Regulation and innovation: The intermediate role of resource reallocation

Fang Wang [*], Xiaoyong Dai [†]

Abstract

Regulations have been identified as important factors influencing the innovation activities of companies, industries and entire economies. This paper investigates the potential impacts of regulations on the innovative performance of firms in China. We discover an inverted U-shaped relationship between regulation and innovation performance: Regulations in China play positive roles in promoting innovation within the threshold and the more actively firms respond to regulations, the better performance of product innovation firms experience. After it reaches the threshold, the situation reverses. Actively coping with regulations facilitates firms' access to financial resources, which in turn promotes product innovation. Meanwhile, output distortion significantly impedes the performance of product innovation; however, regulations do not show a measurable impact on output distortion.

Keywords: Regulation, product innovation, resource reallocation, China

JEL: F14, O12, D21

1 Introduction

Regulation generally refers to the implementation of rules by government institutions to influence market activity and the behavior of private actors in the economy. While it has been identified as an important factor influencing the innovation activities of companies, industries and entire economies, the effects of regulation on innovative performance have been a topic of debate for several decades. The Regulatory Capture view (**?**) and the Public Interest perspective, pioneered by **?** hold the opposite views on the role of regulations in affecting the development of industries. The former addresses the manipulation of regulations by certain industries for their own benefit, while the latter advocates its positive impacts on correcting market failure. The degree to which regulations promote or inhibit competition can substantially affect innovative performance by influencing the cost of innovative projects or changing the industry structure. A major issue facing government is achieving the trade-off to society between over-regulation and

[*]Institutes of Science and Development, Chinese Academy of Sciences, 15 Zhongguancun Beiyitiao, Beijing 100190, P. R. China. Tel: +86 10 5935 8420. Email: fwang@casipm.ac.cn.

[†]School of Economics and Finance, Xi'an Jiaotong University; daixy87@gmail.com

under-regulation (**?**). Due to a lack of a coherent theoretical framework to analyze the impacts of regulations on innovation performance (**?**), the causal relationship between the degree and scope of regulations and the performance of innovation remains unclear. Meanwhile, the emergence of new technology and sharing economics brings new challenges for regulations, such as car sharing platforms, Fintech, green energy, etc.

The extent to which governments have intervened to drive technological change has varied considerably across countries and sectors. Firms in developing and transition economies often face different problems in dealing with regulations for their innovation projects compared with their counterparts in developed countries. The successful catching-up experiences in East Asian economies highlight the importance of regulations (**?**). For example, regulations on intellectual property rights (IPR) in Korea shifted from loose control toward a higher level of IPR protection in the late 1980s in order to provide more incentives for increasing innovation efforts. It is acknowledged that governmental intervention in entry and operation helped the technological leapfrogging of the automotive industry in Japan and Korea, although different countries adopted various regulations. As regulations shape the potential paths of technological developments, it is highly important to understand their influence and functionality in order to increase innovation performance.

From the viewpoint of empirical analysis, China is a particularly interesting context to investigate due to its highly centralized governance structure and massive efforts in promoting innovation-oriented growth. On the one hand, the government controls the allocation of resources to a large degree in China, which leaves rooms for a high level of bureaucracy and strong regulations in certain areas such as market entry and financial control. This may cause rent-seeking and distortions in resource allocation, and therefore result in poor innovation performance. On the other hand, China has witnessed a continuous regulatory reform in different regimes such as the financial market, new energy and the intellectual property rights during the marketization process over the last three decades. Due to the path dependency in innovative behaviors, industrial foundation and capital constraints, the response to regulation in terms of innovation varies across firms substantially.

Hence, this paper intends to investigate the following two questions: (1) What are the potential impacts of regulation on the innovative performance of firms in China; and (2) how do the regulations impose their impacts on innovation performance?

While regulation has been widely identified as an important cause of resource misallocation in the existing literature (**?**), the impacts of resource misallocation on the observable relationship between regulation and product innovation are still under-explored. Following **?**, we construct a measure of firm-level distortions and employ financial resource accessibility to reflect across-firm resource reallocations. A structural equation model is designed to investigate the relationship between regulation, resource reallocation and the performance of product innovation.

Analyzing the causal relationship between regulations and firm performance in innovation presents two challenges. First, it is difficult to define and measure the level of regulations

quantitatively. Second, regulations normally interweave with each other and generate both positive and negative effects on firms. The implication is that any analysis on the relationship between regulations and firm performance should identify and disentangle these two aspects.

This paper contributes to studies on the determinants of innovation in two ways: First, it builds a general framework to analyze a potential connection between regulation and innovation performance at the firm level by using the allocation of resources as a mediating factor, thus to provide evidence on the impacts of regulation on innovative behaviors of firms in China. It establishes a mechanism by which government intervention transmits its role on innovation performance via resource allocation across firms. Second, it constructs an identification strategy to disentangle the potential negative and positive effects resulting from regulation, which helps to understand the micro-level performance in response to macro-level regulation in a transitional environment.

The remainder of this article is organized as follows. Section 2 reviews the related literature on the connection between regulations and innovation. Section 3 constructs the econometric models analysing the impacts of regulations on the tendency and intensity of product innovation as well as the mediating effects of resource allocation. Section 4 presents data and measurements. Section 5 discusses the empirical findings. Section 6 concludes the article.

2 Regulation and Innovation: A Review

The occurrence of regulations and government interventions are typically traced back to a market failure. Market and government intervention are identified as two main channels that distribute resources. The free market provides information and incentives for agents; however, market failure arises in the presence of monopoly, externalities and asymmetric information. The government's intervention through regulation of the economics performance can be divided into three categories: economic regulations designed to avoid market failure, such as market entry, competition policy and price regulation; social regulations designed to prevent negative externalities, such as environmental regulation and consumer safety regulations; and more generic institutional regulations based on liability law, such as intellectual property rights (**??**). Regulations concerning market failure and externalities are especially relevant for innovation performance because science and technology that are closely associated with innovation performance feature public goods.

Previous studies have analyzed the impact of government regulations on innovation performance from three aspects. First, regulations influence the direction and rate of innovation by creating markets and reshaping the competition landscape (**???**). Regulation may drive out firms that find no compliance with existing products and processes, thus spurring either compliance innovation or circumventive innovation. Circumventive innovation occurs when the scope of the regulation is narrow and the resulting innovation allows firms to escape the regulatory constraints. Regulations determine the allocation of resources that are required for technological

innovation. ? found that regulations lead to higher innovation efficiency in markets with low uncertainty, while the situation reverses in cases of high market uncertainty. Strict market entry regulations may hinder the adoption of existing technologies and innovation, possibly by reducing competitive pressures, technology spillovers, or the entry of new high-tech firms; Countries where it takes less time to enter the market have seen more entry in industries that experienced expansionary global demand and technology shifts (???).

Second, red tape arising from strong regulations creates compliance burdens for would-be innovators (??). This increases the transaction costs and lowers the R&D investment, thereby tampering with innovation performance. ? consider red tape a "time tax" imposed on firms, reflecting their different opportunity costs. More efficient agents are able or willing to buy more effective red tape, reflecting in a lower time tax on firms. ? demonstrates that the time spent as a result of red tape, such as filling out paperwork, obtaining permits from different offices, etc., may be considered a fixed cost of entry that is positively correlated with individual ability, as the opportunity cost of time is increasing in ability. Thus, reducing red tape may raise the average quality of new firms, while cutting monetary costs may lower it.

Third, public choice approach links regulatory intervention with resource misallocation, rent-seeking, preferentialism, and corruption, which leads to distortion of resource allocation among firms and lowers the incentives for innovation (?). Regulatory capture occurs when the interests of firms or political groups are prioritized over the interests of the public, leading to a net loss to society as a whole; an example is lobbying standard which in turn influences the technological infrastructure of a particular market (??). Countries with heavier regulation tend to have higher corruption and larger unofficial economies. Efficiency might be lowered through increasing the cost of government goods and services, distortion, and creating additional efficiency costs of competition (??). Such distortion distracts entrepreneurial talent from improving productivity, but directs them toward rent extraction, which lowers the level of product innovation (??).

All three aspects show allocation of resources as an important mediating factor in connecting regulations with innovation performance. On the one hand, regulations influence the distribution of resources across incumbent firms, thereby affecting the innovative performance of firms. ? demonstrate that the misallocation of resources across firms caused by policy distortion can lead to aggregate productivity loss, for example by subsidizing unproductive firms and taxing productive firms. Following this idea, ? discovered a potential 30 to 50 percent increases in aggregate productivity by China, which could be achieved by more efficient resource allocation. On the other hand, regulations play important roles in industry dynamics by affecting the entry and exit of firms. ? find that environmental regulation affects the quantity of the input used and the price in the energy market. ? find that in countries with high entry regulation, industries respond to growth opportunities through the expansion of existing firms, while in countries with low entry regulation, growth opportunities lead to the creation of new firms. While some studies have investigated the impact of regulations on the innovation performance for certain industries in China such as energy, telecommunications, automobiles and pharmaceuticals, little is known

about the overall regulation level and its interaction with innovation performance in China.

Overall, the evidence of regulation on innovation performance is mixed, implying that regulation can promote and suppress innovation (**?**). Existing studies in this field tend to adopt case studies to analyze certain industries and specific regulations. For example, **?** argue that the patent law changes in India's pharmaceutical industry hinder domestic efforts in innovation in that insecure property rights reduces the appropriability for the returns to innovation. (**?**) has documented minor effects of regulations on industrial innovation projects, but the magnitude of their impacts varies across industries. **?** documented the negative impact of regulation on business innovation in the U.S. and that regulation has delayed and even prevented innovation in a number of areas in pharmaceuticals and chemistry. It helps to create an overall climate for industry that is generally unfavorable to technological risk taking. Firms have been relatively successful in coping with government regulation in the area of safety, pollution control, etc. (**?**).

One important indication is that the impact of government regulations on economic performance varies in response to other intervening factors such as political organization of structure, financial market and corruption. **?** discovered a positive relationship between regulation and firm growth in China. They argue that regulation appears not to be a vital constraint on firm growth if financial markets are underdeveloped in China. **?** found that firms in more contract-dependent industries that are located in more corrupt regions, tend to have lower management quality, a more centralized decision-making process, and a lower level of education among administrative staff in Central and Eastern Europe. In more regulated regions, contract-dependent firms are also characterized by lower investment in R&D, and smaller product markets.

This paper aims to fill this gap by building a general analytical framework to identify the causality between regulations and innovation considering the essential role of resource allocation.

3 Econometric Models

First, we estimate the impact of regulations on the tendency of firms to conduct product innovation using Probit specification shown in Equation 1 and 2.

$$Prob(BPI_i = 1|X) = c + \beta_1 REG_i + \beta_2 REGsq_i + \beta \mathbf{Z_i} + \epsilon_i \tag{1}$$

$$\hat{REG}_i = c_0 + \gamma_1 ILR_i + \gamma \mathbf{Z_i} + \delta_i \tag{2}$$

where BPI_i denotes the tendency of firm i to conduct product innovation; REG_i denotes the regulation level; $REGsq_i$ is the square item of regulation level REG_i. According to **?**, many other factors may influence firms performance in product innovation. Control variable set $\mathbf{Z_i}$ includes the process innovation PRC_i, the decision of conducting R&D RND_i, skill level of employees SKL_i, training TRA_i, size SIZ_i, years established AGE_i, export ratio EXP_i, import ratio IMP_i, competition COM_i, ownership dummy, region dummy and industry dummy. Innovation activities are driven by the level of competition. **?** demonstrate an inverted U-shaped

relationship between competition and innovation. **?** points out that new firms will usually turn to the government for protection of their investments and future returns. Existing economic interests can depend on their longstanding associations with bureaucratic and political supporters for protection, and therefore time established is relevant for firms' response to regulations and innovation performance. **?** discovers the importance of R&D investment and trade choices such as exports and imports in improving the performance of innovation.

The endogeneity problem arises because firms with better performance might also devote more effort to managing relationships with government officials. The level of regulations might be determined by the performance of product innovation. These result in bidirectional causality between product innovation and regulations. **?** demonstrate that bureaucrats have discretionary power given a certain regulation on firms according to their innovative performance. We address this endogeneity issue by adopting specification of two-stage Probit regression. Inspired by **?**'s approach in addressing the endogeneity issue between corruption and growth, we use the industry-average IRA_i and location-average of regulation LRA_i (at the city level) as instruments of the regulation level. It is arguable that the industry averages and location averages are closely related to firms' practical response to regulations but have little connection with their performance in product innovation.

In practice, we first estimate a regulation determination regression with the instruments and all other explanatory variables show as Equation 2; we then substitute the predicted values of regulation into the Probit estimation on innovation tendency regression shown as Equation 1.

Second, we estimate the intensity of product innovation using ordinary least square regression (OLS) and two stage least square (TSLS) estimation shown as Equation 3 and 4.

$$PDI_i = c + \beta_1 REG_i + \beta_2 REGsq_i + \beta \mathbf{Z_i} + \epsilon_i \tag{3}$$

$$\hat{REG}_i = c_0 + \gamma_1 ILR_i + \gamma \mathbf{Z_i} + \delta_i \tag{4}$$

where PDI_i denotes the intensity of product innovation for firm i. Control variable set $\mathbf{Z_i}$ includes the same variables as Equation 1. As before, we use the industry-average and location-average of regulation IRA_i and LRA_i as instruments of the regulation level in the TSLS estimation to address the endogeneity problem.

Finally, to understand the way by which regulations act on firms performance in product innovation, we construct a structural equation model that incorporates a measure of firm-level distortions DIS_i and the accessibility of financial resource (FIN_i), as shown in Equation 5.

$$\begin{aligned}
PDI_i &= c + \beta_1 REG_i + \beta_2 REGsq_i + \beta_3 FIN_i + \beta_4 DIS_i + \beta \mathbf{Z_i} + \epsilon_i \\
REG_i &= c_0 + \gamma_1 ILR_i + \gamma \mathbf{Z_i} + \delta_i \\
DIS_i &= c_1 + \eta_1 REG_i + \eta_2 INV_i + \eta_3 OWN_i + \xi_i \\
FIN_i &= c_2 + \eta_4 REG_i + \eta_5 LAN_i + \eta_6 OWN_i + \nu_i
\end{aligned} \tag{5}$$

where DIS_i represents a measure of firm-level distortions and FIN_i denotes financial resource accessibility. The two indicators are designed to capture across-firm resource allocations, which enables us to investigate the role of resource reallocation in the observable relationship between regulation and product innovation. Distortion of resource allocation DIS_i is specified as a function of regulation REG_i, investment in fixed assets INV_i, ownership dummy OWN_i; Financial resource accessibility FIN_i is specified as a function of regulation REG_i, land ownership LAN_i, and ownership dummy OWN_i. The control variable set $\mathbf{Z_i}$ includes the same variables as equation 1. This specification particularly addresses two potential impacts of regulation on innovation: the efficiency of resource allocation within and across firms, especially the accessibility to financial resources. The prevalence of regulation may distort resource allocation by increasing the returns to rent-seeking compared to those of productive activities (**?**). **?** demonstrate that policies which create heterogeneity in the prices faced by individual producers can lead to sizeable decreases in output and measured total factor productivity (TFP) and that differences in the allocation of resources across establishments that differ in productivity may be an important factor in accounting for cross-country differences in output per capita.

The regulation variable in our paper essentially reflects both the constraint of government regulations and the efforts of firms that are actively devoted to dealing with regulations. We assume that over-regulation causes an increase in resource misallocation, which has a negative effect on product innovation, while firms that actively respond to government regulations may gain easier access to certain financial resources which in turn has a positive impact on product innovation. Hence the overall impact of regulations on product innovation depend on the trade-off between these two aspects.

4 Data and Measurement

The data are taken from Chinese Business Environment Enterprise Performance Survey (BEEP), collected and maintained by the World Bank in 2012. This survey was designed to assess the impact of government policies and practices on business activities worldwide. The sample in China was selected using a stratified random sampling in 25 cities. The data provide detailed information about their innovation performance and the business environment, such as firm characteristics, financial performance, as well as business-government relationships, among other aspects. Table 1 summarizes the measurements of the main variables and descriptive statistics.

We adopt the percentage of time spent by senior managers dealing with regulations to measure the degree of government regulation in China. **?** consider this measurement to be red tape. Some studies use this indicator to measure the level of the corruption directly (**?**). However, in China or other developing economies, this indicator incorporates active efforts of firms in seeking better government relationships apart from red tape in order to obtain technical resources, government fundings, and market entry permits. In developing markets, government behavior

Table 1: Measurements of variables and their descriptive statistics

Variables	Measurements	Obs	Mean	SD	Min	Max
Product innovation	Ratio of new product to sales	2719	11.04	18.1	0	100
Innovation tendency	Binary variable indicating whether firms have new product sales	2719	.44	0.50	0	1
Regulation	Percentage of time spent by senior manager dealing with regulations	2595	1.34	3.86	0	100
Process Innovation	Percentage of establishment's annual production volume associated with new or improved processes introduced over the last three years	2719	8.93	15.61	0	100
Skill	Average education years of employees	1657	10.18	1.89	1	18
R&D	Binary variable indicating whether firms conduct R&D	2719	.98	.86	0	1
Size	Number of full-time employees in logarithm	2699	4.15	1.37	1.39	10.30
License	The use of foreign licenses	2719	-2.37	5.24	-9	2
Competition	Number of competitors	2719	553.65	159.34	0	601
Age	Years established	2627	16.72	7.91	4	129
Export	Ratio of export to sales	2698	10.87	24.63	0	100
Import	Ratio of imported intermediate input to inputs	1690	3.78	13.38	0	100
Capital distortion	Calculated based on equation 6	980	1.13	1.79	-4.13	12.26
Output distortion	Calculated based on equation 7	1558	.36	.467	-4.29	1.9
Finance accessibility	Percentage of the firm's working capital that was borrowed from banks	2639	6.90	14.86	0	100

Notes: Missing values are coded as -9 for License variable.

is one of the main potential risks (**?**). Policy uncertainty occurs when a firm or industry anticipates the enactment of a regulation at some time in the future. The response to regulations by firms acts as a way to hedge and safeguard against the full losses of bad economic policy. This measurement reflects the comprehensive response by Chinese firms to regulations.

Innovation performance is measured by both the tendency to conduct product innovation and the intensity of product innovation to sales. Missing values in product innovation are considered in the absence of new product in sales and are therefore are replaced by zeros. This applies to process innovation as well.

Following the pioneer work by **?**, we construct the distortion variables as follows.

$$\tau_{K_{si}} = -1 + \frac{\alpha_s}{1-\alpha_s}\frac{\omega L_i}{RK_i} \tag{6}$$

where $\tau_{K_{si}}$ captures capital distortion. K_i is the capital input of firm i; L_i is the labor input of firm i. ω denotes wage. α_s is the share of capital in industry s. R is the interest rate, assumed as 10 percent. $\tau_{K_{si}}$ is larger when a firm has more difficulties in accessing financial credit.

Output distortion reflects the additional operational cost or impediment to production of firms caused by government intervention that is not tied to capital.

$$\tau_{Y_{si}} = 1 - \frac{\alpha_s}{1-\alpha_s}\frac{\sigma}{\sigma-1}\frac{\omega L_i}{PY_i} \tag{7}$$

where $\tau_{Y_{si}}$ is the output distortion. σ is the elasticity of substitution between different firms' goods, which is assumed to be 3 in this case following **?**.

The measure of distortions reflects the consequences of government regulations on the production of firms. $\tau_{K_{si}} > 0$ or $\tau_{Y_{si}} > 0$ implies that firms face capital or output burdens, which may take the form of taxes, in terms of either finance or time. These firms produce less than their counterfactual optimal levels. If $\tau_{K_{si}} < 0$, $\tau_{Y_{si}} < 0$, firms are receiving preferential regulations, for example, R&D subsidies on certain technology, and expected to produce more than their counterfactual optimal level. That is, regulations may distort firms' production behavior and lead to resource misallocations across firms.

As seen from the correlation coefficients in Table 2, time spent on government regulations presents a significantly positive relationship with the intensity of product innovation and the accessibility of financial resources, while it does not significantly correlate with output distortion. The time dealing with government regulations significantly correlates with process innovation, skilled level of workers, R&D investment, size, export and import, while it does not show a significant correlation with training, competition, and time established.

Table 2: Cross-correlation table

	PRD	REG	PRC	SKL	RND	TRA	SIZ	LIC	COM	AGE	EXP	IMP	DIS	FIN
PRD	1													
REG	0.12***	1												
PRC	0.29***	0.05*	1											
SKL	0.06*	0.09***	0.09***	1										
RND	0.40***	0.13***	0.29***	0.12***	1									
TRA	0.08***	0.03	0.10***	0.04	0.13***	1.00								
SIZ	0.07***	0.04*	0.21***	0.06*	0.24***	0.19***	1.00							
LIC	- 0.10***	- 0.06**	0.35***	- 0.13***	- 0.18***	0.01	0.19***	1						
COM	- 0.06**	-0.01	0.20***	- 0.11***	- 0.13***	- 0.00	0.12***	0.62***	1.00					
AGE	-0.01	-0.00	0.01	0.05*	0.02	0.02	0.25***	0.04*	0.06**	1.00				
EXP	0.03	0.10***	0.12***	0.01	0.08**	0.03	0.15***	0.10***	- 0.11***	0.00	1.00			
IMP	0.07**	0.08**	0.06*	0.08***	0.07**	0.02	0.10***	- 0.15***	- 0.14***	-0.02	0.32***	1.00		
DIS	-0.02	0.00	-0.00	0.08**	0.07**	0.10***	-0.02	-0.01	0.04	0.04	- 0.10***	-0.02	1.00	
FIN	0.11***	0.11***	0.10***	0.14***	0.15***	0.01	0.18***	0.01	- 0.05**	0.02	0.07***	0.04	0.02	1.00

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

To comprehensively review the relationships among regulations, resource allocation and product innovation, we plot the scatter graph among the three variables at the firm and industrial

level in Figure 1. Figure 1 (a) indicates an inverted U-shaped relationship between the time spent in dealing with regulations and intensity of product innovation. We then calculate the average capital distortion, product innovation, and time dealing with regulations for each industry. Figure 1 (b) shows that the more time spent with government regulations, the higher the level of product innovation at the industrial level, and the higher the level of the capital distortion. This preliminary evidence is consistent with the hypothesis in econometric model 5.

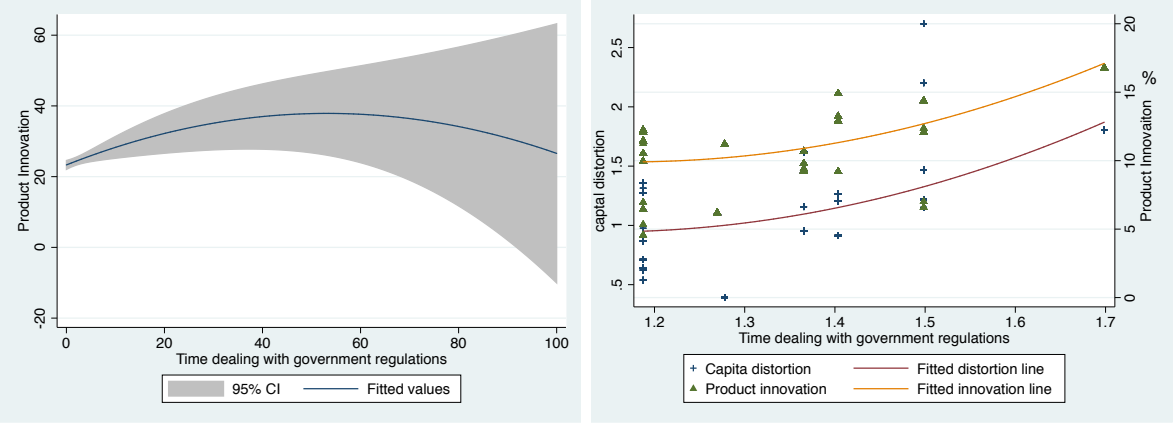

Figure 1: Regulations and product innovation

5 Results

We conduct an empirical analysis to identify the causality between government regulations, resource allocation and product innovation by applying the econometric models specified in section 3 on the above survey data.

5.1 Impact of regulations on the decision of product innovation

First, the impact of regulations on the tendency to conduct product innovation is estimated using Equation 1. The dependent variable is the binary variable indicating whether firms have new product revenue. Robust standard errors are used as a way of addressing the heteroskedasticity problem. Table 3 presents the estimation results generated by both Probit regression in columns (1) and (2) and instrument Probit specification in columns (3) and (4). In both cases, square item of regulation $REGsq_i$ is incorporated into the estimation separately. The coefficients of instrument variables industry-average and location-average are significants in the instrument Probit regression. The Wald test rejects the null hypothesis of on endogeneity, and therefore the estimation of instrument Probit regression is valid.

As seen from Table 3, the square item of regulation is significant in both the ordinary Probit regression (column (2)) and the instrument Probit regression (column(4)). This indicates that the time spent in dealing with government regulations has a concave effect on firms' tendency

Table 3: Impact of regulations on product innovation decision

	(1) Probit	(2) Probit	(3) IVProbit	(4) IV Probit
Regulation	0.042*	0.121***	0.110***	0.175**
	(1.90)	(4.20)	(2.68)	(2.25)
Regulationsq		-0.004***		-0.006**
		(-3.93)		(-2.07)
Process innovation	0.012***	0.012***	0.012***	0.012***
	(4.92)	(4.92)	(5.03)	(4.87)
R&D	1.180***	1.192***	1.141***	1.184***
	(14.98)	(15.04)	(12.92)	(14.66)
Skill	0.005	0.005	0.008	0.002
	(0.21)	(0.21)	(0.34)	(0.10)
Training	0.162	0.154	0.152	0.147
	(1.50)	(1.42)	(1.44)	(1.36)
Size	0.027	0.023	0.060*	0.020
	(0.82)	(0.70)	(1.93)	(0.62)
Age	-0.003	-0.003	-0.003	-0.003
	(-0.55)	(-0.61)	(-0.71)	(-0.64)
Export	-0.002	-0.002	-0.001	-0.002
	(-1.06)	(-1.15)	(-0.84)	(-1.24)
Import	0.002	0.002	0.002	0.001
	(0.68)	(0.56)	(0.66)	(0.48)
Competition	0.000	0.000	0.000	0.000
	(0.75)	(0.85)	(0.77)	(0.82)
Foreign license	0.307	0.115		0.092
	(0.52)	(0.21)		(0.17)
State-owned	-0.531***	-0.534***	-0.504***	-0.513***
	(-2.95)	(-2.96)	(-3.06)	(-2.89)
Region	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Constant	-2.180***	-2.076***	-1.963***	-2.050***
	(-3.37)	(-3.36)	(-5.33)	(-3.29)
Industry-average			0.927***	0.504***
			(7.76)	(9.15)
Location-average			0.631***	0.240**
			(2.86)	(2.15)
N	1549	1549	1549	1549
AIC	1606.576	1597.572	9030.589	6797.607
BIC	1740.210	1736.551	9292.511	7091.602
athrho2			-0.200*	-0.077
			(-1.81)	(-0.74)
lnsigma2			0.950***	0.241***
			(10.30)	(4.99)

Notes: Robust standard errors. t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

to conduct product innovation, that is, firms spending more time on government regulations are more likely to conduct product innovation; after it reaches to the threshold point, it has negative effect on the innovation decision. Based on the estimation results, instrument Probit regression incorporating the square item of regulation in column (4) is the most appropriate estimation. Process innovation and R&D investment show significantly positive effects on firms' tendency to conduct product innovation. State-owned firms are less likely to conduct product innovation compared to private firms (-0.513). Training, time established, skill level of workers, competition and trade variables do not show significant effects on the decision of firms to conduct product innovation.

Table 4: Marginal effects of regulations on product innovation decisions

	(1) Probit	(2) Probit	(3) IVProbit	(4) IV Probit
Regulation	0.017*	0.048***	0.013	0.045*
	(1.90)	(4.19)	(0.82)	(1.48)
Regulationsq		-0.002***		-0.002*
		(-3.92)		(-1.32)
Process innovation	0.005***	0.005***	0.005***	0.005***
	(4.90)	(4.90)	(5.13)	(4.84)
RND (d)	0.443***	0.448***	0.449***	0.448***
	(16.72)	(16.82)	(15.01)	(16.50)
Skill	0.002	0.002	0.008	0.002
	(0.21)	(0.21)	(0.86)	(0.23)
Training(d)	0.063	0.060	0.064	0.061
	(1.52)	(1.44)	(1.58)	(1.47)
Size	0.010	0.009	0.025**	0.010
	(0.82)	(0.70)	(2.01)	(0.74)
Age	-0.001	-0.001	-0.001	-0.001
	(-0.55)	(-0.61)	(-0.71)	(-0.64)
Export	-0.001	-0.001	-0.000	-0.001
	(-1.06)	(-1.15)	(-0.64)	(-1.14)
Import	0.001	0.001	0.001	0.001
	(0.68)	(0.56)	(0.83)	(0.56)
Competition	0.000	0.000	0.000	0.000
	(0.75)	(0.85)	(1.09)	(0.87)
Foreign licenses (d)	0.341	0.269		0.265
	(1.63)	(1.30)		(1.27)
State-owned (d)	-0.192***	-0.193***	-0.195***	-0.192***
	(-3.34)	(-3.36)	(-3.52)	(-3.32)
N	1549	1549	1549	1549
AIC	1606.576	1597.572	9030.589	6797.607
BIC	1740.210	1736.551	9292.511	7091.602

Notes: Robust standard errors. t statistics in parentheses. (d) for discrete change of dummy variable from 0 to 1. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

It is not appropriate to interpret the coefficients in the Probit regression directly, and therefore their marginal effects are computed and presented in Table 4. Based on the two-stage

Probit estimation in column (4), there is an inverted U-shaped relationship between regulations and the product innovation decision. The turning point of regulation on the product innovation decision is 11.25. When senior managers spend more than 11.25 percent of their time in dealing with regulations, firms' tendency to sell new products decreases, accounting for approximately 1.8 percent of sample firms (46). R&D investment significantly improves firms' tendency to sell new products by 0.45, while process innovation improves this tendency by 0.005. Compared to private firms, state-owned firms are less likely to conduct product innovation (-0.192). As before, training, time established, skill level of workers, competition and trade variables do not show significant effects on the decision of firms to conduct product innovation.

The inverted U-shaped relationship suggests that actively dealing with regulations is associated with higher innovation probability when government regulation is within a rational level. However, an environment of over-regulation can hinder firm innovation, and firms spending too much time in dealing with regulations may prefer to actively establish political connections rather than implement product innovation.

5.2 Impacts of regulation on intensity of product innovation

Then, we estimate the impact of regulations on intensity of product innovation based on equation 3 and 4 and the results are shown in Table 5. Control variables are incorporated into the OLS estimation gradually in order to justify the validation of control variables. Robust standard errors are used to address the heteroskedasticity problem. The adjusted R^2 increases from 0.071 to 0.346 in the OLS estimation, suggesting that adding more variables increases the goodness-of-fit and explanation power. Hence, we adopt the whole variable set to conduct instrument TSLS estimation in the last two columns. Instrument variables industry-location-averages show significantly positive effects on the regulation variable. The Wald test rejects the null hypothesis of no endogeneity on regulation. A weak instrument test rejects the null hypothesis of weak instruments. Hence, the instrument TSLS estimation including the square item of regulation is preferred.

As shown in Table 5, regulations show positive effects on the intensity of product innovation for all regressions in question. The square item of regulations shows significantly negative signs in both OLS and TSLS estimation, indicating an inverted U-shaped relationship between time spent in dealing with regulations and product innovation performance. The trend is similar to the previous Probit regression. The turning point of regulations in TSLS estimation is 14.4, similar to 11.25 estimated by the IV Probit regression. Senior managers in 42 firms (1.6 percent) spend more than 14.4 percent of their times on government regulations covered in the sample.

As before, both process innovation and R&D investment significantly improve the product innovation performance (0.312 and 8.397, respectively). The ratio of exports to sales shows a negative effect on the intensity of product innovation. This result is consistent with **?** who argues that export shows negative effect on learning and productivity improvement in labor-

Table 5: OLS and IV regression on the intensity of product innovation

	OLS	OLS	OLS	OLS	OLS	TSLS	TSLS
Regulation	0.570***	0.460***	0.603***	0.562***	0.976***	1.890***	3.312***
	(4.15)	(3.85)	(3.18)	(3.17)	(3.39)	(4.57)	(4.32)
Regulationsq					-0.022*		-0.115***
					(-1.68)		(-3.69)
Process innovation		0.409***	0.339***	0.318***	0.318***	0.306***	0.312***
		(11.16)	(8.42)	(8.02)	(8.02)	(13.52)	(14.01)
R&D			9.192***	8.624***	8.638***	7.952***	8.397***
			(9.61)	(9.22)	(9.23)	(9.36)	(10.21)
Skill			0.184	-0.005	-0.013	-0.224	-0.144
			(0.76)	(-0.02)	(-0.05)	(-1.00)	(-0.66)
Size			0.107	-0.256	-0.283	-0.203	-0.374
			(0.34)	(-0.81)	(-0.90)	(-0.63)	(-1.16)
Age			-0.055	-0.053	-0.054	-0.062	-0.064
			(-1.34)	(-1.31)	(-1.34)	(-1.28)	(-1.34)
Export			-0.029*	-0.038**	-0.039**	-0.045***	-0.048***
			(-1.76)	(-2.25)	(-2.32)	(-2.74)	(-2.89)
Import			0.009	0.004	0.003	-0.004	-0.008
			(0.29)	(0.13)	(0.09)	(-0.14)	(-0.25)
Training			0.238	0.287	0.212	0.157	-0.163
			(0.22)	(0.28)	(0.20)	(0.14)	(-0.14)
Competition			-0.001	-0.001	-0.001	-0.002	-0.001
			(-0.38)	(-0.75)	(-0.71)	(-1.33)	(-0.84)
Foreign license				11.207***	10.255***	17.085***	8.838*
				(2.90)	(2.87)	(3.36)	(1.84)
State-owned	-5.492***	-2.597*	-0.289	-0.048	0.055	0.387	0.681
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	5.225***	0.363	-2.451	-3.868	-3.127	-8.423	-2.011
	(3.17)	(0.21)	(-0.69)	(-0.79)	(-0.66)	(-1.42)	(-0.35)
N	2594	2594	1549	1549	1549	1549	1549
R^2	0.071	0.171	0.319	0.344	0.346	0.302	0.313

Notes: Robust standard errors. t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

intensive sectors in China. Training, time established, skill level of employees, competition, imports, license and ownership variables do not show significant effects on the intensity of product innovation.

5.3 Impact of regulations on product innovation via resources allocation

As we discussed earlier, regulation may create rents for bureaucrats, induce misallocation of resources, and increase the size of the bureaucracy, and therefore, we investigate the potential impacts of regulations on product innovation via resource allocation using the structural equation specification shown in equation 5. The estimation results are described in table 6.

As shown in Table 6 column (2), the square item of regulations does not show a significant

Table 6: Regulations on product innovation through resources allocation

	Structural Equation Model (1)		Structural Equation Model (2)	
->Product innovation				
Regulation	0.640***	(4.37)	0.747***	(2.58)
Regulationsq			-0.006	(-0.43)
Finance	0.055*	(1.86)	0.054*	(1.84)
Distortion	-1.573*	(-1.88)	-1.576*	(-1.88)
Process innovation	0.322***	(14.31)	0.323***	(14.31)
RND	8.363***	(9.98)	8.367***	(9.99)
Training	0.949	(0.84)	0.921	(0.82)
Size	-0.573*	(-1.74)	-0.581*	(-1.76)
Age	-0.057	(-1.20)	-0.057	(-1.20)
Export	-0.034**	(-2.08)	-0.034**	(-2.09)
Import	0.007	(0.24)	0.007	(0.23)
Foreign-owned	11.700**	(2.42)	11.369**	(2.32)
Skill	-0.231	(-1.07)	-0.233	(-1.08)
Competition	-0.000	(-0.32)	-0.000	(-0.32)
Constant	-2.125	(-0.36)	-1.864	(-0.31)
Regulation -> Finance accessibility	0.381***	(2.83)	0.381***	(2.83)
Foreign-owned -> Finance accessibility	-4.807***	(-2.62)	-4.807***	(-2.62)
Land ownership -> Finance accessibility	0.001	(0.07)	0.001	(0.07)
Regulation -> Distortion	0.002	(0.41)	0.002	(0.41)
State-owned -> Distortion	0.282***	(4.53)	0.282***	(4.53)
Investment in fixed assets -> Distortion	0.149	(0.86)	0.149	(0.86)
Industry average -> Regulation	0.944***	(14.90)	0.944***	(14.90)
Location-average -> Regulation	0.750***	(3.66)	0.750***	(3.66)
var(e.PRD)	192.469***	(26.57)	192.444***	(26.57)
var(e.REG)	6.084***	(26.57)	6.084***	(26.57)
var(e.FIN)	181.164***	(26.57)	181.164***	(26.57)
var(e.DIS)	0.206***	(26.57)	0.206***	(26.57)
N	1412		1412	

Notes: Robust standard errors. t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

effect on product innovation in this analysis. This might be due to that the resource allocation variables absorb the negative impacts of regulation to a certain degree. Regulation shows a significantly positive effect on product innovation (0.774). Firms that actively deal with government regulations, which we associate with spending more time in dealing with regulations, have easier access to financial resources (0.381), which in turn facilitates product innovation of firms (0.054).

Output distortion has a significantly negative effect on product innovation (-1.576), while regulation does not show a significant effect on output distortion. The latter point is inconsistent with the hypothesis, implying that regulations does not cause significant distortion in output among firms. Previous studies do not find consistent results on the impact of regulations on distortion. For example, **?** has discovered that deregulation led to a shift toward more productive coal mines in the U.S., and further demonstrated asymmetric information, capital bias, and regulatory capture as important sources of regulatory distortion. **?** argue that the impact of research and development investment, induced by environmental regulation, on manufacturing quality competitiveness is greater than that induced by non-environmental regulation in China, and that environmental regulation can generally promote technological innovation.

The insignificant effect of regulation on distortion is mainly due to the issue of measurement. While the measure of regulation captures both the toughness of government regulations and the efforts of firms actively devoted to deal with regulations, the two aspects of information embodied in the measure of regulation have a completely adverse effect on firm-level distortions. According to the literature on misallocation and productivity, tougher government regulation can act as a form of tax and lead to resource misallocations. This means that regulation should be positively associated with firm-level distortions. However, firms actively dealing with regulations are more likely to build political connections and as a result perceive distortions as a form of subsidy. When the regulation variable captures the efforts of firms devoted to deal with regulation, the regulation variable can negatively correlate with firm-level distortion. Therefore, the two adverse driving forces can result in an observed insignificant relationship between regulation and distortion as a whole.

Meanwhile, different types of firm ownership exhibit various performance in resource allocation. Foreign-owned firms are less likely to obtain financial resources in China (-4.874), while state-owned firms experience a higher level of output distortion (0.282). R&D investment presents a significantly positive effect on intensity of product innovation. Firm size and export level have a significantly negative effect on product innovation intensity. Training, time established, skill level of employees, competition, import, license and ownership variables do not show significant effects on the intensity of product innovation. Combining with the results, our study confirms that resource reallocation is an important channel through which regulation can affect product innovation.

5.4 Robustness Check

We conduct a robustness check by incorporating the distortion variables, accessibility of financial resources, and their interaction items with regulations into two-stage least squares (TSLS) estimation. The results are shown in Table 7. The first column shows TSLS estimation with output distortion and its interaction item with regulation variable. The second column presents TSLS estimation with financial resource accessibility and its interaction item with regulation variable.

As seen from Table 7 column (3), TSLS estimation generally confirms the results from structural equation models, with a significantly negative coefficient for the square item of regulations. The turning point for regulation is 17.9, higher than the previous IV Probit and TSLS analysis without resource allocation variables. Easier access to financial resources significantly improves the performance of product innovation, however, its interaction item with regulation does not show a significant effect. The interaction item of output distortion with regulation presents a significantly negative effect on product innovation intensity, implying that given a certain level of regulation, output distortion will impede product innovation. Similar to the above analyses, process innovation and R&D investment present a significantly positive effect (0.319 and 8.229 respectively), while export and size present significantly negative effect (0.039 and 0.737 respectively). Training, time established, skill level of employees, competition, import, license and ownership variables do not show significant effects on product innovation intensity.

Additionally, the estimation results on the tendency to conducting product innovation using the IV Probit regression are similar to that of TSLS regression on the intensity of product innovation. This confirms the robustness of estimation to a certain degree.

6 Conclusion and Discussion

The aim of this study is to understand how Chinese firms respond to government regulations in terms of product innovation. Unlike the majority of studies that investigate the impact of certain regulations on innovation performance, this paper investigates the overall regulation level in China and analyzes its impacts on resource allocation, which in turn plays an important role in affecting firms performance in product innovation. Utilizing the Business Environment Performance data collected by the World Bank in 2012, we obtain the following research findings regarding the impact of regulations on the product innovation performance using instrument variable regression and the structural equation model.

First, we find an inverted U-shaped relationship between regulations and product innovation in China. Regulations play a positive role in promoting innovation within the threshold, and the more actively firms respond, the better performance of product innovation firms experience. After it reaches a threshold, the situation reverses. The turning point of the regulation variable is approximately 14.4, which implies that 1.7 percent of sample firms experienced side effects

Table 7: Impact of regulations on product innovation via resource allocation

	(1)	(2)	(3)
Regulation	3.894***	3.366***	3.793***
	(4.04)	(3.74)	(3.65)
Regulationsq	-0.115***	-0.108***	-0.106***
	(-3.31)	(-3.42)	(-2.98)
Distortion	0.174		-0.038
	(0.16)		(-0.04)
Distortion*Regulation	-1.652***		-1.484***
	(-2.76)		(-2.67)
Finance		0.047	0.068*
		(1.36)	(1.92)
Finance*Regulation		-0.021	-0.017
		(-1.44)	(-1.20)
Process innovation	0.313***	0.324***	0.319***
	(13.52)	(14.11)	(13.57)
Training	-0.227	0.590	0.542
	(-0.19)	(0.51)	(0.46)
RND	8.374***	8.404***	8.229***
	(9.66)	(10.05)	(9.44)
Size	-0.579*	-0.494	-0.737**
	(-1.69)	(-1.50)	(-2.12)
Competition	-0.001	-0.001	-0.001
	(-0.64)	(-1.01)	(-0.65)
Age	-0.073	-0.056	-0.065
	(-1.46)	(-1.15)	(-1.30)
Export	-0.038**	-0.051***	-0.039**
	(-2.21)	(-3.01)	(-2.28)
Import	-0.009	-0.003	-0.003
	(-0.28)	(-0.11)	(-0.09)
Foreign license	10.086**	10.075**	11.022**
	(2.06)	(1.99)	(2.15)
Skill	-0.270	-0.209	-0.352
	(-1.19)	(-0.95)	(-1.55)
State-owned	2.021	1.007	2.477
	(0.97)	(0.51)	(1.17)
Region	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Constant	-2.169	-2.892	-2.398
	(-0.36)	(-0.48)	(-0.39)
N	1434	1522	1412
R^2	0.304	0.318	0.312

Notes: t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

caused by the regulations. During the time covered by the survey, the majority of firms spent time within threshold on government regulations, implying that overall regulation in China plays a positive role in influencing firms innovative behavior. These findings are in line with studies addressing the managerial ties - innovation link (**?**). Institutional voids in China force managers to rely on personal ties and connections to substitute for formal institutional support. Social network theory suggests that managerial ties play a "conduit" role by providing opportunities to approach external resources. Nevertheless, overregulation or too much time in dealing with government regulation by firms may cause a negative effect. For example, **?** argue that political ties hinder the relation between inter-functional coordination and innovation in China.

Second, regulations influence the performance of firms innovative behavior via their allocation in financial resources among firms. Consistent with the hypothesis, actively coping with regulations, shown as spending more time in dealing with regulations, facilitates firms' access to financial resources in China, which promotes product innovation accordingly. This finding confirms arguments by **?** and **?** who state that externally financed investment is positively related to firm innovation. Meanwhile, the result implies that private firms in China have less access to the formal banking system. This might be due to the insufficient enforcement of enterprise law and information asymmetry (**?**). Financial friction distorts entry and technology adoption decisions, generating dispersion in the returns to capital across existing producers (**?**).

Third, output distortion significantly impedes the performance of product innovation, however, regulations have no measurable effect on output distortion. The latter finding occurs because the measure of regulation in this study captures both the constraints of government regulations and the efforts firms devoted to dealing with regulations. Tougher regulation is fundamentally associated with more severe output distortion. For example, **?** and **?** confirm the various effects of regulation on distortion for structure of industry and inter-sectoral allocations. However, firms actively dealing with regulations are more likely to establish political connections, which in turn leads to easier access to certain resources. The overall impact of regulation on output distortion is therefore shown as a net effect of both positive and negative influences. Nevertheless, our results confirm that regulations result in resource reallocations across firms and accordingly affect the innovative performance of firms.

Our results must be viewed in the light of the study's limitations. First, regulation is measured as time spent in dealing with regulations. We assume this indicator includes the efforts to deal with red tape and to build government relations as well as managerial ties. These different types of activities are not separately analyzed in the paper. Second, the research is based on a cross-sectional data. As with all cross-sectional analyses, our results suffer from the endogeneity bias by arguing the causal relationship between product innovation and regulations. Although we apply instrument TSLS and a structural equation model to address the endogeneity problem, a longitudinal structure would reveal the dynamic changes of regulations and their impacts over time.

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