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Abstract: Does the variation in the quality of local government institutions affect the capacity of firms to innovate? This paper uses a unique dataset that combines the specific features of 2,700 firms with the institutional and socioeconomic characteristics of the 25 cities in China where they operate, in order to assess the extent to which institutional quality – measured across four dimensions: rule of law, government effectiveness, corruption, and regulatory quality – affects both the innovation probability and intensity of firms. The results of the econometric analysis show that poor institutional quality in urban China is an important barrier for firm-level innovation. In particular, a deficient rule of law, high corruption, and a weak regulatory quality strongly undermine firm-level innovation. The role of these factors is far more limited in the case of innovation intensity. Better institutions also reduce the amount of time firms spend dealing with government regulations in order to facilitate innovation. The results also indicate that the cost of weak institutions for innovation is higher for private than for state-owned firms, at least in the early stages of innovation. In general, differences in institutional quality generate local urban ecosystems that impinge on the propensity of firms to innovate.

Keywords: Innovation; institutions; government quality; firms; cities; China.

JEL codes: H1, O3, O31

1. Introduction

Firm-level innovation is generally considered to be at the heart of increases in productivity, employment, and economic growth. It is therefore no surprise that a huge amount of research has vied to identify what makes individual firms more innovative. Most of this research has focused on how the individual characteristics of firms determine their propensity and intensity to innovate. Firm size, the type of ownership, the financial structure, or how much a firm invests on science and technology have been over the years closely scrutinized as key factors for different types of innovation (Li and Song, 2010; Choi et al., 2011; Jiang et al., 2013; Jiao et al. 2015; Kafouros et al., 2015; Zhou et al., 2017).

Increasingly, the interest on the characteristics of the territorial ecosystem where a firm operates have joined firm-level attributes in the study of innovation. Recent research has approached the role of agglomeration economies and knowledge spillovers in determining firm-level innovation (Bell, 2005; Naz et al., 2015; Haus-Reve et al., 2019). Even more recently, the focus has been on quality of local institutions (De Waldemar, 2012; Chadee and Roxas, 2013; Dong and Torgler, 2013; Paunov, 2016; Nguyen et al., 2016; Barasa et al., 2017; Dincer, 2019), especially in the context of emerging countries, where government intervention is considered key for firms to set up shop and innovate (Dunning et al., 2008). Most of these relevant studies have concentrated on corruption and efforts to combat it (De Waldemar, 2012; Dong and Torgler, 2013; Paunov, 2016; Nguyen et al., 2016; Dincer, 2019), with relatively limited attention paid to the role of government effectiveness, rule of law, and regulatory quality as factors behind the introduction of new products and processes in the firm. Additionally, the majority of scholarly work on how these types of institutions affect innovation has been concerned with the national (e.g. Varsakelis, 2006; Tebaldi and Elmslie, 2013; Oluwatobi et al., 2015; Barasa et al., 2017) or the regional level (e.g. Rodríguez-Pose and Di Cataldo, 2015). Most of this research has been fundamentally concentrated on the developed world. The exceptions dealing with this topic in emerging countries have mainly concerned China, Russia, and India (e.g., De Waldemar, 2012; Bruno et al. 2013; Chadee and Roxas; 2013; Xu and Yano, 2017; Su et al., 2018; Rodríguez-Pose and Zhang, 2019).

However, research that combines individual firm characteristics, with the socioeconomic traits of the places where a firm is located, and with the local quality of the institutional environment where it operates is in short supply. There is even more limited evidence on how local government institutions affect firm-level innovation in emerging countries and even less on the direction and outcomes of how differences in government quality shape innovation. Moreover, no research to date has made the distinction between the propensity of firms to innovate – i.e. making the jump from not innovating to innovating – and the intensity of innovation – i.e. the value added of new innovations for firms. In this paper, we address these questions by linking the innovation performance of individual firms to not only the characteristics of the firm or the basic socioeconomic traits of the city in which it operates, but also to four specific local government quality measures – rule of law, government effectiveness, regulatory quality, and the control of corruption. This is done by exploring the following two questions: i) To what extent local government quality affects firm-level innovation?; and ii) Does local institutional quality play a greater or lower role than both firm-specific characteristics and other local social and economic traits for innovation?

By answering the above questions, this research contributes to the debate on the importance of a firm's external factors, relative to its internal factors, in shaping its innovative performance. Given the increasing interest by governments in emerging markets to tackle institutional bottlenecks, this paper additionally contributes to providing in-depth insights on how government quality shapes firm-level innovation in emerging markets.

Both product innovation and process innovation are investigated in this paper. The former refers to the type of innovation activities that introduce new products or services, or add new features to existing products or services. The latter covers innovative activities that introduce process improvements in production or operations. Moreover, innovation is measured in two ways. First, we are concerned with a firm's propensity to innovate, appraised by whether an individual firm has produced innovation over the last three years. Second, the intensity of firm-level innovation, proxied by the percentage of a firm's total annual sales accounted for by innovation in the last three years.

This paper is set in China. As a leading emerging country, China has been undergoing a fundamental institutional reform over the past four decades. However, the influence of Chinese government remains rife in the market, in spite of having an economy that is now overwhelmingly market-oriented. In modern China, government remains in control of the supply of important resources and also intervenes in business activities in a number of ways (Jiao et al., 2015; Scuotto et al, 2019; Tian, 2019). Moreover, despite continuous efforts at reform local government, the quality of local government and authorities varies markedly across regions (Wang, 2019). Thus, China serves as a suitable example for examining the role of institutional quality in emerging countries.

The paper relies on a custom-based dataset, combining a 2012 World Bank survey of innovation in 2,596 privately-owned firms and 104 state-owned firms, containing firm-level data on firm characteristics and their perception of local institutions, with socioeconomic indicators of the 25 large Chinese cities where they are located.

The results of the econometric analysis – using both logit methods, to identify the propensity of firms to innovate, OLS econometric analysis, for the intensity of innovation, and instrumental variables, to deal with endogeneity issues – show that poor local institutions represent a considerable barrier for firm-level innovation in China. Firms in cities with serious deficiencies in the rule of law, with a lower regulatory quality, or a greater degree of corruption, once other factors are controlled for, are less likely to innovate than those in cities with better institutional conditions. A low institutional quality particularly weakens the propensity of process innovation, while product innovation is less affected by poor government institutions. Achieving product innovation in weak institutional conditions is more difficult, but, once innovation takes place, it does not deter firms from increasing their share of product innovation. Better institutional environments also reduce the amount of firm managers' time dealing with government regulations in order to facilitate innovation. Moreover, firms with a lower share of state ownership innovate more in better local institutional environments.

The paper is structured along the following sections. The next section introduces the theoretical discussion about the role of institutions for innovation, both at a global scale and, more specifically, for China, before presenting the main hypotheses. Section 3 presents the regression model and describes the dataset. This is followed by some stylized facts about the quality of government institutions in the cities covered in the study. The results of the econometric analysis for the propensity to innovate and innovation intensity are reported in Section 4, while Section 5 concludes and develops some preliminary implications.

2. Theory and hypotheses

2.1 What determines firm-level innovation?

Innovation at firm-level has traditionally been all about the specific characteristics of the firm. Firm-size (Acs and Audretsch, 1987; Cohen and Klepper, 1996; Yu et al., 2019), R&D investment (Teece, 1986; Zhou and Wu, 2010; Kafouros et al., 2015; Naz et al., 2015), or the sector the firm is in (Mansfield, 1963; Bhattacharya and Bloch, 2004; De Jong and Vermeulen, 2006; Ganau and Rodríguez-Pose, 2019) have been at the forefront of research dealing with innovation. Who owns a firm – and, especially whether a firm is publicly or privately-owned – has also attracted considerable attention in this respect (Choi et al., 2011; Howell, 2016; Paunov, 2016; Rong et al., 2017).

Research has also focused on the attributes of the place where a firm is located (e.g. Sternberg and Arndt, 2001; Beugelsdijk, 2007; Gössling and Rutten, 2007). Factors such as the population of the place where a firm operates (Duranton and Puga, 2001), its level of development or wealth (De Noronha Vaz et al., 2006), the amount of innovation being conducted locally (Anselin et al., 1997; Bottazzi and Peri, 2003; Moreno et al., 2005), the pool of educated workers and skills available (Glaeser and Resseger, 2010), the unemployment rate (Horta et al., 2016), the presence of special economic status conditions (Sharif and Tang, 2014), or the level of regional diversity (Niebuhr, 2010; Solheim and Fitjar, 2018) have come under considerable scrutiny as potential shapers of innovation. The combination of a high density of skilled and innovative economic actors in a confined but diverse geographical space produces formal and informal interactions that create an innovation buzz (Storper and Venables, 2004). It also produces positive externalities that lead to multiplier effects behind a greater innovativeness of firms in cities (Glaeser, 2011). Whether it is through easier networking (Komninos, 2013), the presence of urban clusters or the formation of local innovation systems (Cooke, 2001; Asheim and Gertler, 2009), or simply by spillovers linked to the circulation of codified and tacit knowledge (Audretsch, 1998; Feldman and Audretsch, 1999), the consensus is that firms generally benefit from 'being there' where the best innovation prone environments are (Gertler, 2003).

When confronting the role of innovation of factors internal and external to the firm, previous studies tend to support the idea that firm-level factors are generally more relevant for innovation than those related to the environment in which the firm operates (Sternberg and Arndt, 2001; Beugelsdijk, 2007). For example, Sternberg and Arndt (2011: 379) underline that a "firm without considerable [internal] innovation potential cannot generate notable innovations, even if the innovation conditions in the region where it is located are very favorable". Ample research has tended to corroborate this finding (e.g. Boschma, 2005; Boschma and Ter Wal, 2007; or Wang and Lin, 2012, for the specific case of China). Along the lines of the majority of the literature presented above, we posit that firm-level innovation is subject to be influenced by both internal and external factors.

2.2. **Local government quality and firm-level innovation**

Although the environment in which a firm operates is considered relevant for firm-level innovation, most research zooming into the local environment has overlooked a crucial factor affecting the capacity of firms to function at all levels: the institutional quality of the place where a firm is located. Whether a firm can benefit from the local diversity and availability of skills and whether it can reap the knowledge spillovers associated with positive externalities, greatly depends on how local institutions function. Good institutions facilitate the creation of local networks and the assimilation of spillovers. Poor institutions limit interaction and increase transaction costs (Rodríguez-Pose, 2013). And, within the whole gamut of institutions, local government quality is crucial for the behavior of firms in all aspects of their activity.

Yet the interest on how local government quality shapes firm-level innovation has, until recently, been rather trivial. The few exceptions mostly feature corruption. Anokhin and Schulze (2009), for example, found that a better control of corruption is connected with rising levels of innovation and entrepreneurship. Adopting a broader framework, Rodríguez-Pose and Di Cataldo (2015) reported that ineffective and corrupt governments are a central impediment for local innovation capacity, especially in less developed areas. Poor government quality dents the impact of policies and interventions aimed at promoting greater innovation. Paunov (2016) demonstrated that corruption affects the innovation capacity of smaller firms and lowers investments behind different types of innovation. This literature, however, focuses on aggregate innovation and is not concerned with how these government quality conditions impinge on innovation at the level of the individual firm.

The research dealing specifically with firm-level innovation is also limited and frequently reaches contradictory results. Some find that informal payments and other corruption-linked practices by firms facilitate most types of innovation – as reported by Nguyen et al. (2016) in the case of Viet Nam. Others, by contrast, arrive to the conclusion that local corruption and bad government practices undermine firm-level innovation in the case of emerging countries (Alam et al., 2019), as was also found for India (De Waldemar, 2012) or the US (Dincer, 2019). Based on the above discussion we propose the following hypothesis:

Hypothesis 1: *The likelihood of a firm innovating is affected by the quality of the local government. The better the quality of the local government, the higher likelihood of a local firm innovating.*

2.3 The moderating role of firm strategy

When confronted with the same quality of government institutions, the innovative performance of firms may also be determined by what are their individual strategies for dealing with institutional weakness. In emerging markets, it is not rare for firms to bribe government officials to process permits or get preferential treatment. Other strategies involve building political links with government officials or spending more time on dealing with regulations. So far, there is not much research about how the different strategies adopted by individual firms influence the innovation capacity and, often, this research reaches contradictory results. One of the exceptions is Yu et al. (2019), who find that less corrupt local environments attenuate the influence of local officials on the activities of firms, given them a freer rein to invest in R&D. On political connections, while Wu (2011), Shi and Zhu (2014), Tian et al. (2019), and Yuan et al.(2019) indicate that resorting to political connections or building a closer business-government relationship positively affects firms' innovation capacity and outputs, Lin et al. (2014) find the exact opposite result. Taking this into account, we propose the following hypothesis:

Hypothesis 2: *The impact of local government quality on firm-level innovation is mediated by differences in firms' strategies in dealing with government institutions.*

2.4 The moderating role of state ownership

In emerging countries, state-owned firms often account for a large market share. Compared to private firms, state-owned firms have a more natural connection with government and this may affect the impact of local institutional quality on firm-level innovation. Frequently, stated-owned enterprises in emerging markets have an easier access to scare resources, financial support, R&D subsidies, and preferential policies (Choi et al., 2011; Chen et al., 2014; Zhou et al., 2017; Scuotto et al., 2019). Using transaction cost and agency theories embedded in the context of China, Chen et al. (2014) reveal that firm-ownership structure provides an important mechanism through which firms can assemble and direct the resources necessary for innovation. Although some studies argue that problems arise from the nature of a government's choices with regard to social and political policy goals beyond profit maximization (Dewenter and Malatesta, 2001), the results of Zhou et al. (2017) support a positive impact of state ownership on R&D input. We consider that state ownership, while facilitating access to factors of production, may weaken the incentives to innovate, making a minority state ownership optimal for innovation development. Given this, we propose the following hypothesis:

Hypothesis 3: *State ownership weakens the incentives to innovate.*

3. Data, variables, and model

3.1. The dataset

In order to test the hypotheses raised in the last section, we construct a novel data set. The data for the analysis stems mainly from a large-scale survey conducted by the Enterprise Survey Unit (ESU) of the World Bank (World Bank, 2012). The objective of the survey was to highlight the constraints to the growth of private sector firms, tracking changes in the business environment and evaluating the potential influence of different economic reforms on firm performance. The survey collected a wide range of individual firm information from a total of 2,596 Chinese privately-owned enterprises and 104 state-owned enterprises located in 25 of the largest cities of the country. The subjects covered in the survey ranged from access to finance, corruption, and infrastructure development, to crime, competition, labor, or barriers to growth, among other factors. The ESU used stratified random sampling to select the same amount of firms, meaning that the firms included in the final sample are evenly distributed across industrial sectors.[1] The information gathered concerned the performance of firms for the fiscal year 2011. We complement the ESU survey with a raft of socioeconomic and government and governance quality indicators for the cities where the firms operate (Table A1 in Appendix introduces these cities).

The dataset has significant advantages relative to other firm-level surveys in China. First, firms of all sizes are covered. The smallest firm has just 5 workers, while the largest 28,000 in total. This is far wider than surveys limited to listed firms. Second, the ESU comprises a wide range of indicators about how Chinese firms perceive local government and the local ecosystem in which they operate. These include questions about the perception of individual firms about the rule of law, government regulations, the efficiency of government officials, and levels of corruption, which are key for the purpose of this research. Third, the use of stratified random sampling to collect the data reduces potential errors in the estimations.

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1 Some sectors are excluded from the sample. These include financial intermediation, real estate and renting activities, and all public utilities.

3.2. Variables

Innovation variables

In the paper, two types of innovation are considered: product and process innovation. The former is concerned with the introduction of new products or services and with the adding of new features to existing products or services. The latter encompasses innovative activities that (i) introduce new technology and equipment for product or process improvements; (ii) establish new quality control procedures in production or operations; (iii) introduce new managerial/administrative processes; (iv) provide technology training for staff; (v) take measures to reduce production cost; or (vi) implement actions to improve production flexibility. Compared to process innovation, product innovation is deemed to be more knowledge-intensive.

Table 1. Innovation in Chinese firms

Product innovation propensity			**Process innovation propensity**		
Answers	Observations	Percentage (%)	Answers	Observations	Percentage (%)
Yes	1260	46.81	Yes	1485	55.00
No	1432	53.19	No	1215	45.00
Observations	2692		Observations	2700	
Product innovation intensity					
Observations	Mean	Std. Dev.	Min	Max	Obs
1185	25.3460	19.8325	0	100	1185
Process innovation intensity					
Observations	Mean	Std. Dev.	Min	Max	Obs
1176	20.6420	17.9369	0	100	1176

Note:

(1) The question for product innovation propensity is: “in the last three years, has this establishment introduced any new products or services or added new features to existing products or services?”;

(2) The question for product innovation propensity is: “In the last three years, has this establishment engaged in the following innovation activities? (i) introduced new technology and equipment for product or process improvements; (ii) introduced new quality control procedures in production or operations;(iii) introduced new managerial/administrative processes; (iv) provided technology training for staff; (v) taken measures to reduce production cost; or (vi) implement actions to improve production flexibility?”;

(3) The question for product innovation intensity is: “in the fiscal year 2011, what percent of this establishment’s total annual sales was accounted for by products or services that were introduced in the last three years?”;

(4) The question for process innovation intensity is: “in the fiscal year 2011, what percent of this establishment’s total annual sales was accounted for by new/improved processes that were introduced in the last three years?”;

(5) All the “don’t know” (-9) and “not applicable” (-7) observations are treated as null values. The missing values and invalid responses are also cleaned.

We are also interested in two dimensions of firm-level innovation. On the one hand, firm innovation propensity refers to whether a firm produced any new products and/or processes in the three years of operation before the survey took place; in brief, to whether a firm innovates or not. On the other, innovation intensity concerns the overall value of innovation for that firm; that is, the share of a firm's revenue that originates from innovation.

The innovation propensity variable is obtained using the survey question asking firms to report whether any new product, service, or process has been introduced in the past three years. Firms that answer "Yes" are then classified as innovative. Those that answer "No" are considered non-innovative. The innovation intensity variable measures what share of sales in a firm stem from the sales of new products, services, or from new processes introduced in the last three years. In the sample, 46.81% of the firms are considered product innovative, while 55% process innovative (Table 1). In these innovative firms an average 25.3% of their revenue in the three years before the survey stemmed from newly-introduced innovation. 20.6% of their revenues were derived from improved/new processes. However, the variation among product and process innovative firms was huge, as indicated by the large standard deviation (Table 1).

Quality of institutions indicators

Our main interest lies in examining four different dimensions related to local institutional quality. We use the ESU to create institutional variables by assessing the response of firms operating in different Chinese cities in matters that concern local government and governance quality. Four types of institutional variables are created: *rule of law, government effectiveness, regulatory quality, and control of corruption*. The rule of law variable is constructed by resorting to the question of whether local courts are *"fair, impartial and uncorrupted*". The answers by firms are provided in a four-point scale (1= strongly disagree, 4=strongly agree). Individual responses are aggregated at the city-level in order to generate an indicator of the quality of the rule of law in a city.

Government effectiveness is built using two separate survey questions. The questions refer to how long it takes for a firm to obtain, first, an operating license and, second, an import license. These licenses are awarded to firms by local governments. The lower the time in both cases, the more effective the local government. The responses to each question are averaged to produce a single indicator of government quality. As in the previous variable, the responses of individual firms are pooled at the city level. The resulting index is multiplied by (-1) to match the interpretation of government effectiveness: the faster a license is awarded, the higher the government effectiveness.

The regulatory quality variable is constructed using other two survey questions. These questions ask respondents to indicate on a five-point scale (1=not an obstacle, to 5=very severe obstacle) to what degree, first, tax rates and, second, business licensing and permits are obstacles to their business operation. Low scores suggest a higher regulatory quality of local government institutions. The composite indicator is then processed using the same method as in the previous two variables. Higher values in the resulting index depict a better regulatory quality.

Finally, control of corruption is put together using three different survey items: i) to what degree corruption represents an obstacle to the current business operation; ii) whether firms have been requested gifts or informal payments in inspections or meetings with tax officials; and iii) the share of total annual sales firms have paid informally or as gifts to public officials to "get things done" in customs, tax, licenses, regulatory, or service issues. The three individual indicators are combined using principal component analysis (PCA). The results of the PCA are presented in Table A2 in Appendix. The first component of the analysis is used as the composite indicator, which is then aggregated at city level, following the same method as in the previous institutional variables.

Firm-level strategies

To reflect the differences in strategies developed by firms to overcome government institutional weakness, we introduce one additional survey item. The item refers to the percentage of total time senior managers spent in dealing with requirement and regulations imposed by governments. The greater the time senior managers spend dealing with such requirement and regulations, the less they can devote to tending normal business. However, more time by individual firms dealing with government officials may, under certain circumstances, help overcome specific obstacles that prevent firms from innovating.

Control variables

Firm-level innovation can be additionally influenced, as indicated in the literature review section, by both firm-level variables and local socioeconomic indicators. We introduce both types of indicators in the analysis as controls.

Firm-level controls include quality certification, as a proxy of the quality of the products and processes produced by a firm; firm size (measured by employment size); ownership structure (measured by the percentage of public ownership); financial constraints (measured by the percentage of payment delays as a share of total sales), and legal personality (whether the firm is a subsidiary of a larger firm).

City-level controls include the overall level of education of the population, population size, patent applications per capita, number of universities, student enrolment in universities, unemployment rate, average wages, wealth (measured using GDP per capita), and whether the city is a special economic zone (SEZ) enjoying favorable conditions since 1984.[2] The patent data is gathered from the State Intellectual Property Office of the People's Republic of China. The SEZ data is drawn from the website of Baidupedia, while all the other city-level data stem from the China City Statistical Yearbook. Additionally, industry dummies are included to control for the industry characteristics.

Tables A3 and A4 in appendix provide a detailed definition of each variable and their descriptive statistics, respectively.

3.3. Model

Based on the theoretical discussion and hypotheses proposed in section 2, the basic models in the analysis adopt the following forms:

For innovation propensity:

$$inno\ prop_i = \beta_0 + \beta_1 instqual_i + \beta_2 firm\ strategy_i + \beta_3 firmcontrols_i + \beta_4 citycontrols_i + \vartheta_i + \epsilon_i \quad (1)$$

For innovation intensity:

$$inno\ int_i = \beta_0 + \beta_1 instqual_i + \beta_2 firm\ strategy_i + \beta_3 firmcontrols_i + \beta_4 citycontrols_i + \vartheta_k + \epsilon_i \quad (2)$$

where i represents an individual firm;

$inno\ prop_i$ and $inno\ int_i$ stand for a firm's innovation propensity and innovation intensity, respectively.
$instqual_i$ depicts one of the four dimensions of local institutional quality considered: rule of law, government effectiveness, control of corruption, and regulatory quality;
$firm\ strategy$ refers to the share of senior management time spent dealing with requirements imposed by government regulations;
$firmcontrols_i$ represents a number of firm-level control variables, including quality certification (*Quality certification*), firm size (*Firm size*), measured by number of

[2] In May 1984, the Chinese government established fourteen SEZs in the more developed coastal areas of the country, with six additional cities adopting that status in subsequent years. In these zones firms enjoy a favorable treatment, including fiscal and non-fiscal incentives and lighter touch bureaucracy. In contrast to most other SEZs in the emerging world (Frick et al., 2019), most of the early Chinese SEZs have grown well above average. The cities with SEZs include Shanghai, Tianjin, Qingdao, Weihai, Yantai, Dalian, Qinghuangdao, Lianyunguang, Fuzhou, Ningbo, Nantong, Guangzhou, Shenzhen, Zhanjiang, Zhuhai, Shantou, Xiamen, Haikou, Sanya, and Beihai.

employees, ownership structure (*Share public*), financial constraints faced by the firm (*Share loan*), and legal personality (*Subsidiary*), proxied by a dummy variable indicating whether the firm is a subsidiary of a larger firm;
$citycontrols_i$ covers a number of city-level controls, including the level of education of the population (*Education*), patents per capita (*Patents*), population size (*Population*), number of universities (*Universities*), student enrolment in universities (*University enrollment*). unemployment rate (*Unemployment*), average wages (*Wages*), Special Economic Zones (*SEZs*), and GDP per capita (*GDPpc*);
ϑ_k controls for the industry sector;
ϵ_i stands for the error term.

To test hypothesis 2, we introduce the interaction between the institutional variables and the amount of time spent by managers dealing with government regulations. This implies transforming models (1) and (2) in the following way:

$$inno\ prop_i = \beta_0 + \beta_1 instqual_i + \beta_2 firm\ strategy_i + \beta_3 instqual_i * firm\ strategy_i + \beta_4 firmcontrols_i + \beta_5 citycontrols_i + \vartheta_i + \epsilon_i \quad (3)$$

and:

$$inno\ int_i = \beta_0 + \beta_1 instqual_i + \beta_2 firm\ strategy_i + \beta_3 instqual_i * firm\ strategy_i + \beta_4 firmcontrols_i + \beta_5 citycontrols_i + \vartheta_k + \epsilon_i \quad (4)$$

To test hypothesis 3, we consider the interaction between the institutional variables and the concentration of state ownership. This leads to the following extended models:

$$inno\ prop_i = \beta_0 + \beta_1 instqual_i + \beta_2 firm\ strategy_i + \beta_3 instqual_i * ownership_i + \beta_4 firmcontrols_i + \beta_5 citycontrols_i + \vartheta_i + \epsilon_i \quad (5)$$

and:

$$inno\ int_i = \beta_0 + \beta_1 instqual_i + \beta_2 firm\ strategy_i + \beta_3 instqual_i * ownership_i + \beta_4 firmcontrols_i + \beta_5 citycontrols_i + \vartheta_k + \epsilon_i \quad (6)$$

As the dependent variable for innovation propensity (models 1, 3 and 5) is a binary variable, the model is estimated using logit regressions. OLS methods are used for models 2, 4 and 6, as the dependent variable for innovation intensity is a continuous one.

Regarding the potential endogeneity in the estimations, we address in by means of an instrumental variable approach. The instrument is the historical record of the geographical origin of *Jinshi* recipients during Ming era (1368-1644).

The *Jinshi* was the title awarded to those individuals passing the highest exam for public office during the Chinese imperial era. The *Jinshi* system was created during the Sui dynasty (581-619) to select the most able civil servants from the pool of talent available in the country. By passing the exam, individuals demonstrated their expertise and value and, as a consequence, acquired enormous personal prestige, social recognition, and status (Fang and Li, 2013). The *Jinshi* was originally intended to choose the very best among a large number of candidates. The exam was highly competitive and, depending on the period, between two or three percent of the exam-takers were awarded a *Jinshi* title. However, in fifteen centuries of operation, the *Jinshi* system progressively became marred by corruption and bribery. By the period of the Ming (1368-1644) and Qing (1636-1912) dynasties, cheating was rife and the chances of candidates from poorer backgrounds and certain parts of the country had greatly diminished. According to McMullen (2011), the meritocratic principle behind the exam was undermined by the costs of preparation, the regional imbalances – with *Jinshi* holders much more likely to come from the rich southern provinces – and by a "significant element of corruption, impersonation, cheating and bribery" (McMullen, 2011: 10). During the Ming dynasty exam-takers frequently made what some have called 'desperate' attempts to bribe examiners (Zhang, 2017: 142-163; see also Shi, 1998). In the final years of the Ming dynasty, the origin of *Jinshi* holders more often reflected wealth and connections than true talent. Hence, we expect that the geographical origins of *Jinshi* degree holders during the Ming dynasty are a sign of weak institutions.[3]

Zhu and Xie (1998) gathered the CVs for a total of 14,116 *Jinshi* degree holders during the 276 years of the Ming dynasty. We matched the birthplace of each *Jinshi*-degree holder, based on their biography, to their city of origin in order to calculate the number of *Jinshi* holders of each city during Ming era.

In the first stage regressions, the concentration of *Jinshi* degree holders from a particular city is, connected to weaker institutional quality today, matching our expectations. The instrument is not only significant in the first stage regressions, but also passes the f-test 'rule of thumb' criterion for instrument relevance. Given the historical nature of the instrument, we can consider the number of *Jinshi* degree holders to be exogenous from current firm-level innovation in China.

3.4 Basic facts about institutional quality in urban China

The 25 cities included in the survey[4] represent the majority of the largest and most vibrant cities in China. They have all been remarkably dynamic from an economic perspective. Yet, the quality of their institutions varies considerably among them. Figure 1

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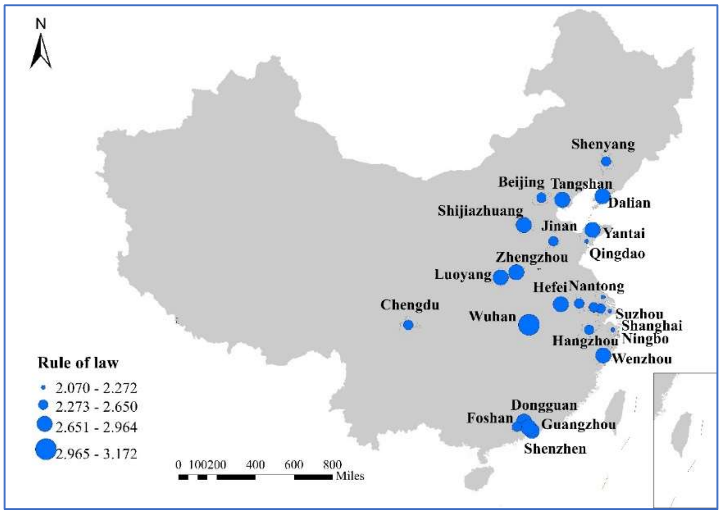
[3] Xia and Lu (2018) have also used the number of *Jinshi* recipients during the Ming and Qing dynasties to flag the current distribution of human capital in China.

[4] Hefei, Beijing, Guangzhou, Shijiazhuang, Zhengzhou, Wuhan, Nanjing, Shenyang, Jinan, Shanghai, Chengdu, Hangzhou (all provincial capitals) as well as Shenzhen, Foshan, Dongguan, Tangshan, Luoyang, Wuxi, Suzhou, Nantong, Dalian, Qingdao, Yantai, Ningbo, and Wenzhou.

maps the spatial distribution of rule of law index in the 25 cities.

Wuhan, the largest city in central China, has the best rule of law score. Zhengzhou, Tangshan, Hefei, Shijiazhuang cities also score highly in this rank. Southern cities, such as Guangzhou, Dongguan, and Shenzhen, do well. By contrast, cities on the eastern seaboard, such as Nanjing, Ningbo, and Shanghai, have the lowest rule of law score.

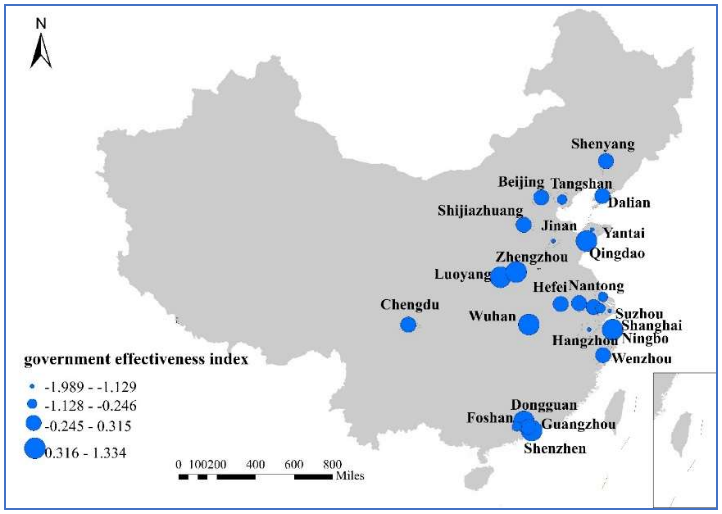
Figure 1. Rule of law



Note: The higher the value of the index, the better the institutional quality in the city, the larger the circle.

The distribution of other institutional quality indicators does, however, not follow the same pattern. Shenzhen and Guangzhou, the two largest cities in southern China, have the highest government effectiveness scores (Figure 2). In contrast, Wuhan, the city with the best rule of law, ranks behind several other cities including Shenzhen, Guangzhou, Ningbo, Qingdao, Luoyang, and Zhengzhou in this respect. City governments in Shanghai, Hangzhou, and Yantai are among the worst performers in the ranking.

Figure 2. Government effectiveness.



The best scores in control of corruption and regulatory quality are found in the south-eastern coastal cities. The top three cities with the best control of corruption, according to local entrepreneurs, are Nanjing, Guangzhou, and Dalian, followed by Wenzhou, Hefei, and Nantong (Figure 3). With the exception of Hefei, all the cities mentioned are on the eastern coastal stripe. The coastal cities of Hangzhou, Wenzhou, Yantai, Wuxi, and Qingdao have higher regulatory quality, as do the northern cities of Shijiazhuang, Hefei, Shenyang, and Beijing (Figure 4). The worst scores in regulatory quality are found in Wuhan, Zhengzhou, and Luoyang. Geographically close cities do not always share similar levels of government quality, which varies significantly from one city to another.

Figure 3. Control of corruption

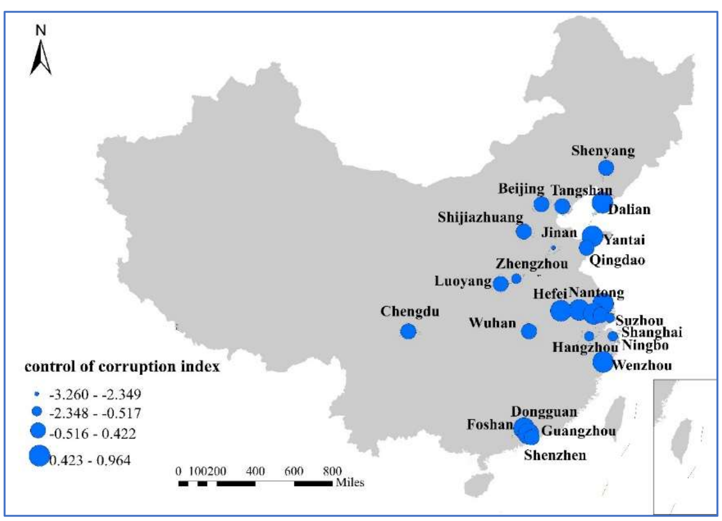
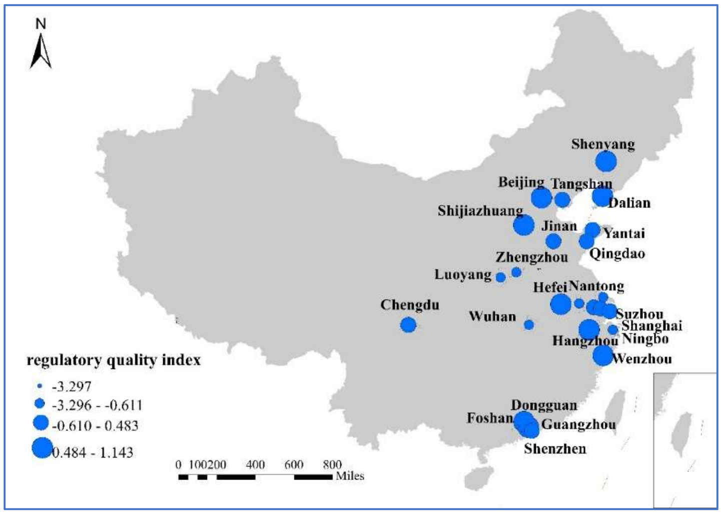


Figure 4. Regulatory quality



On the whole, there are considerable differences in institutions across Chinese cities. No single city outperforms the rest in all aspects of institutional quality. Moreover, the correlations between different aspects of government quality and the innovative performance of Chinese firms are positive, but, in all cases, not significant, with considerable variation among cities and numerous outliers.

4. Econometric results

4.1. Innovation propensity

The results of estimating model (1) using a logit method are presented in Table 2. Columns (1)-(4) in the Table report results using product innovation propensity as the dependent variable, while columns (5)-(8), those using process innovation propensity.

Table 2 suggests that the propensity to innovate in Chinese firms is, to a large extent, driven by both internal and external factors. In general, larger firms with a greater capacity to get certifications are far more likely to innovate. The coefficients for these variables are positive and highly significant. However, the impact of internal factors on firm-level innovation varies by innovation type. Firms with a higher share of state ownership are less prone to generate product innovations. They are, by contrast, more likely to produce process innovations. Subsidiary firms innovate more, but merely in the product innovation sphere. Firms more dependent on internal capital have a higher tendency to deliver product innovation, but are less likely to succeed in process innovation (Table 2).

The socioeconomic conditions of the city where a Chinese firm operates also shape its propensity to innovate. Once other factors are controlled for, Chinese firms are more innovative if they are located in wealthier cities and in cities with a larger critical mass of skilled workers (Zhang, 2015; Howell, 2019). The presence of local universities and university students has also a positive effect on firm-level innovation, while higher wages deter innovation. Differences in regional conditions also affect product and process innovation differently. For example, overall patenting is positively associated with product innovation, but negatively connected to process innovation. This is probably because process innovation more often than not is internal to the firm, while product innovation depends to a great extent on collaboration with the outside world and benefits more from regional knowledge spillovers. Moreover, a larger market only elicits product innovation, while the presences of SEZs propels process innovation, but not product innovation. High unemployment has mixed effects on both types of innovation (Horta et al., 2016).

The results also indicate that an emerging country such as China is no exception to the dominating rule. As underlined by Sternberg and Arndt (2001), Beugelsdijk (2007), and Wang and Lin (2012), although in China both internal and external factors are important for firm-level innovation, conditions internal to the firm remain on the whole more important for innovation than the ecosystem in which it operates. The econometric significance for the coefficients for firm controls is, on average, far greater than for city-level controls (Table 2).

There is, however, one important exception. And it relates to institutional quality. Here, rule of law, control of corruption, and regulatory quality display highly significant and positive coefficients (Table 2). Institutional quality thus seems to be the missing ingredient determining the propensity to introduce new products, services, and processes by Chinese firms. A better rule of law, lower corruption, and a higher regulatory quality all facilitate innovation at firm-level (Table 2). There is no discernible difference in this respect between product and process innovation, although the coefficients for the latter are stronger.

As indicated, the propensity to innovate may be affected by the strategies when dealing with local governments adopted by firms. Does spending more time dealing with regulatory issues affect the propensity of a firm to innovate in China? The results of the analysis point in that direction. Firms whose managers spend more time trying to navigate the often complex government regulations and dealing with government innovate more (Tables 2 and 3). However, a better institutional quality reduces the amount of time needed dealing with bureaucracy and regulations in order to innovate. When interacting – as per model (3) – the different dimensions of institutional quality with the amount of time spent by firm managers steering government regulations, the interaction coefficients are in all cases (with the exception of government effectiveness) negative and significant (Table 3). Managers interacting more with governments in cities with better institutions spend less time in bureaucracy and, perhaps, wooing government officials than those in areas with a worse institutional quality (Table 3). And the moderating effect of government institutional quality on firm strategy does not differ between product innovation and process innovation.

Given the expected closer connection between state-owned firms and government, are state-owned firms more capable of overcoming institutional obstacles in innovating activities? The results in Table 4 answer this question. As envisaged, firms with a higher share of state ownership are less affected by weak government institutions. This implies that innovation in the private sector is more vulnerable to poor government institutional quality (Table 4). By contrast, the advantages of publicly-owned firms in this respect are greater for product than for process innovation, where the benefits vis-à-vis firms in the private sector are negligible (Table 4).

Table 2. Innovation propensity, logit IV regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	**Product innovation propensity**				**Process innovation propensity**			
Institutional quality								
Rule of Law	1.781*				3.477***			
	(0.972)				(0.656)			
Government Effectiveness		-0.024				0.079		
		(0.164)				(0.244)		
Control of Corruption			0.242*				0.559***	
			(0.129)				(0.132)	
Regulatory Quality				0.201*				0.440***
				(0.106)				(0.128)
Firm controls								
Firm size	0.106***	0.139***	0.117***	0.122***	0.207***	0.352***	0.266***	0.295***
	(0.024)	(0.026)	(0.023)	(0.023)	(0.048)	(0.046)	(0.036)	(0.036)
Quality certification	0.118*	0.169**	0.056	0.057	0.473***	0.705***	0.367***	0.429***
	(0.063)	(0.072)	(0.076)	(0.075)	(0.124)	(0.118)	(0.130)	(0.125)
Share public	-0.009***	-0.009***	-0.012***	-0.013***	0.010***	0.003	0.002	0.001
	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)	(0.005)	(0.003)	(0.004)
Share loan	-0.004***	-0.002*	-0.003***	-0.003***	-0.002	0.004*	-0.001	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Subsidiary	0.384***	0.411***	0.382***	0.326***	-0.054	-0.238	-0.067	-0.199
	(0.083)	(0.111)	(0.083)	(0.084)	(0.124)	(0.199)	(0.132)	(0.137)
Time	0.036***	0.038***	0.043***	0.042***	0.007	0.025**	0.026***	0.028***
	(0.011)	(0.010)	(0.009)	(0.009)	(0.011)	(0.012)	(0.009)	(0.010)
City controls								
Education	-0.159	0.307*	0.046	0.216**	-0.067	1.217***	0.355**	0.794***
	(0.184)	(0.172)	(0.095)	(0.092)	(0.217)	(0.252)	(0.150)	(0.128)
Patents	0.010	0.086***	0.053***	0.038**	-0.127***	-0.075	-0.034	-0.074***
	(0.027)	(0.026)	(0.018)	(0.018)	(0.024)	(0.046)	(0.027)	(0.027)
Population	-0.333*	0.108	-0.524***	-0.343*	0.365	0.669	-0.029	0.403
	(0.186)	(0.279)	(0.180)	(0.177)	(0.238)	(0.549)	(0.272)	(0.267)
Universities	-0.002	0.011***	0.014**	-0.001	-0.011**	0.013*	0.024***	-0.010
	(0.005)	(0.004)	(0.006)	(0.004)	(0.005)	(0.007)	(0.007)	(0.006)
University enrollment	0.121***	-0.015	0.013	0.086***	0.031	-0.295***	-0.192***	-0.037
	(0.040)	(0.035)	(0.033)	(0.028)	(0.051)	(0.068)	(0.040)	(0.048)
Unemployment	-0.097	0.098***	-0.053	-0.022	-0.219***	0.147**	-0.158***	-0.082*
	(0.063)	(0.032)	(0.042)	(0.031)	(0.052)	(0.062)	(0.052)	(0.047)
Wages	0.075	-0.474***	-0.413***	-0.326***	0.306	-0.759***	-0.782***	-0.618***
	(0.208)	(0.072)	(0.088)	(0.057)	(0.203)	(0.134)	(0.091)	(0.082)
SEZs	0.108	-0.148	-0.058	-0.029	0.026	0.113***	0.147***	0.113***
	(0.100)	(0.120)	(0.068)	(0.066)	(0.033)	(0.034)	(0.025)	(0.026)
GDPpc	-0.003	0.024	0.049**	0.029*	0.326***	-0.054	-0.036	0.029
	(0.023)	(0.018)	(0.022)	(0.017)	(0.100)	(0.210)	(0.092)	(0.096)
Constant	-3.742**	-2.316	0.672	-1.267*	-9.544***	-9.875***	-0.701	-5.646***
	(1.714)	(1.518)	(1.107)	(0.767)	(1.070)	(2.221)	(1.606)	(1.124)
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First stage results								
Jinshi	-0.000***	-0.002***	-0.002***	-0.002***	-0.000***	-0.002***	-0.002***	-0.002***
Wald test of exogeneity	[0.213]	[0.552]	[0.002]	[0.000]	[0.001]	[0.493]	[0.000]	[0.000]
Observations	2458	2091	2458	2458	2205	1878	2205	2205

Instrument: Number of *Jinshi*-degree holders during the Ming dynasty.

Standard errors in parentheses. p value in square brackets. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 3. Logit IV regressions, interacting time with institutional quality

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	**Product innovation propensity**				**Process innovation propensity**			
Institutional quality								
Rule of law	2.349**				4.020***			
	(1.181)				(0.623)			
*Rule of law*time*	-0.154*				-0.242***			
	(0.080)				(0.051)			
Government effectiveness		-0.019				0.078		
		(0.177)				(0.261)		
*Government effectiveness*time*		-0.003				-0.009		
		(0.017)				(0.024)		
Control of corruption			0.311**				0.687***	
			(0.152)				(0.145)	
*Control of corruption*time*			-0.048**				-0.095***	
			(0.019)				(0.018)	
Regulatory quality				0.243**				0.506***
				(0.119)				(0.140)
*Regulatory quality*time*				-0.044***				-0.066***
				(0.015)				(0.017)
Firm controls								
Firm size	0.096***	0.138***	0.109***	0.114***	0.172***	0.353***	0.241***	0.282***
	(0.026)	(0.026)	(0.022)	(0.023)	(0.053)	(0.046)	(0.037)	(0.036)
Quality certification	0.133**	0.169**	0.069	0.058	0.443***	0.709***	0.385***	0.430***
	(0.061)	(0.071)	(0.074)	(0.075)	(0.127)	(0.115)	(0.127)	(0.124)
Share public	-0.008*	-0.009***	-0.012***	-0.013***	0.010***	0.003	0.001	0.001
	(0.004)	(0.003)	(0.002)	(0.002)	(0.003)	(0.005)	(0.003)	(0.004)
Share loan	-0.004***	-0.002*	-0.003***	-0.003***	-0.003*	0.004*	-0.001	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Subsidiary	0.383***	0.411***	0.376***	0.338***	-0.026	-0.256	-0.057	-0.175
	(0.083)	(0.108)	(0.083)	(0.083)	(0.116)	(0.196)	(0.130)	(0.136)
Time	0.438**	0.040***	0.051***	0.064***	0.637***	0.025**	0.043***	0.059***
	(0.204)	(0.011)	(0.009)	(0.011)	(0.129)	(0.012)	(0.009)	(0.011)
City controls								
Education	-0.240	0.304*	0.029	0.233**	-0.198	1.222***	0.301**	0.821***
	(0.214)	(0.175)	(0.097)	(0.095)	(0.218)	(0.254)	(0.153)	(0.128)
Patents	0.003	0.085***	0.056***	0.034*	-0.123***	-0.073	-0.026	-0.080***
	(0.030)	(0.026)	(0.018)	(0.018)	(0.022)	(0.046)	(0.027)	(0.027)
Population	-0.343*	0.104	-0.529***	-0.339*	0.266	0.646	-0.075	0.404
	(0.184)	(0.279)	(0.179)	(0.178)	(0.225)	(0.547)	(0.269)	(0.266)
Universities	-0.004	0.011***	0.015***	-0.002	-0.013***	0.013*	0.027***	-0.011*
	(0.006)	(0.004)	(0.006)	(0.005)	(0.005)	(0.007)	(0.007)	(0.006)
University enrollment	0.143***	-0.015	0.012	0.091***	0.067	-0.294***	-0.191***	-0.029
	(0.046)	(0.035)	(0.034)	(0.029)	(0.051)	(0.067)	(0.039)	(0.049)
Unemployment	-0.105*	0.097***	-0.045	-0.019	-0.206***	0.153**	-0.139***	-0.077*
	(0.063)	(0.032)	(0.040)	(0.031)	(0.044)	(0.064)	(0.049)	(0.046)
Wages	0.165	-0.472***	-0.423***	-0.303***	0.409**	-0.765***	-0.790***	-0.589***
	(0.244)	(0.071)	(0.090)	(0.055)	(0.198)	(0.133)	(0.088)	(0.081)
SEZs	0.157	-0.149	-0.026	-0.007	0.017	0.113***	0.151***	0.100***
	(0.116)	(0.113)	(0.066)	(0.066)	(0.032)	(0.034)	(0.025)	(0.027)
GDPpc	-0.008	0.024	0.053**	0.020	0.379***	-0.044	0.027	0.060
	(0.024)	(0.018)	(0.022)	(0.017)	(0.093)	(0.201)	(0.090)	(0.097)
Constant	-4.733**	-2.291	0.834	-1.461*	-10.016**	-9.911***	-0.224	-5.926***
	(2.020)	(1.537)	(1.142)	(0.786)	(0.960)	(2.227)	(1.629)	(1.118)
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First stage results								
Jinshi	-0.000***	-0.002***	-0.001***	-0.002***	-0.000***	0.002***	-0.001***	-0.002***
Wald test of exogeneity	[0.172]	[0.560]	[0.002]	[0.000]	[0.001]	[0.471]	[0.000]	[0.000]
Observations	2458	2091	2458	2458	2205	1878	2205	2205

Instrument: Number of *Jinshi*-degree holders during the Ming dynasty.

Standard errors in parentheses, p value in square brackets. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4. Logit IV regressions, interacting state ownership with institutional quality.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	**Product innovation propensity**				**Process innovation propensity**			
Institutional quality								
Rule of law	1.685*				3.313***			
	(0.904)				(0.678)			
*Rule of law*share public*	-0.009				-0.028*			
	(0.012)				(0.015)			
Government effectiveness		-0.033				0.083		
		(0.161)				(0.239)		
*Government effectiveness*share public*		-0.011***				0.005		
		(0.003)				(0.005)		
Control of corruption			0.275**				0.557***	
			(0.130)				(0.135)	
*Control of corruption*share public*			-0.026***				0.011	
			(0.006)				(0.009)	
Regulatory quality				0.206*				0.443***
				(0.107)				(0.129)
*Regulatory quality*share public*				-0.006*				-0.009
				(0.003)				(0.007)
Firm controls								
Firm size	0.108***	0.142***	0.118***	0.120***	0.222***	0.356***	0.268***	0.294***
	(0.023)	(0.026)	(0.023)	(0.023)	(0.046)	(0.047)	(0.036)	(0.036)
Quality certification	0.116*	0.176**	0.053	0.059	0.491***	0.699***	0.363***	0.432***
	(0.063)	(0.072)	(0.076)	(0.075)	(0.121)	(0.117)	(0.130)	(0.125)
Share public	0.014	-0.006**	-0.008***	-0.010***	0.080**	0.003	0.002	0.005
	(0.031)	(0.003)	(0.003)	(0.002)	(0.039)	(0.006)	(0.004)	(0.005)
Share loan	-0.003***	-0.002**	-0.003***	-0.003***	-0.002	0.004**	-0.001	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Subsidiary	0.388***	0.390***	0.384***	0.318***	-0.055	-0.225	-0.052	-0.211
	(0.084)	(0.110)	(0.083)	(0.084)	(0.128)	(0.197)	(0.132)	(0.137)
Time	0.037***	0.034***	0.041***	0.042***	0.009	0.026**	0.026***	0.028***
	(0.011)	(0.010)	(0.009)	(0.009)	(0.011)	(0.012)	(0.009)	(0.010)
City controls								
Education	-0.143	0.372**	0.069	0.215**	-0.022	1.186***	0.356**	0.793***
	(0.173)	(0.162)	(0.094)	(0.092)	(0.217)	(0.246)	(0.149)	(0.128)
Patents	0.014	0.081***	0.049***	0.037**	-0.123***	-0.074	-0.035	-0.075***
	(0.025)	(0.026)	(0.018)	(0.018)	(0.025)	(0.046)	(0.027)	(0.027)
Population	-0.344*	0.058	-0.563***	-0.354**	0.368	0.675	-0.026	0.392
	(0.183)	(0.279)	(0.180)	(0.177)	(0.245)	(0.548)	(0.273)	(0.268)
Universities	-0.002	0.011***	0.015***	-0.001	-0.010*	0.013**	0.024***	-0.009
	(0.005)	(0.004)	(0.006)	(0.004)	(0.005)	(0.007)	(0.007)	(0.006)
University enrollment	0.116***	-0.023	0.001	0.084***	0.017	-0.292***	-0.188***	-0.039
	(0.038)	(0.036)	(0.034)	(0.028)	(0.051)	(0.068)	(0.041)	(0.048)
Unemployment	-0.089	0.102***	-0.055	-0.021	-0.204***	0.146**	-0.160***	-0.080*
	(0.058)	(0.032)	(0.042)	(0.031)	(0.053)	(0.062)	(0.051)	(0.047)
Wages	0.051	-0.498***	-0.435***	-0.323***	0.246	-0.745***	-0.773***	-0.614***
	(0.190)	(0.070)	(0.087)	(0.057)	(0.201)	(0.133)	(0.092)	(0.082)
SEZs	0.093	-0.121	-0.053	-0.030	0.033	0.114***	0.146***	0.113***
	(0.092)	(0.115)	(0.068)	(0.066)	(0.033)	(0.034)	(0.025)	(0.026)
GDPpc	-0.001	0.023	0.052**	0.029*	0.286***	-0.071	-0.039	0.025
	(0.022)	(0.018)	(0.022)	(0.017)	(0.102)	(0.203)	(0.092)	(0.097)
Constant	-3.586**	-2.781*	0.599	-1.246	-9.436***	-9.676***	-0.758	-5.631***
	(1.618)	(1.446)	(1.103)	(0.766)	(1.130)	(2.172)	(1.604)	(1.125)
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First stage results								
Jinshi	-0.000***	-0.002***	-0.002***	-0.002***	-0.000***	-0.002***	-0.002***	-0.002***
Wald test of exogeneity	[0.209]	[0.393]	[0.001]	[0.000]	[0.001]	[0.519]	[0.000]	[0.000]
Observations	2458	2091	2458	2458	2205	1878	2205	2205

Instrument: Number of *Jinshi*-degree holders during the Ming dynasty.

Standard errors in parentheses, p value in square brackets. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.2. Innovation intensity

What about innovation intensity? Are firms in cities with better institutions more likely to extract a greater share of their revenue from new innovations? Do innovative firms in urban China benefit from a better institutional environment?

Table 5 reports the results of the 2SLS (instrumental variables) regressions for the intensity of innovation in the cities considered in the analysis. The number of observations declines relative to Tables 2-4, as only innovative firms are included in the analysis. The results of estimating model (2) highlight that, in the case of product innovation, once Chinese firms have crossed the barrier between not innovating and innovating, most firm-level conditions matter less in terms of the share of revenue that comes from innovations. Once a firm has become innovative, only dependency on external funding affects the intensity of innovation (Table 5). Other individual characteristics, such as firm size, whether a firm is a subsidiary of a larger firm, whether it has achieved quality certification, the type of ownership, or the amount of time spent by managers navigating government regulation and dealing with officials becomes irrelevant (Table 5). In contrast, many of the local conditions identified as relevant for the propensity of firms to innovate stand. The innovation intensity of firms in urban China is related to the presence of local universities and large pools of university students. For product innovation intensity, bigger and more educated cities are, in contrast to expectations, not more conducive to innovation. This is possibly due to a fiercer market competition in this type of cities. Having a special economic status, however, improves the innovation intensity of local firms.

When focusing on process innovation intensity, both internal and external factors matter. Larger subsidiaries of private firms without quality certification are getting a greater share of their revenues from process innovation. Many other local conditions, ranging from the average level of education in the city, the number of universities, patenting, wages, unemployment, local wealth, and the economic status of the city, also affect the process innovation intensity at the level of the firm (Table 5).

The impact of government institutional quality on innovation intensity also differs between innovating activities. For product innovation intensity as the dependent variable, only the coefficient for government effectiveness is positive and significant (Columns (1)-(4) in Table 5). This suggests that, among the institutional variables, only the effectiveness of a local government plays any role in the overall capacity of a firm to increase its share of revenues from new products. For process innovation intensity as the dependent variable, both the coefficients for government effectiveness and control of corruption are positive and significant (Columns (5)-(8) in Table 5). Hence, firm-level process innovation intensity benefits from a highly effective government with a greater capacity to control corruption.

When considering, following model (4), the interaction between local institutional conditions and the amount of time spent by firm managers coping with government regulations, we find that all the interaction variable, as well as single firm strategy variable coefficients are insignificant. This implies that, once a firm crosses the innovation threshold, the efforts aimed at navigating government become unnecessary. This rule applies to both firm-level production and process innovation (Table 6).

Last, Table 7 presents the results by regressing model (6) including the interaction between local institutional conditions and the share of public ownership. All the interaction coefficients and the single ownership variable are insignificant (Table 7). This denotes that, once a firm becomes innovative, its ability to generate revenues from innovating activities has nothing to do with its ownership structure.

Some additional tests to check the robustness of the results have been conducted by adding firm-level R&D intensity in the model. Considering that firm-level R&D input data are only available for innovative firms and that this type of analysis is, furthermore, affected by a severe missing data problem, we only report the results using innovation intensity as dependent variable in Table A5 in the appendix. The results in Table A5 suggest that the impact of government institutions on firm-level innovation intensity remain robust when other factors are controlled for.

On the whole, the results show that once a Chinese firm becomes innovative, its ability to achieve revenues from innovation is less deterred by weak government institutions, especially in the case of product innovating activities. Also, a firm's strategy to navigate local government regulation and its type of ownership are less relevant than at the initial innovation stage.

Table 5. Innovation intensity, 2SLS IV regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	**Product innovation intensity**				**Process innovation intensity**			
Institutional quality								
Rule of law	-57.643				486.026			
	(45.769)				(526.058)			
Government effectiveness		5.083*				16.545***		
		(2.827)				(2.828)		
Control of corruption			-19.408				38.159**	
			(16.706)				(15.246)	
Regulatory quality				-9.238				-5.7e+03
				(6.310)				(340097)
Firm controls								
Firm size	0.066	-0.601	-1.046	-1.023	0.978	0.654	3.086**	-516.374
	(0.702)	(0.518)	(0.871)	(0.681)	(2.194)	(0.519)	(1.203)	(30666)
Quality certification	3.166	-0.032	7.975	4.139	-20.179	-4.465**	-20.014**	2750.032
	(2.839)	(1.501)	(6.839)	(2.996)	(23.173)	(1.789)	(8.491)	(163029)
Share public	-0.011	-0.001	-0.074	0.027	1.101	-0.168***	-0.157***	34.928
	(0.078)	(0.069)	(0.101)	(0.072)	(1.348)	(0.042)	(0.052)	(2079.001)
Share loan	0.114***	0.044**	0.144**	0.100***	-1.063	0.112***	-0.263*	40.269
	(0.043)	(0.022)	(0.069)	(0.030)	(1.225)	(0.027)	(0.136)	(2383.723)
Subsidiary	-3.622	0.849	-6.359	-1.002	9.860	6.939***	9.463**	-248.797
	(2.854)	(1.970)	(5.055)	(1.714)	(12.916)	(2.300)	(4.650)	(14812.550)
Time	0.190	0.126	0.155	0.148	-2.076	-0.196	-0.239	37.448
	(0.166)	(0.127)	(0.170)	(0.134)	(2.293)	(0.199)	(0.314)	(2226.914)
City controls								
Education	8.074	-15.245***	12.644	-6.898***	-115.898	-34.602***	-52.518***	506.062
	(11.367)	(4.215)	(16.188)	(2.194)	(107.234)	(3.627)	(14.545)	(31029.961)
Patents	1.322*	2.304***	2.779	2.027**	-2.141	2.150***	0.958	281.844
	(0.677)	(0.552)	(1.830)	(0.973)	(4.625)	(0.606)	(0.784)	(16607.954)
Population	-25.096***	-1.672	42.586	-4.375	82.752	-7.539	-113.389***	6787.019
	(6.155)	(5.870)	(54.766)	(11.983)	(107.165)	(6.417)	(40.300)	(403250.42)
Universities	0.474***	0.373***	-0.377	0.610***	-1.159	0.597***	1.569***	193.936
	(0.157)	(0.084)	(0.590)	(0.221)	(1.631)	(0.084)	(0.510)	(11479.186)
University enrollment	-2.053	0.471	1.247	-2.250	17.504	1.236	0.922	-1.6e+03
	(1.707)	(0.721)	(1.395)	(1.592)	(17.090)	(0.814)	(1.123)	(96373.546)
Unemployment	5.907**	1.669**	9.414	4.062***	-33.123	0.682	-10.941**	1069.740
	(2.961)	(0.768)	(6.180)	(1.363)	(37.316)	(0.686)	(4.978)	(63349.251)
Wages	-9.330	2.068	26.522	11.130*	102.319	3.556**	-44.224**	4838.858
	(8.709)	(1.594)	(21.636)	(6.736)	(109.975)	(1.540)	(18.142)	(286841.1)
SEZs	2.213	-1.193	18.109	8.472**	45.476	-11.891***	-21.482**	2217.751
	(2.227)	(2.455)	(12.962)	(3.967)	(50.170)	(2.329)	(8.785)	(131515
GDPpc	-4.707	-9.125	-117.355	-48.316	-121.943	14.110**	166.820**	-1.8e+04
	(7.146)	(6.279)	(96.712)	(29.971)	(139.559)	(6.528)	(65.529)	(1053209)
Constant	118.373***	147.991***	-242.003	28.829	-456.624	316.404***	747.079***	-3.1e+04
	(45.838)	(38.014)	(269.492)	(34.870)	(679.538)	(33.690)	(235.271)	(1857693)
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First stage results								
Jinshi-holders	-0.001***	-0.002***	-0.000*	-0.001***	0.000	-0.002***	-0.001**	-0.000
F test of excluded instruments	17.01	91.21	13.46	14.42	0.8	84.74	17.17	0.00
Sargan test	[1.000]	[1.000]	[1.000]	[1.000]	[1.000]	[1.000]	[1.000]	[1.000]
Wu-Hausman F test	[0.041]	[0.082]	[0.109]	[0.139]	[0.000]	[0.000]	[0.000]	[0.922]
Durbin-Wu-Hausman chi-sq test	[0.040]	[0.080]	[0.106]	[0.136]	[0.000]	[0.000]	[0.000]	[0.921]
Observations	1115	997	1115	1115	1112	991	1112	1112

Instrument: Number of *Jinshi*-degree holders during the Ming dynasty.

Standard errors in parentheses, p value in square brackets. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6. Innovation intensity 2SLS IV regressions, interacting time with institutional quality

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	**Product innovation intensity**				**Process innovation intensity**			
Rule of law	-57.777				452.348			
	(46.039)				(447.022)			
*Rule of law*time*	0.069				-3.357			
	(0.923)				(4.891)			
Government effectiveness		5.069*				16.602***		
		(2.843)				(4.551)		
*Government effectiveness*time*		0.040				-0.060		
		(0.318)				(3.468)		
Control of corruption			-19.438				37.861**	
			(16.980)				(15.395)	
*Control of corruption*time*			0.014				0.446	
			(0.916)				(0.680)	
Regulatory quality				-9.231				7787.749
				(6.453)				(648248)
*Regulatory quality*time*				0.013				105.931
				(2.043)				(8780)
Time	0.009	0.120	0.152	0.140	7.059	-0.175	-0.247	-82.044
	(2.435)	(0.134)	(0.265)	(1.250)	(11.824)	(1.186)	(0.318)	(680)
Firm controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First stage results								
Jinshi-holders	-0.000**	-0.003***	-0.000*	-0.001***	-0.000	-0.002***	-0.001**	-0.000
F test of excluded instruments	13.55	94.13	13.48	10.47	0.96	15.1	17.13	0.00
Sargan test	[1.000]	[1.000]	[1.000]	[1.000]	[1.000]	[1.000]	[1.000]	[1.000]
Wu-Hausman F test	[0.041]	[0.042]	[0.109]	[0.262]	[0.000]	[0.000]	[0.000]	[0.922]
Durbin-Wu-Hausman chi-sq test	[0.040]	[0.040]	[0.106]	[0.258]	[0.000]	[0.000]	[0.000]	[0.921]
Observations	1115	997	1115	1115	1112	991	1112	1112

Instrument: Number of *Jinshi*-degree holders during the Ming dynasty.

Standard errors in parentheses, p value in square brackets. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 7. Innovation intensity 2SLS IV regressions, interacting state ownership with institutional quality

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	**Product innovation intensity**				**Process innovation intensity**			
Rule of law	-51.049				0.797			
	(93.923)				(124.290)			
*Rule of law*share public*	2.881				3.927**			
	(38.460)				(1.639)			
Government effectiveness		2.307				17.218		
		(47.472)				(41.546)		
*Government effectiveness*share public*		2.897				0.257		
		(48.468)				(15.714)		
Control of corruption			-29.302				80.583	
			(906.181)				(287.192)	
*Control of corruption*share public*			-2.290				22.016	
			(209.259)				(142.412)	
Regulatory quality				-9.353				-57.549
				(18.799)				(134.851)
*Regulatory quality*share public*				-0.034				6.402
				(5.373)				(5.753)
Share public	-7.547	1.482	-0.977	0.031	-9.826**	-0.364	-6.864	-2.891
	(100.612)	(24.805)	(82.446)	(0.535)	(4.283)	(11.979)	(43.392)	(2.770)
Firm controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First stage results								
Jinshi-holders	-0.000**	-0.003***	-0.000**	-0.001***	0.000	-0.006	-0.001	0.003
F test of excluded instruments	0.09	0.00	0.00	0.2	1.01	0.01	0.03	1.96
Sargan test	[1.000]	[1.000]	[1.000]	[1.000]	[1.000]	[1.000]	[1.000]	[1.000]
Wu-Hausman F test	[0.912]	[0.899]	[0.957]	[0.791]	[0.864]	[0.814]	[0.746]	[0.657]
Durbin-Wu-Hausman chi-sq test	[0.911]	[0.898]	[0.957]	[0.790]	[0.862]	[0.812]	[0.744]	[0.654]
Observations	1115	997	1115	1115	1112	991	1112	1112

Instrument: Number of *Jinshi*-degree holders during the Ming dynasty.

Standard errors in parentheses, p value in square brackets. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5. Conclusion and discussion

5.1. Conclusion

What is the cost of weak institutions for innovation in cities in an emerging country, such as China? This paper has addressed the extent to which local institutional conditions affect the innovative capacity of firms in some of the largest urban agglomerations in China. The results show that firm-level innovation in China is, as expected, more closely connected with the characteristics of the firm than with the urban environment in which a firm operates. Having said that, local conditions matter for innovation and, in particular, the institutional quality of the city where a firm is located. Better rule of law, government and regulatory quality, and lower levels of corruption spur innovation in China. Private firms located in cities with better overall institutions are far more likely to break the barrier that separates innovative from non-innovative firms. They also save in terms of the amount of time required in dealing with government regulations, which can represent an important drag on other firm activities. Hence, local institutional quality is an influential factor for overall firm-level innovation capacity in China.

However, the influence of institutional factors is far more important in the early stages of the innovative process that for the overall importance of innovation in a firm's revenue. Local institutional quality affects the propensity of firms to innovate to a far greater extent than the intensity of their innovation. Once a firm has crossed the innovation threshold, the influence of local conditions on the relevance of innovation for the revenues of the firm wanes. Institutional factors are also more likely to facilitate the propensity and intensity of process innovation, whereas for product innovation this influence is limited to the propensity stage.

The analysis also shows that private firms, or firms have a larger share of private ownership, are more vulnerable to the negative impact of weak government institutions in early stages of innovation. This negative influence wanes once an individual private firm manages to become innovative.

5.2. Theoretical contribution and policy implications

This paper has made a number of important contributions to our understanding of firm-level innovation in an emerging country such as China. First, it has combined in one analysis firm-level and city-level conditions, putting special emphasis on institutional factors as determinants of innovation at the level of the firm. This is a topic that, in spite of its importance, has received until now very limited attention. The few exceptions that focus on the impact of government institutions on firm-level innovation have been mostly concerned with corruption, often reaching contradictory results (De Waldemar, 2012; Nguyen et al., 2016; Alam et al., 2019; Dincer, 2019). In doing so, the paper has brought to the fore the importance of local institutional quality for firm-level innovation in the context of emerging countries.

Second, past research has hardly paid any attention to how local institutional quality mediates firm-level strategies in dealing with institutional frailties in the process of innovation. By exploring whether firms' strategy in dealing with government regulations is conditioned by the quality of local institutional conditions, we bring to the fore an aspect that is of crucial importance for the survival and prosperity of many firms in emerging countries that have to cope with suboptimal institutional environments. The results of the analysis show that good institutions not only stimulate firm-level innovation, but also reduce the time firms spend dealing with government regulations and bureaucracy.

Third, regarding the impact of government institutions on firm-level innovation, few studies have paid attention to the different impacts of variations in institutional quality on product and process innovation or on the innovation propensity and intensity of individual firms. The link between firm ownership and local institutional quality has been similarly overlooked. By analysing all these factors together, we have pushed the boundaries of our knowledge of how local conditions affect innovative activities in China and, possibly, in other emerging countries.

The findings of the study have implications for investors and policy-makers, when assessing how to improve the innovation potential of firms in different urban ecosystems. Overall, this paper clearly demonstrates that government institutional quality matters for innovation. Firms in places with inefficient governments or where corruption is rife face far greater barriers to become innovative. They also have to waste far more precious time dealing with bureaucracy and red-tape, a factor which can further affect their revenues and profitability. Consequently, improving the rule of law, government quality and overall regulation, as well as fighting corruption can bring about vital benefits in terms of pushing many Chinese private firms in urban environments – and possibly others in emerging economies – towards becoming innovative. Poor institutions tie the hands of firms pursuing innovation. Dealing with such a barrier can unleash a significant innovation potential that, otherwise, may remain untapped.

5.3. Limitations and future directions

The current study has a few limitations that will need to be considered in future research on the topic. First, the measurement of government quality is subjective. It is based on perceptions of firm managers gathered in a survey put together by the World Bank, which mainly focuses on broader measures of the business environment. For the same reason, the definition of innovation is, in line with most innovation surveys, perception-based. Innovation is defined by combining four survey items of the 2012 World bank Survey. A more objective measurement of innovation would possibly provide a more accurate picture of the transformation happening within firms.

Secondly, the study fails to take the role of informal institutions into account. In emerging markets, informal institutions such as norms, conventions and social network may act as important substitutes for dysfunctional formal institutions and contribute to shape overall economic performance (Tonoyan et al., 2010; Estrin and Prevezer, 2011). Third, the study only documents the static effect of government quality on firm-level innovation, due to the limitations associated with the survey-based nature of the data. As it may take time for firms to innovate and for innovation to generate returns, an avenue of future research would be to account for time lags. This will provide further insights into the dynamic effects of government institutions on firm-level innovation.

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Appendix

Table A1. Cities in the survey

Number	City	Observations	Number	City	Observations
1	Hefei	112	14	Suzhou	117
2	Beijing	118	15	Nantong	114
3	Guangzhou	115	16	Shenyang	111
4	Shenzhen	116	17	Dalian	114
5	Foshan	115	18	Jinan	112
6	Dongguan	94	19	Qingdao	115
7	Shijiazhuang	112	20	Yantai	111
8	Tangshan	112	21	Shanghai	36
9	Zhengzhou	112	22	Chengdu	115
10	Luoyang	111	23	Hangzhou	79
11	Wuhan	101	24	Ningbo	115
12	Nanjing	113	25	Wenzhou	113
13	Wuxi	117			

Table A2. Test results for the principle component analysis

A. Eigenanalysis of the correlation matrix

Government effectiveness			
Component	Eigenvalue	Difference (%)	Cumulative (%)
Comp1	1.198	59.898	59.898
Corruption			
Component	Eigenvalue	Difference (%)	Cumulative (%)
Comp1	2.128	70.927	70.927
Regulatory quality			
Component	Eigenvalue	Difference (%)	Cumulative (%)
Comp1	1.660	82.998	82.998

B. Principal components' coefficients

Government effectiveness		***Regulatory quality***	
Variable	Comp1	Variable	Comp1
goeffi_import	0.646	regu_tax	0.549
goeffi_operate	0.646	regu_license	0.549
Control of corruption			
Variable	Comp1		
corru	0.385		
corru_inspe	0.396		
corru_sales	0.407		

Note: The scores for all the *Comp1* in the three principle component analysis have been multiplied by -1 to match the interpretation of the government effectiveness, regulatory quality, and control of corruption.

Table A3. Variable definition

Variables	Name	Dimension	Definition
Dependent variable			
Innovation propensity	product innovation propensity	Firm-level	In the last three years, has this establishment engaged in the following innovation activities? (i) introduce new products or services; (ii) add new features to existing products or services? 1=Yes, 0=No
	process innovation propensity	Firm-level	In the last three years, has this establishment engaged in the following innovation activities? (i) Introduce new technology and equipment for product or process improvements; (ii) establish new quality control procedures in production or operations;(iii) introduce new managerial/administrative processes; (iv) provide technology training for staff; (v) take measures to reduce production cost; or (vi) implement actions to improve production flexibility 1=Yes, 0=No
Innovation intensity	product innovation intensity	Firm-level	Percentage of this establishment's total annual sales that was accounted for by products or services that were introduced in the last three years
	process innovation intensity	Firm-level	Percentage of this establishment's production volume that was associated with new/improved processes in year 2011
Institutional variables			
Rule of Law	court	city average	The court system is fair, impartial and uncorrupted. 1=strongly disagree; 2=tend to disagree; 3=tend to agree; 4=strongly agree
Government Effectiveness	goeffi_import	city average	Number of days it takes to obtain an import license from the day of the application to the day it was granted
	goeffi_operate	city average	Number of days it takes to obtain the operating license from the day of the application to the day it was granted
Regulatory Quality	regu_tax	city average	To what degree are tax rates an obstacle to the current operations of this establishment? 0=no obstacle; 1=minor obstacle; 2=moderate obstacle; 3=major obstacle;4=very severe obstacle
	regu_license	city average	To what degree are business licensing and permits an obstacle to the current operations of this establishment? 0=no obstacle; 1=minor obstacle; 2=moderate obstacle; 3=major obstacle;4=very severe obstacle
Control of Corruption	corru	city average	To what degree is corruption an obstacle to the current operations of this firm? 0=no obstacle; 1=minor obstacle; 2=moderate obstacle; 3=major obstacle;4=very severe obstacle
	corru_inspe	city average	In any of the inspections or meetings with tax officials, was a gift or informal payment expected or requested? 1=Yes, 0=No
	corru_ssales	city average	Percentage of total annual sales paid as informal payments or gifts to public officials to “get things done” with regard to customs, taxes, licenses, regulations, services and the like.

Firm strategy variable			
Time spent	time	Firm-level	Percentage of total senior management's time spent on dealing with requirements imposed by government regulations
Firm control variables			
Quality certification	quality_certification	Firm-level	Does this establishment have an internationally-recognized quality certification? 1=Yes, 0=No
Firm size	firmsize	Firm-level	Natural logarithm of permanent, full-time individuals working in this establishment in the end of 2009
Ownership	sharepub	Firm-level	Percentage of ownership held by Government or State
Financial constraint	shareloan	Firm-level	Percentage of this establishment's total annual sales of goods or services paid for after delivery
Legal personality	subsidiary	Firm-level	Is this establishment part of a larger firm? 1=Yes, 0=No
RD intensity	RD intensity	Firm-level	Expenditures on R&D performed within this establishment as a percentage of total annual sales, %
Industry control variables			
Industry	industry		industry
City control variables			
Education	edu	City-level	Average years of schooling of the population above 6 years old
Innovation	patents	City-level	Number of patent applications per 1,000 inhabitants
Population	popu	City-level	City population at year end
Universities	universities	City-level	number of regular institutions of higher education
Universities enrollment	univ_enrollment	City-level	number of student enrollment in regular institutions of higher educations. 100,000 person
Unemployment	unemploy	City-level	unemployment rate, %
Wages	wage	City-level	average wage of employed staff and workers, 10,000 yuan per year
SEZs	special economic zone	City-level	1=cities that receive favorable development policies (*special economic zones*) since 1984, 0=otherwise
GDP per capita	GDPpc	City-level	GDP per capita, Yuan per person

Table A4. Descriptive statistics for the variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Product innovation propensity	2692	0.4681	0.4991	0	1
Process innovation propensity	2700	0.5500	0.4976	0	1
Product innovation intensity	1185	25.3460	19.8325	0	100
Process innovation intensity	1176	20.6420	17.9369	0	100
Rule of Law	2700	2.6357	0.2566	2.0696	3.1717
Government Effectiveness	2249	0.0776	0.9387	-1.9892	1.3342
Control of Corruption	2700	0.0185	0.9990	-3.2596	0.9641
Regulatory Quality	2700	-0.0125	0.9934	-3.2972	1.1426
Time	2595	1.3364	3.8642	0	100
Quality certification	2669	0.6205	0.4854	0	1
Firm size	2620	3.9703	1.3855	0.6931	10.2400
Share pub	2692	3.0431	15.4529	0	95
shareloan	2642	63.6809	29.5585	0	100
RD intensity	602	5.3656	9.4440	0	78.9716
Subsidiary	2700	0.1326	0.3392	0	1
Education	2700	10.0441	0.7642	8.4000	11.7100
Patents	2700	1.9528	2.6395	0.1248	11.5702
Population	2700	0.6911	0.2491	0.1787	1.4007
Universities	2700	33.3052	26.7573	3	89
University enrollment	2700	3.5083	2.7931	0.4455	9.2037
Unemployment	2700	2.2658	1.2691	0.4943	5.5851
Wages	2700	4.7408	0.9526	3.3472	7.7031
SEZs	2700	0.3096	0.4624	0	1
GDPpc	2700	6.1066	2.3899	3.0428	12.2565

Table A5. Innovation intensity 2SLS IV regressions, add RD intensity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	Product innovation intensity				Process innovation intensity			
Rule of Law	-124.367				-279.163			
	(93.801)				(211.764)			
Government Effectiveness		16.046***				22.020***		
		(4.805)				(4.336)		
Control of Corruption			-108.849				125.062	
			(237.669)				(169.933)	
Regulatory Quality				-128.678				51.283
				(328.060)				(32.152)
RD intensity	0.546*	0.170	0.579	-0.098	0.681	-0.037	-0.558	0.136
	(0.298)	(0.113)	(0.921)	(1.039)	(0.539)	(0.120)	(1.025)	(0.247)
Firm controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First stage results								
Jinshi-holders	-0.000*	-0.002***	-0.000	-0.000	-0.000	-0.002***	-0.000	0.001
F test of excluded instruments	3.03	34.7	0.20	0.14	2.08	41.21	0.49	2.59
Sargan test	[1.000]	[1.000]	[1.000]	[1.000]	[1.000]	[1.000]	[1.000]	[1.000]
Wu-Hausman F test	[0.006]	[0.002]	[0.020]	[0.023]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	418	387	418	418	507	474	507	507

Instrument: Number of *Jinshi*-degree holders during the Ming dynasty.

Standard errors in parentheses, p value in square brackets. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$