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The Impact of Tax-Related Incentives on Innovation: Evidence from China

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Abstract

In the past decade, China has astonished the world with its speedy transformation into an innovation superpower. It is of interest to understand the strategies that have been implemented by the Chinese Government to achieve the great advancements that have been made in terms of innovative development in China. The objective of this paper is to examine the impact of tax-related incentives on the innovation performance of Chinese firms. Based on data from 9,531 firm-year observations of 2,359 firms between 2009 and 2013, we find that tax-related incentives have positive impacts on a firm's spending on R&D, but negative impacts on a firm's patenting performance. The finding may provide policy implications and insights for national leaders and enterprises with agendas that entail moving up the technology ladder.

In the report made to the 17th National Congress of the Communist Party of China (CPC) on behalf of the 16th Central Committee, dated 15 October 2007, ex-President Hu Jintao stated that China aims to enhance its capacity for independent innovation, to make China an innovative country through scientific and technological advancement. In 2006, China launched the "Outline of the National Program for Long and Medium-Term Scientific and Technological Development (2006-2020)", a 15-year plan to form a national innovation system. After more than 10 years of scientific and technological advancement, China has moved up the technology ladder at an astonishing pace to become a technologically-leading nation. According to the Global Innovation Index (GII) 2019, China rose from 43rd place (its lowest rank) in 2010 to 14th (its highest rank) in 2019. In 2016, China, as an emerging market and a "middle income" nation in Asia, ranked as the 25th most innovative economy and second in regard to GDP in the world. These facts alert policy-makers to the way in which encouraging innovation is important to a competitive economy.

In the past two decades, the Chinese Government has played an active role in supporting the development of innovation in China. The US National Science Foundation reports that China is on its way to becoming an innovation superpower (World Economic Forum, 2018). However, innovation is not just a numbers game. The issues involved also concern whether or not there are proper policies to encourage and facilitate sustainable growth in terms of innovation activity within enterprises.

The objective of this paper is to study the tax policy used by the Chinese Government in transforming China into an innovative nation. In the report made to the 17th National Congress of the CPC on 15 October 2007, ex-President Hu Jintao mentioned that China would adopt a fiscal and taxation system conducive to scientific development. In particular, we examine the impact of tax-related incentives on the innovation performance of firms. China provides an ideal research setting for this paper, as China is one of the largest producers of patents worldwide and ranks second in GDP in the world. Using data from Chinese firms from between 2009 and 2013, we find that tax-related incentives as a ratio to total assets have a positive effect on a firm's spending on R&D. However, tax-related incentives have a negative effect on patenting performance and this negative effect is stronger for firms in non-patent intensive industries. This paper sheds light on the impact of tax-related incentives on the input (measured by spending on R&D) and output (measured by the number of patents owned) of innovation. Our results suggest that simply providing tax-related incentives may not be sufficient to foster R&D and innovation development.

Background of Research

R&D and innovation are long-term and risky investments with uncertain returns. Hence, R&D and innovation activities have been under-invested. Neoclassical theory suggests market failure as an explanation for why firms underinvest in innovation (Arrow, 1962). Arrow (1962) states that R&D has characteristics of a public good (non-rivalry and non-excludability) because it can generate positive external effects that cannot be internalised by firms carrying out R&D investment, creating a situation involving imperfect appropriability in regard to R&D output. The characteristics of R&D as a public good and the imperfections of capital markets constitute a form of market failure for R&D investments. Therefore, there is an economic rationale behind public intervention. One way to mitigate the market failure is through the provision of government subsidies to incentivise greater R&D investment in the private sector. Otherwise, the level of R&D activity in the private sector is lower than is socially desirable. Based on public finance theory (e.g., David et al., 2000; Dimos and Pugh, 2016; Klette et al., 2000), government subsidies should exert three direct policy effects on innovation. The first direct effect is termed input additionality and incentivises greater investment in R&D. Behavioural additionality is the next effect; it encourages more corporate activities regarding R&D. The last effect is output additionality, which causes the quantity of R&D output to become larger. Hence, the source of financial support is always a concern for innovation-oriented entrepreneurship. Although there is an economic rationale behind government initiatives providing R&D subsidies to mitigate market failure, determining the extent to which government interventions can trigger more firm-financed R&D investments is an empirical issue.

The government is the major resource provider in the market. A variety of financial assistance is offered by the government to encourage enterprises to engage in more R&D activities. These forms of financial assistance include direct subsidies (e.g., financial support for the construction of a technology centre) and indirect financial assistance, such as tax-related incentives (e.g., corporate income tax cuts, reduced custom duties, tax rebates, and exemptions on R&D expenses) and research funding schemes. Most research funding schemes and subsidy programmes encouraging R&D activities involve applications and selective procedures, which are costly in terms of time and money. An advantage of using tax-related incentives is that they are relatively simpler and more cost-efficient in terms of time and administrative costs, as compared to subsidy schemes that require applications and screening processes (for details of the differences between direct financial support through government subsidies and indirect assistance through tax incentives, see Carvalho, 2012; Montmartin and Herrera, 2015)

Hence, in this study, our focus is on tax-related incentives. The objective of R&D tax-related incentives is the reduction of tax liabilities for enterprises undertaking R&D and innovative activities. Evidence from studies examining the impact of tax credits on innovation output is mixed. There is evidence that R&D tax credits have a positive effect on Canadian manufacturing firms in terms of the number of new products produced and the market share of the new products (Czarnitzki et al., 2011). However, no impact is found in regard to tax-related incentives and patenting activity for Norwegian firms (Cappelen et al., 2012). Bérubé and Mohnen (2009) compare the impacts of R&D grants and R&D tax credits, and find that Canadian firms receiving both R&D grants and R&D tax credits are more innovative in terms of new products than when only R&D tax credits are given. Using a sample of US firms, Moretti and Wilson (2014) report a limited impact of state-based incentives (including tax credits and subsidies for R&D) on the number of patent inventions for firms in the biotech industry.

With the aim of becoming a global superpower in science and innovation, China is one of the largest spenders on R&D, which is an indicator of investment in technology. The spending of China on R&D is so huge that it accounted for 21 per cent of the country's global spending (about US$2 trillion) in 2015. In addition, between 2010 and 2015, R&D expenditure increased by a yearly average of 18 per cent (World Economic Forum, 2018). Since the Hu Jintao's speech during the 17^{th} National Congress in 2007, the Chinese Government has implemented a number of fiscal and taxation policies conducive to scientific development. There are now various types of financial incentives (subsidies in different forms, tax-related incentives, government research funding schemes, and reductions in custom duties) for Chinese enterprises, particularly high-tech enterprises (HTEs) and technology advanced service enterprises (TASEs). The new Enterprise Income Tax Law (effective from 2008) provides a series of tax incentives, such as reduced corporate income tax, R&D expense rebates, tax relief, and exemption, for enterprises that participate in innovative and R&D activities. Since financial resources are an important element in the innovation process, we hypothesise that there is a positive effect of tax-related incentives on innovation input and output.

Hypothesis 1: Tax-related incentives have positive effects on innovation input.

Hypothesis 2: Tax-related incentives have positive effects on innovation output.

Data and Methodology

We conduct analyses using firms from China between 2009 and 2013. We drop firms in financial sectors, as the financial reporting requirements for financial firms and non-financial firms are different. The source of the patent information is the State Intellectual Property Office (SIPO) of China. The firm financial characteristics (profitability, leverage, firm size, and R&D expenses) and board characteristics (board size and professional qualifications) are obtained from the China Stock Market and Accounting Research (CSMAR) database. We extract information about government budgetary expenditure regarding the science and technology expenses of various provinces in China for each year over the sample period from the National Bureau of Statistics of China (www.stats.gov.cn). The sample consists of a panel of 2,359 firms, creating 9,531 firm-year observations. The following equations are used to test the relationship between tax-related incentives and input, as well as innovation output:

$$\begin{aligned}\text{R\&D Expenses} = {} & \alpha_0 + \beta_1 \text{ Tax-Related Incentives} + \beta_2 \text{ Patent Intensive Industry} \\ & + \beta_3 \text{ Tax-Related Incentives x Patent Intensive Industry} \\ & + \beta_4 \text{ Control} + \beta_j \Sigma \text{ Industry}_j + \beta_t \Sigma_t \text{ Year}_t \qquad (1)\end{aligned}$$

$$\begin{aligned}\text{Number of Patents} = {} & \alpha_0 + \beta_1 \text{ Tax-Related Incentives} + \beta_2 \text{ Patent Intensive Industry} \\ & + \beta_3 \text{ Tax-Related Incentives x Patent Intensive Industry} \\ & + \beta_4 \text{R\&D Expenses} + \beta_5 \text{Control} + \beta_j \Sigma_j \text{ Industry}_j + \beta_t \Sigma_t \text{ Year}_t \qquad (2)\end{aligned}$$

Measurement of Key Variables

We use two dependent variables to measure innovation input and output. The innovative activity of a firm should be related to the amount of expenditure on research and development. Somaya et al. (2007, p. 923) argue that "R&D is seen as an input into the production of firm-specific knowledge resources, which in turn facilitate the identification, assimilation, and exploration of information generated both within and outside the firm". Hence, *R&D Expenses* (the dollar amount of a firm's spending on research and development activity in logarithm form) is used as the measure of innovation input.

Hagedoorn and Cloodt (2003) show that patents are an appropriate measure of innovation output.

According to information from the SIPO, a patent is an exclusive right regarding invention, utility model, or design. Hence, this paper adopts the number of patents granted by the SIPO as an indicator of innovative activity. *Number of Patents* is measured by the number of exclusive rights (in logarithm form) regarding invention, utility model, and design owned by a firm.

We have two measures each for the dependent variables of *R&D Expenses* and *Number of Patents*. *R&D Expenses in Current Period* is the dollar amount of R&D expenses in the current period and *R&D Expenses in Subsequent Period* is the dollar amount of R&D expenses in the subsequent period. *Number of Patents in Current Period* is the number of patents in the current period and *Number of Patents in Subsequent Period* is the number of patents in the subsequent period.We measure innovation performance in terms of the dollar amount of a firm's spending on R&D and the number of patents owned by a firm in both the current and subsequent years, as it may take time for tax-related incentives to take effect.

As the objective of this paper is to examine the impact of tax-related incentives on the innovation performance of firms, our explanatory variable is *Tax-Related Incentives*, which is the ratio of the total dollar amount of the tax-related incentives received by the firm to total assets. Examples of tax-related incentives include corporate income tax cuts, reduced custom duties, tax rebates, and exemptions from R&D expenses.[1] In order to test if the impact of tax-related incentives is more significant for firms in patent intensive industries than in non-patent intensive industries, we include the variable, *Patent Intensive Industry*, in the model. *Patent Intensive Industry* is a dummy, coded as 1 if the firm is in a patent intensive industry and 0 otherwise. Patent intensive industries have a higher number of patents. There are about 40 industry sectors in the Chinese market and the number of firms in each sector varies. Hence, it is not appropriate to use the total number of patents in each industry to identify patent intensive industry sectors. Instead, we compute the average number of patents in each industry for each year in our sample. In each year, each industry sector has an average number of patents. In order to create comparable subsamples of patent intensive industries versus non-patent intensive industries, we use the industry median to divide the sample. We measure an industry median number of patents for each year using the average number of patents in each industry sector. Industry sectors with the average number of patents (which is equal to and above the industry median number of patents) are considered to be patent intensive industries.

Measurement of Control Variables

The control variables in the model are grouped into four types: financial characteristics, board characteristics, ownership structure, and variables controlling for the differential development in R&D across various regions in China. There are four control variables for financial characteristics: *Total Assets, Debt-to-Assets Ratio, Return-on-Assets Ratio,* and *Firm Age*. Audretsch (2002) and Audretsch and Vivarelli (1996) found that R&D productivity is related to firm size. *Total Assets* is measured by the log value of total assets, which is a variable controlled for firm size. *Debt-to-Assets Ratio*, which is used to measure a firm's financial leverage, is computed by the ratio of total liabilities to total assets. *Return-on-Assets Ratio* is the return on assets, which is a proxy for profitability. Since firm age is related to innovation output (Hansen, 1992), we include *Firm Age* (the logarithm transformation of the number of years the firm has been established) in our model.

Board characteristics include *Board Size* (the log value of the total number of directors on a board) and *Proportion of Scientist Directors* (the proportion of directors with professional qualifications in science and technology disciplines, such as medicine and engineering). Previous studies document two opposing arguments for the relationship between board size and likelihood to innovate. O'Reilly et al. (1989) and Zona et al. (2013) argue that, owing to the need to make compromises among different board members, there is a lower likelihood for firms with larger boards to take risks and to innovate. However, Hillman et al. (2009) suggest that a firm with a greater number of board directors will have more opportunities to obtain resources from external environments, which can result in more innovative investments. Engineers and scientists are important human resources in the innovation process and, hence, it is expected that firms with a higher proportion of directors with knowledge in regard to science, technology, and engineering will have better patenting performance.

We use two control variables for ownership structure: *Central SOE* and *Local SOE*. *Central SOE* is a dummy with the value of 1 if the firm is a state-owned enterprise controlled by the central government or its related agencies, and 0 otherwise. *Local SOE* is a dummy with a value of 1 if the firm is a state-owned enterprise controlled by the local government or its related agencies, and 0 otherwise.

There are more than 30 administrative divisions (provinces, municipalities, and autonomous regions) in China. The Chinese Government's spending on science and technology varies across regions. To control for the differential levels of scientific and technological development stages in various regions across China, we use *Ratio of Regional Science & Technology Budget to Total Budget*, which is the ratio of regional budgetary expenditure for science and technology to total regional public budgetary expenditure. *Industry* and *Year* represent the industry and year dummies, which are used to control for the fixed effects across different industry groups and to account for the effect of time trend across the years included in the sample period. As there are multiple firm-year observations in the sample, a firm random-effects panel model is used to control for firm heterogeneity.

Results

Table 1 presents descriptive statistics (means and standard deviations) and a correlation matrix for the variables in the model. The firms spend about RMB6.82 million (*R&D Expenses in Current Period*) and RMB7.95 million (*R&D Expenses in Subsequent Period*) on R&D activity in the current period and in the subsequent period, respectively. The average numbers of patents owned by the firms are 40.5 in the current year (*Number of Patents in Current Period*) and 51.4 in the subsequent year (*Number of Patents in Subsequent Period*). The mean tax-related incentives to total assets ratio is 0.09%. Of the 9,531 firm-year observations, 4,923 observations (51.65%) are firms in patent-intensive industries. Firm size, proxied by total assets, is on average RMB9,252.2 million. The average debt-to-assets ratio and return-on-assets ratio are 0.43 and 0.04, respectively. The firms have a mean age of 12.97 years. The mean number of directors is 9.69, 13.25% of whom are directors with professional qualifications in scientific and technological disciplines. There are 1,472 observations and 2,796 observations that are central SOEs (15.44%) and local SOEs (29.34%), respectively. The remaining firms are privately owned firms (5,263 observations; 55.22%). Almost 3% of the regional public budgetary expenditure is spent on science and technology.

Among the independent variables, the correlation coefficients in the matrix are in the range of -0.27 and 0.51, indicating a low risk of multicollinearity if the variables are included in the model. The multicollinearity test, shown by the variance inflation factor (with the highest value of 2.72), also reveals that the model does not suffer from multicollinearity problems.

This study argues that tax-related incentives should have a positive effect on innovation input and output. Table 2 depicts the results. Models (1) and (2) show the results with *R&D Expenses* as the dependent variable and Models (3) and (4) show the results with *Number of Patents* as the dependent variable. In Models (1) and (2), *Tax-Related Incentives* are marginally significant (p-value < 0.1), indicating that tax-related incentives have a positive effect on a firm's spending on R&D in both the current period (*R&D Expenses in Current Period*) and the subsequent period (*R&D Expenses in Subsequent Period*). The coefficients on *Tax-Related Incentives* are significantly negative (p-value < 0.01) in Models (3) and (4), implying that tax-related incentives do not result in better patenting performance for all firms in the current year (*Number of Patents in Current Period*) or the subsequent year (*Number of Patents in Subsequent Period*). While *Patent Intensive Industry* and *Tax-Related Incentives x Patent Intensive Industry* do not show significant relationships with R&D expenses in Models (1) and (2), they are significant in Models (3) and (4). The number of patents owned by the firms in non-patent intensive industries is significantly less than that in patent intensive industries, as indicated by the positive coefficient on *Patent Intensive Industry* (p-value < 0.01). When the tax-related incentives and patent intensive industry variables interact (*Tax-Related Incentives x Patent Intensive Industry*), their coefficients are significantly positive (p-value < 0.05). *R&D Expenses* is positively related to the number of patents, a finding consistent with that Somaya et al. (2007); R&D is an input into the generation of firm-specific knowledge resources.

Overall, our results demonstrate that tax-related incentives have a positive effect on a firm's spending on R&D but have negative effects on patenting performance; this negative effect is stronger for firms in non-patent intensive industries, as shown by the positive coefficients of the interaction term (*Tax-Related Incentives x Patent Intensive Industry*) in Table 2. These findings provide evidence for Hypothesis 1 but not for Hypothesis 2.

In regard to the control variables, consistent with previous studies conducted by Audretsch (2002) and Audretsch and Vivarelli (1996), Total Assets is positively related to innovation performance. We find the *Return-on-Assets Ratio* to be negatively related to the number of patents granted to a firm. The coefficients of *Firm Age* are negatively related to *R&D Expenses* in Models (1) and (2) and positively related to *Number of Patents* in Models (3) and (4). Research has documented the way in which employees with knowledge in science, technology, engineering, and mathematics (STEM) display better innovative performance (e.g., Peri et al., 2015). Our finding concerning the significant and positive coefficients on *Proportion of Scientist Directors* (Models (2) and (4)) is consistent with the findings of previous studies. *Central SOE* has a positive relationship with *R&D Expenses* and *Local SOE* has negative relationship with *Number of Patents*. It is expected that the innovative performance of a firm is better when there is greater support from the government. *Ratio of Regional Science & Technology Budget to Total Budget* is positively related to *Number of*

Patents, indicating that the higher the budgetary expenditure for science and technology, the better the innovative performance of the firms located in the region.

Conclusion, Limitations, and Future Research

In the past decade, China has transformed into an innovative nation at an extremely fast pace. In this paper, we examine the impact of tax-related incentives on the innovation performance of Chinese firms. Based on data from 9,531 firm-year observations of 2,359 firms between 2009 and 2013, we find evidence to suggest that tax-related incentives provided by the Chinese Government have a positive effect on the R&D spending and a negative effect on the patenting performance of the Chinese firms. The findings from this study may provide some insights for policy-makers and enterprises in other countries. Innovation is not just a numbers game. While tax policies are an essential component of fiscal policies, there should be a comprehensive fiscal strategy regarding the use of government spending in order to facilitate the development of R&D and innovation activities.

One limitation of our study is that we are not able to categorise the tax-related incentives into different categories for further analysis, due to the lack of availability of the data. Future research with a more detailed classification of tax-related incentives can focus on examining the impacts of R&D-related tax incentives on innovation performance. Another limitation is that our study only examines the impact of tax-related incentives on innovation performance over a relatively short period of time. However, innovation and R&D activities are long-term investments and it takes time for an impact to be made. Hence, future studies should investigate innovation performance over a longer period of time.

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Table 1 Descriptive Statistics and Correlation

		Mean	Standard deviation	1	2	3	4	5	6
1	*R&D Expenses in Current Period*	2.6945	6.0223	1.00					
2	*R&D Expenses in Subsequent Period*	2.9583	6.2940	0.85**	1.00				
3	*Number of Patents in Current Period*	1.9518	1.8717	0.12**	0.12**	1.00			
4	*Number of Patents in Subsequent Period*	2.1490	1.9559	0.12**	0.13**	0.98**	1.00		
5	*Tax-Related Incentives*	0.0009	0.0035	0.08**	0.09**	0.05**	0.06**	1.00	
6	*Patent Intensive Industry*	0.5165	0.4998	0.05**	0.05**	0.47**	0.48**	0.04**	1.00
7	*Total Assets*	21.7799	1.2483	0.01	-0.00	0.05**	0.04**	-0.06**	-0.06**
8	*Debt-to-Assets Ratio*	0.4324	0.2180	-0.07**	-0.09**	-0.14**	-0.16**	-0.10**	-0.13**
9	*Return-on-Assets Ratio*	0.0442	0.0733	0.02*	0.03**	0.05**	0.06**	0.06**	0.02
10	*Firm Age*	2.4501	0.5312	-0.05**	-0.06**	-0.17**	-0.21**	-0.05**	-0.15**
11	*Board Size*	2.2471	0.2205	0.00	-0.00	0.02	0.02*	-0.01	-0.02
12	*Proportion of Scientist-Directors*	0.1325	0.1668	0.01	0.01	0.16**	0.18**	0.05**	0.11**
13	*Central SOE*	0.1544	0.3614	0.09**	0.09**	0.05**	0.04**	-0.01	0.00
14	*Local SOE*	0.2934	0.4553	-0.09**	-0.10**	-0.18**	-0.19**	-0.04**	-0.14**
15	*Ratio of Regional Science & Technology Budget to Total Budget*	0.0291	0.0169	0.05**	0.06**	0.05**	0.05**	0.04**	0.03**

		7	8	9	10	11	12	13	14
7	*Total Assets*	1.00							
8	*Debt-to-Assets Ratio*	0.51**	1.00						
9	*Return-on-Assets Ratio*	-0.01	-0.27**	1.00					
10	*Firm Age*	0.15**	0.32**	0.06**	1.00				
11	*Board Size*	0.25**	0.15**	-0.04**	0.09**	1.00			
12	*Proportion of Scientist-Directors*	0.08**	-0.02*	0.01	-0.14**	0.00	1.00		
13	*Central SOE*	0.22**	0.16**	-0.06**	0.06**	0.10**	0.12**	1.00	
14	*Local SOE*	0.25**	0.28**	-0.07**	0.24**	0.15**	-0.04**	-0.28**	1.00
15	*Ratio of Regional Science & Technology Budget to Total Budget*	0.03**	-0.12**	0.05**	-0.08**	-0.04**	-0.04**	0.05**	-0.10**

* and ** denote significance at the 5% and 1 % levels, respectively.

Table 2 Regression Results

	R&D Expenses in Current Period (1)	R&D Expenses in Subsequent Period (2)	Number of Patents in Current Period (3)	Number of Patents in Subsequent Peraiod (4)
Intercept	-4.54*	-2.86	-1.68**	-1.94**
Tax-Related Incentives	40.35†	36.65†	-10.51**	-9.32**
Patent Intensive Industry	-0.02	0.01	0.19**	0.20**
Tax-Related Incentives x Patent Intensive Industry	-17.88	-10.77	9.79*	8.17*
R&D Expenses			0.01**	0.01**
Total Assets	0.35**	0.29**	0.07**	0.10**
Debt-to-Assets Ratio	-0.28	-0.40	0.07	-0.05
Return-on-Assets Ratio	-0.37	0.52	-0.21*	-0.15†
Firm Age	-0.35†	-0.50**	0.34**	0.17**
Board Size	0.02	0.03	-0.01	0.05
Proportion of Scientist-Directors	0.25	0.68†	0.10	0.17**
Central SOE	1.05**	1.17**	0.07	0.06
Local SOE	-0.17	-0.30	-0.11*	-0.12*
Ratio of Regional Science & Technology Budget to Total Budget	5.02	8.19	7.73**	7.21**
Year- and Industry-Fixed Effects Included				
Adjusted R-square	0.09	0.10	0.36	0.38
F-statistics	25.18	29.02	138.99	152.93
p-value	0.00	0.00	0.00	0.00
Number of Observations	9531	9531	9531	9531

†, * and ** denote significance at the 10%, 5%, and 1 % levels, respectively.

Endnote:

1. Owing to a lack of availability of data, we do not have the information necessary to further differentiate the types of tax-related incentives into those that are specifically for R&D activities and for other purposes in general, except for tax exemptions for R&D expenses. This is a limitation of our study. T