How local is local? Evidence from bank competition and corporate innovation in U.S.

By

Lin Tian

Surrey Business School, University of Surrey, Guildford, Surrey, GU2 7XH, U.K

Email: Lin.Tian@surrey.ac.uk

and

Liang Han

Henley Business School, University of Reading, Reading, RG6 6UD, U.K

Email: liang.han@henley.ac.uk

Abstract

This paper aims to fill in a research gap in the effects of bank competition on corporate innovation. In addition to the evidence on the favorable effects of bank competition on corporate innovation, we show novel evidence on the substitution effects of bank competition in a wider region and neighbor-state to local bank competition in financing corporate innovation activities. In banking market, we show 'how local is local' depends on the operating scope and information transparency of firms. Local banks have an information advantage over distant banks in financing local businesses and informationally opaque corporate innovation activities.

Key words: Bank competition; Corporate innovation; Substitution; Operating scope, Information transparency

JEL code: G10; G20; G21

1. Introduction

Given the substantial changes in banks' networks after liberalization and deregulation, existing literature has identified diversity and various correlation in cross-regional banking competition structures (e.g. Degryse and Ongena, 2005; Richards et al., 2008; Michalski and Ors, 2012) and the role played by local bank competition on corporate innovation (e.g. Cornaggia et al., 2013). What is little known, however, is how such a cross-regional or neighboring banking competition since deregulation in U.S has contributed to corporate innovation. This is important because with the removal of bank entry barriers in U.S. since 1990s, banking market has become more competitive (Rice and Strahan, 2010), enabling businesses to access out-of-state bank finance. Focusing on the relevancy of geographic proximity in banking finance, this paper aims to fill in such a research gap in current literature by investigating how bank competition in a wider regional area and neighbor states affects corporate innovation in home-state.

This paper is motivated by the fact that banks always possess a certain degree of market power and price accordingly when borrowers are separated from geographically disparate banks (Greenhut and Greenhut, 1975). Based on transportation costs, the spatial pricing discrimination models formalize the idea that the cost of credit for businesses and borrower-lender distance is negatively related (e.g. Degryse and Ongena, 2005). This is because banks would charge higher loan rates on closer borrowers who face higher transportation costs to approach alternative banks which are located farther away from them. In sharp contrast, information theory predicts a positive relation between loan prices and borrower-lender distance. Since distance proximity gives advantages to closer lenders in screening perspective borrowers and monitoring loans (e.g. Agarwal and Hauswald, 2010), closer banks would charge lower rates on loans due to the cost savings in acquiring private information and monitoring. Such an information advantage could be more pronounced in financing informationally opaque corporate innovation activities. Therefore, the main propositions of our analysis are first, corporate innovation in home-state would be less sensitive to neighbor state bank lending and second, asymmetric access to soft information over space could make it less viable for distant banks to substitute local banks in financing corporate innovation activities.

We commence our analysis by examining how banking market competition affects corporative innovations and the sensitivities of innovation activities to bank competition within home-state and in a wider regional area. Consistent with existing literature (Amore et al., 2013; Chava et al., 2013; Cornaggia et al., 2015), we find a favorable effect of bank competition on corporate innovation. Contributing to banking and innovation literature, we show that such a favorable effect is stronger for home-state bank competition and for businesses which operate locally than for regional bank competition and for those businesses which operate in a wider geographic area. The favorable effect and its variation are economically sizable. For example, a 0.1 increase in home-state (regional) bank competition (measured by Panzar-Rosse H) would improve the numbers of patents and citations by 20% (3.5%) and 49% (7.95) respectively. In addition, our results show that the higher regional competition does not directly affect the underline nature and risks of innovation being patented. Our unique evidence is in favor of the theories on geographic proximity that physical distance acts as a source of inefficiency in credit markets and incurs economic costs for both lenders and borrowers (e.g. Degryse and Ongena, 2004).

This paper also contributes to literature in spatial analysis in banking by testing the role played by bank competition in neighbor states in financing corporate innovation. We provide a more nuanced answer to the question that how spatial interdependency in competition may alter the importance of local banks on commercial lending. With interstate deregulation in banking, improved geographic diversification enables banks to finance more freely in other states in U.S (Goetz et al., 2012) and geographic proximity between borrowers and alternative lenders may substantially reduce the borrowing costs for firms due to the increased price competition among banks (Fuentelsaz and Salas, 1992; Petersen and Rajan, 1995; Degryse and Ongena, 2005).

However, such a substitution effect has been neglected by existing literature due to the lack of reliable data. Aiming to fill in this research gap, we follow Osborne (1988) and Bellón (2016) and propose a novel testing group to evaluate the substitution effects exercised by bank competition in neighbor states on corporate innovation. The strategy is based on the overlap between financial and industrial markets (e.g. Asker and Ljungqvist, 2010) on the determination of demand for credits in a local bank market. In specific, we propose that firms operating over larger geographical areas would be more sensitive to the structure of more than one 'local' banking market. This is because their non-local industrial competitors are affected by bank competition in their own home markets and there have been lower barriers for non-local banks to lend in other markets since bank deregulation. We show that the substitution effects of bank competition on corporate innovation do exist but for those firms operating in a wider geographic area only. In contrast, firms operating locally are not sensitive to bank competition in neighbor states, suggesting that local bank market structure is more important for such 'local' firms (Rajan and Zingales, 1998; Nanda and Nicholas, 2014), in a corporate innovation setting.

Due to the inefficiency of distant banking in screening and monitoring distant borrowers, we further investigate the role played by information. Contributing to literature, we show novel evidence that financially constrained firms and those innovation activities with a greater degree of proprietary information would benefit a stronger favorable effect from home-state bank competition, supporting the heterogeneity of bank competition effects (Hannan, 1991; Petersen, 2004; Stein, 2002). In contrast, those with greater information transparency would benefit more from bank competition in neighbor states than those informationally opaque firms, again confirming the disadvantages of distant banks in information collection.

The remainder of the paper proceeds as follows. Section 2 reviews the relevant literature on the effects of bank market competition on credit availability and, thereby, the corporate innovation. We provide background information on bank competition in U.S in Section 3 and describe data and variables in Section 4. Sections 5 and 6 report the results from empirical analysis robustness tests. We further investigate the effects of asymmetric information in Section 7 and conclude in Section 8.

2. Theoretical Backgrounds

The roles played by banking market structure have been widely acknowledged (e.g. Berger et al, 2005; Beck and Demirgüç-Kunt 2006). As a lingering debate, the theoretical predictions have presented both positive and negative relationships between banking competition and credit availability for firms and their innovation activities. According to the market power hypothesis, corporate innovation would benefit from banking market competition because of the improved credit supply (e.g. Boot and Thakor 2000), lowered credit prices (e.g. Black and Strahan 2002) and improved bank operating efficiency (Benfratello et al, 2008). In contrast, information-based hypothesis proposes that banks in a concentrated market would have a stronger motive to acquire private information, e.g. by relationship lending, than those in competitive markets because of the free-riding issues (Diamond 1984; Petersen and Rajan 1995; Dell'Ariccia and Marquez 2004). The credit supply to informationally opaque and financially constrained firms and projects, therefore, could be greater in a concentrated banking market where banks subsidize high risk borrowers at the beginning of the relationship and extract rent in the future from those who are eventually successful (Sharpe 1990; Petersen and Rajan 1995).

Building on the seminal paper by Hotelling (1929), a focus on location and spatial interaction in competition has recently gained more attention. Such a focus is attributed to the growing interest within theoretical economics that move towards an explicit accounting for the interaction of an economic agent with other heterogeneous agents in the system (Anselin, 2001; LeSage, 2014). In a banking market, this is especially important where banks offer horizontally differentiated products or services. Intuitively, competition between banks is inherently spatial as borrowers would have to travel between banks or bank branches to complete different transactions, despite the improvement in online banking technologies. Economic theories have taken physical distance as a source of inefficiency in credit markets, causing economic costs for both banks and borrowers (Degryse and Ongena, 2004).

The first channel through which distance may affect the availability and cost of credit for firms is transportation costs. Formalized in the context of location, the traditional product differentiation models predict a negative relationship between loan prices and the borrower-lender distance, but a positive relationship between the loan rates and the borrower-closest competing bank distance. The rationale lies in the fact that closer borrowers face higher transportation costs to approach competing banks that are located farther away. This allows the lending bank to engage in spatial price discrimination on the basis of the physical distance separating them from the borrowing firms (Dell'Ariccia, 2001; Petersen and Rajan, 2002;

Park and Pennacchi, 2009). They may increase the loan rates by an amount equivalent to the opportunity transportation cost faced by the borrowers. However, for banks, the total costs of monitoring are also expected to be positively associated with the distance between the bank and its borrowers, decreasing the willingness of banks to extend credits to more distant borrowers (Brevoort and Wolken, 2009).

The increasing monitoring costs may open another window for banks to engage in further discriminatory pricing by subsequently passing along such costs to borrowers by setting higher loan rates. The costly-state-verification framework (Sussman and Zeira, 1995) shows that banks have local economies of scale with advantages for monitoring closer clients, thus discouraging distant competitors from entering the local bank market. Empirical evidence shows that even a stronger bank competition reduces loan prices due to the decreased average distances between all possible combinations of firms and neighbor banks (Degryse and Ongena, 2005), an increase in the number of banks aggravates the adverse selection problem by enabling low-quality borrowers to obtain finance (Broecker, 1990), leading to a retrenchment towards relationship lending (Hauswald and Marquez, 2006) and resulting in higher loan rates. Therefore, proximity of the borrower to an alternative (nearest competing) lender is another a significant element in the relationship between distance and business lending.

The second rationale refers to information asymmetries as bank lending is an information intensive process by which banks collect relevant information from both borrowers and local markets. If the severity of the asymmetric information problem intensifies with distance, banks can strategically use their informational advantage to create a threat of adverse selection for their rivals, and thus soften competition. Hence, this mechanism concerns the advantage that proximity may give local lenders in screening perspective borrowers and monitoring loans, particularly in lending small or informationally opaque businesses where banks[1] rely more heavily on ‘soft’ information collected through multiple interactions

[1] Bank customers may undertake additional information costs related to searching information about alternative suppliers. These searching costs may vary directly with the distance between the customer and financial institutions and the degree of heterogeneity in financial services. Providing information to prospective customers can also impose costs on financial institutions in the form of advertising or the costs associated with maintaining relationships with brokers or other agents that interact with potential customers (Brevoort and Wolken, 2009).

with the firms. The relationship lending is accumulated over time and therefore is costly to lenders and not easily transferable (Petersen, 2004; Stein, 2002). The costs of building and sustaining the banking relationship are positively associated with the physical distance between the lender and borrower where farther away loan applicants are more likely to be credit rationed and lending decisions become less efficient with increasing distance (Hauswald and Marquez, 2006; Carling and Lundberg, 2005).

3. Bank Competition in U.S

The U.S. banking industry has changed dramatically over the past decades in response to a nationwide deregulation in banking sector. Coincided with the development in information technology and communications, interstate banking deregulation and the ability of bank holding companies (BHCs) to operate at a nationwide level have led to a significant consolidation wave in banking industry during the late 1990s and an effective expansion of the banking market. In spite of the advance of disintermediation, the U.S. banking sector has grown in real terms (Berger et al., 1995) and become more open to competition. At the same time, small banks have become less important (Jones and Critchfield, 2005). The restructuring has raised numerous concerns about the conduct and performance of commercial banks and underlined the importance of both localized and multi-market competition in banking.

Some advocates of reform claim that the Riegle–Neal Interstate Banking and Branching Efficiency Act (IBBEA) has made the operation of banking institutions more efficiently in U.S by removing barriers to geographic expansion and helped BHCs better diversify their assets and liabilities. One of the most important implications, with regard to availability of credit, is that fewer restrictions across states can improve the scope for geographic diversification, allowing banks to finance more freely across state boarders. The consolidation activity has increased the ‘geographical reach’ of banks substantially (Kwast et al., 1997; Berger et al., 1999; Brevoort and Hannan, 2006). The lowered costs and the ability to transmit information almost globally have effectively freed the financial service industry from the constraints of time and spaces. These changes have sparked a renewed interest in the broader role of bank-borrower distance on lending behavior in a less regulated environment.

For example, Dell'Ariccia and Marquez (2004) theoretically model how the extension of credit in local markets would be affected by changes in either the cost advantages of the less-informed banks or in the degree of information asymmetries among financial institutions. They show that a greater competition from outside lenders will motivate local banks to reallocate credit towards borrowers from whom the local lenders possess an information advantage, suggesting that a greater competition from outside lenders would encourage local lenders to reduce the distance over which they extend credit to businesses. Consistent with this view, Kroszner and Strahan (1999), Petersen and Rajan (2002) and Brevoort and Hannan (2006) additionally propose that the proximity between borrowers and lenders is now less important than in the past. This is because advances in computing and communications technology have increased the availability of quantifiable information about potential borrowers and reduced the importance of 'soft' information, empirically in small business lending. All these research efforts conclude that the structure changes in the competitive environment might lead local lenders to restrict their lending activities to a smaller geographic area. However, this question has not been the subject of extensive empirical study due to the unavailability of data.

4. Data and Variables

4.1. Data collection

We collect data from various sources. Within a patent-metrics, we collect corporate innovation data from National Bureau of Economics Research (NBER) patent database (1976-2004) which contains information on the patents granted by the United States Patent and Trademark Office (USPTO). We exclude patents granted to universities, governments and foreign companies who have weak dependency on local banking markets. We evaluate banking market competition at state level for 51 states in U.S and exclude Hawaii and Alaska which do not have neighbors when investigating the substitution effects of bank competition. We collect bank deposit data from Federal Deposit Insurance Corporation (FDIC) on the values disclosed at the end of each fiscal year by commercial, cooperative and saving banks operated in U.S. In addition, all firm-level information for control variables is available from COMPUSTAT for listed corporations, and state specific control variables are obtained from the Federal Reserve Bank of ST. Louis and National Venture Capital Association (NVCA). We restrict our data between 1992 and 2004 so as to have a full set of information on both patents and bank deposit.

4.2. Measuring corporate innovation

Following existing literature (e.g. Amore et al., 2013), we measure corporate innovation by patent-metrics. It prevents the problems arising from accounting practices, such as R&D expenditure, and it better represents the output or the commercialization of innovation activities than other measures. In specific, we measure innovation outputs by the number of patents filed by company *i* in state *j*[2] in year *t* and the number of citations received by the patents to capture the economic importance of innovation activities[3] (Hall et al., 2001). We also use additional patent-based measures to evaluate the underlying risk and nature of corporate innovation activities. First, we make a distinction between highly cited (top quartile) patents ($HighCited$) and less frequently cited (bottom quartile) patents ($LowCited$) to measure the underlying risk of particular innovation activities (Chava et al., 2013). Second, we measure the generality and originality of a specific patent by the indices of $Generality_{it}$ and $Originality_{it}$. The greater the value of *Generality*, the more likely the patent is being drawn upon by a more diverse array of subsequent patents. Similarly, a patent would have a greater *Originality* if it cites a wider array of technology classes of patents (see Appendix for variable construction).

4.3. Measuring banking market competition

[2] We merge the NBER patent data with the COMPUSTAT firm sample using a bridge file provided by the NBER database in which GVKEY is the common identifier. For cases in which the corporate headquarter is different from the assignee state, we use the headquarter state of the corporation shown in COMPUSTAT.

[3] We follow existing literature to date patents to the year of application to reflect the signaling effects and weight-average the number for three years to mitigate the truncation bias. Please see Appendix and Hall et al. (2001 and 2005) and Cornaggia et al (2015) for more detail.

We use both structural and non-structural measures to evaluate bank competition. In the main tests, we use Panzar-Rosse H-statistic[4] (Panzar and Rosse, 1984) (*H* henceforth) with a long term equilibrium and Herfindahl-Hirschman Index (*HHI* henceforth) in the robustness tests. *H* has been widely used to assess banking market competition (Bikker and Haff, 2002) which is derived from profit-maximizing equilibrium conditions (Claessens and Laeven, 2005) and ranges from 0 (monopolistic markets) to 1 (competitive markets).

Unlike exogenous shocks, bank competition in a local banking market could be jointly determined with corporate innovation decisions by unobserved state characteristics. To overcome the possible endogeneity issue, we use state median Tier 1 risk-based capital ratio as an instrument for bank competition[5]. The Tier 1 ratio is a valid instrument because banks with high capital ratio have better ability to accumulate capital to build a buffer against unexpected losses (e.g. Corbae and D'Erasmo, 2014) and such capital regulation directly constrains banks' entry into a local market. A state with lower median value of Tier 1 ratio would have a more competitive banking market[6] because of both the low exit and low entry requirement. We have no reason to believe that performed capital ratio of banks directly affects corporate innovation activities.

4.4. Additional control variables

Following existing literature (e.g. Aghion et al., 2005), we control for both firm and state characteristics that may affect corporate innovation outputs, such as firm size, age, profitability (ROA), cash holding, growth opportunity (sales and Tobin's Q), asset tangibility, leverage, capital to labor ratio, and industry concentration. At state level, we control for coincident index (Crone and Clayton-Matthews, 2005) and venture capital ratio which proxy for the time-variation in the availability of alternative financing

[4] Derivation of H is available from the authors on request.
[5] Current capital requirement in U.S. is based on Basel III and enforced jointly by the Office of the Comptroller of the Currency (OCC), the Board of Governors of the Federal Reserve System and the FDIC.
[6] The correlation between state average H and state median Tier 1 risk-based capital ratio during 1992 to 2004 is – 0.1718 and is significantly different from zero at the 1% level.

sources for corporate innovation. We winsorize all control variables at $1^{st}/99^{th}$ percentile and variable definitions are provided in Appendix.

4.5. Summary statistics

Table 1 reports the descriptive statistics for the variables used in the following analysis with a total of 32,869 firm-years observations from 49 U.S. contiguous states during 1992 – 2004. On average, each sample firm is granted 11 patents which receive a total of 137 citations annually. The local (home-state) banking market is monopolistically competitive. *H* (*HHI*) ranges from 0.114 (0.012) to 1 (0.551) with an average of 0.594 (0.01) and a standard deviation of 0.239 (0.397).

[Table 1 insert here please]

4.6. Identification strategy and regression specifications

Our key objective is to investigate the variation of bank competition effects of *home-state* and *neighbor states* on corporate innovation. This is important because, first, borrowers may face a trade-off in accessing distant bank market where transaction costs (e.g. transportation) could be high on one hand and on the other, they could reduce costs by borrowing from more competitive but distant markets (substitution effects). Second, home-state banks may have an advantage in private information collection and monitoring because of the geographic proximity to borrowers (information effects).

To examine the effects of neighbor state bank competition on home state corporate innovation, it is essential to control for the determination of demand for home-state bank credits which depends on the preserving credit conditions of the banking market in home-state. Due to the overlap between financial and industrial markets (e.g. Asker and Ljungqvist, 2010), it is anticipated that the access to cheaper finance in a competitive bank market would offer a business a strategic advantage in the product market over its competitors in a concentrated bank market, known as indirect competition in banking sector (Osborne, 1988). Therefore, the geographical span of industrial markets in which firms operate may affect their demand for credit and we expect that firms with wider areas of operation, encompassing several banking markets, would be less dependent on local (home state) banking market competition. Thus, we follow Porter (2003) and identify sample firms in traded industries[7] from our samples that operate in a wider geographical area are likely be affected by unobservable heterogeneity in the locations where they are headquartered but the interest rates they face are less subject to the exercise of market power by banks. While, firms that operate in other industries compete against others within one geographical market may be more affected by the condition of banking markets where they are located.

To investigate the effects of bank competition (local, regional and neighbor) on corporate innovation, we establish the following baseline specifications:

$$ln(Innovation)_{it} = \alpha_1 + \beta_1 \widehat{H_{jt}} + \gamma_{1n} \sum Z_{n,it} + Industry_k + Year_t + \varepsilon_{1it} \quad (1)$$

$$ln(Innovation)_{it} = \alpha_2 + \beta_2 \widehat{Region\_H_{rt}} + \gamma_{2n} \sum Z_{n,it} + Industry_k + Year_t + State_j + \varepsilon_{2it} \quad (2)$$

$$ln(Innovation)_{it} = \alpha_3 + \beta_3 Neigh\_H_{jt} + \gamma_{1n} \sum Z_{n,it} + Industry_k + Year_t + State_j + \varepsilon_{1it} \quad (3)$$

To capture the causal (substitution) effects of localized and neighboring banking markets, in addition, we take into account the vertical relationship (Osborne, 1988) that exists between banking and other industries and estimate the specification as:

$$ln(Innovation)_{it} = \alpha_1 + \beta_1 \widehat{H_{jt}} + \beta_2 \widehat{H_{jt}} \times Traded\_firm_i + \beta_3 Traded\_firm_i + \gamma_{1n} \sum Z_{1n,it} + \gamma_{2n} \sum Z_{2n,jt} + Industry_k + Year_t + \varepsilon_{it} \quad (4)$$

$$ln(Innovation)_{it} = \alpha_2 + \beta'_1 \widehat{Region\_H_{rt}} + \beta'_2 \widehat{Region\_H_{rt}} \times Traded\_firm_i + \beta'_2 Traded\_firm_i + \gamma'_{1n} \sum Z_{1n,it} + \gamma'_{2n} \sum Z_{2n,jt} + Industry_k + Year_t + State_j + \varepsilon_{it} \quad (5)$$

$$ln(Innovation)_{it} = \alpha_2 + \beta''_1 Neigh\_H_{jt} + \beta''_2 Neigh\_H_{jt} \times Traded\_firm_i + \beta''_2 Traded\_firm_i + \gamma''_{1n} \sum Z_{1n,it} + \gamma''_{2n} \sum Z_{2n,jt} + Industry_k + Year_t + State_j + \varepsilon_{it} \quad (6)$$

[7] We only measure two clusters in our estimations. The resource based clusters are considered into local industries because employment in these industries is located primarily where the needed natural resources are found, although the industries somewhat compete with other domestic or international locations.

where i, t, j, r and k represent company, time, state, region and industry respectively. $Innovation_{it}$ is corporate innovation for company i in state j year t, measured as patents, citations and etc. $\widehat{H_{jt}}$ and $\widehat{Region\_H_{rt}}$ are the 'Tier 1 risk-based capital ratio' instrumented local and regional bank competition and their coefficient, β, captures the causal effect of H on corporate innovation outcomes. Z_{it} denotes a vector of firm- and state-level controls. We also control for the aggregate trends in industry, year and state[8] fixed effects.

$Neigh\_H_{jt}$[9] is the average H of state j's neighbor states. According to LeSage (1999), locational information always presents contiguity, reflecting the relative position in space of one regional unit of observation to others. Empirically, we consider the importance of distance for models involving spatially heterogeneous relationships and define the average $Neigh\_H_{jt}$ on the basis of inverse distance weights *W*. Given the latitude-longitude coordinates of a state, we define the weights matrix W (49 × 49) as:

$$W = \frac{w_{jl}^*}{\sum_l w_{jl}^*} \tag{7}$$

where

$$w_{jl}^* = \begin{cases} \dfrac{1}{d_{jl}}, & if\ j \neq l\ and\ l \in N_K(j)\ or\ j \in N_K(l) \\ 0, & otherwise \end{cases} \tag{8}$$

and d_{jl} stands for the great circle distance between centroids of state j and l. In robustness tests, we use alternative binary weights that equal to 1 when state j and l share a common boundary.

In Eqs (4) – (6), we consider the interaction effects where bank competition affects loan prices with an interaction with geographical span of industrial markets (Bellón, 2016). We define $Traded\_firm_i = 1$ if a sample firm competes in wider geographical markets within only one geographical banking market and

[8] Concerning the potential bias that is caused by multicollinearity, we exclude the state fixed effects from Eq.(1) since H_{jt} is defined at state × year level. The identification of β1, therefore, is not solely from within-state variation across time (Chava et al., 2013).
[9] We test the effects of home-state H and neighbour-state H in separate models. This is because the interdependence between H_{jt} and $Neigh\_H_{jt}$ may cause a potential multicollinearity problem. In addition, the main purpose of the paper is to investigate whether commercial lending markets in neighbor states can alter the impacts of localized banks (i.e. substitution effects) rather than the spillover of banking competition.

$Traded\_firm_i = 0$ if it competes within only one geographical banking market. Hence, the estimated coefficient β_1 captures the causal effects of the home-state bank competition on corporate innovation. β_3 considers the industrial effects and β_2 measures the way in which firms are influenced by neighbor or regional bank competition.

5. Empirical Results

5.1. The effects of home-state bank competition on corporate innovation

We start our empirical analysis by examining the effects of bank competition in home states on the quantity and quality of corporate innovation, in terms of the numbers of patents obtained by sample firms and the number of citations received by the patents (Table 2). For ease of comparison, we firstly report the pooled OLS estimates in Model 1 and 6 with cluster standard errors by firms. In Model 2 – 5 and 7 – 10, instead, we address the endogeneity of *H* by instrumenting *H* and running 2SLS models. To test the validation of our instrument, we perform the first-stage regressions and the estimates are reported separately in Table 2, where the estimated coefficient of Tier 1 ratio on *H* is negative and statistically significant at 1%. In addition, the F-statistic of the first-stage regression is large enough with statistically significant *p*-value, suggesting that Tier 1 ratio is a valid instrument for *H* in our estimation.

Table 2 shows that the coefficients of *H* in home-state are positive and statistically significant at 1% level (p-value < 0.01) across all 2SLS estimations, consistent with existing literature on the facts that bank competition in home-state enhances innovative activities (Cornaggia et al., 2013) where firms would have better access to bank finance in a more competitive market (Rice and Strahan, 2010), supporting market power hypothesis (Boot and Thakor 2000; Black and Strahan 2002).

In specific, Models 5 and 10 report the results of Eq. (4). Holding other factors constant, the key coefficient we are concerned with is the one on the interaction between banking competition in home markets and geographical span of industrial operations. In Model 5, this estimated coefficient is negative and statistically significant at 1% level, suggesting a less *favorable* effect exercised by local banking competition on corporate innovation produced by firms that operate in wider geographical areas. The difference of economic magnitude is significant. For example, a 0.1 increase in H_{jt} would increase the number of patents (citations) by 19% (47%) for traded firms and 34% (90%) for other firms. Such a result is consistent with our earlier expectation that the innovation activities carried out by firms operating in local markets ($Traded\_firm_i = 0$) are more sensitive to local bank competition. As a robustness test by grouping samples, we re-run Eq. (1) and show that the coefficient of *H* is greater for firms operating in local markets ($Traded\_firm_i = 0$, Model 4) than for traded firms (Model 3), consistent with the results in Model 5.

[Table 2 insert here please]

Next, we explore four additional patent-based measures to assess if a greater bank competition in home-state would alter the nature and risk of corporate innovation by following Chava et al. (2013). First, we consider that more patents in the top quartile of citation distribution ($ln(HighCited)_{it}$ vs. $ln(LowCited)_{it}$) would be an indication of a better experimentation with new technologies and a lower risk associated with innovative activities. Second, we evaluate the effect of home-state H_{jt} on the underlying nature of innovation being patented by using patent generality and originality scores. If improved banking market competition is associated with a greater tolerance to new technological experimentation, we would expect firms to produce more patents that are in a wider range of technological fields (greater generality) and can influence new areas of research (greater originality).

Table 3 shows that consistent with above findings but expect for innovation originality, businesses operating in local product markets ($Traded\_firm_i = 0$) benefit more from the improved home-state bank competition. It also shows that bank competition has a stronger favorable effect on high risk innovation activities (*lowcited*) (Models 2 vs. 4) where the size of coefficient of *H* is more than 4 times greater for *lowcited* innovation (Model 2) than for *highcited* innovation. Such a result suggests that an improved bank competition would supply more credits to firms undertaking high risk innovation activities and initial and uncertain stage of technology development would take more advantage from greater competition in local banking market. Finally, we find that bank competition improves the generality of corporate innovation.

[Table 3 insert here please]

5.2. Regional bank market competition and corporate innovation

Along with existing literature (e.g. Chava et al., 2013), our earlier findings suggest a favorable effect of home-state bank competition on corporate innovation. However, what is little known is how the bank competition in a wider geographic region would affects home state corporate innovation. In these two sections, we aim to fill in the gap in existing literature by investigating the effects of regional and neighbor state bank competition on corporate innovation in home state.

Table 4 presents the regression results of Eq. (2) and (5), examining the effects of regional banking competition ($Region\_H_{rt}$) on the level of corporate innovative outputs. To address the potential endogeneity of *H* at a regional level, we follow the same identification strategy and employ regional median Tier 1 risk-based capital ratio ($Region\_Tier\ 1\ ratio_{rt}$) as an instrument. The first stage regression is reported in the last column, showing the estimated predictions and validations of the instrument employed. Table 4 shows that the coefficients of regional *H* are positive and statistically significant at 1% level in all 2SLS estimations, where the dependent variables are the numbers of successful patent applications (Model 1 – 3) and citations (Model 4 – 5), respectively. Even though, there is a significant drop in the magnitude of the coefficients compared with that of home-state *H* (Table 2). An increase of home-state *H* by 0.1 would increase patent counts by 20% (=$e^{0.180}$ – 1) (Model 2, Table 2) and 49% (=$e^{0.400}$ – 1) in citations (Model 7, Table 2). In contrast, the economic significances of the coefficients of regional *H* are only 3.5% (=$e^{0.0345}$ – 1) for patent counts (Model 2) and 7.9% (=$e^{0.0757}$ – 1) for citations (Model 5). Moreover, the interaction effect between regional *H* and industrial operations turns to be positive and economically significant (Model 3 and 6). This finding suggests that the improvement of banking competition within a greater geographical span is more benefitial for those firms that serve markets beyond the state in which they are located.

[Table 4 insert here please]

In addition, we perform the estimations against the underlying risk of corporate innovation and the results are reported in Table 5. Except for the effect on patents' generality scores (Model 5 and 6), we find little evidence on the effects of regional bank competition on the risk (low vs. high cited) and originality of corporate innovation. Such evidence implies that the competitive conditions of banking market within a wider scope of geographical areas appear to be less effective on explaining the nature of innovation being patented. It might do because compared with local banks, distant banks always have a disadvantage in soft information collection over distance (e.g. Almazan, 2002; Agarwal and Hauswald, 2010). In terms of innovation generality, since a higher score reflects a greater propensity of a patent being drawn upon by a more diverse array of subsequent patents, the geographic divarication in banking market, with advances in information collecting and sharing, would allow banks to better assess the potential credit demand from businesses over a wider geographical scope.

[Table 5 insert here please]

5.3. Neighbor-state banking market competition and corporate innovation

As reviewed above, after interstate deregulations, the removal of bank entry barriers across states in U.S. has improved the scope for geographic diversification (Goetz et al., 2012), allowing banks to finance more freely cross state boarders. Accordingly, we expect that firms' access to finance, and in turn their innovativeness, may not only depend on banking market condition in their home-state, but also on the competition in neighbor banking markets. Table 6 presents the estimations for Eq. (3) and (6), providing evidence in line with the expectation. The table shows overall favorable effects of bank competition in neighbor states on corporate innovation in home state (Models 1 and 5) and in specific, such effects are statistically significant for those businesses operating in a wider geographic product market (Models, 2, 4, 6 and 8). The innovation activities by those businesses who operate in local state markets ($Traded\_firm_i = 0$) are not sensitive to bank competition in neighbor states (Models 3 and 7). It implies that firms operating within a single geographic area are expected to benefit only from their home-state banking market competition in terms of the volume of innovative activities.

[Table 6 insert here please]

In spite of the presence of an effect on the level of innovative activities undertaken by traded firms, what is puzzling as shown in Table 7 is that bank competition in neighbor states appears to have little impact on the underlying risk of innovation being patented in home state. Across different specifications, none of the estimated coefficients of $Neigh\_H_{jt}$ is statistically significant and the magnitude drops substantially compared to those on patent and citation counts (Table 6). Whereas the interaction effect on patents' generality scores for traded firms are significant (Model 2), the evidence suggests that increasing competition in neighbor banking markets has limited ability to substitute the favorable effects of local banking competition on providing firms with more flexibility to experiment with new technologies.

[Table 7 insert here please]

Overall, our findings show a substitution effect of neighbor state bank competition to that of home state on corporate innovation carried out by businesses with a greater geographic scope of operation and such an effect is limited to the numbers of patents and citations only with little evidence on the risk and nature of innovation. Our results support the propositions on the advantages of local banks in private information acquisition from the informationally opaque corporate innovation activities.

6. Robustness tests

We undertake a rich set of robustness tests and our results are robust to a variety of identifications. First, we re-estimate our specifications by using Herfindahl-Hirschman Index (*HHI*) as an alternative proxy for banking market competition. Results for home state effects and neighbor states effects given the same spatial weights matrix W (49×49) are reported in Table 8 and 9 respectively, where the OLS models follow the idea of exogenous banking market competition (e.g. Benfratello et al., 2008) and 2SLS models employ an instrumental variable[10] approach to address the endogeneity issue of banking market competition. Both tables show consistent results that overall, bank concentration (*HHI*) of both home-state market (Table 8) and neighbor state markets (Table 9) has *unfavorable* effects on corporate innovation and the innovation activities of those firms operating in a wider geographic area are more sensitive to neighbor state bank competition, confirming that our findings are not subject to the way of how banking market structure is measured.

[Table 8 and 9 insert here please]

Next, Table 10 reports the parameter estimates for Eq. (3) and (6) by measuring $Neigh\_H_{jt}$ with alternative binary weights that equals to 1 when state *j* and *l* share a common boundary. Our earlier results still hold.

[Table 10 insert here please]

In addition, we restrict the observation period from 1997 only in order to control for the potential effects caused by the implementation of IBEEA. The results in Table 11 indicate that our findings are not affected by the time trend and are not correlated with state policy shocks. Given the significant coefficients in Model 2 and 4, a 0.1 increase in *H* in local home state banking markets would increase patents by 14% and citations by 53% between 1997 and 2004. Although the evidence consistently suggests a favorable effect of local bank competition on corporate innovation, such a favorable effect of home-state *H* has somewhat become smaller since 1997. In contrast, we find that the impacts of regional competition (Model 5 – 8) and neighbor-state *H* (Model 9 – 12) have been improved after IBEEA. The finding provides evidence on the extended and integrated tendency of so-called local market in U.S. banking industry in a post deregulation period.

[Table 11 insert here please]

[10] We use the same instrument in estimating HHI and the correlation coefficient of state median Tier 1 risk-based capital ratio with HHI is 0.4973 significantly different from zero at a 1% level.

Finally, we test whether the significantly positive effect of state *H* is driven by a few firms that patent extensively. To address the concern, we separate the sample firms into various groups according to their book value of assets, age and R&D efficiency, and find that the local banking market competition still improve corporate innovation. Besides, we follow Hombert and Matray (2014) and consider 'innovator' as an alternative explanation to measure the extensive margin of innovation. By exploiting a Probit model, we find a similar effect of both home-state *H* and neighbor-state *H* in the promoting innovation. Such results are not reported but available from authors upon request.

7. Information effects

Existing banking literature has proposed two theoretical frameworks in relation to the significance of geographic distance in lending markets. The spatial pricing discrimination models, which are based on transportation costs, formalize the idea that the cost of credit for businesses and borrower-lender distance is negatively related (e.g. Degryse and Ongena, 2005). In contrast, the information asymmetry rationale concerns that proximity may give advantages to closer lenders in screening perspective borrowers and monitoring loans. Therefore, firms would receive better loan terms from local banks because the severity of the asymmetric information problem may intensify with physical distance (e.g. Degryse and Ongena, 2005; Agarwal and Hauswald, 2010). This is probably more pronounced for distant banks to finance informationally opaque corporate innovation activities.

Above analysis has shown consistent evidence that home-state bank competition improves corporate innovation; but one may concern that such a favorable effect may vary over the degree of business financial constraints and information asymmetries when banks finance informationally opaque corporate innovation activities. We expect that the favorable home-state bank competition effects on innovation would be stronger for informationally opaque firms and those financially constrained firms. In order to test the conjecture, we group the sample firms according to their Kaplan-Zingales (1997) index and patent types distribution, as proxies for financial constraints and the level of information asymmetries at firm-year level, respectively. In light of the innovation literature, the higher information specialization poses a problem for the innovative firms when they come to terminating or initiating a lending relationship with banks, so that information differentiation captures the degree of specialization in relationship building (Boot and Thakor, 2000). If firms with intensive proprietary information cannot switch banks easily even if the rival banks from more competitive markets tend to reduce loan prices, local banks may have advantages to extract information rents in the range of switching costs and the higher the degree of information specialization, the greater the rent a bank would create from information advantage.

We re-run Eq. (4) on sample firms with either low or high Kaplan-Zingales index and dispersed or concentrated patent type distribution (Table 12) and show, first, our earlier results on the favorable effects of bank competition and their heterogeneity over business operation scope still hold. Second, Table 12 shows that consistent with our expectation, the innovation activities, carried out by financially constrained firms (high Kaplan-Zingales index) and by those with more concentrated patent type distributions, would benefit more strongly from improved home-state bank competition.

[Table 12 insert here please]

Following a similar logic, we examine the effects of neighbor state bank competition on corporate innovation (Table 13) and show that the favorable effects of neighbor state bank competition on corporate innovation are only statistically significant for those firms operating widely ($Traded\_firm_i = 1$) but insignificant for those operating locally, supporting our conjecture on the disadvantages in information collection for distant banks.

[Table 13 insert here please]

8. Conclusion

This paper aims to complement the existing literature on bank competition and corporate innovation. Consistent with literature (e.g. Chava et al., 2013), we show evidence on the favorable effects of bank competition on corporate innovation, supporting market power hypothesis. In addition, our work contributes to knowledge by providing novel evidence on the information advantages local banks possess where locally operating firms benefit more from home-state bank competition than that in a wider region or in neighbor-states.

Overall, our evidence lends support to the notion that the impacts of banking market competition would be different across borrowers characterized by different degrees of asymmetric information, financial constraints and operating scope. The more pronounced impacts on informationally opaque firms suggest that local banking competition plays a more important role in financing the innovation activities of local firms, in line with the propositions by Rajan and Zingales (1998) and Nanda and Nicholas (2014). We show that the substitution effects of bank competition do exist but are only significant for those firms operating widely. Such a substitution effect is not important for informationally opaque firms due to the inefficiencies in credit supply for distant banks. This can be attributed to the fact that the information provided by those opaque firms to their lenders cannot be transferred (Hannan, 1991; Petersen, 2004; Stein, 2002) easily to distant lenders. As such, distant banks generally face a higher degree of information opacity relative to local banks because, reducing their willingness to extend credit to distant borrowers. Our empirical evidence on bank competition, therefore, suggests that 'how local is local' depends on the operating scope and information transparency of corporate borrowers.

References

Agarwal, S. and Hauswald, R., 'Distance and private information in lending', *Review of Financial Studies*, Vol. 23, 2010, pp. 2757–2788.

Aghion, P., Bloom, N., Blundell, R., Griffith, R. and Howitt, P., 'Competition and innovation: An inverted-U relationship', *Quarterly Journal of Economics*, Vol. 120, 2005, pp. 701–728.

Almazan, A., 'A model of competition in banking: Bank capital versus expertise', *Journal of Financial Intermediation*, Vol. 11, 2002, pp. 87–121.

Amore, M.D., Schneiderb, C. and Žaldokas, A., 'Credit supply and corporate innovation', *Journal of Financial Economics*, Vol. 109, 2013, pp. 835–855.

Anselin, L., 'Spatial econometrics', in Badi H. Baltagi, ed., *A Companion to Theoretical Econometrics* (Blackwell Publishing Ltd, Oxford, 2001), pp. 310–330.

Asker, J. and Ljungqvist, A., 'Competition and the structure of vertical relationships in capital markets. *Journal of Political Economy*, Vol.118, 2010, pp. 599–647.

Beck, T. and Demirgüç-Kunt, A., 'Small and medium-sized enterprises: Access to finance as a growth constraint', *Journal of Banking and Finance*, Vol. 30, 2006, pp. 2931–2943.

Bellón, C., 'How local is a local banking market? Bank competition, borrower competition and interest rates', *Research Paper*, 2016, available at: http://dx.doi.org/10.2139/ssrn.2665173.

Benfratello, L., Schiantarelli, F. and Sembenelli, A., 'Banks and innovation: Microeconometric evidence on Italian firms', *Journal of Financial Economics*, Vol. 90, 2008, pp. 197–217.

Berger, A.N., Miller, N.H., Petersen, M.A., Rajan, R.G. and Stein, J.C., 'Does function follow organisational form? Evidence from the lending practices of large and small banks', *Journal of Financial Economics*, Vol. 76, 2005, pp. 237–269.

Berger, A.N., Demsetz, R.S. and Strahan, P.E., 'The consolidation of the financial services industry: causes, consequences, and implications for the future', *Journal of Banking and Finance*, Vol. 23, 1999, pp.135–194.

Berger, A.N., Kashyap, A.K. and Scalise, J.M., ‘The transformation of the U.S. banking industry: What a long, strange trip it’s been’, *Brookings Papers on Economic Activity*, Vol. 26, 1995, pp. 55–218.

Bikker, J.A. and Haaf, K., ‘Competition, concentration and their relationship: An empirical analysis of the banking industry’, *Journal of Banking and Finance*, Vol. 26, 2002, pp. 2191–2214.

Black, S. and Strahan, P.E., ‘Entrepreneurship and bank credit availability’, *Journal of Finance*, Vol. 57, 2002, pp. 2807–2833.

Boot, A.W.A. and Thakor, A.V., ‘Can relationship banking survive competition?’ *Journal of Finance*, Vol. 55, 2000, pp. 679–713.

Brevoort, K.P. and Hannan, T.H., ‘Commercial lending and distance: Evidence from community reinvestment act data’, *Journal of Money, Credit and Banking*, Vol. 38, 2006, 1991–2012.

Brevoort, K.P. and Wolken, J.D., ‘Does distance matter in banking?’ in Pietro Alessandrini, Michele Fratianni and Alberto Zazzaro eds., *The Changing Geography of Banking and Finance* (Springer, Berlin Heidelberg, 2009), pp. 27–56.

Broecker, T., ‘Credit-worthiness tests and interbank competition’, *Econometrica*, Vol. 58, 1999, pp. 429–452.

Carling, K. and Lundberg, S., ‘Asymmetric information and distance: An empirical assessment of geographical credit rationing’, *Journal of Economics and Business*, Vol. 57, 2005, pp. 39–59.

Chava, S., Oettl, A., Subramanian, A. and Subramanian, K.V., ‘Banking deregulation and innovation’, *Journal of Financial Economics*, Vol. 109, 2013, pp. 759–774.

Claessens, S. and Laeven, L., ‘Financial dependence, banking sector competition, and economic growth’, *Journal of the European Economic Association*, Vol. 3, 2005, pp. 179–207.

Corbae, D. and D'Erasmo, P., ‘Capital requirements in a quantitative model of banking industry dynamics’, *Federal Reserve Bank of Philadelphia Working Paper* No. 14–13, Federal Reserve Bank of Philadelphia (2014).

Cornaggia, J., Mao, Y., Tian, X. and Wolfe, B., ‘Does banking competition affect innovation?’ *Journal of Financial Economics*, Vol. 115, 2015, pp. 189–209.

Degryse, H. and Ongena, S., ‘The impact of technology and regulation on the geographical scope of banking’, *Oxford Review of Economic Policy*, Vol. 20, 2004, pp.571–590.

Degryse, H. and Ongena, S., ‘Distance, lending relationships, and competition’, *Journal of Finance*, Vol. 60, 2005, pp. 231–266.

Dell’Ariccia, G., ‘Asymmetric information and the structure of the banking industry’, *European Economic Review*, Vol. 45, 2001, pp. 1957–1980.

Dell’Ariccia, G. and Marquez, R., ‘Information and bank credit allocation’, *Journal of Financial Economics*, Vol. 72, 2004, pp. 185–214.

Diamond, D.W., (1984) ‘Financial intermediation and delegated monitoring’, *The Review of Economic Studies*, Vol. 51, 1984, pp. 393–414.

Duchin, R., Ozbas, O. and Sensoy, B.A., ‘Costly external finance, corporate investment, and the subprime mortgage credit crisis’, *Journal of Financial Economics*, Vol. 97, 2010, pp. 418–435.

Fuentelsaz, L. and Salas, V., *Spatial Competition in Retail Banking – Theory and Empirical Evidence from Spain and Other European Countries*, Unpublished manuscript (Universidad Autónoma de Barcelona, 1992).

Goetz, M., Laeven, L. and Levine, R., ‘The valuation effects of geographic diversification: Evidence from U.S. banks’, *IMF Working Paper* No.12/50, International Money Fund (2012).

Greenhut, J.G. and Greenhut, M.L. ‘Spatial price discrimination, competition and locational effects’, *Economica*, Vol. 42, 1975, pp. 401–419.

Hall, B.H., Jaffe, A.B. and Trajtenberg, M., ‘The NBER patent citation data file: Lessons, insights and methodological tools’, *NBER Working Paper* No. 8498, National Bureau of Economic Research (2001).

Hall, B.H., Jaffe, A. and Trajtenberg, M., ‘Market value and patent citations’, *RAND Journal of Economics*, Vol. 36, 2005, pp. 16–38.

Hannan, T.H., ‘Bank commercial loan markets and the role of market structure: Evidence from surveys of commercial lending’, *Journal of Banking and Finance*, Vol. 15, 1991, pp. 133–149.

Hauswald, R. and Marquez, R., ‘Competition and strategic information acquisition in credit markets’, *Review of Financial Studies*, Vol. 19, 2006, pp. 967–1000.

Hotelling, H., ‘Stability in competition’, *Economic Journal*, Vol. 39, 1929, pp. 41–45.

Jones, K.D. and Critchfield, T., ‘Consolidation in the U.S. banking industry: Is the “long, strange trip” about to end?’ *FDIC Banking Review*, Vol. 17, 2005, pp. 31–61.

Kaplan, S. and Zingales, L., ‘Do investment-cash flow sensitivities provide useful measures of financing constraints?’ *Quarterly Journal of Economic*s, Vol. 112, 1997, pp. 169–215.

Kroszner, R.S. and Strahan, P.E., ‘What drives deregulation? Economics and politics of the relaxation of bank branching restrictions’, *Quarterly Journal of Economics*, Vol. 114, 1999, pp. 1437–1467.

Kwast, M.L., Starr-McCluer, M. and Wolken, J.D., ‘Market definition and the analysis of antitrust in banking’, *Antitrust Bulletin*, Vol. 42, 1997, pp. 973–995.

LeSage, J.P., ‘The theory and practice of spatial econometrics’, *University of Toledo Working Paper*, Department of Economics, University of Toledo (1999).

LeSage, J.P., ‘What regional scientists need to know about spatial econometrics’, *The Review of Regional Studies*, Vol. 44, 2014, pp. 13–32.

Michalski, T. and Ors, E., ‘(Interstate) banking and (Interstate) trade: Does real integration follow financial integration?’ *Journal of Financial Economics*, Vol. 104, 2012, pp. 89–117.

Nanda, R. and Nicholas, T., ‘Did bank distress stifle innovation during the great depression?’ *Journal of Financial Economics*, Vol. 114, 2014, pp. 273–292.

Osborne, D.K., ‘Competition and geographical integration in commercial bank lending’, *Journal of Banking and Finance*, Vol. 12, 1988, pp. 85–103.

Panzar, J.C. and Rosse, J.N., ‘Testing for monopoly equilibrium’, *Journal of Industrial Economics*, Vol. 35, 1984, pp. 443–456.

Park, K and Pennacchi, G., ‘Harming depositors and helping borrowers: The disparate impact of bank consolidation’, *Review of Financial Studies*, Vol. 22, 2009, pp. 1–40.

Petersen, M.A. and Rajan, R.G., 'The effect of credit market competition on lending relationships', *Quarterly Journal of Economics*, Vol. 110, 1995, pp. 406–443.

Petersen, M.A., *Information: Hard and Soft* (Northwestern University, Chicago, IL, 2004).

Petersen, M.A. and Rajan, R.G., 'Does distances still matter? The information revolution in small business lending', *Journal of Finance*, Vol. 57, 2002, pp. 2533–2570.

Porter, M.E., 'The economic performance of regions', *Regional Studies*, Vol. 37, 2003, pp. 549–578.

Rajan, R.G. and Zingales, L., 'Financial dependence and growth', *American Economic Review*, Vol. 88, 1998, pp. 559–566.

Rice, T. and Strahan, P.E., 'Does credit competition affect small-firm finance?' *Journal of Finance*, Vol. 65, 2010, pp. 861–889.

Richards, T.J., Acharya, R.N. and Kagan, A., 'Spatial competition and market power in banking', *Journal of Economics and Business*, Vol. 60, 2008, pp. 436–454.

Sharpe, S., 'Asymmetric information, bank lending and implicit contracts: A stylized model of customer relationships', *Journal of Finance*, Vol. 45, 1990, pp. 1069–1087.

Stein, J., 'Information production and capital allocation: Decentralised versus hierarchical firms', *Journal of Finance*, Vol. 57, 2002, pp. 1891–1921.

Sussman, O. and Zeira, J., 'Banking and development', *CEPR Discussion Papers 1127*, Centre for Economic Policy Research (1995).

Appendix: ***Variables construction***

Innovation variables:

$ln(Patent)_{it}$: Natural logarithm of one plus company i's total number of successful patents filed in years *t*, where the aggregated counts are adjusted by using the 'weight factors' computed from the application-grant empirical distribution and averaging the number of patents within three years (year *t* to *t+2*).

$ln(Citation)_{it}$: Natural logarithm of one plus company i's total number of citations received of its patents filed in years *t*, where the number of citations are corrected for truncation (Hall et al., 2001, 2005) and averaging within three years (year *t* to *t+2*).

$ln(HighCited)_{it}$: Natural logarithm of the number of patents applied by company *i* in state *j*, year *t*, whose citations are above the 75th percentile of year t's citation distribution in state j.

$ln(LowCited)_{it}$: Natural logarithm of the number of patents applied by company *i* in state *j*, year *t*, whose citations are below the 25th percentile of year t's citation distribution in state j.

$Generality_{it}$: An index equals to $1 - \sum_{k}^{n_k} s_{kl}^2$, where s_{kl}^2 denotes the percentage of citations received by a patent *k* that belongs to the patent technology class *l* out of n_k patent classes (Hall et al., 2001). It ranges between 0 and 1, and the higher a patent's generality score, the more that the patent is being drawn upon by a more diverse array of subsequent patents. In the analysis, we take an average value for all patents generated by the company i in year t. For companies that generate no patents in a year, the index are undefined and therefore treated as missing.

$Originality_{it}$: An index equals to $1 - \sum_{k}^{n_k} s_{kl}^2$, where s_{kl}^2 denotes the percentage of citations made by a patent *k* that belongs to the patent technology class *l* out of n_k patent classes (Hall et al., 2001). It is bounded between 0 and 1, and the higher a patent's originality score, the more the patent draws upon a diverse array of existing knowledge. In the analysis, we take an average value for all patents generated by the company *i* in year *t*. For companies that generate no patents in a year, the index are undefined and therefore treated as missing.

Banking market competition variables:

H_{jt}: Panzar-Rosse (1984) H-statistic of the banking market in state *j* year *t*, which is estimated by the sum of the elasticity of total revenue with respect to three inputs prices used by banks, which are the labor, funds and physical capital, ranging from 0 to 1. The detailed derivation is available upon request from the authors.

$Region\_H_{rt}$: Panzar-Rosse (1984) H-statistic of the banking market in region *r* year *t*. The division of region areas follows the U.S. Census Bureau definitions, including New England, Mid-Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain and Pacific (http://www.census.gov/geo/maps-data/maps/pdfs/reference/us_regdiv.pdf).

$Neigh\_H_{jt}$: Spatially average weighted Panzar-Rosse (1984) H-statistic of state *j*'s K number of neighbor states in year *t*. Given the latitude-longitude coordinates of a state, in specific, the weights matrix W (49 × 49) is measured by $W = \frac{w_{jl}^*}{\sum_l w_{jl}^*}$, where $w_{jl}^* = \frac{1}{d_{jl}}$ if $j \neq l \; and \; l \in N_K(j) \; or \; j \in N_K(l)$. And in the robustness test, we measure $w_{jl}^* = 1$ if $j \neq l \; and \; l \in N_K(j) \; or \; j \in N_K(l)$.

HHI_{jt} ($Region\_HHI_{rt}$): Herfindahl-Hirschman Index, the sum of squared share of deposits for each branch in state *j* (region *r*) year *t*. We take weighted averages across markets for banking institutions in multiple local markets using the proportions of total deposits as the weights.

$Neigh\_HHI_{jt}$: Spatially average weighted Herfindahl-Hirschman Index of banking concentration of state *j*'s K number of neighbor states in year *t*, measured on the bases of inverse distance weights matrix W (49 × 49) $= \frac{w_{jl}^*}{\sum_l w_{jl}^*}$, where $w_{jl}^* = \frac{1}{d_{jl}}$ if $j \neq l \; and \; l \in N_K(j) \; or \; j \in N_K(l)$.

Other control variables:

$Traded\_firm_i$: The measure of the geographical span of industrial competition. It takes value of one if a sample firm competes beyond one geographical product market and zero if it competes within only one geographical market.

$Size_{it}$: Natural logarithm of the book value of total assets of company *i* measured at the end of fiscal year *t*.

Age_{it}: Natural logarithm of (1+age), where age is the number of years that the company *i* has been in COMPUSTAT.

ROA_{it}: EBITDA to total assets for company *i* in year *t*.

$Cash\ holding_{it}$: Cash and marketable securities to total assets for company *i* in year *t*.

$Asset\ tangibility_{it}$: Ratio of net property, plants and equipment (PPE) to total assets for company *i* in year *t*.

$Capital\ to\ labor\ ratio_{it}$: Natural logarithm of the ratio for company *i* in year *t*, where capital is represented by property, plants and equipment (PPE), and labor is the total number of employees.

$Leverage_{it}$: Debt to equity ratio of company *i* in year *t*.

$ln(Sales)_{it}$: Natural logarithm of the total sales of company *i* year *t*.

$Tobin's\ Q_{it}$: Equals to the total market value of company *i* in year *t* divided by its total assets value. According to Duchin et al. (2010), the market value = Total assets + Market value of common equity – Common equity – Deferred taxes. The total assets value = 0.9 × Book value of assets + 0.1 × Market value of assets.

$Product\ market\ HHI_{it}$: Herfindahl-Hirschman Index of the industry in which company *i* operates, computed as the sum of squared market share of all firms, based on sales, in a given three-digit SIC industry in year *t*.

$Coincident\ index_{jt-1}$: An index used to control for regional economic trend, which combines data on nonfarm payroll employment, average hours worked in manufacturing, unemployment rate, and wage and salary disbursements deflated by the consumer price index.

$Venture\ capital_{jt}$: Ratio of total venture capital investments to total investment in state j year t.

$Kapla\_Zingales\_index$: A measure for the financial constraints at firm-level (Kaplan-Zingales, 1997) which is equal to [– 1.002 × Cash flow + 0.283 × Tobin's Q + 3.319 × Debt – 39.368 × Dividends – 1.315 × Cash].

$Patent\ distribution_{it}$: A measure of specialized information of the innovation being patented. Based on 6 different patent categories defined by Hall et al. (2001), the innovative activity is considered as 'concentrated' if the kurtosis value of the empirical distribution of patents produced by company *i* in year *t* among different categories is greater than 3, otherwise is defined as 'dispersed'.

Table 1 Descriptive Statistics

Variables	Obs	Mean	Std. dev.	Min	Max
$Patent_{it}$	32,869	11	76	0	3769
$Citation_{it}$	32,869	137	922	0	42339
$HighCites_{it}$	7,995	11	45	1	1207
$LowCites_{it}$	5,889	10	27	0	566
$Generality_{it}$	15,799	0.373	0.291	0	1
$Originality_{it}$	15,799	0.526	0.243	0	1
H-statistic (H_{jt})	32,869	0.594	0.239	0.114	1.000
HHI (HHI_{jt})	28,513	0.010	0.397	0.012	0.551
Average H-statistics of Neighboring state ($Neigh\_H_{jt}$)	32,869	0.647	0.169	0.187	0.968
Distance weighted average H-statistics of Neighboring state ($WNeigh\_H_{jt}$)	32,869	0.644	0.252	0.085	1
Regional H-statistic ($Region\_H_{rt}$)	32,481	0.554	0.229	0.124	0.968
Size	31,789	5.188	2.597	-6.908	13.920
Age	31,098	2.348	1.048	0	4.007
ROA	31,593	-0.042	0.454	-2.708	0.407
Cash holding	31,774	0.227	0.258	-0.008	1
Asset tangibility	31,726	0.241	0.193	0	1
Capital to labor ratio	29,432	4.321	1.053	-1.792	11.598
Leverage	30,440	0.011	0.040	0	1.450
Ln(Sales)	30,927	4.963	2.813	-6.908	12.564
Tobin's Q	32,869	1.325	8.963	-229.930	1082.041
Product market HHI	32,798	0.014	0.024	0.007	0.404
Coincident Index	32,842	124.853	15.954	92.600	203.120
Venture capital ratio	32,727	3.267	7.436	0	52.302

Note: This table reports the descriptive statistics of the key variables used in the empirical analysis. The samples collected are from 1992 to 2004 in 49 states (include District of Columbia). 'ln' stands for natural log value. The detailed description of all variables are shown in Appendix and the descriptive statistics of the variables used in the estimation of H-statistics are not reported but available from the authors on request.

Table 2 The Impacts of State Banking Market Competition on the Level of Corporate Innovation

Dependent variable	$ln(Patent)_{it}$					$ln(Citation)_{it}$					H_{jt}
	OLS	2SLS				OLS	2SLS				First stage
	All	All	Traded	Local	Interaction	All	All	Traded	Local	Interaction	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	
$Tier\ 1\ ratio_{jt}$											-0.200***
											(0.006)
H_{jt}	0.028	1.801***	1.783***	4.198***	2.912***	0.203***	4.001***	3.958***	8.281***	6.425***	
	(0.033)	(0.196)	(0.199)	(1.435)	(0.581)	(0.060)	(0.352)	(0.354)	(2.796)	(1.192)	
$H_{jt} \times Traded\_firm_i$					-1.177**					-2.566**	
					(0.559)					(1.152)	
$Traded\_firm_i$					0.848**					1.743**	
					(0.330)					(0.679)	
Size	0.215***	0.222***	0.240***	0.100***	0.222***	0.349***	0.364***	0.391***	0.184***	0.364***	
	(0.007)	(0.007)	(0.008)	(0.032)	(0.007)	(0.013)	(0.014)	(0.015)	(0.062)	(0.014)	
Age	0.071***	0.082***	0.097***	-0.040	0.085***	0.036***	0.060***	0.084***	-0.136**	0.064***	
	(0.008)	(0.008)	(0.009)	(0.035)	(0.008)	(0.013)	(0.014)	(0.015)	(0.068)	(0.015)	
ROA	-0.349***	-0.348***	-0.376***	-0.079	-0.345***	-0.478***	-0.476***	-0.527***	-0.018	-0.470***	
	(0.016)	(0.017)	(0.018)	(0.070)	(0.017)	(0.032)	(0.035)	(0.036)	(0.149)	(0.035)	
Cash holding	0.589***	0.556***	0.584***	0.035	0.553***	1.125***	1.053***	1.102***	0.358	1.050***	
	(0.032)	(0.034)	(0.036)	(0.143)	(0.034)	(0.060)	(0.065)	(0.069)	(0.283)	(0.065)	
Asset tangibility	-0.551***	-0.611***	-0.554***	-0.746***	-0.586***	-0.824***	-0.954***	-0.848***	- 1.207***	-0.916***	
	(0.050)	(0.053)	(0.058)	(0.171)	(0.054)	(0.089)	(0.096)	(0.106)	(0.316)	(0.099)	
Capital to labour ratio	0.107***	0.107***	0.087***	0.156***	0.103***	0.134***	0.134***	0.092***	0.278***	0.129***	
	(0.009)	(0.009)	(0.010)	(0.032)	(0.010)	(0.016)	(0.017)	(0.019)	(0.060)	(0.018)	
Leverage	-0.503***	-0.321*	-0.234	-0.278	-0.320*	-0.913***	-0.522*	-0.495	0.497	-0.519*	
	(0.170)	(0.172)	(0.182)	(0.649)	(0.173)	(0.290)	(0.308)	(0.316)	(1.355)	(0.311)	
Ln(Sales)	0.056***	0.047***	0.043***	0.011	0.046***	0.080***	0.061***	0.061***	-0.029	0.060***	
	(0.006)	(0.007)	(0.007)	(0.028)	(0.007)	(0.013)	(0.013)	(0.014)	(0.057)	(0.014)	
Tobin's Q	0.010***	0.010***	0.011***	-0.001	0.010***	0.019***	0.019***	0.021***	-0.003	0.018***	
	(0.002)	(0.003)	(0.003)	(0.002)	(0.003)	(0.004)	(0.005)	(0.006)	(0.005)	(0.005)	
Product market HHI	0.469***	0.399**	0.442**	0.173	0.390**	1.346***	1.197***	1.416***	0.743	1.165***	
	(0.147)	(0.158)	(0.185)	(0.461)	(0.164)	(0.273)	(0.301)	(0.350)	(0.899)	(0.314)	
Product market HHI^2	-0.745*	-0.439	-0.578	0.066	-0.312	-2.593***	-1.937***	-3.143***	-0.833	-1.638**	

	(0.415)	(0.429)	(0.521)	(1.006)	(0.460)	(0.659)	(0.728)	(1.040)	(1.859)	(0.814)	
Coincident Index	-0.000	-0.008***	-0.008***	-0.020**	-0.009***	0.003*	-0.015***	-0.015***	-0.040**	-0.015***	
	(0.001)	(0.001)	(0.001)	(0.008)	(0.001)	(0.001)	(0.002)	(0.002)	(0.016)	(0.002)	
Venture Capital	0.004***	-0.001	-0.001	-0.008*	-0.001	0.009***	-0.002	-0.003	-0.002	-0.002	
	(0.001)	(0.001)	(0.001)	(0.005)	(0.001)	(0.002)	(0.002)	(0.002)	(0.009)	(0.002)	
Other controls											Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	26,816	26,816	24,724	2,092	26,816	26,816	26,816	24,724	2,092	26,816	26,974
R-squared	0.3563	0.2885	0.3007	0.1534	0.2814	0.3447	0.2453	0.2581	0.0616	0.2347	0.4418
F-statistic	262.16***	240.40***	232.25***	11.63***	222.93***	423.68***	355.49***	347.24***	9.74***	325.17***	1518.21***

Note: This table reports the results (standard errors in parentheses) specified by Eq. (1) (Model 1 – 3 and 6 – 8) and Eq. (4) (Model 5 and 10), where dependent variables are the number of patents and citations being filed by firms respectively. Models employed are pooled OLS with standard robustness errors (Models 1 and 6) and instrumented two-stage least squares (2SLS) (Models 2 – 5 and 7 – 10). The instrument used is state median Tier 1 risk-based ratio. In specific, Model 3 and 8 report the estimations for the subsample firms that operate over larger geographical areas ($Traded\_firm_i = 1$). Model 4 and 9 show the estimations for the subsample firms whose markets are confined to a single banking market ($Traded\_firm_i = 0$). All estimations control for industry and year fixed effects. All models include full set of control variables. The *, ** and *** denote statistical significance at 10%, 5% and 1% level for which the null hypothesis is rejected.

Table 3 The Impacts of State Banking Market Competition on the Nature and Risk of Corporate Innovation

Dependent variable	$\boldsymbol{ln(LowCites)_{it}}$		$\boldsymbol{ln(HighCites)_{it}}$		$\boldsymbol{Generality_{it}}$		$\boldsymbol{Originality_{it}}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\boldsymbol{H_{jt}}$	1.241***	0.715***	1.040***	0.161***	0.348***	0.065***	-0.076	-0.013
	(0.359)	(0.050)	(0.345)	(0.042)	(0.068)	(0.009)	(0.062)	(0.009)
$\boldsymbol{H_{jt} \times Traded\_firm_i}$		-0.631***		-0.067**		-0.033***		0.006
		(0.040)		(0.029)		(0.007)		(0.006)
$\boldsymbol{Traded\_firm_i}$		0.403***		0.655***		0.190***		-0.064
		(0.025)		(0.181)		(0.044)		(0.041)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,032	5,032	6,794	6,794	13,324	13,324	13,324	13,324
R-squared	0.3373	0.4050	0.2914	0.3150	0.2086	0.2547	0.0180	0.0208
F-statistic	102.21***	91.88***	58.85***	56.18***	153.08***	159.42***	6.91***	6.74***

Note: This table reports the results (standard errors in parentheses) specified by Eq. (1) (Model 1, 3, 5 and 7) and Eq. (4) (Model 2, 4, 6 and 8), where dependent variables are the underlying risks and nature of innovation. Specifically, $ln(LowCites)_{it}$ ($ln(LowCites)_{it}$) is the natural logarithm of one plus the total number of patents granted by companies in state *j* in year *t* that are in the top (bottom) quartile of year *t*'s citation distribution. $Generality_{it}$ ($Originality_{it}$) is an index measures the percentage of citations received (made) by a patent that belong to a wide range of technology fields. All specifications are estimated by employing instrumented two-stage least squares (2SLS). The instrument used is state median Tier 1 risk-based ratio. All estimations control for industry and year fixed effects. All models include full set of control variables and the results are available on request from the authors. *, ** and *** denote statistical significance at 10%, 5% and 1% level respectively.

Table 4 The Impacts of Regional Banking Market Competition on the Level of Corporate Innovation

Dependent variable	$ln(Patent)_{it}$			$ln(Citation)_{it}$			$Region\_H_{rt}$
	OLS (1)	2SLS (2)	2SLS (3)	OLS (4)	2SLS (5)	2SLS (6)	First stage
$Region\_Tier\ 1\ ration_{rt}$							-0.141***
							(0.016)
$Region\_H_{rt}$	0.025	0.345***	0.311***	0.047	0.756***	0.727***	
	(0.058)	(0.080)	(0.068)	(0.103)	(0.150)	(0.120)	
$Region\_H_{rt} \times Traded\_firm_i$			0.024***			0.045**	
			(0.009)			(0.018)	
$Traded\_firm_i$			0.054			0.049	
			(0.056)			(0.108)	
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other controls							Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	26,491	26,491	26,816	26,491	26,491	26,816	26,496
R-squared	0.3691	0.2924	0.3710	0.3556	0.2382	0.3572	0.8191
F-statistic	119.02***	107.59***	118.69***	191.21***	155.81***	190.43***	3628.27***

Note: This table reports the results (standard errors in parentheses) specified by Eq. (2) (Model 1 – 2 and 4 – 5) and Eq. (5) (Model 3 and 6), where dependent variables are the number of patents and citations being filed by firms respectively. Models employed are pooled OLS with standard robustness errors (Models 1 and 4) and instrumented two-stage least squares (2SLS) (Models 2 – 3 and 5 – 6). The instrument used is regional median Tier 1 risk-based ratio. All estimations control for industry, year and state fixed effects. All models include full set of control variables and the results are available on request from the authors. *, ** and *** denote statistical significance at 10%, 5% and 1% level respectively.

Table 5 The Impacts of Regional Banking Market Competition on the Nature and Risk of Corporate Innovation

Dependent variable	$ln(LowCites)_{it}$		$ln(HighCites)_{it}$		$Generality_{it}$		$Originality_{it}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Region\_H_{rt}$	0.112	0.128	-0.171	-0.095	0.054*	0.056**	-0.052	-0.047
	(0.193)	(0.170)	(0.145)	(0.130)	(0.031)	(0.026)	(0.032)	(0.029)
$Region\_H_{rt} \times Traded\_firm_i$		0.015		-0.008		0.004		-0.003
		(0.029)		(0.020)		(0.005)		(0.005)
$Traded\_firm_i$		0.245		0.265**		0.013		-0.046
		(0.174)		(0.128)		(0.032)		(0.031)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,951	5,032	6,698	6,794	13,156	13,324	13,156	13,324
R-squared	0.3986	0.4041	0.3200	0.3438	0.2302	0.2586	0.0301	0.0307
F-statistic	89.57***	41.97***	89.39***	43.96***	69.60***	74.27***	4.88***	5.17***

Note: This table reports the results (standard errors in parentheses) specified by Eq. (2) (Model 1, 3, 5 and 7) and Eq. (5) (Model 2, 4, 6 and 8), where dependent variables are the underlying risks and nature of innovation. Specifically, $ln(LowCites)_{it}$ ($ln(LowCites)_{it}$) is the natural logarithm of one plus the total number of patents granted by companies in state *j* in year *t* that are in the top (bottom) quartile of year *t*'s citation distribution. $Generality_{it}$ ($Originality_{it}$) is an index measures the percentage of citations received (made) by a patent that belong to a wide range of technology fields. All specifications are estimated by employing instrumented two-stage least squares (2SLS). The instrument used is regional median Tier 1 risk-based ratio. All estimations control for industry, year and state fixed effects. All models include full set of control variables and the results are available on request from the authors. *, ** and *** denote statistical significance at 10%, 5% and 1% level respectively.

Table 6 The Impacts of Banking Market Competition in Neighboring States on the Level of Corporate Innovation

Dependent variable	$ln(Patent)_{it}$				$ln(Citation)_{it}$			
	All (1)	Traded (2)	Local (3)	Interaction (4)	All (5)	Traded (6)	Local (7)	Interaction (8)
$Neigh\_H_{jt}$	0.226***	0.254***	-0.028	0.016	0.242*	0.278**	-0.015	-0.426
	(0.070)	(0.074)	(0.145)	(0.141)	(0.125)	(0.129)	(0.336)	(0.299)
$Neigh\_H_{jt} \times Traded\_firm_i$				0.232*				0.736**
				(0.141)				(0.296)
$Traded\_firm_i$				0.138***				0.155**
				(0.031)				(0.064)
Control vairables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	26,816	24,724	2,092	26,816	26,816	24,724	2,092	26,816
R-squared	0.3697	0.3782	0.3563	0.3706	0.3555	0.3643	0.3189	0.3564
F-statistic	120.47***	118.64***	17.01***	117.93***	192.93***	189.08***	37.67***	188.85***

Note: This table reports the results (standard errors in parentheses) specified by Eq. (3) (Model 1 – 3 and 5 – 7) and Eq. (6) (Model 4 and 8), where dependent variables are the number of patents and citations being filed by firms respectively. $Neigh\_H_{jt}$ is distance weighted average H value for state j's all contiguous neighbors. Models employed are all pooled OLS with standard robustness errors. In specific, Model 2 and 6 report the estimations for the subsample firms that operate over larger geographical areas ($Traded\_firm_i = 1$). Model 3 and 7 show the estimations for the subsample firms whose markets are confined to a single banking market ($Traded\_firm_i = 0$). All estimations control for industry, year and state fixed effects. All models include full set of control variables and the results are available on request from the authors. *, ** and *** denote statistical significance at 10%, 5% and 1% level respectively.

Table 7 The Impacts of Banking Market Competition in Neighboring States on the Nature and Risk of Corporate Innovation

Dependent variable	$ln(LowCites)_{it}$		$ln(HighCites)_{it}$		$Generality_{it}$		$Originality_{it}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Neigh\_H_{jt}$	0.138	0.183	0.088	0.108	0.011	0.006	-0.028	-0.014
	(0.131)	(0.641)	(0.117)	(0.090)	(0.023)	(0.023)	(0.022)	(0.021)
$Neigh\_H_{jt} \times Traded\_firm_i$		0.223		0.038		0.040*		-0.004
		(0.629)		(0.072)		(0.022)		(0.020)
$Traded\_firm_i$		0.202*		0.167*		0.027		0.004
		(0.120)		(0.094)		(0.025)		(0.023)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,032	5,032	6,794	6,794	13,324	13,324	13,324	13,324
R-squared	0.4023	0.4048	0.3429	0.3444	0.2584	0.2586	0.0302	0.0305
F-statistic	42.73***	42.10***	44.92***	44.07***	75.99***	56.32***	5.14***	5.09***

Note: This table reports the results (standard errors in parentheses) specified by Eq. (3) (Model 1, 3, 5 and 7) and Eq. (6) (Model 2, 4, 6 and 8), where dependent variables are the underlying risks and nature of innovation. Specifically, $ln(LowCites)_{it}$ ($ln(LowCites)_{it}$) is the natural logarithm of one plus the total number of patents granted by companies in state *j* in year *t* that are in the top (bottom) quartile of year *t*'s citation distribution. $Generality_{it}$ ($Originality_{it}$) is an index measures the percentage of citations received (made) by a patent that belong to a wide range of technology fields. $Neigh\_H_{jt}$ is distance weighted average *H* value for state j's all contiguous neighbors. All specifications are estimated by employing pooled OLS with standard robustness errors. All models include full set of control variables and the results are available on request from the authors. *, ** and *** denote statistical significance at 10%, 5% and 1% level respectively.

Table 8 Robustness Tests for the Impacts of State Banking Market Competition on Corporate Innovation: Alternative Banking Competition Measure

Dependent variable	$ln(Patent)_{it}$			$ln(Citation)_{it}$			$ln(LowCites)_{it}$	$ln(HighCites)_{it}$	$Generality_{it}$	$Originality_{it}$
	OLS	2SLS	2SLS	OLS	2SLS	2SLS	2SLS			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
HHI_{jt}	-1.331***	-1.197***	-1.354***	-1.887***	-2.692***	-2.890***	-0.816***	-0.680***	-0.245***	0.057
	(0.154)	(0.129)	(0.132)	(0.289)	(0.227)	(0.231)	(0.236)	(0.234)	(0.090)	(0.083)
$HHI_{jt} \times Traded\_firm_i$			0.222***			0.234***	0.217***	0.142**	0.019	-0.051
			(0.028)			(0.052)	(0.068)	(0.060)	(0.806)	(0.743)
$Traded\_firm_i$			0.026			0.137**	0.186**	0.167**	-0.007	-0.023
			(0.031)			(0.061)	(0.085)	(0.081)	(0.076)	(0.069)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	23,374	26,816	26,816	23,374	26,816	26,816	5,032	6,794	13,324	13,324
R-squared	0.3585	0.3584	0.3607	0.3532	0.3479	0.3493	0.3767	0.3151	0.2530	0.0207
F-statistic	247.20***	263.44***	253.62***	413.22***	427.22***	410.12***	81.59***	56.26***	156.85***	6.72***

Note: This table reports the results (standard errors in parentheses) for robustness tests of Eq. (1) (Model 1 – 2 and 4 – 5) and Eq. (4) (Model 3, 6, and 7 – 10) by employing Herfindahl-Hirschman as the alternative proxy for measuring the level of banking market competition. The dependent variables are the natural logarithm of one plus the total number of patent and citations, patents in the bottom and top quartile of citation distributions, and the percentage of citations received (made) by a patent that belong to a wide range of technology fields respectively. Models employed are pooled OLS with standard robustness errors (Models 1 and 4) and instrumented two-stage least squares (2SLS) (Models 2 – 3, 5 – 6 and 7 – 10). The instrument used is state median Tier 1 risk-based ratio. All estimations control for industry and year fixed effects. All models include full set of control variables and the results are available on request from the authors. *, ** and *** denote statistical significance at 10%, 5% and 1% level respectively.

Table 9 Robustness Tests for the Impacts of Banking Market Competition in Neighboring states on Corporate Innovation: Alternative Banking Competition Measure

Dependent variable	$ln(Patent)_{it}$		$ln(Citation)_{it}$		$ln(LowCites)_{it}$	$ln(HighCites)_{it}$	$Generality_{it}$	$Originality_{it}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Neigh\_HHI_{jt}$	-0.448**	-0.226	-0.636*	-0.286	-0.486	-0.122	-0.010	0.012
	(0.197)	(0.203)	(0.378)	(0.388)	(0.979)	(0.606)	(0.050)	(0.105)
$Neigh\_HHI_{jt} \times Traded\_firm_i$		-0.584***		-0.795***	-0.782	-0.082	-0.037**	0.032
		(0.137)		(0.240)	(0.969)	(0.053)	(0.016)	(0.041)
$Traded\_firm_i$		0.222***		0.327***	0.436***	0.180**	0.012	-0.017
		(0.029)		(0.057)	(0.113)	(0.084)	(0.021)	(0.021)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	23,374	23,374	23,374	23,374	4,103	5,799	11,505	11,505
R-squared	0.3799	0.3712	0.3630	0.3639	0.4072	0.3053	0.2475	0.027
F-statistic	109.11***	106.78***	181.94***	177.84***	35.91***	38.46***	68.75***	4.77***

Note: This table reports the results (standard errors in parentheses) for robustness tests of Eq. (3) (Model 1 and 3) and Eq. (6) (Model 2, 4 and 5 – 8) by employing Herfindahl-Hirschman as the alternative proxy for measuring the level of banking market competition. The dependent variables are the natural logarithm of one plus the total number of patent and citations, patents in the bottom and top quartile of citation distributions, and the percentage of citations received (made) by a patent that belong to a wide range of technology fields respectively. $Neigh\_H_{jt}$ is distance weighted average H value for state j's all contiguous neighbors. All specifications are estimated by employing pooled OLS with standard robustness errors. All estimations control for industry, year and state fixed effects. All models include full set of control variables and the results are available on request from the authors. *, ** and *** denote statistical significance at 10%, 5% and 1% level respectively.

Table 10 Robustness Tests for the Impacts of Banking Market Competition in Neighboring States on the Level of Corporate Innovation: Alternative Weighted Matrix

Dependent variable	$ln(Patent)_{it}$				$ln(Citation)_{it}$			
	All (1)	Traded (2)	Local (3)	Interaction (4)	All (5)	Traded (6)	Local (7)	Interaction (8)
$Neigh\_H_{jt}$	0.251***	0.279***	-0.090	-0.023	0.125***	0.302***	-0.056	-0.126
	(0.033)	(0.035)	(0.085)	(0.079)	(0.048)	(0.032)	(0.144)	(0.108)
$Neigh\_H_{jt} \times Traded\_firm_i$				0.299***				0.271**
				(0.079)				(0.108)
$Traded\_firm_i$				0.180***				0.122
				(0.058)				(0.132)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	26,816	24,724	2,092	26,816	26,816	24,724	2,092	26,816
R-squared	0.3707	0.3793	0.3566	0.3719	0.3571	0.3662	0.3191	0.3581
F-statistic	120.54***	117.87***	16.78***	118.34***	193.39***	189.88***	37.70***	189.87***

Note: This table reports the results (standard errors in parentheses) for robustness tests of Eq. (3) (Model 1 – 3 and 5 – 7) and Eq. (6) (Model 4 and 8) by measuring $Neigh\_H_{jt}$ using alternative binary weights. The dependent variables are the natural logarithm of one plus the total number of patent and citations. All specifications are estimated by employing pooled OLS with standard robustness errors. All estimations control for industry, year and state fixed effects. All models include full set of control variables and the results are available on request from the authors. *, ** and *** denote statistical significance at 10%, 5% and 1% level respectively.

Table 11 Robustness Tests for the Impacts of Banking Market Competition on the Level of Corporate Innovation between 1997 and 2004

	Home-state Banking Market Competition				Neighbor-state Banking Market Competition				Regional Banking Market Competition			
Dependent variable	$ln(Patent)_{it}$		$ln(Citation)_{it}$		$ln(Patent)_{it}$		$ln(Citation)_{it}$		$ln(Patent)_{it}$		$ln(Citation)_{it}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$\boldsymbol{Tier\ 1\ ratio_{jt}}$	0.744***	1.292***	2.145***	4.275***								
	(0.161)	(0.499)	(0.303)	(1.139)								
$\boldsymbol{H_{jt}}$		-0.576		-2.252**								
		(0.497)		(1.130)								
$\boldsymbol{H_{jt} \times Traded\_firm_i}$		0.500		1.591**								
		(0.314)		(0.712)								
$\boldsymbol{Traded\_firm_i}$					0.308***	-0.206**	0.650***	0.093				
					(0.045)	(0.100)	(0.085)	(0.068)				
$\boldsymbol{Neigh\_H_{jt} \times Traded\_firm_i}$						0.559***		0.849***				
						(0.099)		(0.078)				
$\boldsymbol{Traded\_firm_i}$						0.240***		0.336***				
						(0.075)		(0.117)				
$\boldsymbol{Region\_H_{rt}}$									0.369***	0.366***	0.761***	0.747***
									(0.112)	(0.113)	(0.206)	(0.209)
$\boldsymbol{Region\_H_{rt} \times Traded\_firm_i}$										0.045***		0.074***
										(0.010)		(0.022)
$\boldsymbol{Traded\_firm_i}$										-0.108		-0.210
										(0.067)		(0.139)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effect					Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	15,104	15,104	15,104	15,104	15,104	15,104	15,104	15,104	15,104	15,104	15,104	15,104
R-squared	0.3468	0.345	0.351	0.344	0.3689	0.3706	0.3861	0.3948	0.3675	0.3690	0.3844	0.3854
F-statistic	175.10***	161.8***	312.2***	281.8***	72.44***	71.30***	133.00***	134.99***	72.56***	71.41***	133.08***	130.77***

Note: This table reports the results (standard errors in parentheses) for robustness tests for all specifications by restricting sample between 1997 and 2004, where dependent variables are the number of patents and citations being filed by firms respectively. Model 1 – 4 measures the impacts of home state banking market competition by employing instrumented two-stage least squares (2SLS). The instrument used is state median Tier 1 risk-based ratio. Model 5 – 8 display the effects of banking competition in neighboring state by using pooled OLS with standard robustness errors. $Neigh\_H_{jt}$ is distance weighted average H value for state j's all contiguous neighbors. Model 9 – 12 estimate regional banking market effects. The models employed are instrumented two-stage least squares (2SLS) by using regional median Tier 1 risk-based ratio as the instrument. All estimations of neighboring and regional effects control for industry, year and state fixed effects, while the models of state effects only include industry and year fixed effects because H is derived from state-specific reduced-form revenue equation. All models include full set of control variables and the results are available on request from the authors. *, ** and *** denote statistical significance at 10%, 5% and 1% level respectively.

Table 12 Additional Tests for the Impacts of State Banking Market Competition on the Level of Corporate Innovation: The Role of Information

	Panel A: Kaplan_Zingales Index				Panel B: Patent Types Distribution			
Dependent variable	$\boldsymbol{ln}(\boldsymbol{Patent})_{it}$		$\boldsymbol{ln}(\boldsymbol{Citation})_{it}$		$\boldsymbol{ln}(\boldsymbol{Patent})_{it}$		$\boldsymbol{ln}(\boldsymbol{Citation})_{it}$	
	Low	High	Low	High	Dispersed	Concentrated	Dispersed	Concentrated
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\boldsymbol{H_{jt}}$	2.761***	4.029***	6.124***	8.220***	2.393***	3.506***	3.767***	5.096***
	(0.730)	(1.106)	(1.536)	(2.115)	(0.371)	(0.774)	(0.586)	(1.022)
$\boldsymbol{H_{jt}} \times \boldsymbol{Traded\_firm_i}$	-1.435**	-1.334	-3.011**	-2.459	-2.200***	-0.288	-2.595***	-0.317
	(0.715)	(0.990)	(1.511)	(1.900)	(0.598)	(0.235)	(0.816)	(0.398)
$\boldsymbol{Traded\_firm_i}$	1.044**	0.908	2.048**	1.638	1.704***	0.337**	1.971***	0.453*
	(0.425)	(0.581)	(0.894)	(1.115)	(0.358)	(0.153)	(0.495)	(0.258)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	15,744	11,072	15,744	11,072	3,875	9,449	3,875	9,449
R-squared	0.5866	0.4360	0.6550	0.5135	0.4707	0.3705	0.4018	0.2913
F-statistic	158.11***	73.92***	240.18***	94.91***	77.83***	89.54***	63.33***	86.23***

Note: This table reports the results (standard errors in parentheses) for additional tests for Eq. (4) explaining the heterogeneous treatment effects of own-state banking market competition. The dependent variables are the natural logarithm of one plus the total number of patent. Panel A (Model 1 – 4) examines firms' financial constraints by using Kaplan-Zingales (1997) Index. The 'High' ('Low') subsamples comprise firms with the index above (below) the across-industry median values, and we consider firms in the 'High' subsamples to be financially constrained. Panel B (Model 5 – 8) tests the characteristics of patent types distribution, in which the sample firms with higher (lower) kurtosis of the empirical distribution of patents among 6 different categories than 3 in year *t* are defined to be 'Concentrated' ('Dispersed'). All specifications are estimated by employing instrumented two-stage least squares (2SLS). The instrument used is state median Tier 1 risk-based ratio. And all estimations in the table include industry and year fixed effects. All models include full set of control variables and the results are available on request from the authors. *, ** and *** denote statistical significance at 10%, 5% and 1% level respectively.

Table 13 Additional Tests for the Impacts of Banking Market Competition in Neighboring States on the Level of Corporate Innovation: The Role of Information

	Panel A: Kaplan_Zingales Index				Panel B: Patent Types Distribution			
Dependent variable	$ln(Patent)_{it}$		$ln(Citation)_{it}$		$ln(Patent)_{it}$		$ln(Citation)_{it}$	
	Low	High	Low	High	Dispersed	Concentrated	Dispersed	Concentrated
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Neigh\_H_{jt}$	0.161***	-0.015	0.254	0.047	0.093	0.041	0.023	0.020
	(0.043)	(0.039)	(0.213)	(0.075)	(0.096)	(0.035)	(0.124)	(0.062)
$Neigh\_H_{jt} \times Traded\_firm_i$	0.653***	0.284***	0.735***	0.255	0.593***	0.106**	0.649***	0.266***
	(0.080)	(0.052)	(0.101)	(0.213)	(0.163)	(0.049)	(0.199)	(0.083)
$Traded\_firm_i$	0.214***	-0.020	0.153	-0.212	-0.021	0.119*	-0.088	0.128
	(0.063)	(0.069)	(0.157)	(0.142)	(0.158)	(0.068)	(0.208)	(0.123)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	15,744	11,072	15,744	11,072	3,875	9,449	3,875	9,449
R-squared	0.4217	0.3509	0.4036	0.3276	0.5069	0.3945	0.4348	0.3116
F-statistic	137.59***	73.35***	127.68***	66.10***	48.76***	74.42***	36.49***	51.69***

Note: This table reports the results (standard errors in parentheses) for additional tests for Eq. (6) explaining the heterogeneous treatment effects of out-of-state banking market competition. The dependent variables are the natural logarithm of one plus the total number of patent. Panel A (Model 1 – 4) examines firms' financial constraints by using Kaplan-Zingales (1997) Index. The 'High' ('Low') subsamples comprise firms with the index above (below) the across-industry median values, and we consider firms in the 'High' subsamples to be financially constrained. Panel B (Model 5 – 8) tests the characteristics of patent types distribution, in which the sample firms with higher (lower) kurtosis of the empirical distribution of patents among 6 different categories than 3 in year *t* are defined to be 'Concentrated' ('Dispersed'). All specifications are estimated by employing pooled OLS with standard robustness errors. And all estimations in the table include industry, year and state fixed effects. All models include full set of control variables and the results are available on request from the authors. *, ** and *** denote statistical significance at 10%, 5% and 1% level respectively.