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ABSTRACT

This paper exploits a tax reform on manufacturing firms in China to study the impact of taxes on firm innovation. The reform switched the corporate income tax collection from the local to the state tax bureau and reduced the effective tax rate by 10%. The reform only applied to firms established after January 2002, allowing us to use regression discontinuity design as the identification strategy. The results show that lower taxes improved both quantity and quality of firm innovation. Moreover, the reform has a bigger impact on firms that are financially constrained and firms that engage more in tax evasion.

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1. Introduction

Innovation has been increasingly recognized as the main engine for economic growth (Solow (1957); Romer (1990); Grossman and Helpman (1991); Aghion and Howitt (1992); Aghion, Akcigit, and Howitt (2014)). Policy makers in both developed and developing countries have started to use tax incentives to encourage investment in innovation. But we know very little about the impact of such policies on firm innovation and the underlying mechanisms.

Theoretically, taxes can have either positive or negative impacts on firm innovation. On the one hand, lower taxes can increase the after-tax profit of firms, so that they have better capacity to invest in new technologies or products; moreover, lower taxes may reduce resources that firms spend on tax evasion, such as costs of bribing tax officers, which can be instead used on innovation activities. On the other hand, lower taxes may also have a negative impact on innovation because they decrease government revenue, and in turn may reduce government spending on public goods such as research, education, and infrastructure. As a result, whether providing tax incentives can improve firm innovation is ambiguous.

This paper investigates the impact of taxes on firm innovation using a natural experiment in China. In November 2001, China implemented a tax collection reform on all manufacturing firms established on or after January 2002, which switched the collection of corporate income taxes from the local tax bureau to the state tax bureau. Because of differences in management and incentives of those two types of tax bureaus, the reform changed the enforcement of tax collection, resulting in a reduction

of effective corporate income tax rates by almost 10% among treated firms. Since firms registered before 2002 were not affected by the reform, the policy change created exogenous variations in the effective tax rate among similar firms established before or after 2002. We can thus apply a regression discontinuity design (RD) and use the generated variation in the effective tax rate to identify the impact of taxes on firm innovation.

To test the impact of taxes on innovation, we combine a comprehensive dataset of all medium and large enterprises in China between 1998 and 2007 with patent data from the State Intellectual Property Office (SIPO) including all patents applied in China by the year 2014. We use the data to measure three dimensions of innovation activities: input (R&D expenditure and skilled labor ratio), output (number of patent application), and quality (type and characteristics of patent application).

The key assumption of the RD analysis is that firm cohort should have a significant impact on the effective corporate tax rate; however, all other unobserved determinants of firm innovation are not correlated with firm cohort. We provide three pieces of evidence to validate the estimation strategy. First, the reform did significantly reduce the effective tax rate: the tax rate is almost 10% lower among firms establisehd after 2002 compared with those registered before 2002. Second, there's no significant difference in firm entry around 2002, suggesting that the reform was a surprise to firms and they did not selectively postponed the registration date. Third, we don't see significantly higher firm re-registration after 2002.

Our analysis yields several interesting results. First, we show a strong and robust causal relationship between tax rate and firm innovation: decreasing the effective tax rate by one standard deviation (0.01) increases the average number of patent application by a significant 5.7%. The reform also stimulated R&D expenditures and increased the skilled-labor ratio by 14%. Second, the impact of the reform on patenting mainly comes from its effect on invention and utility patents, suggesting that the improvement in innovation outcomes is not merely driven by the low-quality design patents. Third, we provide suggestive evidence that a low tax rate can stimulate firm's innovation by alleviating financial constraints and by reallocating resources from tax evasion activities.

Our work builds on and contributes to three main literatures. First, this paper sheds light on the impact of taxes on firm decision-making and economic growth. Existing research studied the influence of tax policies on economic growth (Romer and Romer (2010); Barro and Redlick (2011)), firm investment (Auerbach and Hassett (1992); Hines and Rice (1994); Cummins, Hassett, and Hubbard (1996); Devereux, Griffith, and Kelmm (2002); Hasset and Hubbard (2002); Djankov et al (2011); Mertens and Ravn (2012); Zwick and Mahon (2017)), corporate financial policy (Auerbach (2002)), entrepreneurial risk-taking (Cullen and Gordon (2007); Haufler, Norback, and Persson (2014)), and location decisions (Devereux and Griffith (2003); Moretti and Wilson (2017)). However, the impact of taxes on firm innovation is not well explored. Mukherjee, Singh, and Zaldokas (2017) and Atanassov and Liu (2014) exploit the effect of staggered changes in state-level corporate tax rates on

innovation behavior of publicly listed firms in the United States, and find significant impact of taxes on innovation, mainly through relieving firms' financial constraints. In two recent working papers, Akcigit et al (2018) uses data on both inventors and firms and shows that higher personal and corporate income taxes negatively affect innovation; Chen et al (2018) finds that cutting corporate taxes for high-tech companies significantly improved firm productivity and R&D investment in China. Our paper differs from those papers in several ways. First, we are the first paper to look at the impact of changes in tax enforcement rather than explicit tax reduction on firms' innovation behavior. Second, out data covers a broad range of firms and a comprehensive set of innovation outcomes, and we answer the question in a developing-country's context.

Second, the paper relates to the literature on the determinants of innovation. Existing evidence shows that product market competition (Aghion et al (2005)), institutional ownership (Aghion, Van Reenen, and Zingales (2013); Ferreira, Manso, and Silva (2014)), laws (Acharya, Baghai, and Subramanian (2014)), investors' attitudes towards failure (Tian and Wang (2011)), managerial incentive (Manso (2011)), and financial development and regulation (Hsu, Tian, and Xu (2014); Amore, Schneider, and Zaldokas (2013); Fang, Tian, and Tice (2014); Cornaggia et al (2015)), all affect innovation. Another branch of papers study the effect of an R&D tax credit on R&D investment (Hall and Van Reenen (2000); Bloom, Griffith, and Van Reenen (2002); Wilson (2009); Rao (2016)). We contribute to this literature by showing that corporate tax policies are also a first order determinant of firm innovation.

Third, the paper also contributes to the literature on tax enforcement. The tax-to-GDP ratio is substantially lower in poor countries compared with developed countries (Gordon and Li (2009); Besley and Torsten (2014)). One important reason of low tax revenue is weak tax enforcement, and several theory papers suggest that policy-makers can use tax enforcement instead of explicitly changing tax rates as a tax instrument (Kaplow (1990)). There are a growing number of papers showing that tax enforcement can be improved by providing performance pay incentives to tax inspectors (Besley and McLaren (1993); Khan, Khwaja, and Olken (2016)), introducing third party reporting to improve information available on tax payers (Kleven et al (2011); Kumler, Verhoogen, and Frias (2015); Naritomi (2016); Pomeranz (2015); Kopczuk et al (2016)), and offering auditing (Slemrod, Blumenthal, and Christian (2001). However, another important but not well-explored factor affecting tax enforcement is the incentive of local governments and tax agencies. Chen (2017) uses China's 2005 agricultural tax abolition as a natural experiment to study the impact of county governments' incentives on tax enforcement, and shows that the revenue loss is largely offset by tougher tax enforcement on value-added taxes. Our study adds to this literature by showing that the management and incentives of tax collection agencies play an important role in tax enforcement and the tax capacity of a country.

The rest of the paper is organized as follows. Section 2 describes the background of China's tax collection system and the reform. Section 3 presents data and summary

statistics. Section 4 explains the identification strategy. Section 5 presents the results, and Section 6 concludes.

2. Institutional background

2.1. China's Tax collection system

Before the economic reform started in 1979, tax administration in China was simple because there were no personal or corporate income taxes. Most of the tax revenues came from profit remittance of state-owned enterprises. Local governments[4] were in responsible for tax collection, but all revenues were consolidated to the central government, who sets spending priorities and redistributes the revenue based on local spending needs. Such a system, called "unified revenue collection and unified spending" (also known as "eating from one big pot"), provides very little incentives for the local government to develop their local economies.

In 1980, the "fiscal contracting system" (also known as "eating from separate kitchens") was introduced. Under this system, local revenue was divided between the central and local governments based on pre-determined sharing schemes. The new system not only guaranteed the central government a certain flow of revenue from local governments, but also provided local governments with incentives to build up local economies and the revenue base. The share of local expenditure increased from

[4] China's government administration has five levels: central, provincial, municipality, county, and township. In this paper we refer to all subnational governments as local governments.

45% of the total in 1981 to 72% in 1993. However, since the sharing rule can be continuously negotiated and changed, local governments view this as a lack of commitment from the central government and they tend to divert funds from budgetary to extra-budgetary revenues, which were not subjected to sharing with the central government. Since the central government relies on local authorities to collect tax, it is hard to monitor and correct such manipulation. From 1980 to 1992, the extra-budgetary revenue to budgetary revenue ratio increased from 48% to 120%. This greatly dampened the central government's fiscal capacity.

In order to strengthen the central government's control on taxation, a major fiscal system reform was introduced in 1994. In the reform, taxes were classified into central, local and shared taxes, which explicitly specified the tax sharing rules between the central and local governments. Specifically, the central taxes include customs duties and consumption taxes; the local taxes include corporate income taxes, real estate and property taxes; and the shared taxes include value-added taxes (75% central, 25% local) and personal income tax.

Moreover, the central government also established its own tax-collection department to centralize the revenue system, preventing the local governments from intervening central and shared taxes. Since then, the tax collection system is divided into two bureaus: the state tax bureau and local tax bureau. The state tax bureau collects central taxes and shared taxes, while the local tax bureau collects local taxes. Both bureaus have branches on the province, city, and county levels. The most significant difference between these two bureaus is in the management system. The

state tax bureau adopts a vertical reporting model: each state tax bureau is directly responsible for the tax bureau at level above. For example, the director of a province-level state tax bureau is appointed by the director of the State Bureau of General Taxation (headquarter of the state tax bureau); the provincial government does not have any power on the state tax bureau of any level. In contrast, the local tax bureau is managed by the local government: the provincial government manages the province-level local tax bureau, appoints their director and provides funding for operation. Under such a system, the interference of local governments in the collection of central and shared taxes is minimized.

2.2. The corporate income tax collection reform in 2002

Since the 1994 tax reform, the local tax bureau collects the corporate income tax of all firms except for foreign and state-owned enterprises, and all the revenue goes to local government. In January 2002, a corporate income tax collection reform was implemented, which switched corporate income tax collection of all domestic private firms established on or after January 1, 2002, to state tax bureau. However, the tax collection for firms registered before 2002 did not change[5]. The reform was a shock for firms, because the decision was not made until December 2001. This is very

[5] The government was planning to switch corporate income tax collection to the state tax bureau for all firms. However, because local and state tax bureaus use completely different tax collection and record systems, it was very difficult to transfer the tax collection on existing firms. As a result, only new firms established after 2002 were covered by the reform.

important for our identification: it ensured that firms did not have enough time to manipulate their registration time.

The reform has two main objectives. First, although the local government did not have the right to change the tax rate[6], they could offer unnecessary tax exemptions or relax tax enforcement to lower the effective tax rate for local firms, in order to protect local firms and improve their competitive power. Second, the central government needed additional tax revenue to support the "western development strategy" proposed in the year 1999. The plan was to promote the growth of the underdeveloped western provinces, which would need financial transfers from the east.

After the reform, similar firms established before or after 2002 could pay very different effective tax rates because of the following reasons. First, the incentives of corporate tax collection were different between the local and central tax bureaus. Just as the target of GDP growth rate is set by the central government every year, tax collection agencies are also assigned with a targeted tax growth rate, and whether the target can be achieved or not may influence the promotion of the tax bureau leaders. For the state tax bureau, value-added tax accounted for 62% of the total tax collected in 2007, while local tax agencies mainly rely on corporate taxes to fulfill the target. Second, the local tax bureau is managed by the local government, so they have more

[6] During our sample period (1998-2007), the corporate income tax rate in China was consistent. From 1994 to 2007, all domestic firms faced a corporate income tax rate of 33%. Foreign firms enjoyed different kinds of tax reduction depending on their industry and location. For example, the tax rate for firms in special economic zones was only 15%. In 2008, China adjusted the corporate income tax rate to 25% for both domestic and foreign firms.

power and information on local firms, which may help enforcing tax collection. However, although local tax bureaus have more incentives and information advantages to enforce corporate tax collection, local governments may protect local firms for long-term growth by encouraging local tax bureaus to loosen the enforcement of tax collection or by offering favorable tax policies[7]. As a result, the tax collection reform may have either positive or negative effects on firms' effective tax rate.

3. Data and Summary Statistics

The empirical analysis is based on two main data sources. The first one is the annual firm survey data developed and maintained by the National Bureau of Statistics of China (NBS). The NBS data contain annual survey data of all "above scale" industrial firms with annual sales of more than 5 million RMB. On average, around 220,000 firms per year from 1998 to 2007 are included in the dataset, spanning 37 two-digit manufacturing industries and 31 provinces or province-equivalent municipal cities. Firms included in this survey accounted for almost 50% of China's industrial value-added, and 22% of China's urban employment

[7] Local governments face targets of GDP growth to fulfill each year. Cities and provinces are also ranked by GDP growth. Whether the local government leaders can meet the growth target and their rankings is an important factor influencing promotion. This leads to intense horizontal competition between local governments across regions (Li and Zhou (2005)). Local governments thus have incentive to protect local firms by lowering their effective tax rate.

in 2005. The original dataset includes 2,226,104 firm-year observations. Since this paper focuses on manufacturing firms, we eliminate non-manufacturing observations. Moreover, because only firms established in and after the year 2002 were covered by the tax collection reform, we only use firm survey data from 2002 to 2007. To further clean the sample, we deleted observations where firm identifiers, county code, sector id, or year of establishment are missing, as well as observations whose value of fixed assets or total sales is below RMB 5 million, or if the number of employees is smaller than 30. In addition, observations are dropped if total assets are less than liquid assets or total fixed assets, if inputs are larger than output, if the firm is less than one year old, or if key variables such as corporate tax, input and total wages are negative or zero. After implementing these data cleaning procedures, we obtain a sample of 472,180 observations for analysis.

The second data source is patent data from the State Intellectual Property Office (SIPO). We purchased all the records of patents approved as of May 1, 2014, from SIPO. The database contains 4,060,392 observations covering all patents applied in China, including 1,097,000 invention patents, 1,620,069 utility model patents, and 1,343,323 design patents. A typical patent entry includes the following information: application number, patent name, applicant, inventor, application date, publishing date, granting date, main International Patent Classification (IPC) number, filing agent's name and institution, applicant address, patent origin (provinces in China or other countries), and a short description of the patent. We also have characteristics of patent including number of characters in the application file, number of claims and

exclusivities, number of figures. We don't have citation data because only in recent years has SIPO begun to track citations. We use firm name, address, and CEO name to merge the patent data with the firm survey data.

In Table 1, we provide summary statistics for key variables. In our sample, about 45.3% firms are private firms established after January 2002, and thus received the policy treatment. Panel A on firm characteristics shows that in the year 2007, average firm age was about 8.09 years, and that 76.4% of firms were domestic private enterprises. We also have about 1.4% State-owned enterprises and 22.2% foreign firms in the sample, who are not influenced by the reform regardless of whether they were registered before or after 2002. The average firm size was about 184 employees, and firms export about 16.7% of their sales.

Panel B presents data on accounting measures of firm performance. Average sales were 66.76 million RMB (about 10 million USD), and the average output was 68.46 million RMB. While firms pay three major types of taxes, including value-added tax, corporate income tax, and business tax, only corporate income tax was affected by the tax collection policy reform. We thus focus on this type of tax in the paper and define the tax rate as the corporate income tax to sales ratio[8]. In the year 2007 the average tax rate was about 1.13%.

[8] We use sales instead of profit to measure the effective tax rate for two reasons. First, there are many zero or negative values of profit; second, some firms may under report profits in order to pay less tax. Differences in tax enforcement could affect the possibility of misreporting; nevertheless, sales are much harder to manipulate.

Panel C reports measures of innovation. We use three indicators of innovation. The first and main indicator we look at is firm-level patent applications. The data shows that during the three years 2007 to 2010, 7.1% firms applied for patents; and among those firms, the average number of patent application was about 8.86 and the approved number of patent was around 2.52 (25% approval rate). The second indicator is the R&D expenditure. In the NBS firm survey data, information on R&D expenses is only available in years 2005-2007, and the average R&D-to-sales ratio in year 2007 was around 0.002. Lastly, we also look at the skilled labor ratio, defined as the share of workers with an above-college-level degree. Information on worker education is only available in the year 2004, and the average skilled labor ratio is 0.11.

4. Empirical Strategy

The main challenge of identifying the causal impact of tax rates on firm innovation is that tax policies can be endogenously determined. Some unobserved factors could affect both tax rate and innovation. For example, high-tech firms are more likely to innovate and normally can get an R&D tax reduction from the local government; more productive firms are more advanced in technology and may also be more skillful managing taxations. Reverse causality is also a problem: more innovative firms charge higher product prices and make more profits at the same sales level.

The introduction of the corporate income tax collection reform was only targeted on private firms established after the year 2002. If the reform indeed changed tax enforcement, two firms established before or after January 2002 but which are otherwise similar should face significantly different effective tax rates. In that case, we can use the regression discontinuity (RD) design to identify the impact of taxes on firm innovation. The key assumption of the RD analysis is that firm cohort should have a significant impact on the effective corporate tax rate; however, all other unobserved determinants of firm innovation are not correlated with firm cohort. With this assumption held, causal inference could be achieved after adjusting for a sufficiently flexible polynomial of cohort.

We firstly check whether the policy reform has any impact on firm effective tax rate. In Figure 1, we restrict the sample to firms established right before (2001) and after (2002) the reform and compare their tax rates. The figure suggests that firms established after the reform pay lower taxes in all years after 2003. We then plot the effective tax rate by firm birth month, normalized by setting January 2002 as 0, using the 2007 data and focusing on firms that were born two years before or after the policy change. As shown in Figure 2, the tax rate paid by firms formed after 2002 is significantly lower than that of firms established before 2002. To check whether such discontinuity in tax rate was driven by the tax collection reform rather than other policy changes, we also plot the figure using a sample of foreign firms, who are not supposed to be affected by the reform. Figure 3 shows that among foreign firms, the tax rate is not influenced by firm establishment year.

To show whether the impact of the reform on tax rate is statistically significant, we estimate the following equation:

$$TaxRate_{it} = \alpha_0 + \alpha_1 Treatment_i + \alpha_2 F(Age)_{it} + \alpha_3 X_{it} + \epsilon_{it} \quad (1)$$

Here i indexes firms, t indexes years, and $TaxRate_{it}$ is the corporate income tax to sales ratio. $Treatment_i$ is an indicator for the policy treatment, which is time-invariant and equals one if the firm was established after January 2002. $F(Age)_{it}$ is a polynomial function of firm birth month, where birth month is normalized by setting January 2002 as zero. We also include the interactions of the treatment variable with polynomial terms. X_{it} is a set of firm characteristics including capital to labor ratio, number of employees, export to sales ratio, and foreign share.

Table 2 reports the results. The three columns presents results using a 60-, 48-, or 24-months window, respectively. As we discussed in the background section, the reform may have either a positive or negative effect on tax enforcement. Results suggest that the negative impact dominates: the tax rate is about 0.1% lower among firms establisehd after 2002. Since the average tax rate was about 0.011 before 2002, this suggests that the reform reduced the effective tax rate by almost 10%.

Although we observe a significant discontinuity in tax rate around the policy cutoff on firm birth month, this could be driven by the fact that firms anticipated the policy change and selectively postponed their registration date. To check whether that is the case, we use the 2007 data to plot the density of firm birth month in Figure 4. The result shows that there's no significant difference in firm entry around 2002. In

addition, we also check whether firms re-registered after the reform to take advantage of the policy. We define re-registration by firms with the same name and owner but a different ID in different years. Figure 5 plots the distribution of re-registration for firms observed in 1998. We don't see significantly higher re-registration after 2002.

Lastly, another identification assumption is that all unobserved determinants of firm innovation are continuously related to the firm birth month. Figure 6 graphically assesses this by testing whether the predicted number of patents, calculated as the fitted value from an OLS regression of patenting on all covariates in subsequent regressions[9], differs between firms born before or after January 2002. The figure suggests that there is no significant discontinuity in the predicted number of patent at the firm cohort cutoff. Based on the above evidence, we believe that in our context RD is a valid identification strategy.

Since the policy rule relating firm birth time to treatment is not deterministic but only changed the probability of tax enforcement changes, we apply a fuzzy regression discontinuity estimation, instrumenting firm tax rate by the policy reform. Specifically, to estimate the impact of the tax reform on firm innovation, we run the following 2SLS regression[10]:

$$Innovation_{it} = \beta_0 + \beta_1 \widehat{TaxRate}_{it} + \beta_2 F(Age)_{it} + \beta_3 X_{it} + u_{it} \quad (2)$$

[9] The set of covariates includes capital to labor ratio, number of employees, export to sales ratio, and foreign share.

[10] Standard errors are clustered to firm cohort in all regressions.

Where $Innovation_{it}$ is an outcome variable measuring firm innovation behavior, such as the number of patent applications, R&D expenditure, or skilled-labor ratio. $TaxRate_{it}$ is instrumented by the policy treatment (first-stage in equation (1)), and $\widehat{TaxRate}_{it}$ represents the fitted values from estimating equation (1). Our coefficient of interest is β_1, which measures the impact of changes in tax rate on firm innovation.

5. Results

5.1. Effect of Taxes on Firm Innovation

We firstly provide graphical evidence in Figure 7, which plots the number of patent applications against firm birth month. The figure shows that there is a discrete increase in patent applications at the firm age cutoff, which mirrors the decrease in the effective tax rate as shown in Figure 2. Figures 2 and 7 reveal a sharp decrease in taxes and a sharp increase in patenting at precisely the cutoff of firm cohort that was influenced by the tax collection reform.

Table 3 reports the 2SLS estimation results for patent as the indicator of firm innovation[11]. Starting with columns (1)-(3), where the outcome is the probability of applying for a patent, results show that a higher tax rate has a significantly negative effect on innovation, and the effect becomes stronger as time evolves. We mainly focus on the patent applications for the next 3 years because innovation is a process

[11] In all the following tables we use firms established two years before or after the reform (2000-2003). We will also show robustness checks using an extended sample.

that needs long-term investment, and many innovating firms do not apply for patents every year. Specifically, column (3) suggests that, increasing the effective tax rate by one standard deviation (0.0122) can decrease the probability of having any patent application in the next 3 years by more than 10%. Similarly, columns (6) shows that the average number of patent application increased by a significant 5.7% if the effective tax rate decreased by 0.01[12].

In Table 4, we explore another two indicators of firm innovation: R&D expenditure and human capital. Results suggest that firms facing higher corporate taxes spend less money on R&D and hire less skilled labor, although the impact on R&D expenditure is not statistically significant. Please note that the sample size is smaller in this table because we only have R&D expenditures in years 2005-2007 and worker education information in the year 2004. The impact of tax on skilled-labor ratio is quite big: the reform decreased the effective tax rate by 0.1%, which in turn increased the skilled-labor ratio by 14%.

Although we have controlled the year trend term in all regressions, the effect could be driven by confounding variables or pre-trend. We use pseudo regressions to test those possibilities. In practice, we generate policy dummies and replicate the regressions in Tables 3 and 4. The results in Appendix table A2 suggest that if the cutoff is not 2002, we don't see a drop in the effective tax rate, suggesting that the policy effect is not just by chance.

[12] We report results using a 72-months window in Appendix table A1 and results are similar.

In summary, the results show a strong and robust causal relationship between tax rate and firm innovation. The tax collection reform reduced tax enforcement, and the resulting lower effective tax rate stimulated both input (measured by R&D expenditure and human capital) and output (measured by the number of patent application) of firm innovation[13].

While the quantity of innovation is important, the quality of innovation is also crucial. We use two ways to measure the quality of innovation[14]. First, the type of patent is a good indicator of the value of patent. There are three main types of patent in China: invention, utility, and design patent. The invention patent is the most difficult one because it needs to contribute very original ideas. For a utility patent, there must be some significant improvement to an existing product or technology. The design patent only requires a modification in product appearance[15]. Among the merged data we have, 16.6% are invention patents, 35.0% are utility patents, and 48.4% are design patents. We use the same 2SLS specification in equation (2) to test

[13] We also did a heterogeneity test (unreported), which shows that firms with lower productivity (so that the return of innovation investment is higher) are more likely to be affected by the policy change.

[14] One commonly used indicator for patent quality is citation but that information is not available for Chinese patents until recently.

[15] Taking innovation on cellphones for example, inventing a new material for battery to improve its endurance involves heavy R&D input and requires an original contribution. It is usually patented as an invention patent; changes in circuit design are less valuable and are not fundamental improvements and are usually be patented as a utility patent; changes in the shape of the cellphone screen can only apply for a design patent.

the impact of taxes on the likelihood and number of different types of patent applications. Table 5 presents the results. The impact of tax reform on patent applications mainly comes from its effect on invention and utility patents: decreasing the effective tax rate by one standard deviation (0.0122) improves the probability of having an invention patent application by 4.4% and increases the number of utility patent applications by 4.7%. This suggests that the improvement in innovation outcomes is not merely driven by the low-quality design patents.

Second, we also use the detailed information of patent applications as proxies for the patent quality, including number of claims, number of independent claims[16], and the amount of effort that was spent on the patent application (length of the application document, number of figures, and length of abstract). In our patent data, only invention and utility patents have the above information, and results in Table 6 suggest that a reduction in tax rate significantly improved patent quality, and the effect is significant for both invention and utility patents.

Overall, the above results show that the tax reform not only increased the quantity of patents, but also improved the quality of innovation activities.

[16] Lanjouw and Schankerman (2004) point out that "the claims in the patent specification delineate the property rights protected by the patent. The patentee has an incentive to claim as much as possible in the application. The patent examiner may require that the claims be narrowed before granting."

5.2. Mechanisms

After seeing a positive and significant impact of an effective tax rate reduction on firm innovation, the next question is: Why is firm innovation affected by the tax reform? We test two potential mechanisms here.

First, if firms are under financial constraints so that they do not have enough funding to invest on innovation, reducing tax cost can help by alleviating financial constraint, and firms can use the money saved to carry out innovation activities. Under a neoclassical framework, if R&D expenditure is fully deductible, the tax rate should not affect innovation since it does not change the after-tax marginal benefit and cost of innovation. However, when the financial market is incomplete or inefficient and a firm mostly relies on its own after-tax profit, a lower effective tax rate could affect innovation investment.

One challenge to test this channel is that it is hard to measure financial constraint. We use the interest payment to asset ratio as the indicator for financial constraint. From the late 1990s to the mid 2000s, although the Chinese economy had been growing at a very fast pace and firms' credit demand grew rapidly, the banking sector and stock market had not developed quickly enough to keep pace with this growing demand. Thus Chinese firms were usually facing severe credit constraints. At the same time, banks in China have little discretion over interest rates they can charge and the corporate bond market is thin due to strict regulations. Therefore, the amount of interest payments reflects mostly how much a firm manages to borrow, not its endogenously chosen optimal capital structure.

We test the financial constraint channel using the following estimation equation:

$$Innovation_{it} = \gamma_0 + \gamma_1 TaxRate_{it} + \gamma_2 Interest_{it} + \gamma_3 TaxRate_{it} * Interest_{it} + \gamma_4 F(Age)_{it} + \gamma_5 X_{it} + u_{it} \quad (3)$$

Where $TaxRate_{it}$ is instrumented by the policy treatment, $Interest_{it}$ is the measure of financial constraint, calculated by the ratio of interest payment to total assets. Our coefficient of interest is γ_3, which measures the variation of the policy impact by firm financial constraint. Results in Table 7 suggest that firms which face more severe financial constraint are more hindered by a higher high tax rate. The coefficient in front of the interaction between effective tax rate and interest payment is positive for all three measures of innovation, although it is only statistically significant when using R&D expenditure as the innovation outcome. This result provides suggestive evidence that a low tax rate can stimulate firms' innovation by alleviating financial constraints.

Second, a lower effective tax rate could also release resources that firms spend on tax evasion, which firms can in turn use on innovation. In that case, firms that are doing more tax evasion can release more resources for innovation. To test this channel, we define tax evasion by the difference between imputed and reported profit[17], and

[17]We follow Cai and Liu (2007) to calculate the imputed profit. Specifically, we compute firm *i's* Imputed Profit_{it} in year t according to the national income accounting system as follows: Imputed $Profit_{it} = Y_{it} - Med_{it} - Fc_{it} - Wage_{it} - Currd_{it} - Vat_{it}$. Here Y_{it} is the firm's gross output; Med_{it} measures its intermediate inputs excluding financial charges; Fc_{it} is its financial charges (mainly interest payments); $Wage_{it}$ is the firm's total wage bill; $Currd_{it}$ is the amount of current depreciation, and Vat_{it} is the value added tax.

assume that firms spend more on tax evasion if the gap is larger. Following the same estimation strategy as in equation (3), we then estimate the heterogeneity of the tax impact by tax evasion. Results in Table 8 show that for all the three measures of firm innovation, the coefficient of the interaction between the effective tax rate and the tax evasion measure is negative and statistically significant, suggesting that that lower effective tax rate has a stronger positive impact on innovation if firms are doing more tax evasion. This is in line with the tax evasion mechanism.

6. Conclusion

In this paper, we offer new evidence on the impact of corporate taxes on both the quantity and quality of firm innovation, and the underlying mechanisms. To estimate the causal impact of taxes on innovation, we take advantage of a tax collection reform applied to manufacturing firms in China established after the year 2002, which switched the collection of corporate income taxes from the local tax bureau to the state tax bureau. Based on a comprehensive dataset of all medium and large enterprises combined with the universal patent application data in China, we use a regression discontinuity design to study the policy impact.

Our results suggest that, first, the reform effectively changed tax enforcement and reduced the effective tax rate by 10%. Using the number of patent applications, R&D expenditure, and skilled labor ratio as indicators of firm innovation, we then show that there is a strong and robust causal relationship between tax rate and firm

innovation: decreasing the effective tax rate by one standard deviation (0.01) can increase the average number of patent applications by a significant 5.7%. The reform also improved R&D expenditures and increased the skilled-labor ratio by 14%. Moreover, the impact of the reform on patenting mainly comes from its effect on the invention and utility patent, suggesting that the improvement in innovation outcomes is not merely driven by low-quality design patents. Lastly, we provide suggestive evidence that a low tax rate can stimulate firm's innovation by alleviating financial constraints and reallocating resources from tax evasion activities.

Reference:

Acharya, Viral V., Ramin P. Baghai, and Krishnamurthy V. Subramanian, "Wrongful Discharge Laws and Innovation," *Review of Financial Studies*, 2014, *27* (1), 301–346.

Aghion, Philippe, Nick Bloom, Richard Blundell, Rachel Griffith and Peter Howitt, "Competition and Innovation: An Inverted-U Relationship," *The Quarterly Journal of Economics*, 2005, *120* (2), 701-728.

Aghion, Philippe and Peter Howitt, "A Model of Growth Through Creative Destruction," *Econometrica*, 1992, *60* (2), 323-351.

Aghion, Philippe, Richard Blundell, Rachel Griffith, Peter Howitt, and Prantl S. Entry, "The Effects of Entry on Incumbent Innovation and Productivity," *Review of Economics and Statistics*, 2009, *91* (1): 20-32.

Aghion, Philippe, John Van Reenen, and Luigi Zingales, "Innovation and Institutional Ownership," *American Economic Review*, 2013, *103* (1), 277–304.

Aghion, Philippe, Ufuk Akcigit, and Peter Howitt, "What Do We Learn From Schumpeterian Growth Theory?" *Handbook of Economic Growth*, 2014, Edition 1, Volume 2, Chapter 0, 515-563.

Aghion, Philippe, Jing Cai, Mathias Dewatripont, Luosha Du, Ann Harrison, and Patrick Legros, "Industrial Policy and Competition," *American Economic Journal: Macroeconomics*, 2015, *7* (4): 1-32.

Akcigit, Ufuk, John Grigsby, Tom Nicholas, and Stepanie Stantcheva, "Taxation and Innovation in the 20th Century," *NBER Working Paper No. 24982*, 2018.

Amore, Mario D., Cedric Schneider, and Alminas Žaldokas, "Credit Supply and Corporate Innovation," *Journal of Financial Economics*, 2013, *109* (3), 835–855.

Atanassov, Julian and Xiaoding Liu, "Corporate Income Taxes, Pledgeable Income and Innovation," *Working Paper*, 2016.

Auerbach, Alan J. and Kevin Hassett, "Tax Policy and Business Fixed Investment in the United States," *Journal of Public Economics*, 1992, *47* (2), 141–170.

Auerbach, Alan J, "Taxation and Corporate Financial Policy," *Handbook of Public Economics*, 2002, Volume 3, ed. Alan J. Auerbach and Martin Feldstein, 1251–92.

Barro, Robert J. and Charles J. Redlick, "Macroeconomic Effects From Government Purchases and Taxes," *The Quarterly Journal of Economics*, 2011, *126* (1), 51-102.

Besley, Timothy and John McLaren, "Taxes and Bribery: The Role of Wage Incentives," *Economic Journal*, 1993, *103* (416), 119-41.

Besley, Timothy and Torsten Persson, "Why do Developing Countries Tax so Little?" *Journal of Economic Perspectives*, 2014, *28* (4): 99-120.

Bloom, Nick, Rachel Griffith, and John Van Reenen, "Do R&D Tax Credits Work? Evidence from a Panel of Countries 1979–1997," *Journal of Public Economics*, 2002, *85* (1), 1–31.

Cai, Hongbin and Qiao Liu, "Competition and Corporate Tax Avoidance: Evidence from Chinese Industrial Firms," *Economic Journal*, 2009, 119, 764-795.

Chen, Xiaoguang, "The Effect of a Fiscal Squeeze on Tax Enforcement: Evidence from a Natural Experiment in China." *Journal of Public Economics*, 2017, *147* (3), 62-76.

Chen, Zhao, Juan Carlos Suarez Serrato, Zhikuo Liu, and Daniel Yi Xu, "Norching R&D Investment with Corporate Income Tax Cuts in China," *NBER Working Paper No. 24749*, 2018.

Cornaggia, Jess, Yifei Mao, Xuan Tian, and Brian Wolfe, "Does Banking Competition Affect Corporate Innovation?" *Journal of Financial Economics*, 2015, *115* (1), 189–209.

Cullen, Julie Berry and Roger H. Gordon, "Taxes and Entrepreneurial Risk-taking: Theory and Evidence for the U.S.," *Journal of Public Economics*, 2007, *91* (7), 1479-1505.

Cummins, Jason G., Kevin A. Hassett, and R. Glenn Hubbard, "Tax Reforms and Investment: a Cross-country Comparison," *Journal of Public Economics*, 1996, *62* (1), 237–273.

Devereux, Michael P., Rachel Griffith, and Alexander Klemm, "Corporate Income Tax Reforms and International Tax Competition," *Economic Policy*, 2002, *17* (35): 449–95.

Devereux, Michael P. and Rachel Griffith, "Evaluating Tax Policy for Location Decisions," *International Tax and Public Finance*, 2003, *10* (2): 107–26.

Djankov, Simeon, Tim Ganser, Caralee McLiesh, Rita Ramalho, and Andrei Shleifer, "The Effect of Corporate Taxes on Investment and Entrepreneurship," *American Economic Journal: Macroeconomics*, 2011, *2* (3), 31–64.

Fang, Vivian W, Xuan Tian, and Sheri Tice, "Does Stock Liquidity Enhance or Impede Firm Innovation?" *Journal of Finance*, 2014, *69* (5), 2085–2125.

Ferreira, Daniel, Gustavo Manso, and Andre C. Silva, "Incentives to Innovate and the Decision to Go Public or Private," *Review of Financial Studies*, 2014, *27* (1), 256-300.

Gordon, Roger and Wei Li, "Tax Structures in Developing Countries: Many Puzzles and a Possible Explanation," *Journal of Public Economics*, 2009, *93* (7-8), 855-866.

Grossman, Gene M. and Elhanan Helpman, "Quality Ladders in the Theory of Growth," *Review of economic Studies*, 1991, *58*, 43-61.

Hall, Bronwyn and John Van Reenen, "How Effective are Fiscal Incentives for R&D? A review of the Evidence," *Research Policy*, 2000, *29* (4-5), 449-469.

Haufler, Andreas, Pehr-Johan Norback, and Lars Persson, "Entrepreneurial Innovations and Taxation," *Journal of Public Economics*, 2014, *113*, 13-31.

Hassett, Kevin A. and R. Glenn Hubbard, "Tax Policy and Business Investment," *Handbook of Public Economics*, 2002, Volume 3, ed. Alan J. Auerbach and Martin Feldstein, 1293–1343.

Hines, James R. and Eric M. Rice, "Fiscal Paradise: Foreign Tax Havens and American Business," *Quarterly Journal of Economics*, 1994, *109* (1): 149–82.

Hsu, Po-Hsuan, Xuan Tian, and Yan Xu, "Financial Development and Innovation: Cross-country Evidence," *Journal of Financial Economics*, 2014, *112* (1), 116-135.

Johansson, Asa, Christopher Heady, Jens Arnold, Bert Brysm and Laura Vartia, "Tax and Economic Growth," *OECD Economics Department Working Papers* # 620, 2008.

Kaplow, Louis, "Optimal Taxation with Costly Enforcement and Evasion," *Journal of Public Economics*, 1990, *43* (2), 221-236.

Khan, Adnan Q., Asim I. Khwaja, and Benjamin A. Olken, "Tax Farming Redux: Experimental Evidence on Performance Pay for Tax Collectors," *Quarterly Journal of Economics*, 2016, *131* (1), 219-271.

Khan, Adnan Q., Asim Ijaz Khwaja, and Benjamin A. Olken, "Making Moves Matter: Experimental Evidence on Incentivizing Bureaucrats through Performance-Based Postings," *NBER Working Paper No. 24383*, 2018.

Kleven, Henrik Jacobsen, Martin B. Knudsen, Claus Thustrup Kreiner, Soren Pedersen, and Emmanuel Saez, "Unwilling or Unable to Cheat? Evidence from a Tax Audit Experiment in Denmark," *Econometrica*, 2011, *79* (3), 651-692.

Kneller, Richard, Michael F. Bleany, and Norman Gemmell, "Fiscal Policy and Growth: Evidence from OECD Countries", *Journal of Public Economics*, 1999, 74 (2), 171-190.

Kopczuk, Wojciech, Justin Marion, Erich Muehlegger, and Joel Slemrod, "Does Tax-Collection Invariance Hold? Evasion and the Pass-through of State Diesel Taxes," *American Economic Journal: Economic Policy*, 2016, *8* (2), 251-86.

Kumler, Todd Johnson, Eric A. Verhoogen, and Judith Frias, "Enlisting Workers in Monitoring Firms: Payroll Tax Compliance in Mexico," *NBER working paper no. 19385*, 2015.

Lanjouw, Jean O. and Mark Schankerman, "Patent Quality and Research Productivity: Measuring Innovation with Multiple Indicators", *The Economic Journal*, 2004, (114), 441-465.

Li, Hongbin and Li-an Zhou, "Political Turnover and Economic Performance: the Incentive Role of Personnel Control in China", *Journal of Public Economics*, 2005, *89* (9-10), 1743-1762.

Manso, Gustavo, "Motivating innovation," *Journal of Finance*, 2011, *66* (5), 182-1860.

Mertens, Karel and Morten O. Ravn, "Empirical Evidence on the Aggregate Effects of Anticipated and Unanticipated US Tax Policy Shocks," *American Economic Journal: Economic Policy*, 2012, *4*(2), 145–181.

Moretti, Enrico and Daniel J. Wilson, "The Effect of State Taxes on the Geographical Location of Top Earners: Evidence from Star Scientists," *American Economic Review*, 2017, *107* (7), 1858-1903.

Mukherjee, Abhiroop, Manpreet Singh, and Alminas Zaldokas, "Do Corporate Taxes Hinder Innovation?" 2017, *Journal of Financial Economics*, *124* (1), 195-221.

Myles, Gareth D., "Economic Growth and the Role of Taxation," *OECD Economics Department Working Paper*, 2009.

Naritomi, Joana, "Consumers as Tax Auditors," *Working paper*, 2016.

Pomeranz, Dina, "No Taxation without Information: Deterrence and Self Enforcement in the Value-Added Tax," *American Economic Review*, 2015, 105(8), 2539-69.

Rao, Nirupama, "Do Tax Credits Stimulate R&D Spending? The Effect of the R&D Tax Credit in its First Decade," *Journal of Public Economics*, 2016, *140*, 1–12.

Romer, Paul, "Endogenous Technological Change," *Journal of Political Economy*, 1990, *98*, S71-102.

Romer, Christina D. and David H. Romer, "The Macroeconomic Effects of Tax Changes: Estimates Based on a New Measure of Fiscal Shocks," *American Economic Review*, 2010, *100* (3), 763-801.

Slemrod, Joel, Marsha Blumenthal, and Charles Christian, "Taxpayer Response to an Increased Probability of Audit: Evidence from a Controlled Experiment in Minnesota," *Journal of Public Economics*, 2001, *79* (3), 455-483.

Solow, Robert M., "Technical change and the aggregate production function," *Review of Economics and Statistics*, 1957, *39*, 312-320.

Tian, Xuan and Tracy Yue Wang, "Tolerance for Failure and Corporate Innovation," *Review of Financial Studies*, 2011, *27* (1), 211-255.

Wilson, Daniel J., "Beggar Thy Neighbor? The In-State, Out-of-State, and Aggregate Effects of R&D Tax Credits," *Review of Economics and Statistics*, 2009, *91* (2), 431-436.

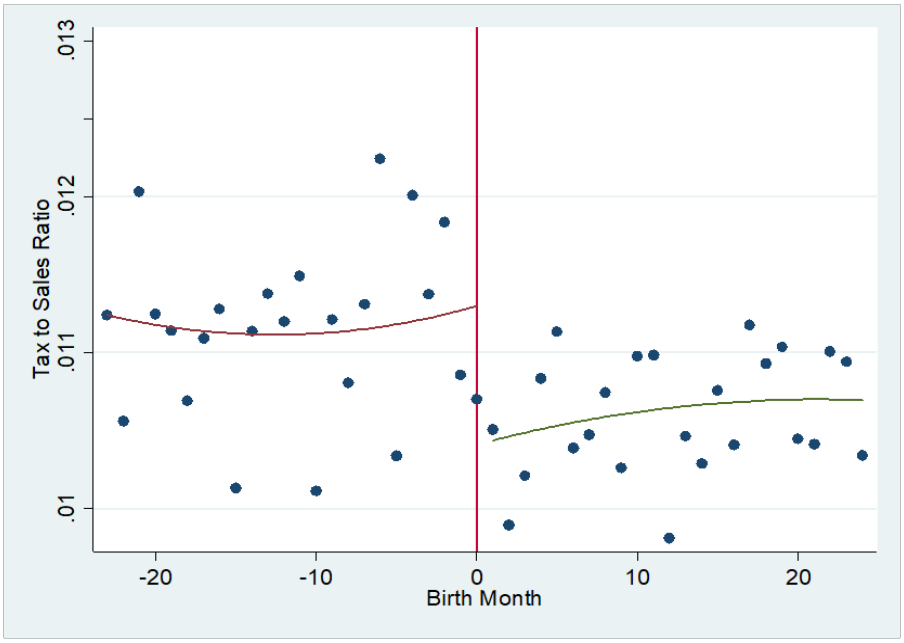
Zwick, Eric and James Mahon, "Tax Policy and Heterogeneous Investment Behavior," *American Economic Review, 2017, 107* (1): 217-248.

Tables and Figures

Figure 1. Effective Tax Rate of Firms Established in 2001 and 2002

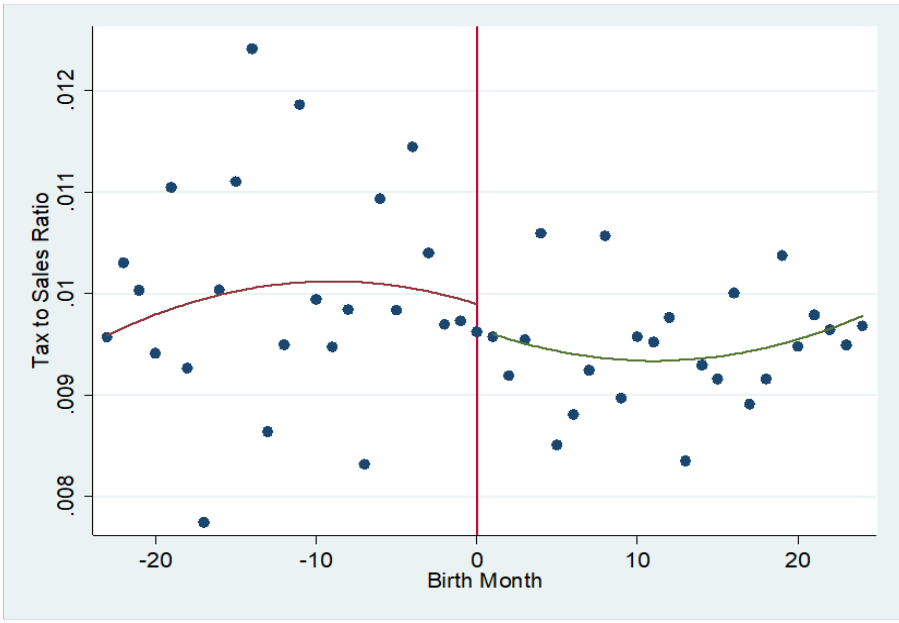
Note: This figure plots the effective tax rate in years 2004-2007 for firms established in years 2001 and 2002.

Figure 2. Effective Tax Rate by Firm Birth Month



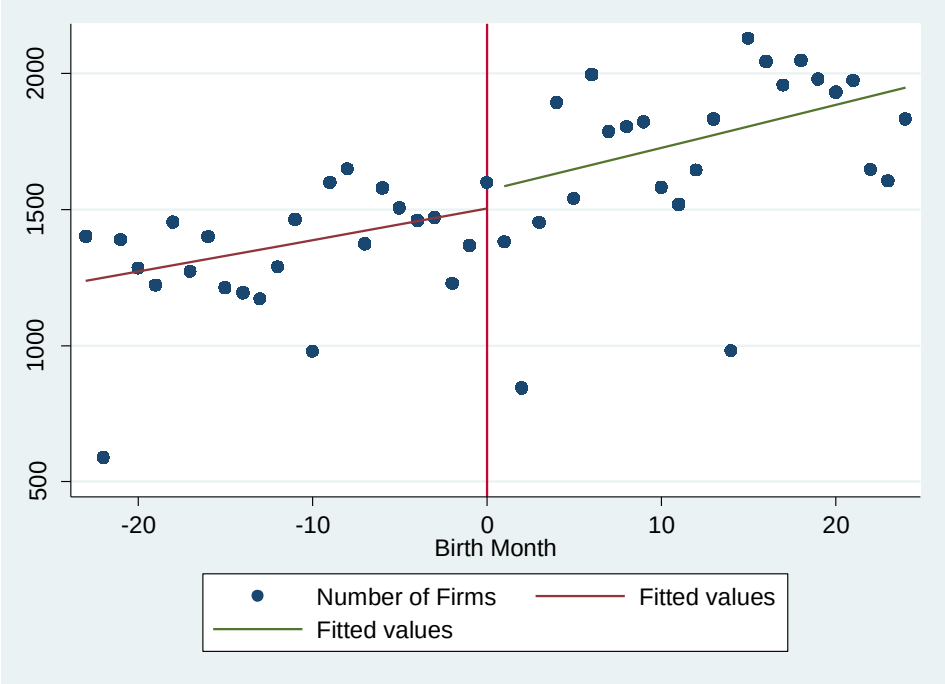
Note: This figure is based on data in the year 2007 and compares the effective tax rate paid by firms established before and after the policy change. Birth month of firms established in January 2002 is normalized to 0.

Figure 3. Effective Tax Rate by Firm Birth Month: Foreign Firms



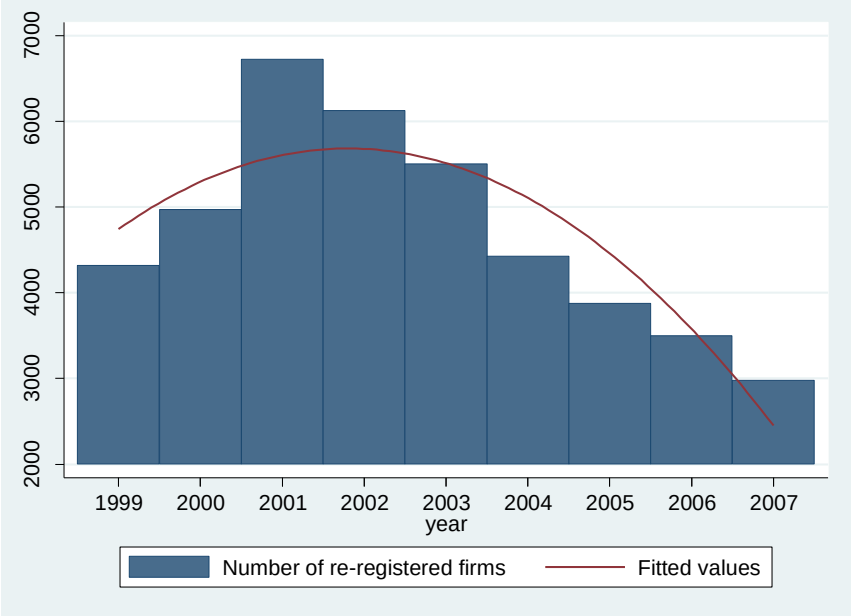
Note: This figure is based on data in the year 2007 and includes foreign firms only. It compares the effective tax rate paid by firms established before and after the policy change. Birth month of firms established in January 2002 is normalized to 0.

Figure 4. Density of Firm Birth Month



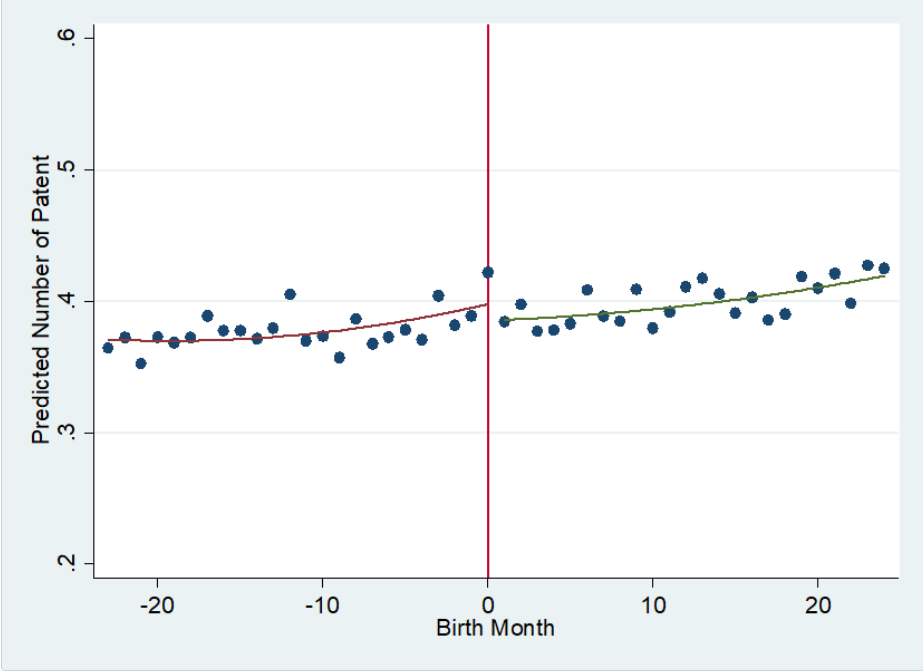
Note: This figure is based on data in the year 2007. Birth month of firms established in January 2002 is normalized to 0.

Figure 5. Distribution of Firm Re-registration



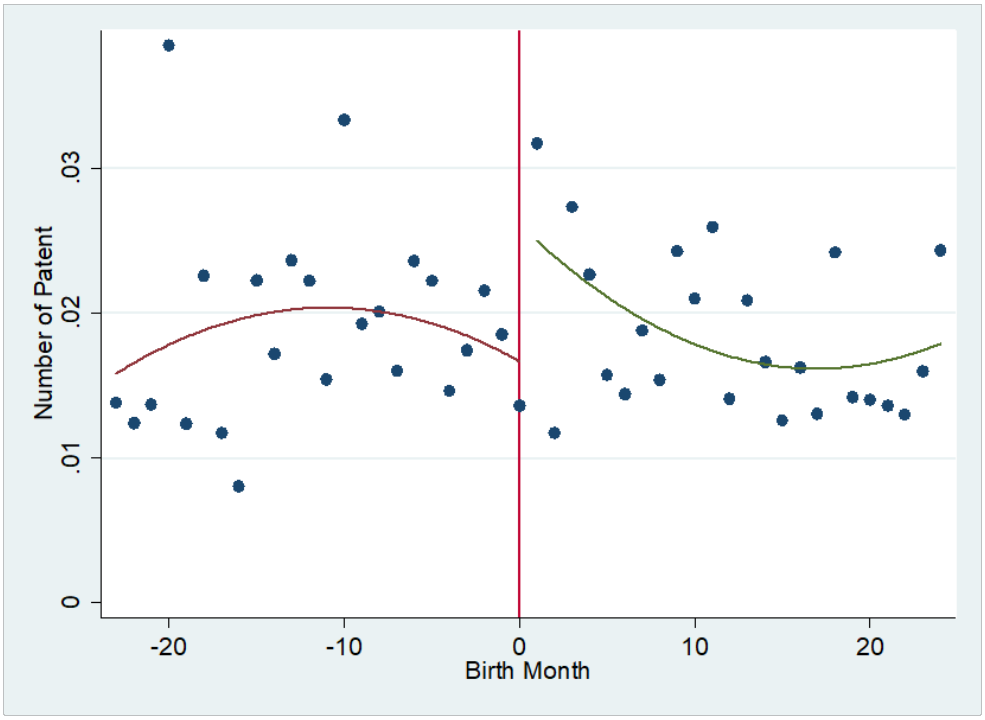
Note: This figure plots the distribution of re-registration for firms observed in 1998. Reregistration is defined as one for firms with the same name and owner but a different ID in different years.

Figure 6. Predicted Number of Patent Application by Firm Birth Month



Note: This figure is based on data in the year 2007 and compares the predicted number of patent applications by firms established before and after the policy change. The predicted number of patent applications is calculated as the fitted value from an OLS regression of patenting on covariates including capital to labor ratio, number of employees, export to sales ratio, and foreign share. Birth month of firms established in January 2002 is normalized to 0.

Figure 7. Number of Patent Application by Firm Birth Month



Note: This figure is based on data in the year 2007 and compares the number of patent applications (weighted by firm size) by firms established before and after the policy change. Birth month of firms established in January 2002 is normalized to 0.

Table 1. Summary Statistics of Key Variables

	Mean	Standard Deviation
Policy Treatment	0.45	0.50
Panel A: Firm Characteristics (Year 2007)		
Firm Age	8.09	7.26
Ownership - State Owned Enterprises	0.01	0.12
Ownership - Domestic Private Firms	0.76	0.43
Ownership - Foreign Firms	0.22	0.41
Number of Employee	184.20	232.60
Expoert to Sales Ratio	0.17	0.34
Panel B: Accounting (Year 2007)		
Sales (1,000 RMB)	66,757	109,953
Output (1,000 RMB)	68,462	112,443
Fixed Assets (1,000 RMB)	13,641	31,461
Corporate Income Tax to Sales Ratio	0.011	0.012
Panel C: Innovation		
Patent Applications (2007-2010)		
Share of Firms Applied for Patent (%)	7.10	0.26
Average Number of Patent Application	8.86	24.68
Average Number of Approved Patent	2.52	5.39
R&D Expenditure/Sales (Year 2007)	0.002	0.016
Skilled Labor Ratio (Year 2004)	0.111	0.155

Note: Policy treatment equals one for firms established after the year 2002, and zero otherwise.

Table 2. Effect of the Tax Reform on Tax Rate

	Tax to Sales Ratio		
	(1)	(2)	(3)
Treatment	-0.00072***	-0.00098***	-0.00089**
(=1 if birth year>2002)	(0.00022)	(0.00028)	(0.00034)
Window	60 months	48 months	24 months
Number of Observation	178188	131515	67323
R-Squared	0.072	0.072	0.076

Note: This table reports the impact of the tax reform on the effective tax rate. Columns (1) to (3) use sample firms established 3, 2, or 1 year before and after the reform, respectively. Firm characteristics including capital to labor ratio, number of employees, export to sales ratio, and foreign share are controlled for in all regressions. Age, square of age, and their interactions with the treatment dummy are also included. *** p<0.01, ** p<0.05, * p<0.1.

Table 3. Impact of the Tax Reform on Firm Innovation: Patent

	Patent Application (1=Yes, 0=No)			Log (Number of Patent Application)		
	Next Year	Next 2 Years	Next 3 Years	Next Year	Next 2 Years	Next 3 Years
	(1)	(2)	(3)	(4)	(5)	(6)
Tax to Sales Ratio	-3.627***	-3.642	-8.210***	-2.633***	-4.229***	-5.719***
	(1.36)	(2.388)	(2.654)	(0.344)	(1.354)	(1.876)
Window	48 Months	48 Months	48 Months	48 Months	48 Months	48 Months
Number of Observation	131515	131515	131515	131515	131515	131515
Pre-2002 Mean of Dependent Variable	0.0203856	0.0351737	0.0494096	0.078	0.188	0.329

Note: This table uses sample of firms established two years before or after the policy reform and reports the impact of the tax reform on patent application. The tax to sales ratio is instrumented by the policy treatment dummy (=0 for firms established before 2002, and =1 otherwise). Firm characteristics including capital to labor ratio, number of employees, export to sales ratio, and foreign share are controlled for in all regressions. Age, square of age, and their interactions with the treatment dummy are also included. *** p<0.01, ** p<0.05, * p<0.1.

Table 4. Impact of the Tax Reform on Firm Innovation: R&D Expenditure and Skilled Labor

	R&D/Total Assets	Skilled Labor Ratio
	(1)	(2)
Tax to Sales Ratio	-0.273	-0.394**
	(0.294)	(0.167)
Window	48 Months	48 Months
Number of Observation	93024	28034
Pre-2002 Mean of Dependent Variable	0.002	0.102

Note: This table uses sample of firms established two years before or after the policy reform. The tax to sales ratio is instrumented by the policy treatment dummy (=0 for firms established before 2002, and =1 otherwise). Column (1) is based on survey data in year 2005-2007 because data on R&D expenditure is only available in those years; column (2) uses data in year 2004 which includes skilled labor information. Skilled labor ratio is defined as the sahre of workers with an above college degree. Firm characteristics including capital to labor ratio, number of employees, export to sales ratio, and foreign share are controlled for in all regressions. Age, square of age, and their interactions with the treatment dummy are also included. *** p<0.01, ** p<0.05, * p<0.1.

Table 5. Impact of the Tax Reform on Different Types of Patent Application

	Patent Application (1=Yes, 0=No)			Log (Number of Patent Application)		
	Invention	Utility	Design	Invention	Utility	Design
	(1)	(2)	(3)	(1)	(2)	(3)
Tax to Sales Ratio	-3.570***	-1.068	0.192	0.791	-3.816**	0.0113
	(1.254)	(1.253)	(1.288)	(1.688)	(1.851)	(2.364)
Window	48 Months	48 Months	48 Months	48 Months	48 Months	48 Months
Number of Observation	131515	131515	131515	131515	131515	131515
Pre-2002 Mean of Dependent Variable	0.023	0.031	0.018	0.073	0.134	0.122

Note: This table uses sample of firms established two years before or after the policy reform. The tax to sales ratio is instrumented by the policy treatment dummy (=0 for firms established before 2002, and =1 otherwise). Firm characteristics including capital to labor ratio, number of employees, export to sales ratio, and foreign share are controlled for in all regressions. Age, square of age, and their interactions with the treatment dummy are also included. *** p<0.01, ** p<0.05, * p<0.1.

Table 6. Impact of the Tax Reform on the Quality of Patent Application

	log (Length of Document)	log (Number of Claims)	log (Number of independent Claims)	log (Number of Figures)	log (Length of Abstract)
	(1)	(2)	(3)	(4)	(5)
Tax to Sales Ratio	-48.78***	-13.57***	-9.137***	-11.73***	-33.57***
	(15.92)	(4.326)	(3.197)	(4.283)	(11.11)
Window	48 Months	48 Months	48 Months	48 Months	48 Months
Number of Observation	131515	131515	131515	131515	131515
Pre-2002 Mean of Dependent Variable	676.855	1.089	0.429	0.761	49.156

Note: This table uses sample of firms established two years before or after the policy reform. The tax to sales ratio is instrumented by the policy treatment dummy (=0 for firms established before 2002, and =1 otherwise). Firm characteristics including capital to labor ratio, number of employees, export to sales ratio, and foreign share are controlled for in all regressions. Age, square of age, and their interactions with the treatment dummy are also included. *** p<0.01, ** p<0.05, * p<0.1.

Table 7. Mechanisms: Financial Constraint

	Patent Application Dummy (3 years, 1=Yes, 0=No)	Log (Number of Patent Application, 3 years)	R&D/Total Assets
	(1)	(2)	(3)
Tax to Sales Ratio	-5.976***	-8.554***	-0.313
	(1.899)	(2.754)	(0.289)
Interest Payment	-0.0041*	-0.0056	-0.0003
	(0.0024)	(0.004)	(0.0003)
Tax to Sales Ratio*Interest Payment	0.211	0.276	0.0317**
	(0.166)	(0.279)	(0.0154)
Window	48 Months	48 Months	48 Months
Number of Observation	131466	131466	92983
Pre-2002 Mean of Dependent Variable	0.0494096	0.329	0.002

Note: This table uses sample of firms established two years before or after the policy reform. The tax to sales ratio is instrumented by the policy treatment dummy (=0 for firms established before 2002, and =1 otherwise). Column (3) uses survey data in year 2005-2007 only because data on R&D expenditure is only available in those years. Firm characteristics including capital to labor ratio, number of employees, export to sales ratio, and foreign share are controlled for in all regressions. Age, square of age, and their interactions with the treatment dummy are also included. *** p<0.01, ** p<0.05, * p<0.1.

Table 8. Mechanisms: Tax Avoidance

	Patent Application Dummy (3 years, 1=Yes, 0=No)	Log (Number of Patent Application, 3 years)	R&D/Total Assets
	(1)	(2)	(3)
Tax to Sales Ratio	-8.037***	-5.649***	-0.27
	(2.586)	(1.847)	(0.296)
Tax Avoidance	0.0005**	0.0003***	0.00001*
	(0.0002)	(0.0001)	(0.0001)
Tax to Sales Ratio*Tax Avoidance	-0.0309***	-0.0159***	-0.0008***
	(0.0112)	(0.0031)	(0.0002)
Window	48 Months	48 Months	48 Months
Number of Observation	131429	132429	92955
Pre-2002 Mean of Dependent Variable	0.0494096	0.329	0.002

Note: This table uses sample of firms established two years before or after the policy reform. The tax to sales ratio is instrumented by the policy treatment dummy (=0 for firms established before 2002, and =1 otherwise). Column (3) uses survey data in year 2005-2007 only because data on R&D expenditure is only available in those years. Firm characteristics including capital to labor ratio, number of employees, export to sales ratio, and foreign share are controlled for in all regressions. Age, square of age, and their interactions with the treatment dummy are also included. *** p<0.01, ** p<0.05, * p<0.1.

Appendix

Table A1. Impact of the Tax Reform on Firm Innovation: Patent (72 Months Window)

	Patent Application (1=Yes, 0=No)			Log (Number of Patent Application)		
	Next Year	Next 2 Years	Next 3 Years	Next Year	Next 2 Years	Next 3 Years
	(1)	(2)	(3)	(4)	(5)	(6)
Tax to Sales Ratio	-2.063***	-3.877***	-6.802***	-3.110**	-4.098	-10.12***
	(-3.04)	(-3.56)	(-3.88)	(-2.13)	(-1.57)	(-3.12)
Window	72 Month	72 Month	72 Month	72 Month	72 Month	72 Month
Number of Observation	178188	178188	178188	178188	178188	178188
Pre-2002 Mean of Dependent Variable	0.0202662	0.0347975	0.0495649	0.083779	0.201204	0.351908

Note: This table uses sample of firms established three years before or after the policy reform and reports the impact of the tax reform on patent application. The tax to sales ratio is instrumented by the policy treatment dummy (=0 for firms established before 2002, and =1 otherwise). Firm characteristics including capital to labor ratio, number of employees, export to sales ratio, and foreign share are controlled for in all regressions. Age, square of age, and their interactions with the treatment dummy are also included. *** p<0.01, ** p<0.05, * p<0.1.

Table A2. Pseudo Test

	Tax to Sales Ratio			
	(1)	(2)	(3)	(4)
Policy Dummy 2000	0.000858***			
(=1 if year>2000, =0 otherwise)	(0.00)			
Policy Dummy 2001		(0.00)		
(=1 if year>2001, =0 otherwise)		(0.00)		
Policy Dummy 2003			0.00	
(=1 if year>2003, =0 otherwise)			(0.00)	
Policy Dummy 2004				0.000641***
(=1 if year>2004, =0 otherwise)				(0.00)
Window	48 Months	48 Months	48 Months	48 Months
Number of Observation	120954	127805	117706	96016
R-Squared	0.071	0.073	0.074	0.078

Note: This table uses sample of firms established two years before or after the policy reform. Firm characteristics including capital to labor ratio, number of employees, export to sales ratio, and foreign share are controlled for in all regressions. *** p<0.01, ** p<0.05, * p<0.1.