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Abstract: This paper investigates the role of regional financial development, in addition to FDI, for regional innovation in China, using a more recent provincial dataset and more sophisticated panel data estimation techniques than previous studies. Two aspects of regional financial system development are considered: its financial depth and government intervention in the financial system. Estimation results show that the financial depth of a region has a significantly positive effect on regional innovation (patenting) performance. This positive effect is found to be higher for minor innovations such as external design patents than for more complicated innovations such as utility model patents and invention patents. Surprisingly, estimation results do not show that government financial system intervention reduces allocative efficiency of resources which would otherwise impede regional innovation performance.

Keywords: regional financial system, FDI, innovation, patent, regional study, China

JEL classification: G20, O30, O53, R10

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1 Introduction

Chinese policy makers have increasingly set their sights on a leadership not follower status in the innovation ability of Chinese firms and research capability of Chinese universities. A succession of policy reports are increasingly urging for higher Chinese innovativeness (e.g. OECD, 2008; Zhang et al., 2009). For this to happen, Chinese firms are encouraged to engage more intensively in own research and development (R&D) activities and to progressively shrug off their dependence on imported inputs as a way to approach the technical frontier. Simultaneously (selected) Chinese universities are encouraged to invest more financial capital and human resources in enhancing their research capability than decades ago. The changing relevance of spending on R&D and imported knowledge and technologies since the new century underscores the move to make innovation in China both long-term and sustainable.

In this systemic shift in the increasing importance of China's indigenous innovative capacity, a sound financial system with sufficient financial depth and with reduced government intervention in financial resource allocation is expected to be crucial. The need for a sound financial system is made more pressing given that 'lack of capital' is argued to be one of the top constraints faced by Chinese owned firms in pursuing innovation (Zhang et al., 2009: xviii). As suggested by Guillaumont Jeanneney et al. (2006):

'….in order to better improve China's efficiency, further policy measures need to be forwarded in the future to stimulate the development of private-sector-oriented financial intermediation, and to provide greater market access to both private and foreign financial intermediaries.' (Guillaumont Jeanneney et al., 2006: 29)

The issue of improving China's innovative capacity through the development of financial intermediation becomes arguably more tractable when viewed through the lens of Chinese provinces. Here the role of agents like banks and investors which support on-the-ground R&D comes to the fore. Feldman and Florida (1994) in a US based analysis suggest that a country's innovative capacity is best approached within a framework that recognizes the spatial grouping of institutions because a country's innovative capacity is increasingly dependent on infrastructures which help to mobilize inputs like human capital and R&D. Moreover, in the context of China, a regional methodology is especially appropriate because although bank lending to industry can technically transcend regions, the bulk of lending is carried out within each of Chinese provinces, making the savings/investment relationship 'much closer to a between-country level than to a within-country level relative to the evidence based on OECD countries. These comparisons suggest the presence of barriers to capital mobility across the Chinese regions.' (Boyreau-Debray and Wei, 2005: 11). One further, more technical reason, to investigate the finance-growth nexus at a regional level for China is to deflect certain criticisms aimed at standard cross-country growth studies for failing to correctly identify determinants of growth and to deal with inter-country heterogeneity (Hasan et al., 2009; Guariglia and Poncet, 2008). Accordingly, we investigate the issue of Chinese innovation and the role of financial system development in this regard by analyzing a regional panel dataset at the Chinese provincial level. In so doing, unobserved regional heterogeneity is expected to be better taken into account.

Both Zhang et al. (2009) as well as the Chinese Ministry of Finance (MOF, 2007) highlight the need for firms in China to access capital for innovation. As one of the first studies on the role of regional innovativeness in China, Cheung and Lin (2004) focus on the role of FDI for patenting activities at the Chinese provincial level. Building on the Cheung and Lin (2004) investigation, we explore, in addition to FDI, how regional financial system development (i.e. financial depth and government financial interventions) affects regional innovativeness measured by the number of patents applied for in Chinese provinces. To do this, we estimate regional knowledge production functions for China, incorporating variables to proxy regional financial system development. The baseline estimation is implemented for a panel dataset of 30 Chinese provinces (Tibet excluded) for the period from 2000 to 2008. In addition we apply two-way error components estimations which enable us to more explicitly deal with the existence of potential unobserved heterogeneity at both the region- and time-level. We find that our measure of regional financial depth (*CREDIT/GDP* ratio) significantly increases regional innovativeness (patent applications). Such effects are highest for external design patents. Here a 1 percent change in the credit measure corresponds to approximately 0.98 percent increase in patenting intensity, based on the baseline model estimation. Moreover, we find a higher elasticity on the coefficient of lending from non-state owned commercial banks than from state-owned ones, a finding roughly in line with Guan and Liu (2005) who concluded that 'R&D loans from Chinese banks are often policy-oriented and cannot be called 'venture investment funds' in the strict sense' (Guan and Liu, 2005: 238).

The remainder of our paper is organized as follows. In Section 2 we first outline key studies which apply a knowledge production function framework before summarizing work in this area specific to China. This is followed by a review, first of general studies and then China-focused studies, on the role of finance in spurring economic growth. This structure of the literature review is due to the fact that there are not many studies focusing directly on the link between innovation and financial development at the regional level, particularly regarding China. These two literature strands inform our subsequent study. The literature review section is followed by Section 3 in which the key analytical concept of the paper and the data used for the analysis are introduced. The empirical estimation models and our results are presented in Section 4. We conclude in Section 5 by summarizing our key findings and highlighting any policy implications.

2 Literature review

2.1 The concept of knowledge production function

Studies documenting returns to R&D inputs on innovative output, take as their point of departure the conceptual framework applied by Griliches (1979) which was subsequently adapted for use with regional data by Jaffe (1989).[1] Studies applying the knowledge production function describe the production of innovative outputs in a multiple-factor Cobb-

[1] Jaffe applies US state-level data from the 1970's up to the early 1980's for analysis, concluding that corporate patenting is substantially driven by industrial R&D. Regional university R&D is also found to have significantly positive effects on corporate patenting. The return to university R&D is smaller than that to industrial R&D, however.

Douglas framework which relates the outcome variable ‘innovative output’ to one or several R&D inputs (e.g. Fritsch and Slavtchev, 2007). Specifically, innovative outputs are expressed in terms of patents or innovation counts, which are in part driven by R&D inputs. This basic knowledge production framework can be modified to account for different aspects of R&D inputs such as the dichotomy between private- and public sector R&D inputs (Anselin et al., 1997; Fritsch and Slavtchev, 2007). Common to several studies since Jaffe (1989) is that innovative capacity is spatially aggregated. A further common denominator in these studies is their recognition of the significance of regional factors in shaping innovative capacity e.g. regional labor skills as proxied by regional income as in Co (2002), regional unemployment as a proxy for the regional labor market situation as in Bilbao-Osorio and Rodríguez-Pose (2004) or regional population size as a measure of aggregation economies (Fritsch and Slavtchev, 2007).

The development of innovation in a region depends on several input factors (Feldman and Florida, 1994; Anselin et al., 1997; Jaffe, 1989). One primary driver of regional innovation is found to be R&D investment. The US study by Feldman and Florida (1994) concludes that a well-functioning technological infrastructure is important for the innovation performance of a region. They find that if the following four core elements of technological infrastructure of a region, namely industrial R&D, university R&D, co-location of firms in related industries and business services, work together efficiently, the interactive and synergistic effects of such a well-functioning technological infrastructure is key to promoting regional innovation.[2] The relevance of business services for the regional innovation capacity finds additional support in Anselin et al. (1997). The same paper also finds that other local economic variables such as specialization in high-technology, and the presence of large firms greatly moderates the effect of private-R&D on innovation outcomes.

On balance, studies generally find a high and positive relationship between private sector R&D and regional innovation and regional technological infrastructure matters. A skeptic might argue that the regional R&D-innovation nexus is of little interest to policy makers unless a subsequent link can be made between regional innovation and a country’s overall economic growth. Bilbao-Osorio and Rodríguez-Pose (2004) close this circle by estimating a country’s logged GDP growth as a function of both the stock as well as flow in patent applications, in addition to other covariates. They find that stocks and flows of patent applications are strongly correlated with a country’s overall growth. Additionally, their findings suggest some growth convergence in line with neoclassical growth theory whereby countries with lower levels of initial patents (lower stocks of innovations) grow faster.

A final point relates to the most appropriate metric for innovative capacity. Several studies we refer to apply patents as output measures in a knowledge production function setting (e.g. Griliches, 1990; Patel and Pavitt, 1997). It is worth noting that as with many proxy variables, there are some caveats which should be flagged up. The first qualifier regarding this metric concerns the *raison d’etre* of patenting: patents allow a firm to appropriate the commercial value of new knowledge generated within the firm. But there are other ways of protecting new

[2] Feldman and Florida (1994) consider the number of innovative products by region instead of the number of patents as the dependent variable of the knowledge production function to proxy the knowledge output.

knowledge apart from patenting. Secrecy and design complexity represent some of these other ways by which firms can appropriate knowledge without resorting to patenting. It should also be added that not all commercially viable ideas are considered sufficiently novel to justify patenting. Even if patents are awarded on the basis of the novelty of a design, formula or process, this does not necessarily mean that high returns will materialize for the patenting firm. Only a few select patents generate disproportionately high revenues as highlighted by Harhoff et al. (2003). Accordingly, the distribution of patent value is highly skewed with a long right tail associated with the few really valuable patents.

These caveats associated with the appropriateness of patents as a measure for innovative capacity have motivated some studies to apply alternative definitions of the innovation outcome variable. Accordingly, Acs et al. (1992) following Jaffe (1989) similarly estimate the returns to R&D but unlike Jaffe (1989), they apply an 'innovation count' measure. They argue that the outcome variable, 'innovation count', is a more appropriate descriptor of innovative capacity than patent counts, including as it does unpatented innovations and excluding patents offering insufficient commercial value.

On balance, the appropriateness of a suitable metric for a region's innovative capacity is country specific and depends largely on the research focus. Hence the innovation count measure, while arguably an appropriate measure for the US when the focus is on private R&D inputs, may fail to adequately capture the knowledge produced by public sector institutions which may be less willing or able to commercialize new knowledge. Nevertheless, the value of knowledge from such institutions should not be overlooked if it generates externalities for private R&D or labor skills. Patent counts capture activities of public sector institutions because such institutions, even if unwilling to commercialize new knowledge, are more likely to patent knowledge outputs.

There are other reasons for applying patent count measures. In some countries, such as China, due to international property rights system reforms, the reliability of the patent count measure has been greatly improved. A further intuition for applying a patent measure is that patent counts sometimes capture aspects of innovation which escape the pure innovation count measure. The patent count measure available in the China data, allows researchers to differentiate between several layers of innovation complexity and strictness of patenting processes from pure invention patents, to utility model patents and to design patents.

The knowledge production function: evidence for China

The innovation environment in our research region – China is different from its Western counterparts, as is the incentive structure. Regarding the system of intellectual property rights in China, Hu and Jefferson (2009) have this to say, 'China's patent explosion has taken place in an institutional environment that is not known for the rule of law and rigorous protection of intellectual property rights' (Hu and Jefferson, 2009: 67).

However, considerable reforms were carried out in China in 1992 and 2000 raising the returns to patenting.[3] Common to some of the studies on regional innovativeness in China but highly different from the corresponding findings in Western studies is the finding that R&D inputs (e.g. regional private sector R&D employment) are either inefficient or represent the primary driver of regional innovative capacity (Sun, 2000; Guan and Chen, 2010; Chen and Guan, 2010; Cheung and Lin, 2004). There is, in addition, the recognition that the changing structure of Chinese industry with growing shares of non-state enterprises (Non-SOE) should induce firms to seek patent protection more aggressively than before (Hu and Jefferson, 2009).

In light of the ambiguous effect of R&D inputs on regional innovative capacity, we turn to Guan and Chen (2010). They argue that if domestic resources are not effectively used for innovation in China, 'additional investment may be of little help in stimulating scientific and technological progress' (p.172). FDI is considered in some studies as a source of additional investment for innovation. FDI to China, which showed brisk growth until the East Asian crisis in 1998 and which was heavily directed towards the highly-developed coastal region (Cheung and Lin, 2004; Fu, 2008). Sun (2000) considers the impact of foreign owned firms on the spatial distribution of patents in China. However, the effect of FDI, in contrast to that of regional exporting, is found to be insignificant, suggesting foreign ventures to be relatively inactive players in Chinese innovation, a finding which makes sense if foreign firms have chosen to locate their R&D activities in the FDI home country. Cheung and Lin (2004) and Fu (2008) consider the role of FDI in China more directly. Specifically, Cheung and Lin (2004) carry out a study on the innovative capacity of China's provinces for the 5-year period from 1995 to 2000, where innovative capacity is denoted by the number of patent applications. Their main hypothesis is that the investment of foreign investors in China may benefit local innovation activities via different spillover channels such as reverse engineering, labor mobility, demonstration effects and supplier-customer relationships. Similar to Sun (2000), Cheung and Lin (2004) decompose patents into 'invention', 'utility model' and 'design' applications. They control for expenditures on scientific development as well as the number of science-based personnel. Other explanatory variables include export–output ratio of FDI firms and per capita GDP of each province. The results for their pooled panels confirm evidence of positive spillovers from FDI (lagged 1 year) on the number of domestic patent applications for all three types of patents. The spillover effect is especially pronounced for minor innovations like external design patents. 'Demonstration' effects of FDI, which are primarily imitative, would be expected to exert the highest impact on external design innovation. Going beyond the consideration of FDI only, Fu (2008) focuses more on interactions between FDI and regional groupings. Her intuition is that the ability of the coastal regional group to appropriate returns to FDI is higher than that of other groups due to its superior endowment of educated R&D labor and the fact that this region is the recipient of most FDI. A precondition for FDI to spillover is that a region possesses sufficient absorptive capacity. She concludes that over the 2000-2004 period, FDI has been instrumental in promoting regional innovation capacity in more highly developed regions but was less effective in the inland provinces.

[3] Hu and Jefferson (2009) in a firm level study noted significant impacts of these reforms on the level of patenting activity.

What is clear from Fu (2008), is that regional heterogeneity may give rise to different innovation outcomes notwithstanding the injection of similar amounts of regional inputs. This finding is in line with Feldman and Florida (1994) which emphasize the substantial importance of properly functioning technological infrastructure of a region for its innovation propensity. Studies dealing with regional innovativeness in China also try to take such regional heterogeneity into account in different ways. For example, Cheung and Lin (2004) control for per capita GDP of each province in an effort to neutralize the effects of regional disparities in development. Guan and Liu (2005) look more explicitly at these disparities. Their core idea is that regional inequalities will hinder the delegation of autonomy for R&D spending to China’s provinces. Employing a system of ridge-regressions they find, similar to previous work, that private enterprise R&D contributes least to regional innovation capacity. Interestingly, they also find evidence that the returns to regional innovation from self-raised (as opposed to bank raised) funds are higher. They conclude from this that ‘the R&D loans from Chinese banks are often policy-oriented and can’t be called ‘venture investment funds’ in the strict sense.’ (Guan and Liu, 2005: 238).

2.2 The finance-growth nexus

The finding from Guan and Liu (2005) that returns to regional innovation from self-raised (as opposed to bank raised) funds are higher, indirectly suggests that less properly functioning financial intermediaries may hinder a region from reaching a higher innovation propensity and furthermore from faster growth. There is, however, no one-size-fit-all constellation of financial intermediaries to support regional innovativeness and to promote regional and/or national growth. Hall (2005) argues, for example, in countries with underdeveloped venture capital markets (e.g. China), the burden of shouldering innovation may well fall to the banks. Hall goes on to argue that different financial intermediaries do not operate completely independently and indicates that stock markets in Western economies respond, for example, favorably to new bank loan offers, since investors see the banks as helping to reduce information asymmetries.

Financial intermediaries represent a vehicle by which savings from private households are channeled to industry (Pagano, 1993). But the scope of financial intermediaries does not limit itself to the investment channel. Intermediaries also identify and select projects with the best chances of generating a positive return (Pagano, 1993; King and Levine, 1993a).

Apart from the screening role of financial intermediaries, a further argument for financial intermediaries in promoting innovation is their ability to increase the amount of funding available to risky innovation by holding diversified portfolios (King and Levine, 1993a). This ability neutralizes risk and encourages investment in innovative activities which feed a country’s growth.

Specifically, King and Levine (1993a) who study 77 countries over the period 1960-1989, controlling for the drivers of long-run growth, analyze whether the level of financial development predicts long-run economic growth, capital accumulation, and productivity growth. They apply several measures of financial development, including ‘depth’ (size of financial intermediaries in terms of liquid liabilities scaled by GDP), ‘bank’ measuring the extent to which the commercial and central bank allocates credit and 'privy' denoting credit to private enterprises divided by GDP. The intuition for this latter measure is that financial systems allocating more credit to private firms are more likely to perform a screening role. King and Levine (1993a) evaluate the strength of the empirical relationship between these banking measures and indicators of a country's level of and growth in GDP and total factor productivity, and growth in capital stocks. Financial development is averaged for the 1960-1989 period. Their cross-section regressions show that there is a strong positive relationship between each of the financial development indicators and the three growth indicators. The coefficient sizes are economically large. Moreover, the coefficient on 'depth' implies that a country increasing this measure from the mean of the slowest growing quartile of countries (0.2) to the mean of the fastest growing quartile of countries (0.6) would have experienced a per capita growth rate of almost 1 percent per year.

A skeptic could argue that financial institutions deepen *in response to* growth and that the direction of the relationship is from growth to financial deepening. To address this concern, King and Levine (1993a) ascertain whether the value of financial depth in 1960 predicts growth rates for the subsequent 30 years. Their results show that financial depth in 1960 is a good predictor of subsequent growth rates. However, it could still be argued that financial markets might merely have arisen in order to meet the demands imposed by future growth. To more explicitly deal with the causality issue, Levine et al. (2000) apply measures of legal origin as instrumental variables arguing that a country's legal origin (British, French, German or Scandinavian law) shapes its financial development and that legal origin is fully exogenous to growth as most countries 'received' their legal systems through a process of colonization. Since finance is grounded in the enforcement of contracts, legal origins ensuring investor protection perform better at promoting financial development.

Following King and Levine (1993a), Levine et al. (2000) analyze a cross-section of 71 countries with data averaged over the period 1960-1995. They perform a set of generalized method of moments (GMM) regressions for per capita GDP growth over the 1960-95 period. Their use of linear moment conditions requires that the instrumental variables are uncorrelated with the error term, an assumption they test using the standard overidentification tests. They add to King and Levine's (1993a) three financial system descriptors by formulating a new measure of overall financial development, 'private credit', which denotes the volume of credits by financial intermediaries to the private sector divided by GDP. Their findings show a very significant connection between the development of financial intermediaries and growth. This strong link is not an artifact of simultaneity bias.

Trew (2006) flags up some of these issues in his review of work by King and Levine (1993a), Levine et al. (2000) and others and calls, inter alia, for more research based on a sub-national level (e.g. on the activities of financial intermediaries aggregated to the regional level) and for research to focus on transitional countries (e.g. China). In this way, data provides a snapshot of an economy whose financial development is still in a state of flux (financial development is not invariant over time).

Financial development and finance-growth nexus in China

The Chinese banking system is highly singular. It is dominated by the Big Four state-owned commercial banks (SOCBs) holding from half to three quarters of industry assets (Hansakul, 2004; Geretto and Pauluzzo, 2009).[4] An additional singularity of the Chinese banking system is that the dominant market share of the Big Four is largely a result of their policy mandate to support China's State-Owned Enterprises (SOEs). However, since China's accession to the World Trade Organization (WTO) in 2001, significant reforms of the banking system have taken place (Hansakul 2004; 2006). One major reform being a relaxation of the rules on foreign ownership whose introduction was staggered across time and provinces (Hansakul, 2004; 2006; Berger et al., 2009). In spite of such progress made, Hansakul (2004) refers to the enduring 'legacy of the centrally-planned economy in which the government, both at central and local levels, continues to play an instrumental role in credit allocation and pricing of capital' (Hansakul, 2004: 3).

A study which echoes Hansakul's (2004) view that central Government still has a major say in distributing funds throughout China's provinces via the Big Four, is the regional analysis by Boyreau-Debray and Wei (2004). Specifically, they estimate the effects of capital flows on the marginal productivity of capital for the period 1952 to 2001, a period straddling the pre-reform and reform periods. They find that the coefficient on regional GDP growth is negative and statistically significant, indicating a tendency for capital to go to less productive regions. The patterns of capital flow in China towards less developed regions subvert the accepted wisdom that capital should flow to the most productive regions in line with allocative efficiency arguments. The State's main objective appears not to maximize efficiency but rather to channel capital to poor, slow-growing regions with the aim of reducing poverty (Boyreau-Debray, 2003; Boyreau-Debray and Wei, 2004). Capital reallocations are carried out via the SOCBs which provide preferential credit treatment to provinces with lower levels of economic development (Hao, 2006). Accordingly, Boyreau-Debray and Wei (2004) argue that 'a smaller role of the government in the financial sector might increase the rate of economic growth' (Boyreau-Debray and Wei, 2004: 5). Interestingly, they observe that patterns of capital flows *within China* bear a striking similarity to patterns of international capital movements, a conclusion which calls for methodologies allowing for regional heterogeneity in capital flows.

On balance, our earlier review of the literature on financial sector development on growth (e.g. Levine, 2005) suggests that banks are able to identify creditworthy projects, mobilize savings, pool risks and reduce transactions costs. Accordingly, a deeper financial sector should accelerate growth. However, as illustrated above, the financial sector in China is still subject to high levels of government intervention, implying that studies on financial development in China might not find a positive effect for the financial development-growth nexus (Hasan et al., 2009).

[4] Geretto and Pauluzzo (2009) estimate the market share of the Big Four at 52 percent. Given that their estimates date to 2009, we take this as the most accurate approximation for market share.

At the regional level, there is an abundance of work on China's finance-growth nexus.[5] Several of these studies follow Levine et al. (2000) by applying a System GMM methodology to deal with weak instruments, reverse causation and omitted variable bias (e.g. Hasan et al., 2009; Guariglia and Poncet, 2008; Cheng and Degryse, 2010).

To summarize these empirical findings, Cheng and Degryse (2010) describe the literature as being split on the effect of finance on growth in China. Most studies find that the banking sector is too weak to enforce sound governance and therefore a positive finance-growth nexus does not exist in China (e.g. Allen et al., 2005; Boyreau-Debray, 2003). Specifically, Boyreau-Debray (2003) find a negative impact on growth for increased levels of banking sector credit which she attributes to the burden of underpinning SOEs. Guariglia and Poncet (2008) employing an especially rich set of financial development descriptors find that banking indicators where government interventions are expected to be higher (e.g. higher ratio of lending by SOCBs) are generally significantly and negatively associated with regional growth. Conversely, Liu and Li (2001) analyzing the links between investment by SOCBs, self-raised funds and foreign direct investment on regional growth for the years 1985 to 1998, find a positively significant coefficient for increases in capital from national bank loans. Aziz and Duenwald (2002) using Chinese provincial data for the period 1988- 1997 do not find that bank lending boosts regional growth. Cheng and Degryse (2010) estimate the effect of financial development on gross provincial output for 27 Chinese provinces (years 1995 to 2003). They include FDI as an additional covariate. In addition to formal banking, Cheng and Degryse (2010) also consider informal sources of credit. Like Guariglia and Poncet (2008) they differentiate between non-bank and bank activities in their financial development measures. They find that bank credit exerts a significantly positive effect on regional growth and that this result is economically important. Finally, Hasan et al. (2009) in their investigation using data for 31 Chinese provinces (1986 to 2002) where financial and institutional variables are assumed endogenous to the system, find a significantly positive effect for private equity but not for banking on regional 3-year average growth rates. Guariglia and Poncet (2008) allude to some lack of consensus among these studies which may be explained by the application of different financial indicators, methodologies or time periods.

Difference and generality in the growth measures used may be one of the reasons behind the inconclusive findings regarding the overall contribution of financial development on growth for China. Against such background, Guillaumont, Jeanneney et al. (2006) apply the DEA technique used also by others reviewed earlier (Guan and Liu, 2005; Chen and Guan, 2010) to calculate by how much total factor productivity growth results from technical progress (frontier shifting) and by how much it owes to efficiency changes (movements towards the technical frontier). They find that growth is primarily driven by technical progress rather than

[5] It is appropriate to examine the determinants of growth at this sub-national level because although bank funding can technically transcend regions, the bulk of lending is carried out within the region. Indeed, the Boyreau-Debray and Wei (2005) report on markets integration in China suggests the presence of barriers to capital mobility across the Chinese regions, thereby underpinning the validity of methodologies viewing the finance-growth nexus at the regional level. There is a further more technical reason underpinning the decision of some researchers to investigate the finance-growth nexus at this level of aggregation. In so doing, Hasan et al. (2009), for the same reason as Guariglia and Poncet (2008), opt to deflect some criticisms aimed at cross-country growth studies.

efficiency improvements. Interestingly, when they estimate a standard GMM to calculate the impacts of financial development on total factor productivity growth, they find a significantly positive effect although this effect is mainly mediated through efficiency.

To conclude, we reviewed above the literature on knowledge production functions (KPFs) and the finance-growth nexus with special attention for studies on regional and Chinese issues. Inspired by these works, in the rest of the paper we will insert within a KPF framework quantitative measures of financial development as illustrated in the next section.

3 Model specification and data description

3.1 Basic model specification

As introduced above, properly functioning technological infrastructure of a region is key for a high regional innovation propensity. The existence of a well-functioning financial system is implicitly assumed to be given in this regard. However, such assumption is unrealistic especially in case of emerging countries like China. Against the background that regional financial systems in China have been continuously improved over the past decades, several studies tried to analyze the relationship between financial development and growth in China. However, results are rather inconclusive. Building on the previous literature, this paper aims at explicitly analyzing the role of regional financial development for exclusively regional innovativeness in China, i.e. a crucial component or driver for sustaining its long-term economic growth.

To do so, this paper is based on the concept of knowledge production function for analysis and builds on the research by Cheung and Lin (2004). Our focus on investigating the role of financial development in addition to FDI for regional innovativeness is not the only novelty of the current paper compared to Cheung and Lin (2004). The second novelty is our use of modern econometric techniques which enables us to more explicitly deal with the potentially existing unobserved heterogeneity problem at both the region- and time-levels. More concretely, we assume a Cobb-Douglas knowledge production function as in other related literature (see Section 2). As a consequence our baseline model after log-log transformation is as follows:

$$Y_{it} = \alpha + X'_{it}\beta + u_{it} \qquad (1)$$

where Y is a dependent variable measured in logged number of patents to proxy innovativeness in the Chinese province i and in the year t, α and β are coefficients to be estimated, X is the vector of regressors and u is the error.

To proxy regional innovativeness, the number of total patent applications in China by Chinese province and time is initially used ($PATall_{it}$). In addition, numbers of three different patent applications – invention patents, utility model patents and design patents - are considered as dependent variables ($PATinv_{it}$, $PATuti_{it}$, $PATdes_{it}$). These three types of patents are different from each other in terms of how radical and novel is the commercial knowledge generated, the application requirements, the length of application processing time, and the length of protection term.[6] The consideration of different types of patent applications enables a more explicit analysis on potentially different roles of regional financial system and FDI for realizing innovations (patents) with different novelty, inventiveness and value.

Turning to the vector of regressors X, three groups of variables are considered:

$$X'_{it} = (X^{fdi}_{it} \quad X^{fs}_{it} \quad X^{c}_{it}) \tag{2}$$

where X^{fdi}_{it} is a variable to proxy FDI measured by the foreign funded part of total investment of (partially) foreign funded companies in stock in US$100 million ($FRCF_{it}$), and X^{fs}_{it} is the vector of variables to reflect the development of regional financial system in terms of financial depth and government intervention. Following Guariglia and Poncet (2008), the overall depth of regional financial system is measured by the ratio of total (bank and non-bank) loans to GDP ($CREDIT/GDP_{it}$) and the potential of government intervention and, thus, potential distortion in regional financial system is measured in the ratio of loans of SOCBs to GDP ($SOCBCREDIT/GDP_{it}$). All these three variables are considered with one-year lags, in order to take into account the potential time lag between the availability of financial resources for being used to finance innovation activities and the realization of innovations for being patented. X^{c}_{it} is the vector of control variables by region and time such as personnel for Science and Technology (S&T) activities[7] ($S\&Tper_{it}$), S&T expenditure ($S\&Texp_{it}$), global engagement ($EXPORT/GDP_{it}$) and GDP per capita ($GDPpc_{it}$) which were found by previous literature to be also determining for regional innovativeness (e.g. Cheung and Lin, 2004). All the independent variables considered in the vector of regressors in the estimation models are log-transformed.

[6] According to the SIPO (2008), invention-creations refer to inventions, utility models and designs. Inventions are new technique programs/projects proposed for products, methods and/or improvement in products and methods. Utility models are new and applicable technique programs/projects proposed for the form, structure or combination of these two elements of products. Designs are industrially applicable new design proposed for the form, figure, color or combination of these elements of products. To apply for an invention patent, the invention-creation of focus must fulfill the requirement of “novelty, inventiveness and practical applicability”. The corresponding application processing work of the Patent Administration Department under the State Council consists of a preliminary examination which lasts no longer than 18 months and an examination as to the substance of the invention-creation considered. Given no cause for rejection of the application after the examination as to its substance, the patent right is to be granted to the invention-creation of focus. The term of protection of an invention patent is 20 years. In contrast, the application requirements are less demanding and thus the processing time lasts normally about 6 months or less for utility model and design patent applications. Although invention-creation, for which a utility model patent is applied, should also fulfill the requirement of “novelty, inventiveness and practical applicability”, no examination as to its substance is required. In case of no cause being found after the preliminary examination for rejection of the utility model or design patent application, the corresponding patent right is to be granted to the corresponding invention-creation of focus. Accordingly, the protection term for these two patent types is also shorter (10 years only) than that of an invention patent.

[7] S&T activities refer to activities strongly related to production, development, distribution and application of scientific knowledge (e.g. NBSC-CNYBST (2009)). Due to the broadness of the “invention-creations” considered in our analysis – inventions, utility models, and designs, we decided to consider the broader definition of innovation inputs, namely S&T related variables instead of R&D related variables, in our estimation models to proxy the innovation efforts made by innovators by region and time.

3.2 Data description

A summary of descriptive statistics of variables considered in the estimation models is presented in Table 1. The dataset for 31 Chinese provinces we need to construct the variables is obtained from three main Chinese official statistical yearbooks in various years. First, innovation-related data are obtained from the China Statistical Yearbooks on Science and Technology (NBSC-CNYBST) to construct patent- ($PATall_{it}$, $PATinv_{it}$, $PATuti_{it}$, $PATdes_{it}$) and S&T-related variables ($S\&Tper_{it}$, $S\&Texp_{it}$). Second, financial data are obtained from the Almanac of China Finance and Banking edited by the People's Bank of China (PBC-ACFB[8]) to construct variables of development of regional financial systems ($CREDIT/GDP_{it}$, $SAVINGS/GDP_{it}$, $SOCBCREDIT/GDP_{it}$, $NONSOCBCREDIT/GDP_{it}$). Third, data are obtained from the China Statistical Yearbooks (NBSC-CNYB) to construct FDI-related variables (TIF_{it}, $FRCF_{it}$) and other control variables ($EXPORT/GDP_{it}$, $GDPpc_{it}$).

Annual statistical data for all variables considered except for those variables of regional financial system development are for the years from 2000 to 2008. Data measuring the overall depth of regional financial systems are available for the years from 2000 to 2007, while data on SOCBs, measuring potential government intervention in regional financial system are only available for the years from 2001 to 2004.

Due to the high relevance of the FDI-related variables as well as the variables of the development of regional financial systems for our paper and due to the problem of limited data availability, the data used for constructing these variables deserve some explanation. Regarding the FDI-related variables, the regional FDI data are only available from the NBSC-CNYB until 2003. This restricts us from using such data to estimate the relation between FDI and regional innovativeness as per Cheung and Lin (2004). As a result, to proxy the investment of foreign investors in China, we opted for alternative data. A possible option is total investment of registered foreign funded enterprises in China at the end of each year, according to the registration information of these enterprises. Total investment of registered foreign funded enterprises (*TIF*) is the amount of investment, including capital for basic infrastructure and working capital, to be invested in supporting the establishment's production as specified in the individual enterprise regulations, which foreign funded enterprises are required by law to formulate. The TIF amount consists of, in practice, the amount of registered capital of the foreign funded enterprises and the loans they obtain for running the business operations.[9] In contrast to aforementioned FDI data, the TIF data are available for the whole research period of this paper. However, these data are also imperfect. That is the TIF amount of foreign funded enterprises, which does not have to be totally foreign owned, may also come from the investment of Chinese partners to the enterprises. Thus, a higher amount of investment must not imply a stronger engagement of foreign investors. To deal with this caveat, we proxy FDI using the foreign funded part of the total registration capital of

[8] Chinese version.

[9] By law there is a clear regulation upon the relations between the TIF amount and the amount of registered capital. In case of the TIF amount not higher than US$3 million, the registered capital-to-TIF ratio should be at least 70%. The ratio is decreasing with the TIF amount. In case of the TIF amount higher than US$30 million, the ratio should be at least 1/3 (SAIC, 1987).

(partially) foreign funded companies (*FRCF*).[10] Though registered capital must not be already invested by the (foreign) investors at the time of registration, (foreign) investors are required to invest the full amount of registered capital within a limited period of time.[11] Such requirement is expected to mitigate the potential problem of overestimating the real amount of foreign investment at the point of time of consideration.

Regarding the data used to construct the variable to proxy the potential extent of government intervention in regional financial system, some remarks are worth noting. First, as mentioned above, the related data (*SOCBCREDIT*) are only available for the period from 2001 to 2004. After 2004, such data are only available for some but not all four SOCBs.[12] In addition, PBC-ACFB provides data on loans in RMB approved by individual SOCB and on loans in foreign currency offered by the corresponding SOCB. The latter one is presented in US$ in PBC-ACFB. The total amount of SOCBCREDIT by year is the sum of both types of loans over the four SOCBs. The exchange rate used to recalculate the loans offered in US$ in the year *t* into RMB is an average rate based on monthly data in the year *t*. The monthly exchange rate data are also obtained from the PBC (PBC).[13]

As seen in Table 1, no province in China exhibits zero annual patent applications over our research period. All kinds of innovators in each Chinese province apply for at least 15 and at most 128,002 patents annually. They seem to be more willing or more capable of applying for design patents than for invention and/or utility model patents. The maximum of the annual amount of design patent applications of a single province over the research period amounts to 82,022 units, almost three times the respective maximum amount of invention patent applications and utility model patent applications. On average, innovators in each Chinese province apply for about 10,802 patents per year, of which 23.6% are invention patents, and 35.6% and 40.8% are utility model and design patents, respectively. The high standard deviations of all patent applications and applications of three different types of patents, however, suggest that Chinese provinces are strongly different from each other in their innovation performance, i.e. in producing “invention-creations”. Different amounts of innovation inputs, e.g. S&T personnel and S&T expenditure, which are invested in the innovation activities, could be expected to be one of the main reasons behind such a substantial difference in innovation performance among Chinese provinces. Indeed, this conjecture receives some support in Table 1, where the standard deviations of S&T personnel and S&T expenditure are also found to be at quite high levels. On average, innovators in each province annually invest 14.5 billion RMB and employ 122 thousands persons in carrying out

[10] TIF would only be used as alternative FDI proxy for rebustness check.

[11] The length of such period is different across foreign funded enterprises by size of registered capital. Investors from enterprises with registered capital not higher than US$500,000 are required to invest the full amount of registered capital within one year after receiving the enterprise operation license, while those from enterprises with registered capital more than US$3 million but not higher than US$10 million are asked to pay off the investment within 3 years. The length of time for paying off the investment in case of registered capital higher than US$10 million will be examined according to the situation by the official bureaus in China case by case (SAIC, 1994).

[12] The four SOCBs are Agricultural Bank of China, Bank of China, China Construction Bank, and Industrial and Commercial Bank of China. Agricultural Bank of China is the only exception, from which *SOCBCREDIT* data can be obtained from 2001 to 2007.

[13] Data from Industrial and Commercial Bank in 2004 is the only exception. For that year, the bank only provides data of loans offered in US$ and data of total loans in RMB.

S&T activities. However, there are some provinces, in which innovators invest less than 1% (2%) of the average S&T expenditure (personnel) for innovation, while there are also other provinces, in which innovators invest about eight (four) times as much as the average S&T expenditure (personnel) for innovation.

Returning to the focus of our analysis, namely the drivers of provincial innovativeness in China, the average amount of total investment of foreign funded companies at the Chinese provincial level reaches about US$45 billion and that of registered capital from foreign investors of foreign funded companies US$19 billion, i.e. about 43% of the average total investment. Again though the amounts of FDI proxied by *FRCR* and *TIF* are different across Chinese provinces, no province exhibits zero foreign investment. The highest amount of *FRCF (TIF)* is about ten (nine) times the corresponding average amount, while the lowest amounts of *FRCF* and *TIF* are much less than 1% of the corresponding averages. In this context, given that foreign investors may bring to China not only financial capital but also advanced technologies and know-how, no Chinese province is fully excluded from the advantage of foreign investment but the advantage obtained may differ in size.

However, lower amounts of foreign investment in certain provinces must not imply that the availability of financial resources to support innovation activities of those provinces is per se restricted. Based on studies introduced in Section 2, a province having a regional financial system offering higher financial depth and lower government intervention is expected to be able to smoothen and facilitate the circulation of capital, thereby enhancing the efficiency of resource allocation and promoting innovation-driven growth. As to financial depth, the average ratio of total credit[14] (savings)[15] to GDP amounts to 106.7% (142.9%). The substantial difference between these two ratios suggests that there is still a large share of financial deposits by region not yet being efficiently allocated for economic use, leaving a substantial potential for further improvement. The ratio we use to proxy the government intervention in regional financial systems is about 68% on average, suggesting that on average about 64% of total credit by province is offered by SOCBs. Compared to other variables considered so far, different provinces in China seem to be less different from each other with respect to the development of regional financial systems, with the maximum ratios about only 2 – 3 times the average ratios and the minimum ratios more than half of the averages. The lower difference across provinces in this regard could be to some extent a result of general government policies to reform financial systems in China during the past decades.

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[14] Total credit refers to total loans (in RMB and in foreign currency) provided by banks and non-bank domestic financial intermediaries. Some data limitation is worth being noted. In 2001, for all provinces only data of loans in RMB were available. In 2002, for Guangdong, Yunnan and Hebei only data of loans in RMB (but not in foreign currency) were available. In 2003, for Hebei only data of loans in RMB (but not in foreign currency) were available. Data of Beijing have included loans provided by foreign financial intermediaries in Beijing since 2002. We were aware that due to such data limitation, the dataset we have for analysis may not be optimal. However, such (slight) inconsistency of data is difficult to be completely avoided in a country like China where financial reforms are in progress (especially after the accession to the WTO). In addition, due to the still relatively strong regulations upon foreign financial operations in China, thus foreign financial operations rather playing an insignificant role in the overall financial operations in China, our dataset could be at least the second best one which we could ever obtain for our analysis.

[15] Total savings refer to household savings in total. Same restrictions as those of total credit also apply here.

Based on the analysis so far it is clear that Chinese provinces are heterogeneous in both innovation-related and financial aspects, while the provincial heterogeneity in the former aspect seems to be even larger than the latter one. However, Chinese provinces are not only heterogeneous in these two specific economic aspects. As regards export activities – the main driver for economic growth of China over the past decades and the GDP per capita at the provincial level, high heterogeneity can also be observed. The average export-to-GDP ratio ($/RMB) across provinces and over the research period amounts to 2.2%, which means that the export value in RMB amounts to about 17.63% of the GDP in RMB on average.[16] The higher than average standard deviation (2.7) implies the existence of high differences among Chinese provinces in exporting and thus in profiting directly from exports for economic growth. The minimum ratio is less than one seventh of the average ratio, while the maximum ratio is more than five times of the average one. Different economic backgrounds and different levels of global integration may be further reflected in differences in regional GDP. The average GDP per capita of a province is 15,000 RMB over the research period, with GDP per capita of the least (most) developed province amounting to about one-fifth (almost five times) of the average one.[17] Such different developing background and resource endowments accumulated over time are expected to have certain effects on innovation preferences and performances of different provinces.

[Table 1 about here]

4 Econometric Analysis

4.1 Estimation models

Following our research goal, several panel data estimations are performed on the basis of Baltagi (2003). First, to enable a comparison between our findings with those of Cheung and Lin (2004) we estimate a one-way error component model (ECM),

$$Y_{it} = \alpha + X'_{it}\beta + \gamma_i + u_{it} \tag{3}$$

where $X'_{it} = \left(X_{it}^{fdi} \quad X_{it}^{c}\right)$, γ is the time-invariant region-specific effect and, u_{it}, the error term, which is assumed to be i.i.d. with distribution $[0, \sigma_u^2]$. Here we focus only on the role of FDIs for regional innovativeness in China and not on that of the regional financial system. In addition to within and random effects estimations, OLS estimations are also carried out (Table 2).

Second, we insert in our model the *CREDIT/GDP* ratio and we switch to a two-way error component model in order to better control for time specific factors:

$$Y_{it} = \alpha + X'_{it}\beta + \gamma_i + \delta_t + u_{it} \tag{4}$$

[16] The average exchange rate for the period from 2000 to 2008 was 8.01 [RMB/$] (PBC).

[17] See Table A1 in Appendix A for more information on the Top-10 ranking by province in innovation, foreign investment, financial system development and economic development at the beginning and the end of the research period.

where δ is the time effect (Table 3). Most previous literature dealing with regional issues in China excluded Tibet from the analysis. To enable a comparative approach, most of our estimations are conducted focusing only on 30 Chinese provinces, i.e. excluding Tibet. However, supported by the dataset we have, as a robustness check, we include Tibet and rerun our baseline model estimation. While doing so, in order to investigate the robustness of the relation between FDI and regional innovativeness, we also use a different variable to proxy FDI, "*TIF*" (Table 4).

Furthermore, regarding financial depth, following the example of King and Levine (1993b) and Levine (1997) – which use among various measures of financial development also the ratio of liquid liabilities of financial intermediaries over GDP - we consider, as a substitute for the "*CREDIT/GDP*" ratio included in previous estimations, another variable, namely "*SAVINGS/GDP*", defined as the ratio of total households' deposits in financial intermediaries over GDP (Table 5). The soundness of this last exercise is confirmed also by the fact that various studies have found capital mobility across provinces to be rather low (Boyreau-Debray and Wei, 2004). In addition, we check whether the finance-innovation nexus is the same across Coastal, Central or Western provinces (Table 6).[18] Then, in order to consider regional financial development with respect to government intervention, we distinguish between the *SOCBCREDIT/GDP* and the loans of non-SOCBs to GDP ratio (*NONSOCBCREDIT/GDP*). The numerator of the latter ratio, namely the *NONSOCBCREDIT*, was obtained by subtracting *SOCBCREDIT* from the total credit by province and time (*CREDIT*). For the estimations we consider also the impact of their interaction on innovative performance (Table 7).

4.2 Estimation results

The general picture that emerges from all these econometric procedures is that the results obtained by Cheung and Lin (2004) that FDI has positive spillover effects on regional innovation measured in number of patents applied do not hold for our sample. In particular, once the estimations move from an OLS to a Within estimator, which is favored by the Hausman test over the random effects estimator, the magnitude of the FDI effect becomes smaller and its significance turns out to be much weaker (Table 2). Both S&T related variables are found to be positively relevant, though not always significant, for regional innovation in China. The other two control variables, *EXPORT/GDP* and *GDPpc*, are also found to be positively relevant in this regard. The positive effect of GDP per capital is found to be significant in most of the Within estimations. Results with respect to the effects of the control variables considered are in line with our expectation that regions with larger investment in innovation, with stronger integration into world trade and with more advanced economic development are more capable of carrying out innovation activities, which in our case are measured in the number of patents applied in regions considered.

[18] The prevalently used definition as Cheung and Lin (2004) is applied here: coastal provinces (Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Guangxi, Hainan), central provinces (Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan), and western provinces (Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang).

[Table 2 about here]

Different data used to proxy FDI could be one possible explanation for the different findings regarding the effects of FDI on regional patenting. However, such differences could be also attributed to the different research period considered by both studies. Compared to the research period considered by Cheung and Lin (2004), we based our analysis on more current dataset. Although FDI may in latter periods have been a mainspring of innovation and technological advancement in China, in contrast to Cheung and Lin (2004), our findings using more recent data suggest that the role of FDI may be gradually substituted by "domestic" financing channeled by financial intermediaries within the continuously improved financial system in China. Indeed, once shifting from the one-way to the two-way error component model and inserting the first lag of *CREDIT/GDP* into the estimation model to proxy the regional financial system development, the variable *CREDIT/GDP* is found to have significantly positive effects on regional patenting in China. The coefficient of this variable is positive and significant both for the within and the random effects estimator, which, in this case, is the one preferred by the Hausman test. Furthermore, all the tests for the presence of two error components – such as the Breusch and Pagan (1980), the Honda (1985), the King and Wu (1997), the Standardized Lagrange Multiplier and the Gourieroux, Holly and Monfort (1982) tests - support the model (Table 3). The good performance of the financial development variables is not harmed by changing the FDI variable, moving from *FRCF* to *TIF* and including Tibet in the sample (Table 4) or using, as an alternative measure of financial development, the first lag of *SAVINGS/GDP* (Table 5). Consistent with the baseline model in which only the FDI variable and regional financial system variables are included, the coefficient of FDI is not found to be significant for regional patenting across all the estimation models in the three last mentioned tables. Such findings suggest that in case of China, domestic financing seems to have become more and more relevant for innovators who tend to make use of the increasingly higher financial depth of regional financial systems more strongly than before. Operating in regions with a higher financial depth may enable innovators to more easily obtain financial resources to support their innovation and patenting activities. In addition, estimation results show that such positive effects remain significant across all estimation models irrespective of patent type which as a dependent variable proxies for regional innovativeness. What is interesting is that such positive effects seem to be relatively higher in the case of minor innovations, i.e. external design patents, than in case of more complicated innovations, i.e. invention patents and utility model patents. This finding is similar to Cheung and Lin (2004)[19], though their finding related to FDI spillover effects instead of effects of domestic regional financial depth. The lack of innovation capabilities and experience of most innovators in China could hinder innovators especially in numerous small- and medium-sized enterprise category from obtaining large bank loans to support more complicated but also costly innovation activities. Such restrictions force them to focus more strongly on obtaining small loans to carry out less complicated innovation activities and to come up with new designs as innovation outcomes. In contrast, larger companies or more qualified universities are better equipped with both internal financial and human capital. This reduces on the one hand their reliance on regional financial systems to finance their

[19] Cheung and Lin (2004) found that FDI spillover effects are higher in case of minor innovations, i.e. external design patents, than in case of more complicated innovations.

innovation activities. On the other hand, they are more capable of carrying out more complicated innovation activities with invention patents as innovation outcomes. That more S&T innovation inputs are required to carry out more complicated innovation activities also finds some support in the estimations which show that coefficients of S&T relevant variables are found to be rather significant and positive in the case of where invention or utility model patents are used as a proxy for regional innovativeness.[20]

[Table 3 – 5 about here]

In Table 6, we investigate instead whether significant statistical differences exist in the finance-innovation nexus in Western, Central and Coastal provinces. The first lag of the log of *CREDIT/GDP* turns out to be insignificant, for Western provinces alone. The Western provinces have a higher average of *CREDIT/GDP* than Coastal or Central provinces, with values of 116.94, 90.51 and 113.99 respectively. The higher average share in the relatively underdeveloped Western provinces in China gives some support to our argument above that financial system development is part of the economic reform in China which emphasized promoting a more harmonized economic development across regions in China especially since the turn of the century. The insignificance of the log of *CREDIT/GDP* among Western provinces may not be that implausible when considering the following two points. First, there is evidence in the international literature on the finance-growth nexus, that the real effects of the *CREDIT/GDP* ratio tend to disappear as the ratio rises (e.g. De Gregorio and Guidotti, 1995; Deidda and Fattouh, 2002; Rioja and Valev, 2004; Shen and Lee, 2006; and Vaona and Patuelli, 2008). Second, Western provinces are on average the least developed provinces in China. In order to promote the economic development on site, the Chinese government has increased its financial support for building basic infrastructure and for encouraging local start-ups and relocation of companies especially from coastal provinces. Normally not all business operations but mostly the low value added part of operations would be relocated to Western provinces. This result points to either the low willingness or limited capability of innovators in Western provinces to efficiently make use of financial resources for innovation.

[Table 6 about here]

Going beyond considering financial depth as the only variable to proxy regional financial system development, Table 7 sheds light on the effects of government intervention in financial markets. Once distinguishing between *SOCBCREDIT/GDP* and *NONSOCBCREDIT/GDP*, both variables have a positive and significant coefficient, but not the interaction between the contributions of both banking types, which is negative. This result can be interpreted in the light of financial repression in China (Dorn, 2006). Under such circumstances interest rates and savings tend to be artificially low, compared to their potential levels without financial repression. As a consequence, SOCBs and NON-SOCBs can attract insufficient deposits and the greater is the intermediation provided by one kind of bank the smaller will be the intermediation of the other kind of bank.

[20] Similar to the baseline estimations, the coefficients of the other two control variables *"EXPORT/GDP* and *GDPpc*" in the estimation models presented in Table 3, 4, and 5 are positive but are not always significant.

The magnitude of the positive effects of *SOCBCREDIT/GDP* is smaller than that of *NONSOCBCREDIT/GDP*, which is consistent with our expectation that non-SOCBs should be more capable of offering loans to credit applicants according to market criteria than SOCBs; thus they are expected to be more strongly influential in promoting regional innovation activities. However, the positive sign for the coefficients of SOCBCREDIT/GDP is surprising. Higher SOCBCREDIT/GDP ratios imply stronger government intervention in regional financial systems – a proxy for more backward regional financial development and stronger intervention is expected to hinder efficient allocation of financial resources which discourages or impedes regional innovation activities. Such findings are also different from those of Guariglia and Poncet (2008), who found that *SOCBCREDIT/GDP* exerts significantly negative effects on the GDP growth rate. Though our positive findings are counter-intuitive, they are not that implausible when one considers the recent Chinese government policy changes towards promoting indigenous innovation activities introduced since the turn of the century. Such policies may affect the willingness and preference of SOCBs to favor credit applicants who plan to invest the (great part of the) credit obtained in innovation-related activities. As a result, innovators in regions where SOCBs provide loans strictly following the changing policy directions may find it less difficult to obtain financial capital to carry out innovation activities and to come out with patents as innovation outcomes. In context also with the findings of Guariglia and Poncet (2008), all these findings seem to suggest that the strongly policy-driven willingness and preference of SOCBs may indeed promote innovation and patenting activities in regions with stronger government intervention. Such policy influence may, however, crowd out the opportunities for other credit applicants to obtain credit loans for business operations, which may be crucial for commercializing the innovation outcomes and for sustaining higher economic growth.

[Table 7 about here]

5 Conclusions

Feldman and Florida (1994), on the basis of their analysis using US state-level data, conclude that a properly functioning technological infrastructure is crucial for regional innovativeness. The existence of a well-functioning financial system is assumed to be also important. However, the role of financial systems in supporting innovation has not been sufficiently investigated in the previous literature, probably due to the assumption that financial systems operate efficiently and that banking systems adhere to market criteria. Such assumptions do not have to necessarily hold when analyzing innovation activities in emerging countries like China. In this context, this paper explicitly analyzes the role of regional financial development - focusing on a banking system still in transition - for regional innovativeness in China. In line with the theories of financial intermediation, the development of a banking system is conjectured to be a crucial driver of long-term economic growth.

The analysis of this paper builds on the research of Cheung and Lin (2004) which set out to investigate the role of FDI for Chinese regional innovation. We investigate, in addition to FDI, the role of regional financial system development. Specifically, we look at the impacts of financial depth and government intervention in the banking system on regional innovation in China where innovation is proxied by the number of (different types of) patents. The inclusion of variables relating to regional financial systems is the first contribution of our paper to the existing literature. This analysis is timely given that an overhaul of (regional) financial systems has been recently recognized and highlighted by the Chinese government as one of the most major reforms to be carried out since the accession of China to the WTO at the turn of the century. Better functioning financial systems are expected to enhance the allocative efficiency of resources used for innovation projects, reducing the dominant role of FDI in supporting technological advancement and economic growth in China. Our second contribution is the more appropriate panel estimation methodology used in this paper. We start with estimating one-way error component models enabling a comparison with the findings of Cheung and Lin (2004). We further estimate two-way error component models and consider different data to proxy our focus variables as additional robustness checks.

Our estimations are based on provincial data collected from different statistical yearbooks of China in various years. The analysis focuses on 30 Chinese provinces, i.e. excluding Tibet, and on the years from 2000 to 2008. Our main findings are robust across models estimated. In contrast to Cheung and Lin (2004), the magnitude of FDI effect on regional innovation is found to be small and the significance of the effect is found to be much weaker in our study. When focusing on the Within estimators, FDI effects on regional innovation are not found to be significant. Instead, variables used to proxy the financial depth of the regional financial systems are found to be significant and positively relevant for regional patenting in all the estimated empirical models. In addition, when considering different types of patents, such effects are larger in the case of minor innovations - such as external design patents - compared to more complicated innovations such as invention or utility model patents. Although FDI may in latter periods have been a mainspring of innovation and technological advancement in China, in contrast to Cheung and Lin (2004), our findings using more recent data suggest that the role of FDI may be gradually substituted by “domestic” financing channeled by financial intermediaries within the continuously improving financial system in China. However, the financial and human capital constraints facing Chinese innovators, especially from small- and medium-sized enterprises, may hinder them from obtaining larger loans and engaging in more costly and complicated innovation activities. More complicated innovation activities seem to be rather carried out by larger enterprises or research-focused universities possessing greater financial and human capital resources. The finding regarding the second aspect of the regional financial system development, namely government intervention proxied by credit volume from SOCBs, is counterintuitive at the first glance. The estimation result shows that government intervention in regional financial systems can be beneficial in promoting regional innovation. However, when one considers that Chinese economic policies have been actively promoting indigenous innovation since the turn of the century, these positive findings are no longer surprising. The more innovative credit applicants in regions where there is a strong showing of SOCB lending – and accordingly higher compliance with recent Chinese policy promoting innovation activities – are seen to have their applications favored over non-innovative credit applicants. Innovators in these regions are seen to face fewer financing difficulties in carrying out costly innovation activities and thus are financially more capable of producing new knowledge and patents as innovation outcomes. However, when one considers the stylized fact that there is a negative relationship between government intervention in regional financial systems and GDP growth, one has to be cautious in concluding that SOCB lending is overall beneficial. Our findings may suggest that policy-driven decisions of financial intermediaries towards favoring innovative borrowers above non-innovative ones may hinder the actions of other economic agents which are crucial for commercializing patents and thus may impede economic growth.

Based on our research findings so far, some policy implications can be made. Financial systems form a crucial component of the infrastructure which underpins a region's innovative capacity. In emerging economies such as China, it is unrealistic to assume that regional financial systems are well established and that they operate efficiently. Instead, as shown above, (regional) governments need to continuously improve the allocative efficiency of regional financial systems which promote and support regional innovation activities. However, while promoting innovation activities, governments should also be aware that their policy agenda should not bias the decisions of financial intermediaries towards favoring applicants for innovative credits only. Under conditions of financial repression, such biased decisions may crowd out the financial resources which other but less innovative economic agents need to support their business operations. Such operations may be complementary to innovation activities and essential for commercializing new knowledge and thereby sustaining higher long-term economic growth.

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Tables

Table 1 - Description and descriptive statistics of variables

Variable	Description	Obs.	Mean	Std. Dev.	Min.	Max.
PATall[a]	Number of applications of all three types of patents	279	10801.7	18108.2	15	128002
PATinv[a]	Number of invention patent applications	279	2552.3	4424.1	4	28394
PATuti[a]	Number of utility model patent applications	279	3843.8	4884.2	3	28883
PATdes[a]	Number of external design patent applications	279	4405.6	9832.7	6	82022
TIF[a]	Total investment of foreign funded companies in US$100 million	279	446.2	728.6	3	4159
FRCF[a]	Registration capital from foreign investors of foreign funded companies in US$100 million	279	190.4	332.4	1	1901
CREDIT/GDP[b]	Ratio of total (bank and non-bank) credit to GDP (*100)	248	106.7	33.8	61.3	253.1
SAVINGS/GDP[b]	Ratio of total household savings to GDP (*100)	248	142.9	58.2	77.9	429.9
NONSOCBCREDIT/GDP[cd]	Ratio of Non SOCB-credit to GDP (*100)	120	45.4	20.4	15.2	137.4
SOCBCREDIT/GDP[cd]	Ratio of SOCB-credit to GDP (*100)	120	67.8	18.4	40.9	134.4
S&Tper[a]	Number of S&T personnel	279	122160.6	103349.3	2395	527477
S&Texp[a]	S&T expenditure in 10,000 RMB	279	1450794	1830335	8006	11200000
EXPORT/GDP[a]	Ratio of export value to GDP [$/RMB] (*100)	279	2.2	2.7	0.29	12.35
GDPpc[a]	GDP per capita in 10,000 RMB	279	1.5	1.2	0.3	7.3

Notes:
[a]for the years 2000-2008; [b]for the years 2000-2007; [c]for the years 2001-2004; [d]Tibet excluded due to data limitation.
Data of all variables presented in this summary table are in pre-log version, based on the original data obtained from different Chinese statistical publications. They are in log when being considered in the estimating models. Own calculation and compilation based on data obtained from NBSC-CNYBST, NBSC-CNYB, and PBC-ACFB in various years.

Table 2 - Ordinary least squares and panel data estimates of FDI effects on domestic patent applications (2000-2008)

	All patents			Invention			Utility Model			External Design		
	OLS	Within	Random effects	OLS	Within	Random effects	OLS	Within	Random effects	OLS	Within	Random effects
FDI_{-1}	0.23*	0.00	0.13*	0.15*	–0.06	0.02	0.17*	–0.05	0.05	0.42*	0.06	0.27*
t-stat.	6.77	0.02	2.65	4.18	–0.80	0.34	4.86	–1.12	1.09	6.93	0.58	3.07
S&Tper	0.48*	0.24	0.44*	0.15	0.37*	0.29*	0.88*	0.27*	0.51*	0.02	–0.02	0.21
t-stat.	4.65	1.83	3.90	1.37	2.48	2.34	8.16	2.64	5.29	0.09	–0.11	1.07
S&Texp	0.37*	0.06	0.35*	0.67*	0.29	0.56*	0.06	0.14	0.30*	0.69	–0.07	0.41*
t-stat.	3.68	0.49	3.22	6.24	1.93	4.67	0.61	1.35	3.17	3.95	–0.31	2.16
Export/GDP	0.1*	0.17*	0.14*	–0.05	0.27*	0.11	0.04	0.11*	0.11*	0.20*	0.21	0.17
t-stat.	2.16	2.48	2.29	–1.08	3.31	1.74	0.8	2.03	2.15	2.53	1.70	1.68
GDPpc	0.08	0.84*	0.30*	0.35*	0.88*	0.55*	0.13	0.52*	0.14	–0.27	1.19*	0.33
t-stat.	0.9	5.58	2.70	3.82	5.04	4.52	1.39	4.30	1.41	–1.8	4.50	1.68
Adj. R^2	0.93	–	–	0.92	–	–	0.92	–	–	0.85	–	–
Hausman test	–	–	29.95	–	–	14.98	–	–	35.59	–	–	23.89
Hausman test p-value	–	–	0.00	–	–	0.01	–	–	0.00	–	–	0.00
Observations	240	240	240	240	240	240	240	240	240	240	240	240

Notes:
*significant at the 5% level.
FDI_{-1} is the FDI stock lagged one year, measured by the foreign funded part of the total registration capital of (partially) foreign funded companies. All variables are in logs and all the estimators include a constant.

Table 3 - Panel data estimates of FDI and financial development effects on domestic patent applications (2000-2008): two-way error components model

	All patents		Invention		Utility Model		External Design	
	Within	Random effects	Within	Random effects	Within	Random effects	Within	Random effects
FDI_{-1}	0.01	0.01	0.03	0.03	–0.05	–0.05	0.02	0.02
t-stat.	0.14	0.17	0.40	0.45	–1.00	–1.10	0.20	0.24
$(CREDIT/gdp)_{-1}$	0.85*	0.85*	0.82*	0.82*	0.66*	0.66*	0.98*	0.98*
t-stat.	6.19	6.82	5.22	5.75	6.24	6.88	3.78	4.15
S&Tper	0.10	0.10	0.36*	0.37*	0.12	0.12	–0.19	–0.18
t-stat.	0.79	0.90	2.52	2.82	1.25	1.40	–0.79	–0.85
S&Texp	–0.15	–0.15	–0.06	–0.06	–0.03	–0.03	–0.23	–0.22
t-stat.	–1.14	–1.24	–0.42	–0.43	–0.27	–0.28	–0.94	–1.01
Export/GDP	0.09	0.09	0.09	0.09	0.04	0.04	0.20	0.20
t-stat.	1.27	1.42	1.08	1.22	0.61	0.69	1.44	1.60
GDPpc	0.77*	0.77*	0.51	0.51*	0.28	0.28	1.58*	1.58*
t-stat.	3.17	3.51	1.83	2.04	1.49	1.66	3.45	3.82
Hausman test	–	0.01	–	0.02	–	0.01	–	0.01
Hausman test p-value	–	1.00	–	1.00	–	1.00	–	1.00
Tests for individual and time effects								
Breusch-Pagan	–	300.97	–	262.94	–	398.14	–	305.63
Honda	–	11.72	–	12.78	–	13.45	–	11.23
King and Wu	–	6.96	–	8.87	–	7.98	–	6.30
Standardized Lagrange Multiplier	–	8.70	–	10.87	–	9.85	–	7.94
Gourieroux, Holly and Monfort	–	300.40	–	262.94	–	397.32	–	303.27
Observations	240	240	240	240	240	240	240	240

Notes:
*significant at the 5% level.FDI_{-1} is the FDI stock lagged one year, measured by the foreign funded part of the total registration capital of (partially) foreign funded companies. All variables are in logs and all the models include a constant.

Table 4 - Panel data estimates of FDI and financial development effects on domestic patent applications (2000-2008): two-way error components model and including Tibet

	All patents		Invention		Utility Model		External Design	
	Within	Random effects	Within	Random effects	Within	Random effects	Within	Random effects
FDI_{-1}	–0.02	–0.02	0.00	0.00	–0.02	–0.01	–0.05	–0.05
t-stat.	–0.29	–0.30	0.03	0.05	–0.30	–0.32	–0.48	–0.51
$(CREDIT/gdp)_{-1}$	0.79*	0.79*	0.79*	0.79*	0.64*	0.64*	0.91*	0.91*
t-stat.	4.89	5.39	4.66	5.14	4.91	5.42	3.25	3.57
S&Tper	–0.02	–0.02	0.27	0.27*	0.13	0.13	–0.36	–0.35
t-stat.	–0.17	–0.16	1.80	2.04	1.11	1.25	–1.48	–1.61
S&Texp	0.13	0.13	0.05	0.06	0.05	0.05	0.16	0.17
t-stat.	0.94	1.07	0.36	0.44	0.47	0.54	0.70	0.81
Export/GDP	0.17*	0.17*	0.12	0.12	0.06	0.06	0.31*	0.31*
t-stat.	2.06	2.30	1.38	1.55	0.85	0.95	2.17	2.42
GDPpc	0.46	0.46	0.39	0.39	0.03	0.04	1.22*	1.21*
t-stat.	1.67	1.86	1.35	1.52	0.15	0.18	2.57	2.85
Hausman test	–	0.02	–	0.03	–	0.01	–	0.02
Hausman test p-value	–	1.00	–	1.00	–	1.00	–	1.00
Observations	248	248	248	248	248	248	248	248

Notes:
*significant at the 5% level.
FDI_{-1} is the FDI stock lagged one year, measured by total investment of (partially) foreign funded companies in stock at the end of the year. All variables are in logs and all the models include a constant.

Table 5 - Panel data estimates of FDI and financial development effects on domestic patent applications (2000-2008): two-way error components model

	All patents		Invention		Utility Model		External Design	
	Within	Random effects	Within	Random effects	Within	Random effects	Within	Random effects
FDI_{-1}	–0.04	–0.04	–0.01	–0.01	–0.08	–0.08	–0.06	–0.05
t-stat.	–0.62	–0.67	–0.11	–0.1	–1.75	–1.92	–0.49	–0.52
$(savings/gdp)_{-1}$	1.06*	1.06*	0.88*	0.88*	0.85*	0.85*	1.57*	1.56*
t-stat.	5.28	5.82	3.79	4.19	5.45	6.01	4.26	4.68
S&Tper	0.24	0.24	0.48*	0.48*	0.23*	0.23*	0.00	0.01
t-stat.	1.83	2.03	3.22	3.60	2.3	2.56	0.01	0.02
S&Texp	–0.09	–0.09	0.01	0.01	0.01	0.02	–0.20	–0.20
t-stat.	–0.71	–0.76	0.05	0.10	0.14	0.18	–0.85	–0.91
Export/GDP	0.09	0.09	0.09	0.09	0.03	0.04	0.20	0.20
t-stat.	1.24	1.38	1.05	1.19	0.59	0.66	1.43	1.58
GDPpc	0.84*	0.84*	0.51	0.51	0.35	0.35*	1.83*	1.82*
t-stat.	3.30	3.66	1.74	1.95	1.76	1.96	3.90	4.31
Hausman test	–	0.01	–	0.03	–	0.01	–	0.01
Hausman test p-value	–	1.00	–	1.00	–	1.00	–	1.00
Observations	240	240	240	240	240	240	240	240

Notes:
*significant at the 5% level.
FDI_{-1} is the FDI stock lagged one year, measured by the foreign funded part of the total registration capital of (partially) foreign funded companies. All variables are in logs and all the models include a constant.

Table 6 - Panel data estimates of financial development effects on domestic patent applications by region (2000-2008): two-way error components model with random effects

	All patents	Invention	Utility Model	External Design
FDI_{-1}	0.03	0.04	–0.03	0.06
t-stat.	0.56	0.57	–0.69	0.54
$(CREDIT/gdp)_{-1}$ in Coastal Provinces	0.94*	0.75*	0.70*	1.36*
t-stat.	5.05	3.68	4.81	3.95
$(CREDIT/gdp)_{-1}$ in Central Provinces	1.01*	0.88*	0.78*	1.19*
t-stat.	6.06	4.77	6.05	3.83
$(CREDIT/gdp)_{-1}$ in Western Provinces	0.12	0.76*	0.19	–0.63
t-stat.	0.52	3.10	1.10	–1.52
S&Tper	0.14	0.37*	0.15	–0.11
t-stat.	1.26	2.87	1.71	–0.51
S&Texp	–0.09	–0.05	0.01	–0.13
t-stat.	–0.78	–0.34	0.12	–0.58
Export/GDP	0.08	0.10	0.03	0.16
t-stat.	1.25	1.26	0.60	1.25
GDPpc	0.72*	0.53*	0.26	1.41*
t-stat.	3.25	2.08	1.51	3.35
Roy-Zellner test for poolability	7.67	0.16	5.02	11.89
Roy-Zellner test for poolability p-value	0.00	0.85	0.00	0.00
Hausman test	0.09	0.02	0.01	0.01
Hausman test p-value	1.00	1.00	1.00	1.00
Observations	240	240	240	240

Notes:
*significant at the 5% level.
FDI_{-1} is the FDI stock lagged one year, measured by the foreign funded part of the total registration capital of (partially) foreign funded companies. All variables are in logs and all the models include a constant.

Table 7 - Panel data estimates of financial development effects on domestic patent applications by region (2001-2005): two-way error components model with random effects

	All patents	Invention	Utility Model	External Design
FDI_{-1}	0.00	–0.01	0.01	–0.01
t-stat.	–0.05	–0.17	0.08	–0.15
$(NONSOCBCREDIT/gdp)_{-1}$	4.39*	3.49*	8.32*	1.74*
t-stat.	5.65	3.43	5.50	2.38
$(SOCBCREDIT/gdp)_{-1}$	3.94*	3.29*	7.34*	1.65*
t-stat.	6.08	3.87	5.82	2.69
$(NONSOCBCREDIT/gdp)_{-1}*(SOCBCREDIT/gdp)_{-1}$	–0.95*	–0.74*	–1.84*	–0.35*
t-stat.	–5.37	–3.21	–5.35	–2.08
S&Tper	–0.21	–0.04	–0.36	–0.12
t-stat.	–1.64	–0.26	–1.42	–1.00
S&Texp	0.11	0.15	0.22	0.03
t-stat.	0.70	0.73	0.75	0.22
Export/GDP	0.04	0.07	0.24	–0.02
t-stat.	0.50	0.63	1.39	–0.29
GDPpc	0.71*	0.23	1.66*	0.36
t-stat.	2.30	0.57	2.81	1.23
Hausman test	0.08	0.18	0.07	0.12
Hausman test p-value	1.00	1.00	1.00	1.00
Observations	120	120	120	120

Notes:
*significant at the 5% level.
FDI_{-1} is the FDI stock lagged one year, measured by total investment of (partially) foreign funded companies in stock at the end of the year. All variables are in logs and all the models include a constant.

Appendix

Table A1 - Top-10 ranking by province in innovation, foreign investment, financial system development and economic development (Top-down: 1st to 10th)

PATall		PATinv		PATuti		PATdes	
2000	2008	2000	2008	2000	2008	2000	2008
Guangdong	Jiangsu	Shanghai	Beijing	Guangdong	Guangdong	Guangdong	Jiangsu
Shanghai	Guangdong	Beijing	Guangdong	Shandong	Shandong	Zhejiang	Zhejiang
Beijing	Zhejiang	Guangdong	Jiangsu	Beijing	Zhejiang	Shanghai	Guangdong
Zhejiang	Shandong	Liaoning	Shanghai	Liaoning	Jiangsu	Shandong	Shandong
Shandong	Shanghai	Shandong	Shandong	Jiangsu	Shanghai	Jiangsu	Shanghai
Jiangsu	Beijing	Jiangsu	Zhejiang	Zhejiang	Beijing	Fujian	Sichuan
Liaoning	Sichuan	Zhejiang	Liaoning	Shanghai	Liaoning	Beijing	Hubei
Sichuan	Hubei	Hunan	Tianjin	Henan	Hubei	Sichuan	Henan
Fujian	Liaoning	Hubei	Hunan	Hunan	Henan	Liaoning	Tianjin
Hunan	Henan	Sichuan	Henan	Hebei	Sichuan	Hunan	Fujian
71.3%	81.5%	71.8%	80.0%	67.3%	76.0%	80.8%	88.4%

S&Tper		S&Texp		TIF		FRCF	
2000	2008	2000	2008	2000	2008	2000	2008
Jiangsu	Guangdong	Beijing	Jiangsu	Guangdong	Jiangsu	Guangdong	Jiangsu
Beijing	Jiangsu	Guangdong	Beijing	Shanghai	Guangdong	Shanghai	Guangdong
Shandong	Beijing	Jiangsu	Guangdong	Jiangsu	Shanghai	Jiangsu	Shanghai
Guangdong	Zhejiang	Shanghai	Shandong	Liaoning	Zhejiang	Liaoning	Zhejiang
Shanghai	Shandong	Shandong	Zhejiang	Fujian	Liaoning	Fujian	Liaoning
Sichuan	Shanghai	Zhejiang	Shanghai	Beijing	Fujian	Beijing	Fujian
Hubei	Sichuan	Sichuan	Liaoning	Shandong	Shandong	Tianjin	Beijing
Liaoning	Henan	Liaoning	Sichuan	Tianjin	Beijing	Shandong	Tianjin
Shaanxi	Liaoning	Hubei	Tianjin	Zhejiang	Hainan	Hainan	Shandong
Henan	Hubei	Shaanxi	Hubei	Hainan	Tianjin	Zhejiang	Sichuan
61.9%	65.8%	72.7%	71.1%	83.0%	82.6%	84.8%	84.5%

CREDIT[a]		SAVINGS[a]		SOCBCREDIT[a]	
2000	2007	2000	2007	2001	2004
Guangdong	Guangdong	Guangdong	Guangdong	Guangdong	Guangdong
Shandong	Zhejiang	Beijing	Beijing	Shanghai	Jiangsu
Jiangsu	Jiangsu	Jiangsu	Jiangsu	Jiangsu	Zhejiang
Shanghai	Beijing	Shanghai	Zhejiang	Shandong	Shanghai
Beijing	Shandong	Shandong	Shanghai	Zhejiang	Shandong
Zhejiang	Shanghai	Zhejiang	Shandong	Beijing	Beijing
Liaoning	Liaoning	Liaoning	Liaoning	Liaoning	Liaoning
Henan	Henan	Hebei	Hebei	Sichuan	Sichuan
Hebei	Sichuan	Henan	Sichuan	Hebei	Fujian
Sichuan	Hebei	Sichuan	Henan	Henan	Hebei
61.4%	65.8%	65.5%	66.7%	60.8%	63.6%

EXPORT[a]		GDP		POP[b]	
2000	2008	2000	2008	2000	2008
Guangdong	Guangdong	Guangdong	Guangdong	Henan	Guangdong
Jiangsu	Jiangsu	Jiangsu	Jiangsu	Shandong	Henan
Shanghai	Shanghai	Shanghai	Shanghai	Guangdong	Shandong
Zhejiang	Zhejiang	Zhejiang	Zhejiang	Sichuan	Sichuan
Shandong	Shandong	Shandong	Shandong	Jiangsu	Jiangsu
Fujian	Beijing	Fujian	Beijing	Hebei	Hebei
Beijing	Fujian	Beijing	Fujian	Hunan	Hunan
Liaoning	Tianjin	Liaoning	Tianjin	Hubei	Anhui
Tianjin	Liaoning	Tianjin	Liaoning	Anhui	Hubei
Hebei	Hebei	Hebei	Hebei	Zhejiang	Zhejiang
90.7%	89.7%	90.7%	89.7%	57.5%	60.0%

Notes:
Shares at the bottom of each column refer to the share of the top-10 provinces with respect to the variable considered.
[a]These variables are the numerator variables of the variables "CREDIT/GDP, SAVINGS/GDP, SOCBCREDIT/GDP, and EXPORT/GDP", respectively. [b]Population number, which is the denominator variable of the variable "GDPpc".
Own calculation and compilation based on data obtained from NBSC-CNYBST, NBSC-CNYB, and PBC-ACFB in various years.