+\beta_{85} SUB_{\text{nic \& telecommunication related industry},} DB_{i,t} + \varepsilon_{i,t}$$

(1)

(2)

(3)

(4)

where $RD_{i,t}$ is the dependent variable, the R&D intensity for firm *i* in period *t*, $RD_{i,t-1}$ is the lagged value of R&D intensity, β is a vector of parameters to be estimated, $AGE_{i,t}$,

$KZ_{i,t}$

$ROE_{i,t}$, $CF_{i,t}$, $CH_{i,t}$, , $WW_{i,t}$, $SA_{i,t}$, denote firm listed years, return on equity, cash flow, cash holdings, long-term debt to total asset ratio, long-term debt, government subsidies to total asset ratio, and the financial constraint indexes (SA index, WW index and KZ index), respectively, for firm *i* in period *t*. Finally, N_i and SEZ_i are dummy variables for firm ownership and location, respectively, and $\varepsilon_{i,t}$ is the error term. See Appendix B for detailed variable definitions.

5. Empirical analyses and discussion

As a first pass, we run the system GMM method that jointly estimates a regression of equations (1) – (4) in differences with the regression in levels, using lagged levels as instruments for the regression in differences and lagged differences as instruments with regression in levels. It is capable of addressing the weak instrument problem that arises from using lagged levels of persistent explanatory variables as instruments for the regression in differences (Brown and Petersen, 2011). Because the two-step GMM is more efficient and hence we report the two-step estimates in the main empirical tests for the large sample analyses that are presented in the first three parts of this section. Because two-step GMM method is severely downward biased in small samples (see Arellano and Bond, 1991; Windmeijer, 2005), we conduct panel OLS estimation with fixed effects in the Table 7 due to the small sub-sample issue as well as for the purpose of robustness checks.

5.1 Innovation and government subsidies

This table demonstrated a significant relation between financial constraints and firms' innovation ability after controlling for other determinants of financial constraints identified in the previous literature. Specifically, the interaction effect between our financial constraints proxies (SA, WW, KZ index), and the total debt ratio is always negative and significant in all nine specifications. However, as our models demonstrates, cash flow ratio and return on equity have a significant positive impact on R&D activity. Overall, these results are consistent with the previous literatures.

[Insert Table 3 here]

Table 4 summarizes the empirical results for equation (2) when we consider the impact of government subsidies on the relation between firm innovation and financial constraints. First of all, we notice that the dummy variable for government subsidies, *GSUB*, is consistently positive and highly significant at 1% level whenever it is included in the two-step dynamic GMM estimation. This suggests that government subsidies play an essential role in stimulating and promoting firm innovative activities, and support our hypothesis that government subsidies are a key factor in helping reduce financial constraints and promoting innovation in these two industries. Some other explanatory variables such as firm ages (*AGE*), returns on equity (*ROE*) and cash flows (*CF*) have positive effects on the R&D intensity as well. Quite interestingly, the results are very consistent across two industries, and the persistence of coefficient on government subsidies is significantly positive, except being higher for the electronics industry than for the automotive industry.

[Insert Table 4 here]

This finding also corroborates international evidence in Almus and Czarnitzki (2003) for the former Eastern German firms and González et al. (2005) for Spanish firms. It further attests to the importance that government subsidies may have on firms' innovative activities, especially for these two strategically important industries that we examine in this paper. Our results are consistent with the evidence in Lee et al. (2014) which argue that financially healthy firms are more likely to make use of subsidies in generating profits and growth opportunities. In addition, we observe that older firms with stronger financial status tend to enjoy higher R&D intensity, as the *AGE*, *ROE*, and *CF* variables are also highly significant throughout the model specifications.

5.2 Innovation and firm ownership

We conjecture that, due to the misalignment of interest between the majority state shareholders and the minority individual shareholders in SOEs, and the fact that SOEs may have other social and political objectives in addition to profit maximization, the SOE firms may not be as efficient and aggressive in pursuing and simulating R&D as private firms.

In addition to all the variables in equation (2), we include additional ownership dummy variables for testing hypothesis H2a in equation (3). For robustness, we further divide the *SOE* dummy into central SOEs (*CSOE*) and local SOEs (*LSOE*) for the reason that, since the fiscal decentralization reform from the 1990s, local governments tend to lend great support to SOEs that have important influence on the local economy (Chen et al., 2008; Li, 1998).

The empirical results reveal an interesting pattern with significant policy implication. In Table 5, whether we look at all SOEs, or separate them into central and local groups, the dummy variable is *negative* throughout all model specifications. For specifications involving all SOEs and local SOEs, the dummy variable for ownership is negative and highly significant at either the 1% level or the 5% level. For central SOEs, it is significant at the 5% level in two out of three model specifications. On the other hand, for private firms, the dummy variable for firm ownership is *positive* and significant at 1% level for all three models. At the same time, the coefficient for government subsidies, *GSUB*, continues to be positive and highly significant.

[Insert Table 5 here]

This distinct pattern is interesting and thought provoking. It indicates that private firms are more efficient and effective in utilizing government subsidies in simulating and promoting R&D compared with SOEs in these two industries. Our finding is also consistent with the evidence in the existing literature on the relationship between ownership and firm innovation. For example, Boardman and Vining (1989) comprehensively show that SOEs significantly underperform their private counterparts. More recently, Hud and Hussinger (2015) emphasize the economic rationale for subsidies to go to the private sector. Our finding, together with the evidence in the literature, suggest strongly that, if the purpose of subsidies is to promote economic growth and innovation, government subsidies are better spent and taken advantage of if it is allocated to privately-owned firms.

For the rest of the variables, we find similar coefficients and statistical significance to those in Table 4. For example, we observe positive and significant coefficient for AGE , ROE , and CF except for one model whereby the coefficient for AGE is negative. This further substantiates the influence of government subsidies on the relation between R&D and ownership.

Table 6 summarizes the number of firms in our sample that report their R&D expenses and/or government subsidies. It also reports the R&D and subsidy intensity, computed as the ratio between R&D expenses and government subsidies, respectively, over the book value of total assets. The p-value tests the null hypothesis that the average between firms in the two industries is equal. The sample period is from 2006 to 2014.

[Insert Table 6 here]

Further to the evidence in Table 5 and the observation in Table 2 that the electronics industry consists predominantly of private firms, it is not surprising to find that in Table 6 the *t*-test consistently show that this industry exhibits significantly higher R&D intensity, defined as the ratio between firm R&D expenses and the book value of total asset. For the full sample, the R&D intensity for the electronics industry is 0.024, higher than that for the automotive industry by 0.02. This difference is significant at the 1% level with a *p*-value of less than 0.01, indicating that the electronics industry as a whole has proportionately invested significantly more in their innovative activities relative to the automotive industry. When we break the entire industries down according to ownership structure, we find that whether we look at central or local SOEs, or the private firms in the two industries, those in the electronics consistently invest proportionately more, and the *p*-value for the difference is always significantly at the 1% level.

At the same time, the subsidy intensity, defined as the government subsidies as fraction of the book value of total assets, is also significantly higher for the electronics industry than for the automotive industry. Interestingly, the difference in subsidy intensity is significantly at the 1% level for private firms but only at the 10% level for central SOEs. The more significantly negative coefficient on local SOEs reveals that the local SOEs are even less efficient and effective in using subsidies in innovation than the central SOEs.

5.3 Innovation and firm location

Table 6 summarizes the two-step dynamic GMM estimates for the relation between firms R&D expenses, financial constraints, and firm location. In this table, we report the estimation results when the firm location dummy variable is included in the model specification. As the *SA* constraint index exhibits a correlation of almost 0.5 with *AGE*, we remove the *AGE* variable whenever the SA index is included in the model.

[Insert Table 7 here]

We find that the dummy variable for the SEZ location is positive and significant at the 1% level in all model specifications. This provides strong evidence for our working hypothesis that firms benefit from the clustering effect of being located in SEZs. Our finding is related to Wang (2013), which argues that the more liberal laws and favourable economic policies make SEZ attractive and this is exactly consistent with our evidence. More generally, when firms locate close to each other, they create the "cluster premium" as Broekel et al. (2015) have convincingly argued. The premium comes from the benefits that similar firms located in clusters enjoy from supportive social and economic policies, better access to networking, knowledge diffusion, skilled workforce, and so on. Our finding is also related to the technological infrastructure in Florida and Kenney (1988) and Feldman and Florida (1994), which document that technological infrastructure, usually available to firms in clusters, constitute a key variable for promoting innovation and economic growth.

Table 7 reports the panel OLS estimates for the relation between firms R&D expenses, government subsidies, and firm location. The benefit of the cluster premium is more evident in Table 7 when we break the full sample into the two respective industries. In Panel A when we examine the automotive industry, we notice that the dummy variable for the SEZ is only marginally significant in one specification. The government subsidies variable, *GSUB*, is significant but the coefficient is significant at the 1% level only model (2) with a *t*-statistic at 4.99. In Panel B for the electronics industry, on the other hand, not only are the SEZ dummy variable consistently significant, they are significant at the 1% level for all models except model (1). More interestingly, the *GSUB* variable now is also consistently and highly significant at the 1% level, with the lowest *t*-statistic at 16.22 for model (4). The difference between the two sets of results highlights the importance for firms to locate in SEZ or other clusters in order to take full advantage of government subsidies to engage and promote innovation. This finding is consistent with the evidence from our interviews, which suggest that the automotive industry suffers from market fragmentation and local protectionism whereas the electronics industry enjoys the premium of regional clustering (Authors' interviews No. 1, 2, 3, 5, 15, 21, and 22).

[Insert Table 8 here]

5.4 Robustness tests

We explore a wide variety of auxiliary regressions and robustness tests and our baseline results remain qualitatively unchanged across alternative R&D measures. In our benchmark models, we use the ratio of R&D expenses by total assets as the proxy of R&D intensity. In this section we consider a different definition of R&D intensity, which is the ratio of R&D expenses by total sales. The measures of other related variables such as cash flow, long term debt, and government subsidies have all been adjusted by the scale of total sales accordingly. For more details, please see Appendix D.

The regression results of the robustness tests are qualitatively similar to our baseline results and some of them are reported in Table 8 (Test of Hypothesis 1). We observe the coefficient on government subsidies (*GSUB_r*) is positive and statistically significant at the 1% level for the both full sample and subsamples. The coefficients on other key independent variables are also qualitatively similar to the baseline results presented in Table 3. For example, the coefficients on Age of firms (*AGE*) and financial constraints (*SA*) are consistently positive across samples. Taken together, these findings suggest that government subsidies are helpful in promoting innovation in both automotive and electronics industries.

[Insert Table 9 here]

In the second robustness check, we employ panel OLS regression methods to see whether different regression methods affect the consistency of our results. The results show that the patterns observed are consistent, and part of the results is displayed in Table 7 that does not employ the two-method GMM method due to the small sample issue. These results are available upon request from the authors.

5.5 Discussion

The quantitative and qualitative results reported in the above sections are summarized and discussed as follows.

First, government subsidies, the government's "visible hand" in innovation financing, exert a positive effect on reducing firm financial constraints and promoting innovative activities in both high technology sectors under scrutiny in our study. Given the evidence in the literature on the close relation between innovation and economic growth, government subsidies thus play an important role for economic growth in China. For development of the strategically important industries or national priority areas, the positive value relevance of government subsidies for Chinese listed companies identified in this study is consistent with that of Lee et al. (2014) and some of our interview evidence.

Second, the effectiveness of government subsidies on innovation and economic growth is not static across board. Instead, our evidence shows that private firms are better than their SOE counterparts in engaging R&D with the government subsidies they receive. Thus the state ownership has limited ability to promote innovation activities, and Chinese governments' industrial policy of accommodating state ownership with FDI has failed to create internationally competitive automotive firms in the perspective of technology innovation by the end of 2014 (Thun, 2006; Brandt and Thun, 2016; Authors' interview No. 21). This can be rationalized on the grounds that SOE have multiple social and economic obligations in addition to profit maximization, which is the sole objective for private enterprises. Hence, if profit generation is the main target for government, then grant subsidies to private firms are more effective. The evidence also reveals that local SOEs are even less efficient and effective in using subsidies in innovation than the central

SOEs. Lee et al. (2014) show that if the local government has budget limitations, the politically connected producer are more likely to be subsidized than their non-connected peers. Local SOEs are more politically connected with local government officials than those central SOEs, and thus personal relations may play a bigger role in subsidization of local SOEs, which reduce the efficiency and effectiveness of government subsidies in promoting innovation (Authors' interview No. 22).

Third and most importantly, the empirical results provide strong evidence that firms located in SEZ enjoy the premium of regional clustering, are less financially constrained and more effective in innovation. It indicates that in order to encourage innovation and economic growth, it is imperative that government considers policies to establish and promote more and better regional clustering or industrial clusters to provide firms with more severe market competition, higher access to innovation financing, better network, government supports, knowledge diffuse, enhanced opportunity for collaborative R&D, and business services that focusing on product marketing and commercialization. This will help reduce regional market fragmentation and local protectionism that are prevalent in the automotive industry and hinder its innovation activities severely (Thun, 2006; Authors' interviews No. 11 and 21).

6. Conclusion

In the last three decades, Chinese government has introduced various forms of industrial policies that support the development of high-tech sectors to strengthen industrial competitiveness, to encourage larger investment in innovation, and to promote high-tech trade (Liu et al, 2011). In this paper, we perform a detailed analysis of the relationship between firms' innovative activities and industrial policies such as government subsidies, ownership structure, and SEZ. We explore two technology-intensive industries that have been the focal point of government support, namely the automotive industry and the electronics industry, using a recent sample of 492 firms from 2006 to 2014.

Our study reveals a host of interesting findings. First, we show that government subsidies play a key role in helping reduce financial constraints and stimulating firm

R&D intensities. Industrial policy such as subsidization has been an important component of the evolution of Chinese electronics manufacturing, which has evolved to become a highly modernized sector with cutting-hedge innovation and an integral part of the Chinese economy. Second, we show that between SOEs and private firms in these two industries, private firms are better at utilizing government subsidies in pursuing innovative activities. We also provide evidence that between the two industries under scrutiny, the electronics industry, with predominant number of private enterprises, invest significantly more proportionately on R&D activities. Finally, consistent with the evidence in the existing literature, we find that firms located in SEZs enjoy the benefit of regional clustering. Locating in a SEZ exerts a positive impact and helps firm to engage in knowledge generation and innovation activities. When we separate the full sample into the two industries, the electronics industry, which has more firms located in SEZs benefit more from government subsidies and engage more efficiently in R&D. These findings contain important policy implications to government in terms of how best to allocate subsidies to promote economic growth and how best to set up economic zones with favorable social and economic that firms can benefit.

Our study suggests that it is of great importance for government to provide financial support and ad hoc R&D policies for industrial upgrading and firm innovation. At the same time, it is of paramount importance to create SEZs which help cluster innovation financing, technology infrastructure and human resources. Nevertheless, China has yet to achieve a stable institutional equilibrium for SOEs and private firms to operate in a level playing field. For development in China to be sustainable in the future, it is necessary to maintain the momentum of institutional reforms in building an inclusive market environment (Acemoglu et al., 2003), which allocates resources to SOEs and private firms evenly. Just as Du and Mickiewicz (2016) suggest very recently, the reforms to create inclusive formal institutions and transparent rules to support emerging private organizations would see a pronounced shift from the uncertainty induced by the lack of transparent rules towards a strong rule-based system.

Our study is consistent with the finding of Aghion et al. (2012) which argues that industrial policy aimed at targeting production activities to one particular sector can enhance growth and efficiency if it makes competition friendlier. Due to the extremely fast evolution of China's economic and institutional infrastructure, new policy considerations and practice have emerged over the recent period, which invite us to revisit the impacts of industry policies. Further research exploring the implementation of industrial policy under unfriendly competition remains an avenue for scholars to explore.

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Appendix A

Information on listed passenger vehicle manufacturers in China

Firm name	Ownership	Date listed	Location
Anhui Jianghuai Automotive Co.,Ltd.	LSOE	2001-08	Anhui
Anhui Ankai Automotive Co.,Ltd	LSOE	1997-07	Anhui
Beiqi Foton Motor Co.,Ltd.	LSOE	1998-06	Beijing
Chongqing Changan Automotive Company Limited	CSOE	1997-06	Chongqing
Chongqing Changan Automotive Company Limited	CSOE	1996-11	Chongqing
China Automotive Engineering Research Institute Co., Ltd	CSOE	2012-06	Chongqing
Xiamen King Long Motor Group Co.,Ltd.	LSOE	1993-11	Fujian
Guangzhou Automotive Group Co., Ltd.	LSOE	2012-03	Guangdong
Dongfeng Automotive Co.,Ltd	CSOE	1999-07	Hubei
Yangzhou Asiastar Bus Co.,Ltd.	LSOE	1999-08	Jiangsu
Jiangling Motors Corporation, Ltd.	CSOE	1993-12	Jiangxi
Jiangling Motors Corporation, Ltd.	CSOE	1995-09	Jiangxi
Faw Car Co., Ltd	CSOE	1997-06	Jilin
Shenyang Jinbei Automotive Company Limited	LSOE	1992-07	Liaoning
Zhongtong Bus Holding Co.,Ltd.	LSOE	2000-01	Shandong
SAIC Motor Corporation Limited	LSOE	1997-11	Shanghai
Tianjin FAW Xiali Automotive Co.,Ltd.	CSOE	1999-07	Tianjin
Haima Automotive Group Co.,Ltd.	Private	1994-08	Hainan
BYD Company Limited	Private	2011-06	Guangdong
Zhengzhou Yutong Bus Co.,Ltd.	Private	1997-05	Henan
China Grand Automotive Services Co., Ltd.	Private	2000-11	Liaoning
Liaoning SG Automotive Group Co.,Ltd.	Private	2000-12	Liaoning
Great Wall Motor Company Limited	Private	2011-09	Hebei
Lifan Industry (Group) Co.,Ltd	Private	2010-11	Chongqing

Appendix B

List of interviewees

No.	Name	Status	Date, City
		1st Round	
1	Anonymous	Director of information technology department, Shuanglin Co., Ltd	04 July 2014, Ningbo
2	Anonymous	Director of central laboratory, Shuanglin Co., Ltd	04 July 2014, Ningbo
3	Anonymous	Senior Manager of Minth Co., Ltd	5 July 2014, Ningbo
4	Anonymous	Manager of a private semiconductor manufacturer	16 December 2014, Beijing
5	Anonymous	A government official in Ningbo Municipal Government	12 March 2015, Ningbo
6	Anonymous	Senior Manager of Minth Co., Ltd	8 May 2015, Ningbo
7	Anonymous	Owner of a private electronics company.	14 May 2015, Shenzhen
8	Anonymous	A venture capitalist of high technology sectors	14 May 2015, Shenzhen
9	Anonymous	Owner of a private auto part manufacturing company.	28 May 2015, Ningbo
10	Anonymous	Owner of a private electronics company.	02 June 2015, Hong Kong
11	Anonymous	A venture capitalist of high technology sectors	03 June 2015, Hong Kong
12	Anonymous	A government official in Ningbo Municipal Government	10 June 2015, Ningbo
13	Anonymous	A venture capitalist of high technology sectors	12 June 2015, Beijing
14	Anonymous	Manager of a private auto part manufacturing company.	18 June 2015, Ningbo
15	Anonymous	A venture capitalist of high technology sectors	22 June 2015, Shanghai
		2nd Round	
16	Anonymous	Senior manager of a private electronics company	27 September 2015, Beijing
17	Anonymous	Owner of a private auto part manufacturer	11 October 2015, Ningbo
18	Anonymous	A venture capitalist of automotive industry	29 October 2015, Shanghai
19	Anonymous	CEO of a private electronics company	30 October 2015, Shanghai
20	Anonymous	CEO of a private electronics company	20 November 2015, Shanghai
21	Anonymous	Vice president of a listed auto part manufacturing company	4 December 2015, Ningbo
22	Anonymous	A government official in Ningbo Municipal Government	4 December 2015, Ningbo

Appendix C

Variable definition

Variables	Descriptions
RD	The percentage company-level research & development expenses to the book value of total assets.
AGE	The number of years a firm is listed.
ROE	The company-level return on asset.
CF	The percentage company-level cash-flow to the book value of total assets.
CH	The company-level cash holdings.
DB	The company-level long-term debt.
DBTA	The percentage company-level long-term debt to the book value of total assets.
GSUB	The percentage company-level government R&D subsidies to the book value of total assets.
SA	Short for SA index, a financial constraint proxy proposed by Hadlock and Pierce (2010) $SA = -0.737*Size + 0.043 * Size^2 -0.04*Age$ Size — Short for the logarithmic company-level total asset Age — The number of years a firm is listed
WW	Short for WW index, a financial constraint proxy proposed by White and Wu (2006) $WW = -0.091 * CF - 0.062 * DIVPOS + 0.021 * DBTA – 0.44 * Size +0.102*ISG - 0.35 * SG$ DIVPOS — Short for dividend dummy, which takes the value of 1 if dividend is paid and 0 otherwise Size — Short for the logarithmic company-level total asset ISG* — Short for the logarithmic industry-level total sales growth SG — Short for the logarithmic company-level total sales growth
KZ	Short for KZ index, a financial constraint proxy proposed by Kaplan and Zingales (1997) $KZ = -1.002 * CF + 0.283 * Q + 3.139 * Leverage - 39.368 * Dividends -1.35 * Cash\ holding$ Q — Short for Tobin's Q, the total assets plus market value of equity minus book value of equity divided by the book value of total assets Leverage — The ratio of debt to total capital Dividend — The ratio of paid dividend to book value of total assets

批注 **[XH1]:** Needs to be more consistent.

Cash holding	The ratio of cash and other equivalent to the book value of total assets
SOE	A dummy variable which equals 1 if the largest shareholder is government related, and 0 otherwise.
LSOE	A dummy variable which equals 1 if the largest shareholder is local government related, and 0 otherwise.
CSOE	A dummy variable which equals 1 if the largest shareholder is central government related, and 0 otherwise.
PR	A dummy variable which equals 1 if the largest shareholder is private, and 0 otherwise.
SEZ	A dummy variable which equals 1 if the company locates in special economic zones, and 0 otherwise.

Note: ISG in the description of variable WW is originally the firm's three-digit industry sales growth in the U.S., here we adapt it to the industry sales growth provided by Wind Database

Appendix D

Definition of adjusted variables in robustness checks

Robust test variables

RD_r	The percentage company-level research & development expenses to the annul sale amount.
CF_r	The percentage logarithmic company-level cash-flow to the logarithmic annul sale amount.
DBTA_r	The percentage logarithmic company-level long-term debt to the logarithmic annul sale amount.
GSUB_r	The percentage logarithmic company-level government subsidies to the logarithmic annul sale amount.

Table 1

Industry, ownership and location distribution of the sample firms

This table reports distribution of firms in terms of industry (Panel A), ownership structure (Panel B), and location (Panel C). Our sample period is from 2006 to 2014. See Appendix A for detailed variable definition.

Panel A. Industry

Full sample		Automotive		Electronics
492		104		388
	Auto part	77	Software	110
	Automotive	27	Hardware	225
			Semiconductor	53

Panel B. Ownership

	Full sample	Automotive	Electronics
SOE	122	45	77
CSOE	76	24	52
LSOE	46	21	25
Private	326	54	272
Other	44	5	39

Panel C. Location

	Full sample	Automotive	Electronics
In SEZ	88	5	83
SOE	10	1	9
Private	63	3	60
Other	15	1	14
Outside SEZ	404	99	305
SOE	112	44	68
Private	259	51	208
Other	33	4	29

Table 2

Descriptive statistics of variables

Full Sample

	Dependent variable	Independent variables											
	RD	AGE	ROE	CF	DBTA	GSUB	SA	WW	SOE	LSOE	CSOE	PR	SEZ
Obs.	6621	8856	8856	6621	4902	5169	8856	8856	8856	8856	8856	8856	8856
Mean	0.0211	4.9759	0.0856	0.5874	0.0587	0.0054	-2.5238	-1.9174	0.2479	0.0934	0.1546	0.6627	0.1790
Medium	0.0115	2.1205	0.0663	0.4808	0.0227	0.0028	-3.2005	-0.4078	0	0	0	1	0
Std.	0.0298	6.0813	0.1381	0.0436	0.4369	0.0152	1.4803	144.656	0.4318	0.2910	0.3614	0.4729	0.3833
Min.	0	0	-379.888	0	-0.0022	-0.0003	-4.0807	-13613.3	0	0	0	0	0
Max	0.5070	24.0493	8.4174	5.1185	6.4403	0.9500	0.0000	0.0971	1	1	1	1	1

Automotive

	Dependent variable	Independent variables											
	RD	AGE	ROE	CF	DBTA	GSUB	SA	WW	SOE	LSOE	CSOE	PR	SEZ
Obs.	1500	1872	1474	1500	1281	1107	1872	1872	1872	1872	1872	1872	1872
Mean	0.0113	7.7359	0.0106	0.7027	0.0621	0.0035	-2.7801	-0.3816	0.4327	0.2212	0.2115	0.5192	0.0481
Medium	0.0059	7.8452	0.0721	0.6122	0.0369	0.0018	-3.3648	-0.4410	0	0	0	1	0
Std.	0.0172	6.8256	2.2002	0.4114	0.0749	0.0061	1.4023	0.2139	0.4956	0.4151	0.4085	0.4998	0.2140
Min.	0	0	-379.888	0	-0.0022	0.0000	-3.9755	-0.8009	0	0	0	0	0
Max	0.4096	22.4521	1.5996	3.6359	0.6772	0.0993	0.0000	0.0971	1	1	1	1	1

Electronics

	Dependent variable	Independent variables											
	RD	AGE	ROE	CF	DBTA	GSUB	SA	WW	SOE	LSOE	CSOE	PR	SEZ
Obs.	5121	6984	5063	5121	3621	4062	6984	6984	6984	6984	6984	6984	6984
Mean	0.0239	4.2361	0.1075	0.5536	0.0575	0.0059	-2.4551	-2.3291	0.1985	0.0593	0.1392	0.7010	0.2139
Medium	0.0141	1.5767	0.0643	0.4358	0.0188	0.0031	-3.1833	-0.3970	0	0	0	1	0
Std.	0.0321	5.6413	0.2689	0.4384	0.1908	0.0168	1.4932	162.8927	03989	0.2362	0.3462	0.4578	0.4101
Min.	0	0	-11.549	0.0000	0.0000	-0.0003	-4.0807	-13613.28	0	0	0	0	0
Max	0.5070	24.0493	8.4174	5.1184	6.4403	0.9499	0.0000	0.09384	1	1	1	1	1

Table 3

The Two-step GMM estimation of R&D and financial constraints proxies.

This table examines the relation between R&D and financial constraints proxies for R&D are considered: R&D/Total asset, R&D/Sale and R&D/ employee. Each column corresponds to a different regression (Two-step GMM for all estimations).

	RD/Total Asset		
	1	2	3
RD(-1) / Total Asset	-0.1844***	-0.1684***	-0.1716***
	(0.0123)	(0.0128)	(0.0132)
WW	-0.0057***	-0.0038***	-0.0059***
	(0.0007)	(0.0006)	(0.0007)
SA	-0.1244***	-0.1087***	-0.1209***
	(0.0076)	(0.0067)	(0.0075)
KZ		-0.0000***	-0.0000***
		(0.0000)	(0.0000)
CF/ Total Asset	0.0546***	0.06056***	0.0551***
	(0.0036)	(0.0028)	(0.0036)
CH/ Total Asset	0.0140**	0.0080**	0.0072
	(0.0046)	(0.0041)	(0.0052)
ROE	0.0396***		0.03145***
	(0.0111)		(0.0109)
ROA	-0.0055		-0.0065
	(0.2443)		(0.0052)
DBTA	0.08765***	0.07973***	0.08760***
	(0.0115)	(0.0096)	(0.0118)

	RD/Sale		
	7	8	9
RD(-1) / Sale	-0.2284***	-0.2413***	-0.2256***
	(0.0118)	(0.0120)	(0.01138)
SA	-0.0092***	-0.2382***	-0.2691***
	(0.0020)	(0.0195)	(0.0216)
KZ	-0.0001**	-0.0001***	
	(0.0000)	(0.0000)	
CF/Sale	1.8419***	1.0740***	1.2075***
	(0.08236)	(0.0753)	(0.0782)
CH/Sale	-0.0122***	-0.0121***	-0.0091***
	(0.0006)	(0.0008)	(0.0007)
ROE			0.0494***
			(0.0137)
ROA		-0.0029	-0.0067
		(0.0049)	(0.0067)
DB /Sale	-0.0037***	-0.0017	-0.0100***
	(0.0008)	(0.0013)	(0.0018)

	RD/employee		
	7	8	9
RD(-1) / Employee	-0.1970***	-0.0996***	-0.1967***
	(0.0167)	(0.0173)	(0.0211)
WW		-3526.4***	-3607.34***
		(631.56)	(634.28)
SA	-209704.8***	-216380***	-183725.2***
	(10865.49)	(11224.59)	(11676.77)
KZ	-58.9144***	-61.3518***	-140.9597***
	(9.3326)	(9.1477)	(13.9201)
CF/employee	0.0464***	0.0488***	0.0414***
	(0.0021)	(0.0025)	(0.0026)
CH/employee			-0.0188***
			(0.0017)
ROE	40096.14***	51965.03***	27827.24***
	(5529.776)	(5630.147)	(6583.497)
ROA	3549.284		1617.194
	(2453.811)		(1989.337)
DB/ employee	-0.03165**	-0.0356***	-0.0137***
	(0.0053)	(0.0049)	(0.0052)

Table 4

The Two-step GMM estimation of R&D expenses, financial constraints, and government subsidies

This table reports the two-step GMM estimates for the relation between firms R&D expenses, financial constraints, and government subsidies. Our sample period is from 2006 to 2014. See Appendix A for detailed variable definition. HAC-consistent standard errors are reported in the parentheses, and ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

	Full Sample			Automotive			Electronics		
	1	2	3	1	2	3	1	2	3
RD(-1)	-0.1128***	-0.1464***	-01474***	-0.0140***	-0.2633***	-0.2716***	-0.1507***	-0.1637***	-0.1646***
	(-0.0129)	(0.0154)	(0.0156)	(0.0000)	(0.0007)	(0.0006)	(0.0118)	(0.0166)	(0.0170)
AGE	0.0041***	0.0046***		0.0040***	0.0025***		0.0037***	0.0044***	
	(0.0002)	(0.0002)		(0.0000)	(0.0000)		(0.0002)	(0.002)	
ROE	0.0431***	0.0738***	0.0761***	0.0057***	0.0068***	0.0094***	0.0410***	0.0602***	0.0632***
	(0.0088)	(0.0090)	(0.0090)	(0.0000)	(0.0001)	(0.0001)	(0.0076)	(0.0109)	(0.0103)
CF	0.0517***	0.0352***	0.03520***	0.0322***	0.0214***	0.0208***	0.0633***	0.0486***	0.0486***
	(0.0024)	(0.0027)	(0.0027)	(0.0000)	(0.0001)	(0.0000)	(0.0025)	(0.0036)	(0.0034)
DBTA	0.1098***	0.0526***	0.04527**	0.0345***	-0.0013***	-0.0032***	0.1501***	0.0766***	0.0726*
	(0.0132)	(0.0159)	(0.01640)	(0.0000)	(0.0002)	(0.0003)	(0.0100)	(0.0250)	(0.0276)
GSUB		0.6316***	0.6275***		0.3400***	0.3450***		0.4007***	0.3968***
		(0.0872)	(0.08576)		(0.0024)	(0.0023)		(0.0889)	(0.0854)
SA			-0.1294***			-0.0729***			-0.1233***
			(0.0061)			(0.0003)			(0.0058)

Table 5

The Two-step GMM estimation of R&D expenses, government subsidies, and firm ownership

This table reports the GMM estimates for the relation between firms R&D expenses, government subsidies, and firm ownership. Our sample period is from 2006 to 2014. See Appendix A for detailed variable definition. HAC-consistent standard errors are reported in the parentheses, and ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

	State-owned firms			Local state-owned firms			Central state-owned firms			Private-owned firms		
	1	2	3	1	2	3	1	2	3	1	2	3
RD(-1)	-0.1129***	-0.1454 ***	-0.1479***	-0.1127 ***	-0.1458***	-0.1468***	-0.1125***	-0.1431***	-0.1439***	-0.1117***	-0.1442***	-0.1450***
	(0.0129)	(0.0154)	(0.0156)	(0.0130)	(0.0154)	(0.0156)	(0.0129)	(0.0156)	(0.0158)	(0.0128)	(0.0154)	(0.0157)
AGE	0.0041***	0.0046***		0.0041***	0.0046***		0.0041***	-0.0046***		0.0041***	0.0047***	
	(0.0002)	(0.0002)		(0.0002)	(0.0002)		(0.0002)	(0.0002)		(0.0002)	(0.0002)	
ROE	0.0433***	0.0732***	0.0755***	0.0429 ***	0.0735***	0.0758***	0.0448***	0.0739***	0.0761***	0.0455***	0.0745***	0.0767***
	(0.0087)	(0.0090)	(0.0090)	(0.0088)	(0.0090)	(0.0090)	(0.0087)	(0.0088)	(0.0088)	(0.0086)	(0.0086)	(0.0087)
CF	0.0520***	0.0356***	0.0353***	0.0518***	0.0353***	0.0353***	0.0513***	0.0364***	0.0365***	0.0515***	0.0364***	0.0364***
	(0.0024)	(0.0027)	(0.0027)	(0.0024)	(0.0027)	(0.0027)	(0.0025)	(0.0027)	(0.0027)	(0.0025)	(0.0027)	(0.0027)
DBTA	0.1121***	0.0530***	0.0453 ***	0.1095***	0.0532***	0.0450***	0.1144***	0.0561***	0.0491***	0.1134***	0.0560***	0.0488***
	(0.0131)	(0.0159)	(0.0163)	(0.0132)	(0.0159)	(0.0164)	(0.0138)	(0.0160)	(0.0017)	(0.0136)	(0.0158)	(0.0163)
GSUB		0.6183***	0.6300 ***		0.6324***	0.6285***		0.5696***	0.5562***		0.5795***	0.5726***
		(0.0874)	(0.0844)		(0.0872)	(0.0857)		(0.1041)	(0.1025)		(0.1021)	(0.1005)
SA			-0.1293***			-0.1293***			-0.1297***			-0.1303***
			(0.0061)			(0.0061)			(0.0060)			(0.0059)
SOE	-0.0116**	-0.0060***	-0.0037**									
	(0.0051)	(0.0015)	(0.0003)									
LSOE				-0.0045***	-0.0046***	-0.0037***						
				(0.0005)	(0.0003)	(0.0003)						
CSOE							-0.0271**	-0.0171*	-0.0180**			
							(0.0119)	(0.0098)	(0.0083)			
PR										0.0250***	0.0184***	0.0184***
										(0.0054)	(0.0022)	(0.0025)

Table 6

The innovation intensity and subsidies intensity

This table summarizes the number of firms in our sample that report their R&D expenses and/or government subsidies. It also reports the R&D and subsidy intensity, computed as the ratio between R&D expenses and government subsidies, respectively, over the book value of total assets. The *p*-value tests the null hypothesis that the average between firms in the two industries is equal. The sample period is from 2006 to 2014.

	R&D intensity			Subsidies Intensity		
	No. of firms	Difference	*p*-value	No. of firms	Difference	*p*-value
SOE	122	0.0120	< 0.0001	122	0.0041	0.0011
Automotive	45	0.0079		45	0.0034	
Electronics	77	0.0146		77	0.0045	
CSOE	76	0.0130	< 0.0001	76	0.0041	0.0709
Automotive	23	0.0096		23	0.0038	
Electronics	53	0.0145		53	0.0043	
LSOE	46	0.0102	< 0.0001	46	0.0036	0.0047
Automotive	22	0.0063		22	0.0020	
Electronics	24	0.0147		24	0.0038	
Private	326	0.0229	< 0.0001	322	0.0060	< 0.0001
Automotive	54	0.0099		54	0.0038	
Electronics	272	0.0267		268	0.0064	
Other	44	0.0257	0.0004	44	0.0051	< 0.0001
Automotive	5	0.0107		5	0.0023	
Electronics	39	0.0282		39	0.0055	
Full Sample	492	0.0199	< 0.0001	488	0.0043	< 0.0001
Automotive	104	0.0091		104	0.0035	
Electronics	388	0.0239		384	0.0059	

Table 7

R&D, financial constraints, and firm location

This table reports the two-step dynamic GMM estimates for the relation between firms R&D expenses, financial constraints, and firm location. Our sample period is from 2006 to 2014. See Appendix A for detailed variable definition. HAC-consistent standard errors are reported in the parentheses, and ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

	1	2	3	4	5
RD(-1)	-0.1101***	-0.1126***	-0.1102***	-0.1133***	-0.1128***
	(-0.0121)	(-0.0129)	(-0.0142)	(-0.0130)	(-0.0145)
AGE	0.0032***	0.0041***	0.0040***		
	(-0.0002)	(-0.0002)	(-0.0002)		
ROE		0.0464***	0.0475***	0.0510***	0.0514***
		(-0.0086)	(-0.0086)	(-0.0088)	(-0.0089)
CF	0.0594***	0.0510***	0.0496***	0.0506***	0.0503***
	(-0.0019)	(-0.0025)	(-0.0035)	(-0.0025)	(-0.0035)
DBTA	0.1457***	0.1127***	0.1163***	0.1029***	0.1046***
	(-0.0117)	(-0.0136)	(-0.0142)	(-0.0138)	(-0.0141)
WW			-0.0026		-0.0001
			(-0.0066)		(-0.0068)
SA				-0.1155***	-0.1144***
				(-0.0068)	(-0.0070)
SEZ	0.0275***	0.0256***	0.0259***	0.0250***	0.0251***
	(-0.0063)	(-0.0054)	(-0.0055)	(-0.0047)	(-0.0047)

Table 8

R&D, government subsidies, and firm location for each industry

This table reports the panel OLS estimates for the relation between firms R&D expenses, government subsidies, and firm location. Our sample period is from 2006 to 2014. See Appendix A for detailed variable definition. HAC-consistent standard errors are reported in the parentheses, *t*-statistics are reported in square brackets, and ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

	Auto related				Electronic related			
	1	2	3	4	1	2	3	4
RD(-1)	0.2469***	0.2039***	0.2503***	0.3089***	0.2462***	0.2373***	0.2253***	0.2272***
	(-0.0406)	(-0.0273)	(-0.0457)	(-0.0410)	(-0.0156)	(-0.0157)	(-0.0176)	(-0.0176)
	[6.0852]	[7.4695]	[5.4811]	[7.5396]	[15.8338]	[15.0549]	[12.8271]	[12.9292]
AGE	-0.0002***	-0.0003***			-0.0003***	-0.0004***		
	(-0.0001)	(-0.0001)			(-0.0001)	(-0.0001)		
	[-3.2015]	[-5.3865]			[-5.1579]	[-5.6857]		
ROE	0.0056*	0.0043*	0.0064*	0.0019	0.0179***	0.0169***	0.0132***	0.0189***
	(-0.0031)	(-0.0026)	(-0.0033)	(-0.0022)	(-0.0030)	(-0.0030)	(-0.0030)	(-0.0030)
	[1.8232]	[1.6200]	[1.9568]	[0.8948]	[5.9624]	[5.6069]	[6.3952]	[6.2834]
CF	0.0139***	0.0096***	0.0133***	0.0011	0.0175***	0.0160***	0.0132***	0.0127***
	(-0.0017)	(-0.0013)	(-0.0021)	(-0.0020)	(-0.0010)	(-0.0011)	(-0.0012)	(-0.0012)
	[8.2498]	[7.4580]	[6.3990]	[0.5802]	[17.1688]	[14.7790]	[11.4007]	[10.8968]
DBTA	-0.0025	-0.0097*	-0.0041	-0.007	-0.0068	-0.0114**	-0.0222***	-0.0238***
	(-0.0100)	(-0.0062)	(-0.0098)	(-0.0078)	(-0.0053)	(-0.0054)	(-0.0054)	(-0.0054)
	[-0.2461]	[-1.5452]	[-0.4138]	[-0.8949]	[-1.2805]	[-2.1100]	[-4.1369]	[-4.4103]
GSUB	0.3735**	0.3268***	0.3772**	0.2987**	1.0148***	0.9882***	0.9749***	0.9723***
	(-0.3735)	(-0.0655)	(-0.1563)	(-0.1327)	(-0.0578)	(-0.0581)	(-0.0600)	(-0.0599)
	[2.4363]	[4.9867]	[2.4131]	[2.2500]	[17.5494]	[17.0207]	[16.2539]	[16.2208]
WW		-0.0116***		-0.0778***		-0.0037***		-0.0023**
		(-0.0026)		(-0.0078)		(-0.0009)		(-0.0010)
		[-4.5258]		[-10.0246]		[-3.9210]		[-2.2176]
SA			0.0005	0.0091***			-0.0005**	-0.0003
			(-0.0004)	(-0.0009)			(-0.0003)	(-0.0003)
			[1.2864]	[10.2819]			[-2.0566]	[-1.0135]
SEZ	0.0029*	0.0022	0.0027	0.0018	0.0037*	0.0034***	0.0033***	0.0034****
	(-0.0018)	(-0.0018)	(-0.0024)	(-0.0013)	(-0.0009)	(-0.0009)	(-0.0009)	(-0.0009)
	[1.5778]	[1.2619]	[1.1113]	[1.3481]	[4.0321]	[3.7624]	[3.5252]	[3.5713]

Table 9

Robust test for equation (1): The GMM estimation of R&D expenses, financial constraint, and government subsidies

This table reports the robust test results for equation (1), the estimation uses one-step GMM estimates for the relation between firms R&D expenses, financial constraint, and government subsidies. Our sample period is from 2006 to 2014. See Appendix A for detailed variable definition. HAC-consistent standard errors are reported in the parentheses, and ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

	Full Sample			Automotive related			Electronics		
	1	2	3	1	2	3	1	2	3
RD_r(-1)	-0.2326***	-0.2265***	-0.2224***	-0.0282***	-0.3008***	-0.2996***	-0.1850***	-0.1645*	-0.1625*
	(-0.0162)	(0.0154)	(0.0154)	(0.0000)	(0.0008)	(0.0007)	(0.0905)	(0.1019)	(0.1019)
AGE	0.0153***	0.0137***		0.0057***	0.0045***		0.0237***	0.0226***	
	(0.0007)	(0.0008)		(0.0000)	(0.0000)		(0.0037)	(0.0041)	
ROE	0.2125***	0.2018***	0.1993***	0.0734***	0.0347***	0.0335***	0.2900***	0.2695***	0.2665***
	(0.0126)	(0.0153)	(0.0154)	(0.0001)	(0.0002)	(0.0001)	(0.0716)	(0.0710)	(0.0702)
CF_r	19.8988***	27.5177***	26.5140***	6.4841***	7.3295***	6.8072***	16.7038**	19.8025*	19.0202*
	(1.4405)	(1.9819)	(1.9962)	(0.0115)	(0.0422)	(0.0165)	(7.4968)	(11.7315)	(11.7140)
DBTA_r	0.0410	-0.0121	-0.0075	-0.0826***	-0.0155***	-0.0159***	-0.0120	-0.0723	-0.0768
	(0.0234)	(0.0306)	(0.0312)	(0.0002)	(0.0001)	(0.0001)	(0.1568)	(0.2080)	(0.2072)
GSUB_r		0.2217***	0.2281***		0.1061***	0.1071***		0.3330***	0.3375***
		(0.0241)	(0.0268)		(0.0008)	(0.0001)		(0.1302)	(0.1282)
SA			-0.3721***			-0.1277***			-0.6074***
			(0.0224)			(0.0002)			(0.1097)