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ARTICLE



Does bank competition spur firm innovation?

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ABSTRACT

For transition economies, the virtues of financial development for economic growth are obvious; however, bank competition has dubious effects due to various firm characteristics. This study uses Chinese banking and firm data from 1998 to 2011 to examine how bank competition affects firm innovation and how firm size and ownership influence the effects of bank competition. The results show that bank competition promotes firm-level innovation and that this positive effect is stronger for small firms and non-state-owned enterprises (non-SOEs). In addition, bank competition has a more beneficial influence on innovation for transparent firms and domestic firms. These conclusions thus shed light on the real effects of bank competition and the determinants of firm innovation in developing countries.

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Bank competition; state-owned commercial bank; firm innovation; SOE

1. Introduction

Exploring the determinants of firm innovation is vital, as it plays an important role in increasing product competitiveness and promoting economic growth. Some studies analyze the effects of various market characteristics on firm innovation, such as the level of market competition (Aghion, Bloom, Blundell, Griffith, & Howitt, 2005), stock market accessibility (Brown, Martinsson, & Petersen, 2013), the availability of venture capital (Hsu, Tian, & Xu, 2014), housing price (Rong, Wang, & Gong, 2016), and college expansion (Rong & Wu, 2020). Other studies consider firm characteristics, such as corporate governance (Meulbroek, Litchell, Mulherin, Netter, & Poulsen, 1990), institutional ownership (Aghion, Van Reenen, & Zingales, 2013), stock liquidity (Huang, Fang, & Miller, 2014), conglomeration (Seru, 2014), and financing constraints (Caggese, 2019).

China's economy has grown rapidly for 40 years, which challenges mainstream academic views. According to institutional economics theory, China's economic success should not occur, because it has an imperfect legal system, inadequate investor protection, and excessive government intervention. The banking sector plays a dominant role as the main source of financing for firms in China's financial system; however, the banking market is dominated by the Big Four state-owned commercial banks. The market share of the Big Four state-owned commercial banks dropped from 63% to 36% (by total assets)

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between 1995 and 2019, but this decrease in bank concentration has not effectively alleviated the financing constraints of non-SOEs and small firms (Lin, Sun, & Wu, 2015).¹ Even though China's banking system has undergone remarkable reforms in the past 20 years and small and medium-sized commercial banks have developed rapidly, the Chinese government acknowledges that small firms face more obstacles in obtaining bank loans than large firms. Banking institutions cannot meet small firms' capital demands at China's current development stage, although such firms have comparative advantages. Thus, verifying the role of bank competition in firm innovation is important to promote innovation and improve capital allocation efficiency for small firms and non-SOEs.

There are two views on the competition effects caused by the monopoly of state-owned banks that explain the puzzling relationship between bank competition and firm financing accessibility. The first view is the size competition view, which highlights the inappropriateness of the banking monopoly by large banks. This view argues that competition among different size banks causes large firms obtaining a larger share of loans than small firms. The second view is the ownership competition view, which holds that banks, especially state-owned banks, are more willing to provide funds to SOEs than to non-SOEs due to government guarantee and intervention. According to both the size competition and ownership competition views, the monopoly of state-owned banks leads to inefficiency in the financial system. Furthermore, as state-owned banks are both the largest banks and state-owned banks, measuring these banks captures the effects of size competition and ownership competition. Therefore, the size competition and ownership competition effects are noticeably intertwined in the literature, and the debate concerning the relationship between bank competition and firm innovation remains inconclusive.

The purpose of this study is to investigate how bank competition affects firm innovation and how both firm size and ownership shape the influence of bank competition on innovation. Specifically, we use a Chinese panel dataset for 1998–2011 with 1,279,690 firm-year observations to extend the understanding of the relationship between bank competition and firm innovation: (1) how bank competition affects firm innovation, (2) whether small firms are more innovative than large firms when bank competition is more intense, and (3) whether non-SOEs are more innovative than SOEs when bank competition is more intense.

The empirical results show that firms' innovation output increases following bank competition and that the overall positive effect of bank competition is driven by small firms, transparent firms, non-SOEs, and domestic firms. We add to this evidence not only by finding that bank competition is positively associated with firm innovation but also by highlighting new channels behind these results: the effects of bank competition on firm innovation differ depending on firm size, opacity, and ownership. These conclusions have important implications for policy makers, suggesting valuable policy issues that merit further exploration, especially for reforms in developing countries.

This study broadens the emerging research on the relationship between banking development and economic growth (Ijaz, Hassan, Tarazi, & Fraz, 2020; Rakshit & Bardhan, 2019). First, prior studies neglect the effects of firm size and ownership when

¹The Big Four state-owned commercial banks are the Industrial and Commercial Bank of China (ICBC), the Bank of China (BOC), the Construction Bank of China (CBC), and the Agriculture Bank of China (ABC).

considering the effects of bank competition on firms' innovation activities, whereas this study improves the understanding of bank competition by estimating the applicability of the size competition and ownership competition effects. Second, previous studies examine the effects of banking sector competition on innovation in developed economies (Cornaggia, Mao, Tian, & Wolfe, 2015; Hsu et al., 2014), whereas this study investigates the effects of bank competition in China, the biggest emerging market and transition economy. Third, this study provides a microeconomic foundation for the literature on the finance-growth nexus by examining the causal effects of bank competition on firm innovation.

The remainder of this study is organised as follows. Section 2 discusses how the study relates to the literature and proposes testable hypotheses. Section 3 describes the methodology and data. Section 4 presents and discusses the test results. Section 5 concludes this study, states its limitations, and provides suggestions for future study.

2. Literature review and hypothesis

2.1. *The effects of bank competition on innovation*

There are two opposing views regarding the effects of bank competition on firm innovation. The information hypothesis argues that bank competition is negatively associated with firms' access to credit because competition lowers banks' incentives to invest in soft information and relationship lending (Owen & Pereira, 2018). Problems such as adverse selection and moral hazard caused by information asymmetry lead to competition in the banking industry, which worsens financing constraints (Ayalew & Xianzhi, 2019). Banks cannot screen potential borrowers in competitive markets and then lend to low-quality borrowers (Marquez, 2002), while banks with monopoly power are more motivated to screen information due to information asymmetry (Stiglitz & Weiss, 1981). Moreover, market power promotes firms' access to credit by providing financial institutions with an incentive to build long-term relationships with borrowers (Petersen & Rajan, 1995). Bank concentration promotes financial inclusion, thus facilitating access to credit (Owen & Pereira, 2018).

In contrast, the market power hypothesis argues that increased bank competition alleviates business financial constraints because competition decreases banks' market power. Increased competition in the financial market promotes firm financing and innovation through reducing credit rationing (Guzman, 2000), promoting firms' operational efficiency (Benfratello, Schiantarelli, & Sembenelli, 2008), decreasing lending rate (Carbo-Valverde, Rodriguez-Fernandez, & Udell, 2009), and alleviating the negative effect of corruption (Barth, Lin, Lin, & Song, 2009). Moreover, the relaxation of the restrictions on bank branches leads to more bank branches competing with each other, which expands the availability of loans and promotes innovation quantity and quality in manufacturing enterprises (Amore, Schneider, & Žaldokas, 2013; Rice & Strahan, 2010). In a highly competitive financial market, banks with low market power are more willing to reduce credit prices than banks with high market power (Lian, 2018). In addition, bank competition' effects on enterprises' access to external financing may depend on the degree of information asymmetry. Bank competition increases the availability of firm financing when there is no information asymmetry in the market (Gonzalez & Gonzalez, 2014).

Enhancing firms' access to bank credit results in more intensive innovation activities, whereas poor access to external financing is likely to hinder firm innovation. We expect that with increased bank competition, innovation at the firm level will increase because firms can use the improved financing conditions and greater credit supply to support innovation projects and increase innovation output. The first hypothesis is stated as follows:

Hypothesis 1: An increase in bank competition has a positive effect on firm innovation.

2.2. The effects of firm size on innovation

The sensitivity of firm innovation to bank competition may vary depending on firm size because different size firms have different financing modes (Beck, Demircuc-Kunt, & Maksimovic, 2008). Some studies show that the improper monopoly of state-owned banks as the largest banks results in an excessive proportion of credit allocated to large firms. These firms have more financing opportunities and asset diversification, and they are generally less risky than small firms (Borisova, Fotak, Holland, & Megginson, 2015; Dimelis, Giotopoulos, & Louri, 2019). As large firms have better access to the lending market, they are less dependent on financing from banks and less influenced by banks' preferences than small firms (Gonzalez, 2017). Moreover, banks' preferences have more influence on small firms, and these firms face more credit constraints than large firms (Adegboye & Iweriebor, 2018; Ayalew & Xianzhi, 2019; Gonzalez, 2015). It is not easy for small firms to obtain loans from large banks or to maintain relations with large financial institutions, because the ability of these financial institutions to process soft information is less developed (Berger & Udell, 2002).

These studies show that large firms have a larger pool of financial institutions from which to obtain external financing than small firms. Compared with small firms, large firms can invest more resources in innovative activities and benefit from economies of scale. Fortunately, the development of city commercial banks and joint-stock banks alleviates small firms' financing constraints (Chong, Lu, & Ongena, 2013). Therefore, we explore whether bank competition's effect on firm innovation differs based on firm size. In view of these issues, the second hypothesis is as follows:

Hypothesis 2: The effect of bank competition on firm innovation is stronger for small firms.

According to the information hypothesis, banks invest more in soft information as bank competition is lower. Small firms are more informationally opaque than large firms, so the information hypothesis should play a significant role for small firms (Berger & Udell, 1995, 2002). Small banks have advantages in forming relationships with opaque firms that use more soft information (Berger, Frame, & Miller, 2005). In addition, in a homogeneous market with many small banks, bank competition increases the access of opaque firms to credit, whereas in a heterogeneous market controlled by large banks, bank competition reduces access to external financing by opaque firms (Heddergott & Laitenberger, 2017). Due to information advantage, the competition of local banks promotes the innovation activities of opaque firms more than that of distant banking

markets (Tian & Han, 2019). On the other hand, bank competition is positively related to financing cost and opaque firms have higher cost of credit (Rahman, Tvaronaviciene, Smrcka, & Androniceanu, 2019). The third hypothesis is stated as follows:

Hypothesis 3: The effect of bank competition on firm innovation is stronger for opaque firms.

2.3. The effects of firm ownership on innovation

The government has strong influence on enterprises in developing countries, for example, providing implicit government guarantees and loans through state-owned banks. Moreover, bank managers may make lending decisions based on politics, ideologies, or personal objectives rather than bank profits. Banks tend to prefer SOEs when building political connections with governments and politicians by providing favourable credit terms to SOEs, which is helpful for banks to obtain lucrative contracts (Butler, Fauver, & Mortal, 2009). Therefore, the level of bank loan discrimination is stronger in less financially developed regions or where government intervention is strong (Jiang & Li, 2006). Government interventions and state-owned commercial banks result in capital misallocation in China, as lending by these banks is in favour of SOEs, which are less efficient, and biased against non-SOEs (Lin et al., 2015).

Since non-SOEs have less access to financing, these firms are more rely on external financing and thus are more influenced by bank competition than SOEs. Increased bank competition may provide opportunities for non-SOEs to access loans with lower borrowing costs. Therefore, the ownership competition view argues that the privatization of state-owned banks and the reduction of government interventions promote bank competition and improve the allocation efficiency of financial resources, as occurred in the United Kingdom. Considering these issues, the fourth hypothesis is as follows:

Hypothesis 4: The effect of bank competition on firm innovation is stronger for non-SOEs than for SOEs.

3. Methodology and data

3.1. Empirical methodology

By estimating various forms of models (1) to (4), we assess how bank competition affects firm innovation and how firm size and ownership shape the effects of bank competition on innovation:

$$Ln_Innovation_{j,i,t} = \beta_0 + \beta_1 BranchCR4_{i,t-1} + \beta_2 F_{j,i,t-1} + \omega_i + \eta_t + \mu_k + \varepsilon_{j,i,t} \quad (1)$$

$$Ln_Innovation_{j,i,t} = \beta_0 + \beta_1 BranchHHI_{i,t-1} + \beta_2 F_{j,i,t-1} + \omega_i + \eta_t + \mu_k + \varepsilon_{j,i,t} \quad (2)$$

$$Ratio_Innovation_{j,i,t} = \beta_0 + \beta_1 BranchCR4_{i,t-1} + \beta_2 F_{j,i,t-1} + \omega_i + \eta_t + \mu_k + \varepsilon_{j,i,t} \quad (3)$$

$$Ratio_Innovation_{j,i,t} = \beta_0 + \beta_1 BranchHHI_{i,t-1} + \beta_2 F_{j,i,t-1} + \omega_i + \eta_t + \mu_k + \varepsilon_{j,i,t} \quad (4)$$

where j indexes firm, i indexes prefecture-level region in China, and t indexes year. $Ln_Innovation_{j,i,t}$ and $Ratio_Innovation_{j,i,t}$ are dependent variables and denote the

innovation performance of firm j in prefecture-level region i in year t .² This study uses two structural measures, the ratio of the Big Four state-owned commercial banks branches to the total number of bank branches (i.e., *BranchCR4*) and the Herfindahl index of the Big Four state-owned commercial banks branches to the total number of bank branches (i.e., *BranchHHI*), to measure bank competition, with lower values indicating more intense competition. If β_1 is negative and significant, increased bank competition exerts a positive effect on firm innovation. If the parameter is positive and significant, increased bank competition hinders firm innovation.

Firms' access to funds from banks is influenced by the market structure, business conditions, information infrastructure, and institutional environment (Berger & Udell, 2002). Therefore, models (1) to (4) control for firm-level and industry-level characteristics that may influence firm innovation. $F_{j,i,t}$ is a series of control variables that includes firm assets, age, capital-labour ratio, leverage ratio, return on assets, government subsidy, asset tangibility, and industry concentration. ω_i is regional fixed effects and is used to tackle the problem of unobservable variables omitted from regional characteristics. For example, faster economic growth in certain areas may be unobservable and correlated with both bank competition and firm innovation. η_t is year fixed effects that absorb time varying characteristics, such as the overall level of economic growth, country-wide policies, and reforms. μ_k is industry fixed effects that absorb the effects of industrial variation. $\varepsilon_{j,i,t}$ is the error term. Standard errors are clustered at both the prefecture and industry levels in the tests.

3.2. Variable measurement

This study constructs two measures for firm innovation. The first measure is a firm's total value of new product. The distribution of firms' new product in the sample is right-skewed, and we thus use the logarithm of a firm's value of new product to measure firm innovation (*Ln_Innovation*). To avoid losing valid observations when a firm's new product is zero, we add one to the new product values when calculating the logarithm. The second measure is the ratio of a firm's new product value divided by its gross industrial output value (*Ratio_Innovation*). In this study, new product is a brand-new product developed and produced using new technical principles and design concepts or a product that is significantly improved in structure, material, process, or other aspects over the original product, thus significantly improving product performance or expanding its function.

Following previous studies (Carlson & Mitchener, 2009; Economides, Hubbard, & Palia, 1996; Temesvary, 2015), this study uses two structural measures, the concentration ratio (*BranchCR4*), and the Herfindahl index (*BranchHHI*) as proxies for bank competition. The traditional structure-conduct-performance (SCP) model argues that low concentration in the financial market is positively related to the degree of competition and

²China's administrative regions are divided into four levels: provincial administrative regions, prefecture-level administrative regions, county-level administrative regions, and township-level administrative regions. As of June 2018, China has 34 provincial-level administrative divisions, 334 prefecture-level administrative divisions, 2,851 county-level administrative divisions, and 39,888 township-level administrative divisions. Note that the level of bank competition measured by this study is at the prefecture level. In view of the special administrative levels of Beijing, Shanghai, Tianjin, and Chongqing, each municipality directly under the central government is treated as an independent sample in the calculations.

results in lower profitability because financial institutions have to set higher deposit interest rates and lower loan interest rates.

In addition, models (1) to (4) control for a vector of firm characteristics that may affect firm innovation. Table 1 reports the variable definitions, including the dependent and independent variables.

3.3. Data

Our sample contains 1,279,690 firm-year observations for 323,885 Chinese industrial firms during 1998–2011. We collect firm-level data from the Annual Survey of Industrial Enterprise (ASIE) by the National Bureau of Statistics of China, which includes comprehensive financial information on SOEs and non-SOEs across Chinese prefecture-level cities. We obtain information for banking financial institutions from the website of the China Banking and Insurance Regulatory Commission, which provides reliable data for us to calculate the bank competition at the prefecture level. These observations constitute an unbalanced panel.

Table 2 presents the summary statistics of the variables for both prefecture-year and firm-year observations. The correlation coefficients among the independent variables are not higher than 0.51. Therefore, multicollinearity is not an issue in the regressions.

4. Empirical result and discussion

4.1. Baseline specification and result

Table 3 reports the regression results estimating models (1) to (4). Columns 1 to 4 in Table 3 only control for regional fixed effects, industry fixed effects, and year fixed effects except for the level of bank competition. The coefficients are negative and significant at

Table 1. Variable definitions.

Variable	Definition
<i>Ln_Innovation</i>	The logarithm of a firm's new product value (in thousands of Chinese yuan)
<i>Ratio_Innovation</i>	The ratio of a firm's new product value divided by its gross industrial output value (%)
<i>BranchCR4</i>	The ratio of the Big Four state-owned commercial banks branches to all commercial banks branches at the prefecture level
<i>BranchHHI</i>	The Herfindahl index of the Big Four state-owned commercial banks branches to all commercial banks branches at the prefecture level
<i>Size</i>	The logarithm of a firm's total assets (in thousands of Chinese yuan)
<i>Age</i>	The number of years since a firm's founding year
<i>K_L</i>	The logarithm of a firm's capital-to-labour ratio, in which capital is represented by fixed assets and labour is represented by the number of employees (in thousand Chinese yuan per person)
<i>Leverage</i>	Leverage ratio, defined as debt divided by total assets
<i>ROA</i>	The ratio of a firm's profit to its total assets
<i>Subsidy</i>	The logarithm of the amount of subsidies from the government (in thousands of Chinese yuan)
<i>Tangibility</i>	The ratio of a firm's tangible fixed assets to its total assets
<i>Industry-HHI</i>	The Herfindahl index of four-digit SIC industry of firms, measured at the end of the fiscal year based on sales
<i>State-ratio</i>	The percentage of a firm's shares held by state shareholders
<i>State-owned</i>	A dummy variable that takes the value of one if the state is the ultimate controlling shareholder of a firm and zero otherwise
<i>Foreign-ratio</i>	The percentage of a firm's shares held by foreign shareholders
<i>Foreign-owned</i>	A dummy variable that takes the value of one if a foreign shareholder is the ultimate controlling shareholder of a firm and zero otherwise
<i>Opacity</i>	The logarithm of the ratio of a firm's total assets to its fixed assets
<i>Ln_R&D</i>	The logarithm of a firm's research and development expenditures (in thousands of Chinese yuan)
<i>Ratio_R&D</i>	The ratio of a firm's research and development expenditures divided by its total sales (%)

Table 2. Summary statistics.

Variable	Min	Mean	Max	S.D.	Observations
<i>Ln_Innovation</i>	0.000	9870	1.32e+08	302,550	1,279,690
<i>Ratio_Innovation</i>	0.000	3.040	100.000	13.765	1,279,690
<i>BranchCR4</i>	0.000	0.478	0.988	0.172	1,279,690
<i>BranchHHI</i>	0.000	0.077	0.923	0.057	1,279,690
<i>Size</i>	18.000	87,113	2.23e+08	790,678	1,279,690
<i>Age</i>	1.000	9.011	62.000	9.193	1,279,690
<i>K_L</i>	0.226	111	1,290,906	1410	1,279,690
<i>Leverage</i>	0.000	0.556	0.999	0.257	1,279,690
<i>ROA</i>	-0.193	0.112	0.908	0.167	1,279,690
<i>Subsidy</i>	0.000	220	4,811,285	7177	1,279,690
<i>Tangibility</i>	0.000	0.357	1.000	0.221	1,279,690
<i>Industry-HHI</i>	0.001	0.036	0.421	0.076	1,279,690
<i>State-ratio</i>	0.000	0.060	1.000	0.224	1,279,690
<i>State-owned</i>	0.000	0.060	1.000	0.238	1,279,690
<i>Foreign-ratio</i>	0.000	0.202	1.000	0.372	1,279,690
<i>Foreign-owned</i>	0.000	0.191	1.000	0.393	1,279,690
<i>Opacity</i>	1.000	9.558	133,211	202	1,279,690
<i>Ln_R&D</i>	0.000	503	7,142,497	17,746	627,128
<i>Ratio_R&D</i>	0.000	0.208	180.579	1.538	627,128

Variable definitions are provided in Table 1. In Table 2, the summary statistics of variables *Ln_Innovation*, *Size*, *K_L*, *Subsidy*, *Opacity*, and *Ln_R&D* are the original values without the logarithm processing.

the 1% level for both *BranchCR4* and *BranchHHI*, which show that an increase in bank competition (i.e., a decrease in the values of *BranchCR4* and *BranchHHI*) leads to an increase in firm innovation. The results in columns 5 to 8 in Table 3 confirm above findings through controlling a host of firm-level and industry-level variables that potentially affect firm innovation. These results reveal that bank competition is positively related to firm innovation, supporting Hypothesis 1.

A possible interpretation is that banks hold most of the free capital in China's financial market, whereas the equity market is relatively small compared with other emerging markets (Jiang & Zeng, 2014). Meanwhile, although state-owned commercial banks continue to dominate China's financial market, the development of small and medium-sized banking institutions has reduced its bank concentration over the past 30 years. City commercial banks and joint-stock banks can better alleviate small firms' financing constraints than state-owned banks (Chong et al., 2013). Therefore, promoting bank competition that alleviates business financial constraints is a vital prerequisite for firm innovation.

For the other explanatory variables, the results in Table 3 show that the coefficient estimates of firm size and firm age are positive and significant at the 1% level, revealing that large firms and old firms are more likely to have higher levels of innovation than small firms and young firms. Moreover, the coefficient estimates reveal that higher profitability, more government subsidies, and higher tangibility are conducive to firm innovation, whereas a higher capital-labour ratio and greater leverage hinder firm innovation. The coefficient estimates for *Industry-HHI* are positive and significant at the 1% level, suggesting industrial agglomeration has a positive effect on firm innovation.

4.2. The role of firm size and opacity in bank competition affecting firm innovation

This subsection checks whether the relation between bank competition and firm innovation differs based on firm size. This study expects to find that the positive effect of bank

Table 3. The estimation results of bank competition's effects on firm innovation.

Dependent variable	Ln_Innovation		Ratio_Innovation		Ln_Innovation		Ratio_Innovation	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>BranchCR4</i>	-0.573*** (0.109)		-1.796*** (0.392)		-0.585*** (0.104)		-1.884*** (0.395)	
<i>BranchHHI</i>		-1.340*** (0.328)		-4.028*** (1.116)		-1.411*** (0.307)		-4.417*** (1.129)
<i>Size</i>					0.597*** (0.007)	0.597*** (0.007)	1.605*** (0.026)	1.605*** (0.026)
<i>Age</i>					0.104*** (0.005)	0.104*** (0.005)	0.121*** (0.022)	0.122*** (0.022)
<i>K_L</i>					-0.194*** (0.006)	-0.194*** (0.006)	-0.234*** (0.028)	-0.234*** (0.028)
<i>Leverage</i>					-0.078*** (0.014)	-0.078*** (0.014)	-0.572*** (0.072)	-0.572*** (0.072)
<i>ROA</i>					0.376*** (0.023)	0.375*** (0.023)	1.500*** (0.101)	1.496*** (0.101)
<i>Subsidy</i>					0.089*** (0.003)	0.089*** (0.003)	0.303*** (0.012)	0.303*** (0.012)
<i>Tangibility</i>					0.403*** (0.028)	0.402*** (0.028)	-0.350*** (0.131)	-0.351*** (0.131)
<i>Industry-HHI</i>					0.276*** (0.046)	0.274*** (0.046)	0.903*** (0.216)	0.896*** (0.216)
<i>Regional FE</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Industry FE</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Year FE</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Observations</i>	1,279,690	1,279,690	1,279,690	1,279,690	1,279,690	1,279,690	1,279,690	1,279,690
<i>R²</i>	0.097	0.097	0.068	0.068	0.170	0.170	0.093	0.093

Regional FE stands for the regional fixed effects. *Industry FE* stands for the industry fixed effects. *Year FE* stands for the year fixed effects. Robust standard errors are in parentheses. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively.

competition increases as the size of firms decreases. We divide the firms into three subsamples according to firm assets (i.e., small firms, medium firms, and large firms) and estimate models (1) to (4).³ Table 4 reports the estimation results.

As shown in columns 1 to 3 of Table 4, the coefficient estimates for both *BranchCR4* and *BranchHHI* are negative and significant at the 1% level, suggesting a higher level of innovation for small and medium firms in areas where banking is more competitive. For large firms, the coefficients of bank competition are positive and significant in column 5 and 6. Therefore, the rising degree of competition in the banking industry significantly reduces the innovation of large firms. These results reveal that small firms benefit the most from increased bank competition. The results in columns 7 to 12 of Table 4 confirm above conclusions, which also support Hypothesis 2. These relationships are consistent with the view that although private firms have more limited access to external financing than public corporations, increased bank competition promotes small firms' innovation (Cornaggia et al., 2015).

One possible explanation is that large banks are not prefer to support small businesses because they may become sources non-performing loans (Dimelis et al., 2019). Small firms are at a disadvantage in competing for limited credit resources (Mudd, 2013), while the increased competition in the banking industry improves their inferior position and thus promotes their access to external financing.

Due to asymmetric information problems, opaque firms typically face more financial constraints and are expected to be more sensitivity to the change in bank competition than transparent firms. Following previous studies (Fungáčová, Shamshur, & Weill, 2017; Patti, Emilia, & Dell'Ariccia, 2004), we investigate whether the effects of bank

Table 4. Bank competition and firm innovation: the role of firm size.

	Small firms		Medium firms		Large firms	
Group	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable			<i>Ln_Innovation</i>			
<i>BranchCR4</i>	−0.624*** (0.121)		−0.367*** (0.114)		0.708* (0.375)	
<i>BranchHHI</i>		−1.640*** (0.356)		−0.441 (0.320)		3.474*** (1.063)
Control variables	<i>Size, Age, K_L, Leverage, ROA, Subsidy, Tangibility, Industry-HHI, Regional FE, Industry FE, Year FE</i>					
Observations	919,624	919,624	318,144	318,144	41,921	41,921
R ²	0.089	0.089	0.174	0.174	0.334	0.334
	(7)	(8)	(9)	(10)	(11)	(12)
Dependent variable			<i>Ratio_Innovation</i>			
<i>BranchCR4</i>	−1.846*** (0.452)		−1.590*** (0.523)		0.751 (1.606)	
<i>BranchHHI</i>		−4.934*** (1.297)		−2.408* (1.397)		11.50** (4.529)
Control variables	<i>Size, Age, K_L, Leverage, ROA, Subsidy, Tangibility, Industry-HHI, Regional FE, Industry FE, Year FE</i>					
Observations	919,624	919,624	318,144	318,144	41,921	41,921
R ²	0.055	0.055	0.112	0.112	0.244	0.244

To save space, we do not report the coefficient estimates of some of the control variables. Robust standard errors are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

³China promulgated the "Statistical Method for Dividing Large, Medium and Small Enterprises (Provisional)", which stipulated the types of firm size and was abolished until September 2011. According to this method, this study defines firms with assets over 400 million yuan as large firms, firms with assets between 40 million and 400 million yuan as medium firms, and firms with assets less than 40 million yuan as small firms.

competition on firm innovation differ based on firms' opacity. Specifically, we use the ratio of total assets to fixed assets as a proxy for firms' private information and use this index to classify all firms into three subsamples of equal size by year and region: low opacity firms, medium opacity firms, and high opacity firms. Table 5 presents the estimation results.

In columns 1 to 6 of Table 5, the coefficients of the bank competition variables are negative and significant at the 1% level. These results suggest that bank competition is positively associated with innovation for the three types of firms. The coefficients of *BranchCR4* and *BranchHHI* have higher absolute values for low opacity firms than for both medium opacity firms and high opacity firms, which imply that low opacity firms have high elasticity of innovation concerning bank competition than medium opacity firms and high opacity firms. As shown in columns 7 to 12 of Table 5, the coefficients of bank competition confirm that the positive effect of bank competition on innovation is greater for low opacity firms than for both medium opacity firms and high opacity firms. This result is not in line with Hypothesis 3 that bank competition leads to greater innovation by more opaque firms.

These regression results imply that the positive effect of bank competition on firm innovation is stronger for transparent firms, which are less likely to be subject to information asymmetry and adverse selection, than for more opaque firms. Financial institutions tend to provide funds for highly transparent firms which have lower risks.

4.3. The role of firm ownership in bank competition affecting firm innovation

This subsection investigates the possible heterogeneity in the causal effects of bank competition on firm innovation among firms with different types of ownership. SOEs

Table 5. Bank competition and firm innovation: the role of firm opacity.

	Low opacity firms		Medium opacity firms		High opacity firms	
Group	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Ln_Innovation					
BranchCR4	−0.819*** (0.132)		−0.568*** (0.111)		−0.369*** (0.106)	
BranchHHI		−1.965*** (0.390)		−1.388*** (0.328)		−0.890*** (0.299)
Opacity	−0.115*** (0.012)	−0.115*** (0.012)	−0.211*** (0.012)	−0.211*** (0.012)	−0.234*** (0.010)	−0.234*** (0.010)
Control variables	Size, Age, K_L, Leverage, ROA, Subsidy, Industry-HHI, Regional FE, Industry FE, Year FE					
Observations	426,563	426,563	426,563	426,563	426,563	426,563
R ²	0.154 (7)	0.154 (8)	0.191 (9)	0.190 (10)	0.179 (11)	0.179 (12)
Group	Low opacity firms		Medium opacity firms		High opacity firms	
Dependent variable	Ratio_Innovation					
BranchCR4	−3.010*** (0.538)		−1.448*** (0.438)		−1.219*** (0.433)	
BranchHHI		−7.030*** (1.537)		−3.491*** (1.258)		−2.806** (1.169)
Opacity	0.109* (0.058)	0.110* (0.058)	−0.111* (0.057)	−0.110* (0.057)	−0.295*** (0.051)	−0.295*** (0.051)
Control variables	Size, Age, K_L, Leverage, ROA, Subsidy, Industry-HHI, Regional FE, Industry FE, Year FE					
Observations	426,563	426,563	426,563	426,563	426,563	426,563
R ²	0.080	0.080	0.100	0.100	0.113	0.113

To save space, we do not report the coefficient estimates of some of the control variables. Robust standard errors are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

suffer fewer financial constraints, as they have easier access to credit from banks via government guarantees than non-SOEs, and thus the effects of bank competition may be different for SOEs and non-SOEs. To gain a clearer understanding of this inference, we decompose firm innovation into innovation by SOEs and non-SOEs and estimate models (1) to (4). Moreover, this study constructs interaction terms between bank competition and state ownership and uses the interaction terms to capture how firm ownership shapes the effects of bank competition on firm innovation. The results of the estimations are reported in Table 6.

In columns 1 to 4 of Table 6, the coefficient estimates of bank competition are significantly negative except for column 4. In columns 5 to 8, the coefficients of bank competition for non-SOEs are negative and statistically significant at the 1% level. The coefficient estimates for both *BranchCR4* and *BranchHHI* have higher absolute values in columns 5 to 8 than those coefficients in columns 1 to 4, which show that the positive effect of bank competition on innovation is stronger for non-SOEs than for SOEs.

Columns 9 to 12 of Table 6 present the results when we add the interaction terms between bank competition and state ownership. The coefficient estimates of the interaction terms are positive and significant at the 1% level, which suggest a negative effect on firm innovation when interacting state ownership and bank competition. For example, in column 9, the coefficient of *BranchCR4* shows that each extra proportion of bank competition increases firm innovation by 0.497 bps when the state ownership of a firm is equal to the mean of *State-ratio*. The significant and positive coefficient on *BranchCR4* × *State-ratio* implies that each extra proportion of state ownership weakens the effects of bank competition on firm innovation by 0.494 bps.

In columns 13 to 16 of Table 6, the coefficient estimates of the interaction terms imply that when bank competition increases, the firm innovation of non-SOEs becomes higher. For example, in column 13, the positive coefficient of *BranchCR4* × *State-owned* is significant at the 1% level, which suggests that the positive effect of bank competition on firm innovation is 0.463 bps weaker for SOEs compared with non-SOEs. Specifically, each extra proportion of bank competition leads to a 0.526 bps increase in innovation for non-SOEs and a 0.063 bps ($0.526 - 0.463$) increase in innovation for SOEs.

Our estimations unambiguously show that the impacts of bank competition on firm innovation increase with a decrease in state-owned shares and are stronger for non-SOEs than for SOEs. These results support Hypothesis 4. State ownership can provide implicit guarantees for firms' debt, so the likelihood of bankruptcy for SOEs is lower than that for non-SOEs (Borisova et al., 2015). The increase in bank competition provides opportunities for non-SOEs to access loans with lower borrowing costs even though they have fewer political resources (Liu, Li, & Huang, 2017).

Interestingly, the sample statistical results show that the average innovation output level of China's SOEs is higher than non-SOEs. The stronger effects of bank competition on non-SOEs than SOEs may explain why the difference in innovation between non-SOEs and SOEs narrows during the sample period. Similarly, Gao, Ru, Townsend, and Yang (2017) find that the intensification of interbank competition results in the improvement of firms' sales, investment and efficiency, especially for private firms.

Foreign firms face fewer financial constraints, as they can obtain funds from their parent firms, and thus foreign firms may be less affected by bank competition than domestic firms. This subsection examines whether the impact of bank competition on

Table 6. Bank competition and firm innovation: the role of state ownership.

Group	SOEs			Non-SOEs		
	<i>Ln_Innovation</i>	<i>Ratio_Innovation</i>		<i>Ln_Innovation</i>	<i>Ratio_Innovation</i>	
Dependent variable	(1)	(2)	(3)	(4)	(5)	(6)
<i>BranchCR4</i>	-0.601*** (0.103)		-1.319* (0.728)		-0.759*** (0.171)	
<i>BranchHHI</i>		-1.032** (0.459)		-0.270 (1.900)		-1.397*** (0.296)
Control variables			Size, Age, K_L, Leverage, ROA, Subsidy, Tangibility, Industry-HHI, Regional FE, Industry FE, Year FE			
Observations	81,096	81,096	81,096	81,096	1,198,594	1,198,594
R ²	0.288	0.288	0.159	0.159	0.157	0.090
	(9)	(10)	(11)	(12)	(13)	(14)
<i>BranchCR4</i>	-0.497*** (0.093)		-1.676*** (0.365)		-0.526*** (0.095)	
<i>BranchHHI</i>		-1.216*** (0.281)		-3.994*** (1.055)		-1.294*** (0.286)
<i>State-ratio</i>	0.461*** (0.021)	0.460*** (0.021)	1.005*** (0.093)	1.004*** (0.094)		
<i>BranchCR4</i> × <i>State-ratio</i>	0.494*** (0.103)		2.174*** (0.447)			
<i>BranchHHI</i> × <i>State-ratio</i>		1.302*** (0.267)		5.561*** (1.125)		
<i>State-owned</i>						
<i>BranchCR4</i> × <i>State-owned</i>					0.429*** (0.020)	0.428*** (0.020)
<i>BranchHHI</i> × <i>State-owned</i>					0.463*** (0.097)	
Control variables						
Observations	1,279,690	1,279,690	1,279,690	1,279,690	1,279,690	1,279,690
R ²	0.170	0.170	0.093	0.093	0.170	0.093

To save space, we do not report the coefficient estimates of some of the control variables. Robust standard errors are in parentheses. *State-ratio* is a continuous variable. In columns 9, 10, 11, and 12, *BranchCR4*, *BranchHHI*, and *State-ratio* are mean centred for the construction of the interaction terms. *State-owned* is a dummy variable. In columns 13, 14, 15, and 16, *BranchCR4* and *BranchHHI* are mean centred for the construction of the interaction terms. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

firm innovation is different between foreign firms and domestic firms. We divide the firms into two subsamples according to the controlling shareholders of firms (i.e., foreign firms and domestic firms). We expect that domestic firms are more sensitive to changes in bank competition than foreign firms, which is supported by the results in Table 7.

In columns 1 to 8 of Table 7, the coefficient estimates of bank competition are not significant for foreign firms, while coefficient estimates of bank competition are negative and significant for domestic firms. Moreover, the coefficient estimates for bank competition in columns 5 to 8 have higher absolute values than those in columns 1 to 4. However, innovation of domestic firms show sensitivity to bank competition, but for foreign firms, the results reveal no significant sensitivity to bank competition. The results in columns 9, 10, 13, and 14 of Table 7 reveal no effects of bank competition on innovation for foreign firms. The results in columns 15 and 16 suggest that the positive influence of bank competition on firm innovation is lower for foreign firms than for domestic firms. For example, in column 15 of Table 7, the coefficient of *BranchCR4* demonstrates that each extra proportion of bank competition increases firm innovation by 1.733 bps for domestic firms. The significant and positive coefficient on *BranchCR4* × *Foreign-owned* implies that the positive effect of bank competition on innovation is 0.980 bps weaker for foreign firms compared with domestic firms. Specifically, each extra proportion of bank competition contributes to a 0.753 bps (1.733–0.980) increase in innovation for foreign firms.

4.4. Robustness tests

This subsection checks the robustness of the main findings using several approaches. The estimation results are reported in Table 8.

First, we perform a sensitivity analysis with different measures of the independent and dependent variables. Specifically, columns 1 and 2 in Table 8 check whether the results are robust to using the expansion of city commercial banks, *Deregulation*, as an alternative proxy for bank competition. The variable is defined as the ratio of cross-regional branches for city commercial banks to all commercial banks branches at the prefecture level, with higher values indicating more intense bank competition. Note that before 2006, the Chinese government restricted city commercial banks from setting up branches across prefecture-level administrative regions. In 2006 and 2009, that control policy was gradually relaxed. The coefficients of *Deregulation* in columns 1 and 2 have opposite signs compared with the coefficients of bank competition in Table 3, and the positive and significant coefficients of *Deregulation* suggest that the establishment of cross-regional city commercial banks branches is conducive to firm innovation. In addition, columns 3 to 6 use alternative proxies, *Ln_R&D* and *Ratio_R&D*, for the firm innovation variables (see Table 1). The coefficients of *BranchCR4* and *BranchHHI* are negative and significant at the 1% level, which imply that bank competition has a positive influence on firms' R&D expenditures and align with the results in Table 3. These results confirm the robustness of our results and provide additional support for Hypothesis 1.

Second, columns 7 to 10 in Table 8 include the square terms, *BranchCR4*² and *BranchHHI*², for the bank competition measure to consider a possible non-linear relation between bank competition and firm innovation. The results show that the linear terms of bank competition, *BranchCR4* and *BranchHHI*, are significantly negative and the squared terms are significantly positive. Specifically, the thresholds of bank competition are 0.988

Table 7. Bank competition and firm innovation: the role of foreign ownership.

Group	Foreign firms			Domestic firms		
	<i>Ln_Innovation</i>	(2)	<i>Ratio_Innovation</i>	<i>Ln_Innovation</i>	(6)	<i>Ratio_Innovation</i>
Dependent variable	(1)		(3)	(5)		(7)
<i>BranchCR4</i>	0.095 (0.118)		0.872 (0.582)	-0.635*** (0.107)		-2.131*** (0.406)
<i>BranchHHI</i>		0.414 (0.302)			-1.489*** (0.309)	
<i>Control variables</i>						
<i>Observations</i>	202,560			1,077,130		1,077,130
<i>R</i> ²	0.133			0.185		0.103
	(9)	(10)	(11)	(13)	(14)	(16)
<i>BranchCR4</i>	-0.488*** (0.093)		-1.572*** (0.363)	-0.501*** (0.095)		-1.733*** (0.368)
<i>BranchHHI</i>		-1.190*** (0.278)			-1.235*** (0.286)	
<i>Foreign-ratio</i>	-0.482*** (0.015)	-0.483*** (0.015)	-1.757*** (0.073)			
<i>BranchCR4</i> × <i>Foreign-ratio</i>	0.035 (0.072)		0.958*** (0.351)			
<i>BranchHHI</i> × <i>Foreign-ratio</i>		0.184 (0.191)				
<i>Foreign-owned</i>						
				-0.432*** (0.014)	-0.432*** (0.014)	-1.584*** (0.068)
<i>BranchCR4</i> × <i>Foreign-owned</i>				0.073 (0.069)		0.980*** (0.329)
<i>BranchHHI</i> × <i>Foreign-owned</i>					0.285 (0.181)	
<i>Control variables</i>						
<i>Observations</i>	1,279,690	1,279,690	1,279,690	1,279,690	1,279,690	1,279,690
<i>R</i> ²	0.172	0.172	0.094	0.172	0.171	0.094

To save space, we do not report the coefficient estimates of some of the control variables. Robust standard errors are in parentheses. *Foreign-ratio* is a continuous variable. In columns 9, 10, 11, and 12, *BranchCR4*, *BranchHHI*, and *Foreign-ratio* are mean centred for the construction of the interaction terms. *Foreign-owned* is a dummy variable. In columns 13, 14, 15, and 16, *BranchCR4* and *BranchHHI* are mean centred for the construction of the interaction terms. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 8. Results of the robustness tests.

Dependent variable	Ln_Innovation	Ratio_Innovation	Ln_R&D	Ratio_R&D	Ln_Innovation	Ratio_Innovation	Ln_Innovation	Ratio_Innovation	Ln_Innovation	Ratio_Innovation	Ln_Innovation	Ratio_Innovation	Ln_Innovation	Ratio_Innovation	Ln_Innovation	Ratio_Innovation		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Deregulation	86.49*** (6.657)	109.7*** (25.83)																
BranchCR4			-0.173*** (0.028)		-0.069*** (0.013)		-1.365*** (0.252)		-3.846*** (1.099)		-0.773*** (0.089)		-0.785** (0.383)		-0.585*** (0.036)		-1.884*** (0.177)	
BranchCR4 ²							0.691*** (0.195)		1.737** (0.875)									
BranchHHI				-0.636*** (0.077)		-0.309*** (0.035)		-1.694*** (0.513)		-5.333** (2.145)		-2.088*** (0.267)		-2.345** (1.079)		-1.411*** (0.100)		-4.417*** (0.478)
BranchHHI ²								0.982* (0.586)		3.185* (1.716)								
Control variables	Size, Age, K_L, Leverage, ROA, Subsidy, Tangibility, Industry-HHI																	
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No
Firm	No	No	No	No	No	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes
Observations	1,279,690	1,279,690	627,128	627,128	627,128	627,128	1,279,690	1,279,690	1,279,690	1,279,690	1,279,690	1,279,690	1,279,690	1,279,690	1,279,690	1,279,690	1,279,690	1,279,690
R ²	0.170	0.093	0.207	0.207	0.056	0.056	0.170	0.170	0.093	0.093	0.706	0.706	0.621	0.621	0.170	0.170	0.093	0.093

To save space, we do not report the coefficient estimates of some of the control variables. Robust standard errors are in parentheses. Variable definitions are provided in Table 1. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

(column 7), 0.863 (column 8), 1.108 (column 9), and 0.837 (column 10). Before bank concentration reaches a certain level, an increase in bank concentration hinders firm innovation. After bank concentration crosses the inflection point, it promotes firm innovation. According to statistical data, the bank concentration is less than these inflection point values in most regions of China, so the relationship between bank competition and firm innovation mainly occurs on the left side of these inflection points. That is, a rise in bank concentration (i.e., bank competition decreases) leads to a decline in firm innovation. The analysis of the non-linear relationship between bank competition and firm innovation reveals that the coefficients of bank competition remain both significantly and economically relevant.

Third, columns 11 to 18 of Table 8 examine whether the documented effects of bank competition on firm innovation are robust to alternative specifications of the main models. Specifically, columns 11 to 14 check whether the main results are robust to controlling for regional, industry, and year fixed effects and clustering errors at the firm level. Columns 15 to 18 test whether the main results are robust to estimates with firm fixed effects. In columns 11 to 18 of Table 8, the coefficient estimates of *BranchCR4* and *BranchHHI* are significantly negative and consistent with the baseline results, which confirm the robustness of our results.

5. Conclusion

This study examines how changes in bank competition affect firm innovation and highlights the heterogeneous effects of bank competition based on firm size and ownership using a sample of firms in China from 1998 to 2011. The results show that bank competition and firm characteristics result in differences of firm innovation. Specifically, this study provides evidence that bank competition promotes firm innovation. Bank competition has a greater positive effect on innovation for small firms, transparent firms, non-SOEs, and domestic firms, whereas it has less influence on opaque firms, and SOEs. There is no conclusive evidence that bank competition affects the innovation of foreign firms. In addition, we find that bank competition is beneficial for firms to increase R&D investment, and the expansion of city commercial banks is beneficial for firm innovation. Bank competition may expand firms' access to funds and alleviate firms' financial constraints, thus promoting investment in innovation projects.

Innovation is an important driving force for economic growth, so the importance of these conclusions goes beyond the effects on firm innovation. This study makes a case for banking reforms to promote small and medium-sized banks and to enhance bank competition in developing economies, which are effective in reducing credit discrimination and promoting firm innovation. Moreover, due to credit discrimination, non-SOEs and small firms face more difficulties in obtaining external financing than SOEs and large firms. State ownership of firms may result in low efficiency as a result of the implicit debt guarantee and ineffective supervision, implying that privatising SOEs and reducing government intervention would be effective ways to promote capital allocation efficiency. These suggestions are instructive for the reforms of SOEs and the marketisation of transition economies, and may therefore be more important for policy makers.

The analysis could be extended using a variety of methods to examine both the relevance of these interpretations and the general applicability of the results to other developing countries. However, there are some deficiencies in this study. Since we did not obtain every loan information each firm obtained from different banks, we therefore had to measure the external financing of the firm based on its total loan amount. According to institutional economics theory, China's economic success should not have happened because of its imperfect legal system and excessive government intervention. Therefore, we argue that the current institutional environment hides an alternative institutional arrangement which replaces formal institutions in some funds allocation projects. This alternative institutional arrangement may be an informal rule based on corruption acts, such as bribery. Therefore, the effects of corruption on firm financing and innovation are another suggestions for future study.

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