Capacities of Business Incubator and Regional Innovation Performance

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Abstract

Recent years have witnessed the fast development of business incubators in many emerging economies, such as China. Business incubators are seen as important facilitators for innovation which provide office space, equipment, mentoring services, as well as financial, legal and administrative supports for technology entrepreneurs and start-up companies. Much investment has been undertaken to facilitate the development of business incubators, for example in financial frameworks, human resource development and communication infrastructure. This paper investigates the effects of business incubator capacities on the regional innovation performance, using a panel representing 31 Chinese provinces. This study finds that three capacities of business incubators have significant impacts on the regional innovation performance, while the incubation capacity appears to have a much greater effect than the basic capacity and the finance capacity. Moreover, this study also identifies that the regional communication infrastructure is an important moderator of the relationship between business incubator capacities and the regional innovation performance. This paper supports the view that emerging economies should encourage the development of business incubators in order to promote the development of technology entrepreneurs and domestic innovation performance, but more focus should be on creating free knowledge transfer platforms.

Keywords: Business incubator; Regional innovation; Performance; Communication infrastructure; China

1. Introduction

The incubation program has been widely seen as a significant policy mechanism to support regional innovation and economy (Wonglimpiyarat, 2016; Lukeš et al., 2019; Pustovrh et al., 2020). Business incubators are important platforms to support incubation programs (Baraldi and Havenvid, 2016; Diez-Vial and Montoro-Sanchez, 2017; Xiao and North, 2018). However, few studies have examined how the business incubators affect the regional innovation performance, especially in the context of emerging economies.

This study considers the impact of business incubators on regional innovation performance in the context of China, which is the largest emerging economy and the second largest economy in the world (World Bank, 2018). Innovation-driven development has been advocated by the Chinese government since 2006 (Vinig and Bossink, 2015). By the end of 2018, 4,069 business incubators have been set up in China, which accumulated the incubation of 139,396 start-ups (Ministry of Science and Technology, 2019). For these reasons, China provides an important case to explore the link between the development of business incubators and the regional innovation performance.

This study draws upon psychological capital theory (Luthans et al., 2007) and regional innovation system theory (Asheim and Gertler, 2005) to investigate the regional innovation performance associated with Chinese business incubators. Specifically, this study explores how Chinese domestic regional innovation performance is affected by various capacities of business incubators and factors that moderate this relationship. This study contributes to the existing literature as follows: 1) a better understanding of the benefits of business incubators to the regional innovation performance from a regional economic development perspective; 2) a more comprehensive understanding of regional differences of business incubator capacities in context of emerging economies; 3) a better understanding of the role of business incubators as important

homes of technology entrepreneurs in emerging economies; 4) extension to the regional innovation system theory, and clarification of the significance and importance of business incubators in regional innovation systems.

In the next section, we review the relevant literature and develop hypotheses for testing. This is followed by the discussion of research methods, the dataset and the regression model specification. The results are then presented and discussed. The final section summarises findings of the study, outlines theoretical and practical implications, as well as limitations and future research.

2. Literature review and hypotheses development

Extant literature has identified that technology entrepreneurs are important locus for practicing science and innovation (Marvel and Lumpkin, 2007; Del-Giudice et al., 2013; Mian et al., 2016; Gemmell, 2017). For example, technology entrepreneurs, such as Hewlett and Packard and Microsoft, have played key roles in the practicing science of new areas of software and hardware development in the computer industry (Oakey, 2003). However, technology entrepreneurs and start-ups often lacked physical facilities and equipment, administrative as well as financial support.

Nowadays, more and more technology entrepreneurs are facilitated by business incubators, which refer to mechanisms and platforms for technology transfer to promote the growth of innovation and entrepreneurship (Bakouros et al., 2002; Wonglimpiyarat, 2016). Business incubators not only provide the space for people to meet at unconventional settings for knowledge sharing and transfer, but also attract venture capitals and talented volunteers and groups (Meyer, 2013; Sleator, 2016; Hecker et al., 2018). Business incubators are usually seen as a catalyst enabling the process of knowledge transfer and innovation commercialization through providing office spaces, equipment, mentoring services, venture capitalists as well as other administrative supports for technology entrepreneurs (Lamine et al., 2018; Xiao and North, 2018;

Hillemane et al., 2019). The literature on incubator usually classifies business incubator capacities into three aspects, namely basic service, finance and incubation (Colombo and Delmastro, 2002; Aerts et al., 2007; Bruneel et al., 2012; Zhao et al., 2017), and hence highlighted the importance of the development of these capacities for business incubators (Chan and Lau, 2005; Grimaldi and Grandi, 2005; Mian et al., 2016).

Since the turn of the millennium, a significant number of technology entrepreneurs grew in emerging economies, and they have contributed to innovation in various research areas such as molecular biology, recombinant DNA technologies, bioinformatics, and genetic engineering (Chell and Allman, 2003; Sung et al., 2003; Tello et al., 2012; Matos et al., 2020). In contrast to researchers or scientists based in universities, formal research institutes or R&D departments of firms, technology entrepreneurs typically lacked essential resources such as finance, technology, facilities, equipment and human capital. Technology entrepreneurs are also subject to criticisms in terms of risks in finance, health and safety, legal and ethical standards (Armanios et al., 2017). For this reason, business incubators are regarded as an important home to technology entrepreneurs for knowledge sharing and innovation activities (Schumpeter, 2000; Schmitz et al., 2017). The emerging literature suggests that business incubators are providing important complements to the mainstream innovation. They are attracting scientists and venture capitalists, while making them important homes for talents to advance science, technology, and innovation development of nations (Mian et al., 2016; Xiao and North, 2018; Hecker et al., 2018; Lukeš et al., 2019).

China's business incubators have increased by nearly dozen times between 2007 and 2017 (Ministry of Science and Technology, 2018), and have become a new engine fuelling China's innovation (Zhang and Stough, 2013; Jiang et al., 2016; Xiao and North, 2018). Previous studies recognize that business incubators play an important part in the national and regional innovation system (Klofsten et al., 2020). However, most of the previous literature regards the business incubator as the main unit of analysis,

with limited understanding of the mechanisms by which business incubators, and their capacities, influence the regional innovation.

Not only internal capacities of business incubators, but also external factors, such as regional communication infrastructures, deserves more attention in the studies on regional innovation (Pavic et al., 2007; Allameh et al., 2011). The rapid development of information communication technologies (ICTs) changes the range and the speed of access to technology and information (Lema et al., 2017). Therefore, the communication infrastructure significantly influences the way business incubators access technologies and pursue innovation. However, previous studies are limited in understanding the way regional communication infrastructure influences the relationship between business incubators' capacities and regional innovation performance (Fu and Xiong, 2011).

In summary, despite scholars have recognized the key role of business incubators in promoting regional innovation, most previous studies have not sufficiently explored internal capacities of those incubators. As a result, there is a lack of clarity about the influencing mechanism of business incubator capacities on the regional innovation. Furthermore, the communication infrastructure is vital for innovation activities, but the extant literature has not explained how it influences the relationship between business incubator capacities and regional innovation. In the following sections, this study seeks to bridge the gap in the literature by examining the role of business incubator capacities and the regional communication infrastructure.

2.1 Basic service capacity of business incubators

Psychological capital theory (Luthans et al., 2007) suggests that individuals' performances are functions of psychological capitals which are influenced by factors such as self-efficacy, hope, optimism, and resilience. Self-efficacy is one's belief on his/her ability to succeed in accomplishing a task. Hope is a positive motivational state

that is based on an interactive effect of a derived sense of successful pathways (planning to meet goals) and agency (goal-directed energy). Optimism is an attribution style that explains positive events in terms of personal, permanent causes, such as abilities, and negative events in terms of external and situation-specific causes, such as luck. Resilience is the salient willpower and capacity to rebound or bounce back from adversity, conflict, and failure or even positive and challenging events (Luthans, 2007). The synergy of these factors can directly or indirectly affect the behavioural performance of individuals and organizations to which individuals belong (Lai and Lin, 2015).

Previous research has gained evidence that adequate services provided by business incubators can potentially enhance the synergy of psychological factors and the psychological capital of entrepreneurs which can affect the performance of the entrepreneurs in business incubators, and subsequently affect regional innovation performance (Luthans, 2007; Lai and Lin, 2015; Kiani et al., 2019).For instance, Vanderstraeten and Matthyssens (2012) pointed out that business incubators could further enhance the self-confidence and optimism of innovation by building a stable innovation platform and a solid basic service system. Therefore, effective business incubators can actively promote the creation of strong entrepreneurial atmospheres and enhance the innovators and entrepreneurs' psychological capital. Kiani et al. (2019) revealed that people who worked in business incubators would continue to improve their entrepreneurial self-efficacy, which had a direct positive impact on the innovation performance for start-up technology companies.

The establishment of business incubators provide not only physical innovation spaces for regional innovators or entrepreneurial talents, but also opportunities for the development of inspirational new ideas. In business incubators, both entrepreneurs and innovators can better commit themselves to research and development activities, gradually strengthen their innovative ideas, and commit to continuous innovation.

Therefore, the continuous improvement of basic services of business incubators can promote the accumulation of innovation capabilities, which can significantly improve the performance of technology entrepreneurs and start-up technology companies, and thus enhance the overall performance of the regional innovation. Therefore, this study hypotheses:

H1. The basic service capacity of business incubator is positively related to the regional innovation performance.

2.2 Financial capacity of business incubators

The concept of synergy effect originally refers to the potential ability of individual organizations or groups to be more successful or productive as a result of a merger (Chesbrough et al., 2000). This concept has been applied not only to business incubators, but also to regional innovation studies (Chesbrough et al., 2000). Bruneel et al. (2012) suggested the financial investments received by incubating enterprises usually come from multiple entities such as financial institutions, government and enterprises. Similarly, Wang and Zhou (2012, 2013) argue that financial investments are not immediately available for incubating enterprises without stable financing channels, and that regional innovative performance is unlikely to benefit from business incubators. Luckily, the finance capacities of business incubators can integrate various funding channels and create sustainable funding structures (Wang and Zhou, 2013). A higher degree of finance capacity is thus likely to be directly associated with better innovation performance.

Indeed, it has been suggested that the finance capacities of business incubators not only integrate external financing channels, but also strengthen the internal synergy of incubating enterprises (Zhao et al., 2017). For instance, Bruneel et al. (2012) and Zhao et al. (2017) notes the potential importance of internal synergy for incubating enterprises. With secured financial backing, incubating enterprises has sufficient capital to acquire advanced technology or hire technical experts specialized in product research

and development. This will improve the efficiency of new product development, reduce R&D costs and eventually boost the regional innovation performance (Bruneel et al, 2012; Wang and Zhou, 2013; Zhao et al., 2017). Therefore,

H2. The financial capacity of business incubators is positively related to the regional innovation performance.

2.3 Incubation capacity of business incubators

In addition to transferring various types of resources to technology entrepreneurs and start-up enterprises, business incubators can also promote the flow of knowledge through enhanced social relationships between innovators and entrepreneurs, which is a key part of the incubation capacities of business incubators. Witherspoon et al. (2013) suggest that knowledge sharing is a process in knowledge management to create, harvest, and sustain business processes. Campbell et al. (2017) further suggest that knowledge sharing is to do with the preparation of task information and know-how to facilitate problem solving, implement policies, or promote innovation. In general, knowledge sharing is the practices of exchanging and disseminating ideas, experience, and knowledge with one another to ensure knowledge continues, sustains and retains in businesses.

Effective knowledge sharing was regarded as important facilitator for the development of technology entrepreneurs (Meyer, 2013; Revill and Jefferson, 2014; Seyfried et al., 2014). Previous researchers highlighted the role of business incubators in developing networks between innovators and incubating businesses. For example, Chesbrough (2000) pointed out that even if the business incubator managers cannot directly provide services, they can also facilitate social networks for R&D (Chesbrough et al., 2000). This network is extremely important for the sharing of information and knowledge. Wang and Zhou (2012) also believed that the business incubator integrates various technology entrepreneurship and innovation resources in the region, serves SMEs, and enhances the overall innovation capacity in the region through better knowledge sharing

(Wang and Zhou, 2012).

In summary, the effective knowledge sharing in business incubators can (1) facilitate better utilization of newly acquired knowledge by technology entrepreneurs (Cabrera et al., 2006); (2) strengthen cooperation and encourage mutual learning (Wang and Zhou, 2012); (3) facilitate effective decision making based on better knowledge acquired; and (4) enhance the innovation ability of individuals (Yun et al., 2007). As a result, the regional innovation performance will benefit from better incubation capacity of business incubators. Therefore,

H3. The incubation capacity of business incubators is positively related to the regional innovation performance.

2.4 Communication infrastructure in the domestic region

Geisler and Wickramasinghe (2015) define knowledge management as a series of activities which include identifying, collecting, storing, and transmission of knowledge. The most important basis for knowledge management is the adequate communication infrastructure (e.g. ICT facilities) (Allameh et al., 2011; Geisler and Wickramasinghe, 2015). Cornett (2009) advocates that regional communication infrastructure development policy with the purpose of improving innovation can be conducive to stimulate the efficiency of knowledge management and technical exchange in local industrial sectors. Others also found that regional intelligence is a strong driver of regional innovation and that communication infrastructure is the main tool for gaining and disseminating intelligence (e.g., Fu, 2008; Autant et al., 2013). Therefore, this study expects that higher investment in communication infrastructure can lead to better regional innovation performance. Therefore,

H4a. Regional communication infrastructure is positively related to the regional innovation performance.

This study expects a positive moderating effect of communication infrastructure on the relationship between business incubators basic capacities and regional innovation performance. Pavic et al. (2007) point out that the importance of communications infrastructure stems from its role as one of the main tools employed in the information exchange activities of business incubators. Effective communication enhances mutual understanding between business incubators (Pavic et al., 2007). The presence of communication infrastructure thus acts as a spur to business incubators who are keen to observe, learn from, and emulate the superior competences of their rivals (Duran and Ubeda, 2005; Deng, 2007; Rui and Yip, 2008). For instance, the management and service standards adopted by superior incubators in China have helped other business incubators to learn some advanced experiences and develop capacities (Allameh et al., 2011). A higher presence of communication infrastructure is thus likely to be associated with better basic capacities of business incubators (Rui and Yip, 2008). Therefore,

H4b. Regional communication infrastructure positively moderates the relationship between business incubators' basic capacity and the regional innovation performance.

In a similar vein, this study argues that the communication infrastructure has positive moderating effects on the relationship between finance capacity and incubation capacity of business incubators and the regional innovation performance. The impact of the communication infrastructure on financial capacities of business incubators is much evident (Tian et al., 2019). The rapid development of communication technologies shortens the business lead times and transaction delays which enhances the development of the capital market (Lechman and Marszk, 2015; Tian et al., 2019). Communication infrastructure improves the capital supply, efficiency of capital allocation. A better communication infrastructure is thus likely to be directly associated with better financial capacities of firms (Parida and Örtqvist, 2015). Furthermore, the facilitating role of communication infrastructure will enable business incubators to make better use of various assets and to provide better support (Parida and Örtqvist,

2015; Lechman and Marszk, 2015). The start-up enterprises which grow in incubators thus have a better chance to get better services or support from business incubators, which as a result, improves the incubation success rate and the regional innovation performance. Therefore,

H4c. Regional communication infrastructure positively moderates the relationship between business incubators' finance capacity and the regional innovation performance.

H4d. Regional communication infrastructure positively moderates the relationship between business incubators' incubation capacity and the regional innovation performance.

3. Research method and data

This study focuses on China to analyse the relationship between business incubator capacities and regional innovation performance. Cooke et al. (1997) and Iammarino (2005: 1564) define the regional innovation system as an environment "in which firms and other organizations are systematically engaged in interactive learning through an institutional milieu characterized by embeddedness". Regional innovation systems theory is particularly relevant when examining the determinants of innovation performance of countries which cover huge geographical areas and where there are substantial disparities in terms of regional and economic development (Asheim and Gertler, 2005; Dopfer, 2012; Fu, 2008; Li et al., 2016). China, as a fast-growing emerging economy, has witnessed a substantial development of business incubators in recent years (Ministry of Science and Technology, 2019). Moreover, China is a vast country with many provinces and municipalities to allow cross regional analysis (Child and Rodrigues, 2005; Li et al., 2016). This ensures more relevant data will be available.

This study uses a panel representing 31 provinces and municipalities over the period 2008-2017. The innovation and R&D data are drawn from the China Statistics Yearbook on Science and Technology, compiled by the Ministry of Science and

Technology and National Bureau of Statistics of the People's Republic of China. The data for business incubator capacities are assembled from China Torch Statistical Yearbook, compiled by the Torch High Technology Industry Development Centre from the Ministry of Science and Technology of the People's Republic of China. The authors then calculated the innovation index and business incubator capacities index based on the compiled data set. Furthermore, data were also collected on infrastructure, industrial structure, economic development, labour, international trade and foreign direct investment (FDI) from the China Statistics Yearbook and China Economic and Social Development Yearbook, compiled by the National Bureau of Statistics.

This study calculates the score of regional innovation performance and business incubator capacities using the entropy method, which is an objective weighting methods of quantitative analysis (Furman et al., 2002). Entropy is the measure of uncertainty. This method overcomes measuring and calculating errors caused by manmade factors. Therefore, it makes gauging process more efficient, accurate and reliable (Furman et al., 2002).

3.1 Dependent variable

This study attempts to explore the impact of business incubator capacities on the regional innovation performance. The dependent variable is the regional innovation performance (INN), measured by the natural log of average scores of regional innovation. This study follows the European Innovation Scoreboard (EIS) method to set up two indexes of regional innovation input and regional innovation output as the first level indexes of the evaluation system (Hollanders and Vancruysen 2008). Then, following Acs et al. (2002) and Pan et al. (2015), this study sets up the second level performance index from the perspective of input and output to calculate the comprehensive evaluation score of the regional innovation performance (Acs et al., 2002; Pan et al., 2015).

In terms of innovation inputs, previous studies have considered the innovation process

at the firm, sector, and regional levels (Jaffe et al., 1993; Choi et al., 2011; Fu 2012; Hong and Su, 2013). To obtain the regional innovation input index, this study follows the previous studies which typically measured the R&D inputs (RDI) using the R&D intensity which included the number of R&D projects, R&D staff of full-time equivalent (person/year) and R&D outlay (billion CNY) (Jaffe et al., 1993; Choi et al., 2011; Fu 2012; Hong and Su, 2013).

This study measures the innovation output index based on number of patent applications, number of patent authorizations, and transaction amount of technology market (billion CNY). Although not all innovations are patented, numbers of patents are the preferred measure used in most previous research because they provide a more accurate indication of innovation performance than alternative measures such as "new product" sales (Acs et al., 2002; Choi et al., 2011). This is because "new products" are often loosely defined and can be potentially over-recorded by firms (Usai, 2011; Li et al., 2016). Furthermore, the process of patent registration ensures that quality time-series data are publicly available, and the patent documents typically provide useful technological and organizational information (Griliches, 1990; Malerba et al., 1997).

3.2 Independent variables

This study measures various capacities of regional business incubators. Previous studies have considered the business incubator capacities by space, facilities, service team and resource. This study creates an evaluation system of business incubator capacities in terms of basic service capacity, financial capacity and incubation capacity, following the previous evaluation systems in the literature, to analyse the capacities scores of business incubators in all the 31 provincial administrative regions in China (Iammarino, 2005; Li et al., 2016).

Specifically, basic service capacity is operationalized as the score of last year's (t) basic service capacity of business incubator (Vanderstraeten and Matthyssens, 2012; Lai and Lin, 2015). It includes the number of business incubators, the number of management

practitioners and total incubation funds. Financial capacity is operationalized as the score of last year's (t) financial capacities of business incubators (Bruneel et al., 2012). It includes total venture capital investment and number of incubators receiving funds. Business incubation capacities is operationalized as the number of tenants and accumulated number of graduated tenants in business incubators. Furthermore, following the previous literature (Del et al., 2010; Jiang et al., 2016), the regional communication infrastructure construction intensity is operationalised as the proportion of communication infrastructure investment over regional GDP.

3.3 Control variable

This study controls four variables that may affect regional innovation performance in general. First, the regional GDP per capita is controlled, which may affect the development potential and regional demand for innovation (Fu, 2012; Li et al., 2016; Piperopoulos et al., 2018). This is because the innovation performance tends to be stronger in regions with faster economic growth, and with more funds and human resources available to business incubators in those regions. Furthermore, we would expect regions with higher economic status to have a stronger recognition of intellectual property rights and better communication infrastructure, which can lead to better regional innovation performance.

Second, the quality of labour is a crucial source of advanced knowledge for many emerging economies seeking to improve their innovation capabilities (Li et al., 2016). Higher quality of labour in a region is expected to be positively related to regional innovation performance. Therefore, this study controls the quality of labour, measured by years of education per capita.

Third, previous studies have suggested that the industrial structure may affect innovation performance (Liu et al., 2014; Kusnadi et al., 2015). This study thus controls the proportion of service industry over the GDP in each region.

Fourthly, China was a major participant of international trade over the period covered by this study. Involvement in international trade may affect the innovation performance (Li et al., 2016). This study thus controls the proportion of international trade value over GDP in each region. Detailed definitions of variables are provided in Table 1.

<Insert Table 1 about here>

Table 1. Description of key variables

Variable name	Acronym	Operationalization
Regional innovation	$Inn_{i,t}$	Natural log of regional innovation performance score of region i in year t.
Basic service capacity	$Bas_{i,t}$	Natural log of the basic capacity score of region i in year t.
Financial capacity	$Fin_{i,t}$	Natural log of the finance capacity score of region i in year t.
Incubation capacity	$Inc_{i,t}$	Natural log of the incubation capacity score of region i in year t.
Communication infrastructure	$Inf_{i,t}$	Natural log of communication infrastructure investment of region i in year t
Industry	$Ind_{i,t}$	Natural log of proportion of service industry of region i in year t.
GDP per capita	$Eco_{i,t}$	Natural log of GDP per capita of region i in year t.
Labour	$Lab_{i,t}$	Natural log of years of education per capita of region i in year t.
International trade	$\mathrm{Int}_{i,t}$	Natural log of proportion of international trade of region i in year t.

3.4 Model specification

Literature suggests that quantitative analysis should consider problems of endogeneity (Blundell and Bond, 2000; Liu et al., 2014). Hence, it is worth noting that reverse causation may generate estimation problems in studies of innovation performance. In other words, the explanatory variable may have significant impact on regional innovation performance, but regional innovation performance may also have an impact on some or all the explanatory variables. For example, business incubator capacities may lead to better regional innovation performance, but more innovative enterprises are also likely to be more involved in business incubators. These endogeneity issues may arise through the self-selection of better-performing firms. In such circumstances, much has been written that Ordinary Least Squares (OLS) and within estimators will tend to over-estimate the effects of explanatory variables and also unable to address the simultaneity and endogeneity issues (Blundell and Bond, 2000). It is recommended to include instrumental variables as a further control.

However, because it is difficult to select the appropriate instrumental variables in general economic statistics research, the Generalized Method of Moments (GMM) exhibits advantages. GMM can use lagged dependent variable as an instrumental variable to further control estimation. Hence, this study uses the panel data GMM estimation method to conduct the analysis. This method is regarded as a reasonable method for dealing with unobserved heterogeneity, endogeneity, and also situations where the explanatory variables are not strictly exogenous (Blundell and Bond, 2000; Liu et al., 2014). Meanwhile, the GMM is also suitable for dynamic panel data, because it allows the use of instruments of first differences as instruments and exploits the available moment conditions in the sample more fully (Blundell and Bond, 2000). To this end, this study uses the difference of the lagged dependent and explanatory variables as instruments and the Hansen's test for checking their overall validity. Meanwhile, the Arellano–Bond test for AR is also used to detect the existence of the first or second order serial correlation.

In line with prior studies of regional innovation performance, this study uses system-GMM model proposed by Arellano and Bond (1991) and Blundell and Bond (2000):

$$y_{i,t} = \gamma_0 + \sum_{j=1}^{n} \varphi_{t,j}\, y_{i,t-j} + \sum_{k=1}^{n} \delta_{t,k}\, x_{i,t-k} + \gamma_{i,t} + u_{i,t} \quad (i=1,\cdots,N;\ t=1,2,\cdots,T) \quad \textbf{(1)}$$

Where i refers to region, j,k refers to the lag, γ_0 refers to constant, γ_i refers to individual effects, and $u_{i,t}$ refers to residuals.

This basic model gives a way of avoiding endogenous problems. Here, this study augments the basic model as follows to include our hypothesised variables and other control variables.

$$\begin{aligned} lnInn_{i,t} = {} & \alpha_0 + \alpha_1 \ln Inn_{i,t-1} + \alpha_2 \ln Bas_{i,t} + \alpha_3 \ln Fin_{i,t} + \alpha_4 \ln Inc_{i,t} + \alpha_5 \ln Inf_{i,t} + \\ & \beta_1 \ln Ind_{i,t} + \beta_2 \ln Eco_{i,t} + \beta_3 \ln Lab_{i,t} + \beta_4 \ln Int_{i,t} + \varepsilon_{i,t} \end{aligned} \quad \textbf{(2)}$$

Where,

$Inn_{i,t}$ = innovation performance of region i in period t.

$Bas_{i,t}$ = basic capacity of business incubator of region i in period t.

$Fin_{i,t}$ = financial capacity of business incubator of region i in period t.

$Inc_{i,t}$ = incubation capacity of business incubator of region i in period t.

$Inf_{i,t}$ = proportion of communication infrastructure investment of region i in period t.

$Ind_{i,t}$ = proportion of services industry of region i in period t.

$Eco_{i,t}$ = GDP per capita of region i in period t.

$Lab_{i,t}$ = years of education per capita of region i in period t.

$Int_{i,t}$ = proportion of international trade of region i in period t.

Meanwhile, in the equation (2), α_0 is the constant, α_1 is the lag of regression coefficient of dependent variable, α_2 to α_5 are the lags of regression coefficients of each independent variable; β_1 to β_4 are the lags of regression coefficients of each control variable; $\varepsilon_{i,t}$ is the random disturbance term.

3.5 Descriptive statistics

3.5.1 Regional innovation performance

The extant literature suggests that the nature of regional innovation activities can be explained by regional innovation systems theory. Some scholars (e.g., Cooke et al., 1997) define regional innovation systems as systems in which firms and other organizations are systematically engaged in interactive learning through an institutional milieu characterized by embeddedness. Furthermore, Iammarino (2005: 1564) suggests that regional innovation systems constitute "the localised network of various actors and institutions in different sectors whose activities and interactions generate, absorb, and diffuse new technologies within and outside the region". Regional innovation systems therefore are important entities when examining the determinants of innovation performance in the context of countries which cover various geographical areas and where there are substantial regional disparities in terms of economic and/or innovation capabilities.

<Insert Figure 1 about here>

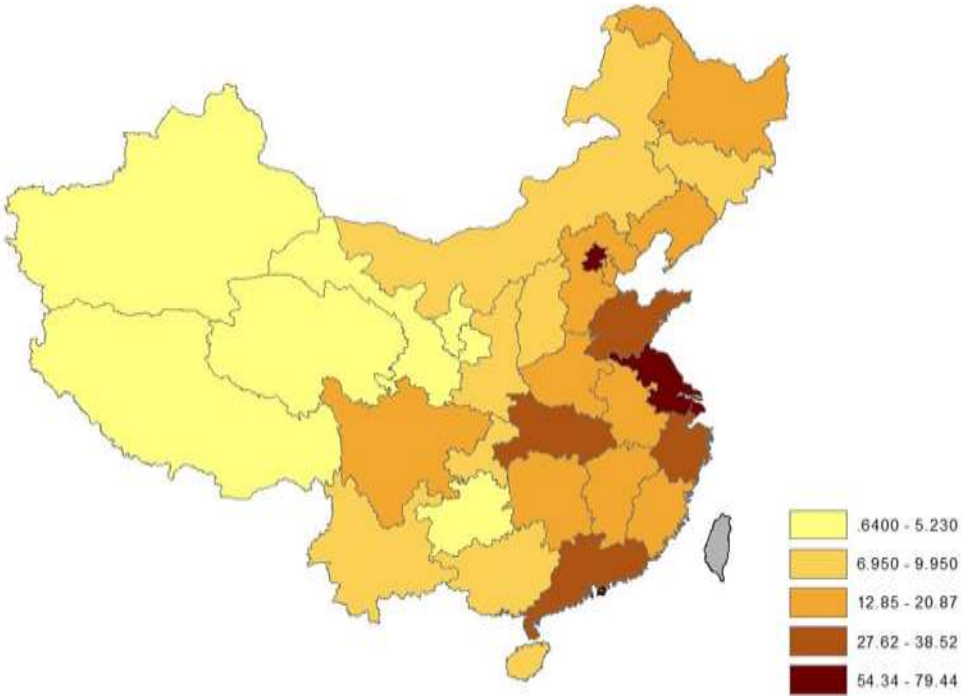

Figure1. Geographic distribution of average score of regional innovation input

Source of data: China Science and Technology Statistics Yearbook (2008-2017)

In this vein, the data has shown that the average score of regional innovation input exhibits major differences among different regions of China (see Figure 1). The better innovation input has been reported in the capital city, Beijing (79.44), and several coastal provinces such as Jiangsu (58.57), Shanghai (54.34), Shandong (38.52) and Guangdong (36.36). Much regional differences are exhibited in those provinces compared with other provinces. Innovation input scores in most of the western regions were less than 6.0, which are far smaller than the national average level. Generally, there are gradient patterns from the east to the central and to the west of China. One of the reasons is that central and western regions in China are facing more challenges of further economic development. Better coordination of national innovation investment and more favourable industrial policy are still needed in those regions.

<Insert Figure 2 about here>

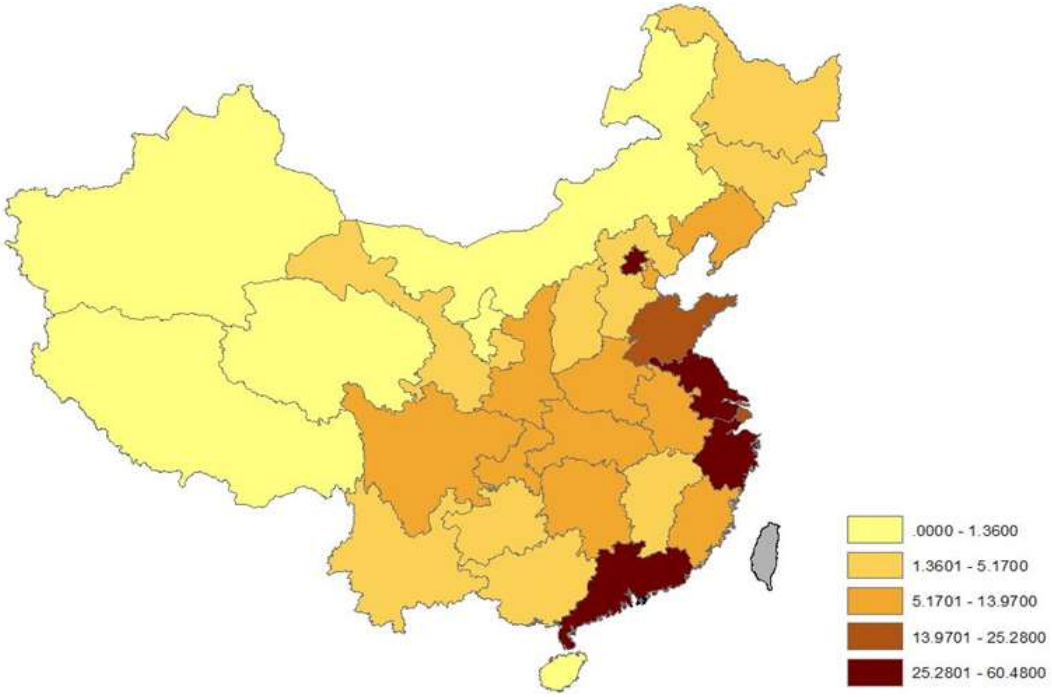

Figure 2. Geographic distribution of average score of regional innovation output

Source of data: China Science and Technology Statistics Yearbook (2008-2017)

Moreover, in terms of innovation output, Figure 2 shows the similar results. The most active regions include the capital city, Beijing (59.87), and coastal provinces such as Jiangsu (60.48), Guangdong (51.96), Zhejiang (42.25), Shanghai (25.28) and Shandong (23.44). Despite some central regions, such as Shaanxi (23.44), Hubei (13.55), Anhui (12.16), Henan (8.52), Hunan (7.16) and Chongqing (7.33), having second best performances, innovation output scores in most western regions were less than 5.0. Thus, the eastern coastal areas have played a leading role in the development of innovation thanks to the infrastructure, talents and technological advances of those regions since the reform and opening policy of China started in 1978. As important national innovation and high-tech industrial centres, the innovation input and output of Jiangsu and Guangdong precede all other regions in general.

<Insert Figure 3 about here>

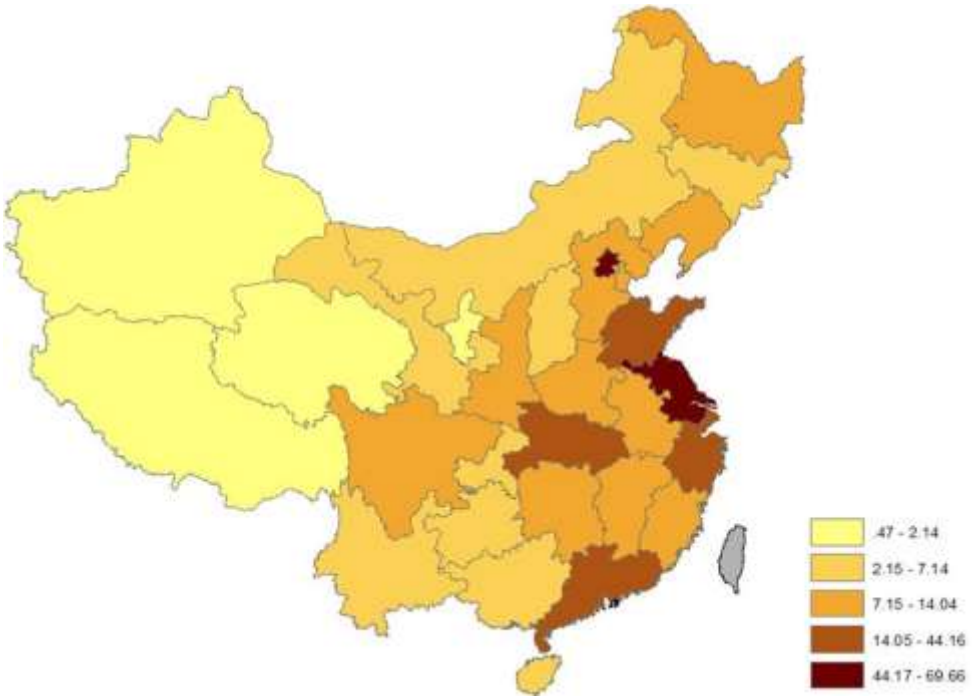

Figure 3. Geographic distribution of average score of regional innovation
Source of data: China Science and Technology Statistics Yearbook (2008-2017)

Overall, in terms of China's regional innovation performance, as show in Figure 3, the most active regions are Beijing (69.66), Jiangsu (59.52), Guangdong (44.16), Shanghai (39.81), Zhejiang (34.93) and Shandong (30.98). Meanwhile, the average score of regional innovation in the central and western regions are generally lower. Particularly in outlying areas, such as Ningxia (0.51), Qinghai (0.62) and Xizang (Tibet) (0.47), since total scores were significantly lower than other regions. To be noticed, at present the central and western regions are facing the dilemma of insufficient innovation resources and a lack of innovation infrastructures. This also reflects the potential issues in the economic transformation of China, where innovation activities focusing on leading technology enterprises which heavily rely on central policy support. As a result much resources and inputs are directed to major cities like Beijing, Shanghai, Guangzhou, and Shenzhen.

3.5.2 Regional business incubator

As shown in Figure 4, Jiangsu province has the highest score of the business incubator basic service capacity, with an average score of 98.73, followed by Beijing, Shandong,

Zhejiang, Shanghai, Guangdong and other eastern regions. For example, by the end of 2017, there were 1,582 business incubators in Jiangsu Province, which ranked first in China (China Torch Statistics Yearbook, 2017).

<Insert Figure 4 about here>

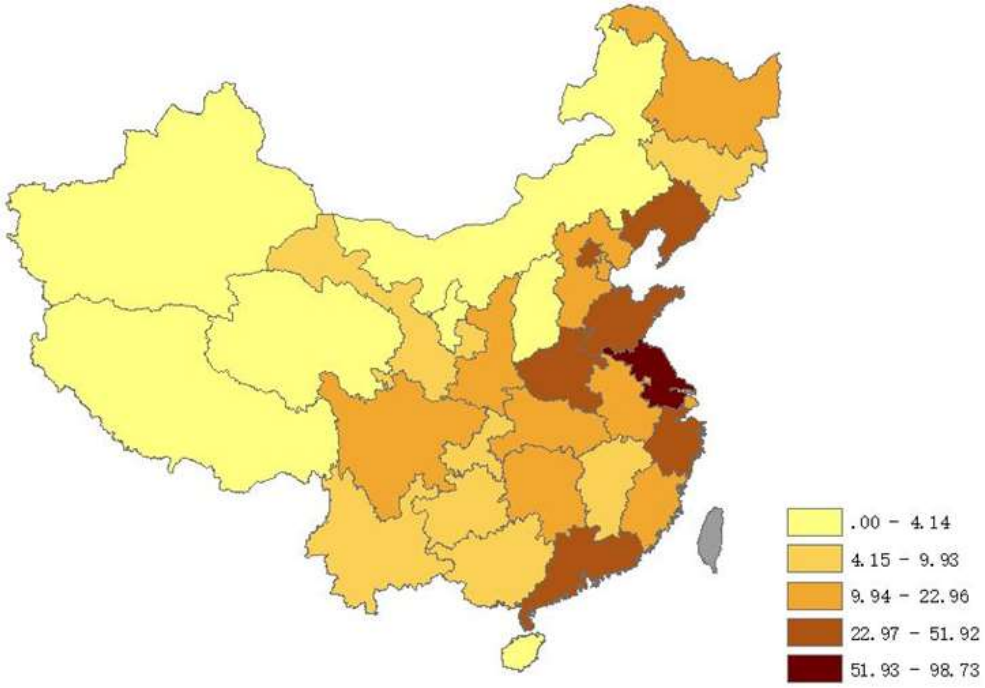

Figure 4. Geographic distribution of score of business incubator basic service capacity
Source of data: China Torch Statistics Yearbook (2008-2017)

Meanwhile, the investment in scientific and technological human resources is also remarkable in Jiangsu province. There are more than 2,700 entrepreneurial mentors in various business incubators in this province, including 117 of whom in the Torch Business Mentoring System of the Ministry of Science and Technology Torch Centre of China. Such resources ensure that Jiangsu has unique and outstanding strength in basic service capacities. Despite that Jiangsu still has to face the competition from other more developed regions, such as Beijing, Shandong, Zhejiang, and Guangdong. The basic service capacity scores in these regions are all above 25. Unsurprisingly, the basic service capacity scores of Qinghai, Ningxia, and Xinjiang (all in western regions of China) are still at the low levels of less than 3.0, partially due to the lower levels of economic development, talent reservation and the lower investment in business incubators in those regions.

As shown in Figure 5, the financial capacity scores of business incubators have the similar pattern with the basic service capacity score. Beijing is again ranked the first, followed by Jiangsu, Shanghai, Guangdong, and Zhejiang, where the economic development is much higher. In addition, it is worth noting that apart from Beijing with very high scores, other eastern coastal areas, such as Jiangsu, Shanghai, Guangdong, and Zhejiang have much similar scores in financial capacity, suggesting the more available financial support for business incubators in Beijing compared to all other regions.

<Insert Figure 5 and 6 about here>

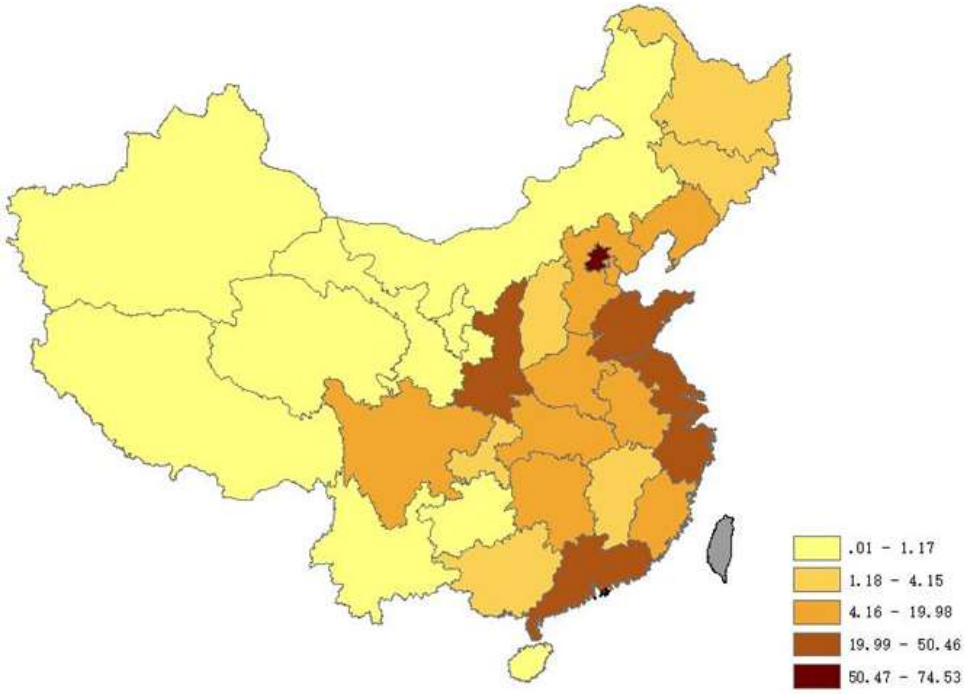

Figure 5. Geographic distribution of score of financial capacity of business incubator
Source of data: China Torch Statistics Yearbook (2008-2017)

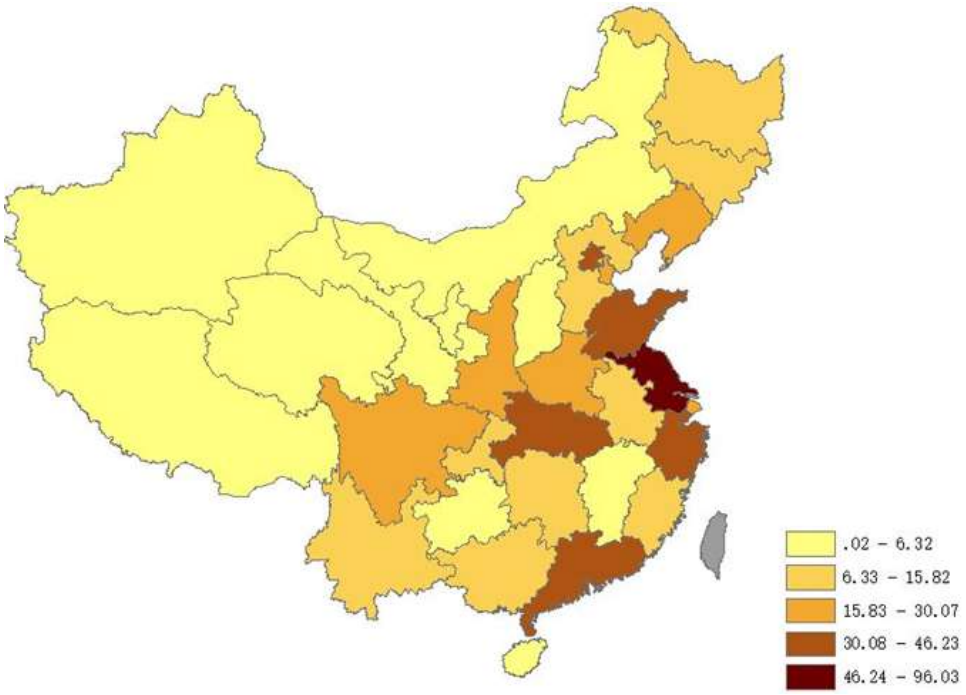

Figure 6. Geographic distribution of score of incubation capacity of business incubator
Source of data: China Torch Statistics Yearbook (2008-2017)

Moreover, Figure 6 suggests that the scores of incubation capacity of business incubators show slightly different patterns with both the basic service capacity and the financial capacity in different regions. This time, Jiangsu is in the first place, followed by Beijing, Zhejiang and other regions with better economic development. The incubation capacity of business incubators in Xinjiang, Qinghai, Ningxia and other western regions are in a much lower position.

Overall, the statistics shows that factors such as levels of economic development and talent reservation are well related to the development of business incubator capacities in terms of basic services, financial, and knowledge incubation.

3.5.3 Regional communication infrastructure

<Insert Figure 7 about here>

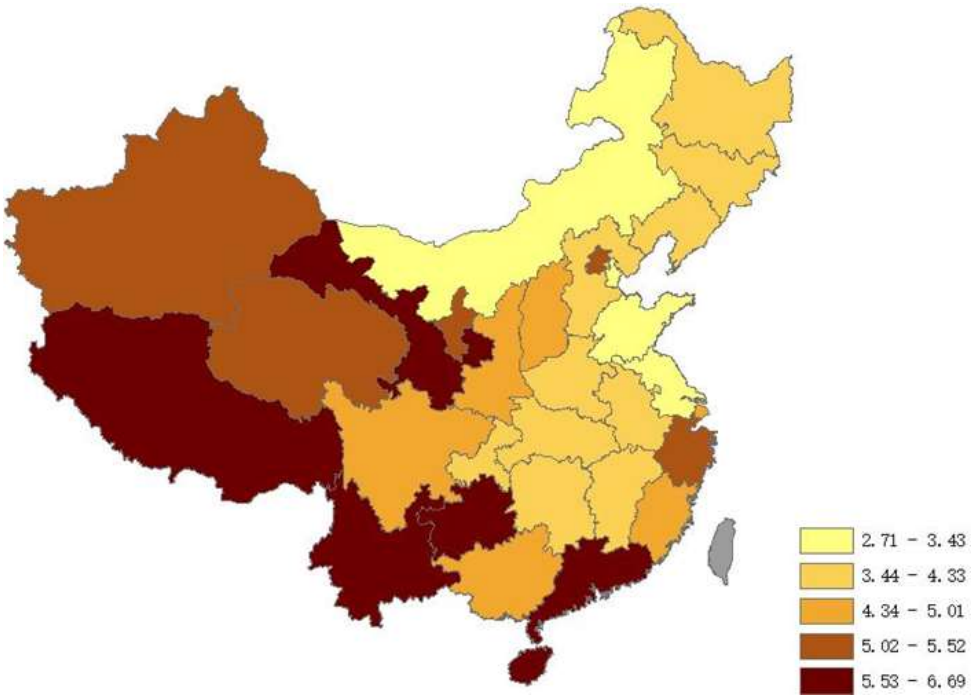

Figure 7. Geographic distribution of intensity of regional communication infrastructure construction

Source of data: China Statistics Yearbook (2008-2017)

Interestingly, the data shows that the distribution of intensity of communication infrastructure construction is rather uniform across Chinese regions. As shown in Figure 7, there is little gap in communication infrastructure construction intensity between central, western and eastern coastal provinces (e.g. between Xinjiang and Guangzhou and between Zhejiang and Sichuan). Many central and western provinces have even better scores than some eastern coastal provinces, such as Guizhou, Xizang (Tibet) and Shaanxi. However, the number and capacities of business incubators in these regions are generally not high, and the innovation performance is also at a lower level than the eastern coastal provinces (as discussed previously).

This phenomenon might be related to the policy orientation of China's reform and opening up policy. Communication infrastructure constructions in some less developed provinces, such as Guizhou, have benefited from more favourable development policies. However, such favourable policy might not directly assist the growth of business incubators and regional innovation performance.

3.6 Correlation matrix

Table 2 provides means, standard deviations and the correlation matrix for all the variables. The mean number of regional innovation performance over the period is 2.12. The average score of basic service capacity of business incubators is 2.30. The average score of financial capacity of business incubators is 1.64. The average score of incubation capacity of business incubators is 2.34. This study used standardized values for the interaction terms (involving Bas, Fin, Inc and Inf) to avoid possible biases arising from high correlations with the main effects (Belsley, 1984).

<Insert Table 2 about here>

Table 2. Descriptive statistics and correlation matrix

Var	Mean	SD	Inn	Ind	Lab	Eco	For	Bas	Fin	Inc	Inf
Inn	2.12	1.302	1								
Ind	3.75	0.194	0.334**	1							
Lab	2.16	0.147	0.490*	0.648	1						
Eco	2.36	0.049	0.479**	0.605*	0.810**	1					
For	2.89	0.956	0.739***	0.466	0.543	0.549*	1				
Bas	2.30	1.303	0.766***	0.076	0.187	0.226	0.526**	1			
Fin	1.64	1.731	0.844*	0.334	0.479	0.513**	0.609	0.750**	1		
Inc	2.34	1.435	0.847**	0.113	0.353	0.387	0.599	0.861**	0.827	1	
Inf	1.42	0.512	-0.059**	0.014	-0.371*	-0.479	0.041*	0.111*	-0.117	-0.108*	1

p-values in parentheses (* p < 0.1, ** p < 0.05, *** p < 0.01)

4. Results

The regression results are reported in Table 3. This study uses the lagged first differences of the dependent and explanatory variables from year 1–4 as instruments and employs the Sargan test for the over-identifying restriction and the overall validity of the instruments in the estimation process. The insignificant values of the Sargan test in models (2), (3), (4) and (5) support the view that the instrumental variables are valid. However, the reported regional innovation performance is significant in model (1) and (2) when only the control variables and business incubator capacities are considered. Moreover, the Arellano–Bond tests in all models indicate that the first-order AR(1), and not the second-order AR(2), error terms are serially corrected. These further support the

use of GMM for the estimation in models (2) – (5). We therefore focus the discussion on models (2) – (5).

In model (2), the lagged value of the dependent variable $\mathrm{INN}_{i,t}$ is significant as expected, so as variables of business incubator capacities. This result suggests that regional innovation performance improvement is a gradual and accumulated process. In this sense, during the formulation of innovation principles and polices, the government should consider the dynamic development process of the innovation capacities in different regions, as well as the long-term development of regional innovation performance.

Furthermore, all four hypothesised variables and their direct effects on innovation performance are highly significant in model (2). In particular, the incubation capacity has the strongest effect, where the estimated coefficient is 0.43. Hypothesis 3 is thus supported. Therefore, it is reasonable to argue that business incubators provide important social network for start-ups and technology entrepreneurs and promotes knowledge transfer between enterprises. Meanwhile, business incubators as knowledge sharing platforms not only encourage mutual learning within incubators, but also knowledge exchange with external knowledge sources, such as universities and research institutions, and promote tacit knowledge transfer between various entities in the innovation ecosystem. This has subsequently promoted the transformation of technological achievements and the enhancement of regional innovation performance.

Moreover, the impacts of basic service capacity and financial capacity of business incubators are relatively small, but still significant (the estimated coefficients are 0.14 and 0.16, respectively). Hence, hypothesis 1 and 2 are supported. However, the smaller effect on regional innovation performance reflects the fact that assets availability (e.g. spaces and talent) and financial support is not as important as knowledge transfer opportunities provided by business incubators. One of the reasons could be that not all

start-ups and technology entrepreneurs in business incubators are seeking tangible or intangible assets. It is knowledge exchange that will enable better innovation activities of technology entrepreneurs.

Furthermore, the estimated coefficient of communication infrastructure is 0.27. The significant effect suggests that high quality communication infrastructure is a necessary antecedent for better regional innovation performance. Hypothesis 4a is thus supported.

In models (3) – (5), this study considered the three interaction terms one at a time. In model (3) coefficient of the interaction term between basic service capacity of business incubators and communication infrastructure is positive and significant (+0.27, $p<0.01$). This supports hypothesis H4b that the communication infrastructure positively moderates the relationship between basic service capacity of business incubator and regional innovation performance. In model (4) the coefficient of the interaction term between financial capacity of business incubators and communication infrastructure is statistically insignificant. Furthermore, its introduction has little effect on the size and statistical significance of the direct effect coefficients. Thus, it appears that the effects on regional innovation performance by financial capacity of business incubators and communication infrastructure are additive, but that the hypothesised moderating effect (H4c) of communication infrastructure on the relationship between financial capacity of business incubators and regional innovation performance is not supported. Finally, model (5) carries out the regression with the interaction term between incubation capacity of business incubators and communication infrastructure included. The coefficient of the interaction term is positive and statistically significant (+0.10, $p<0.01$). Thus, hypothesis H4d is supported. The above result shows the positive impact of incubation capacity of business incubators on regional innovation performance is enhanced in regions where communication infrastructures are more developed, presumably because communication infrastructure assisted the spill over effects (e.g. knowledge transfer) and transformation of innovation results in those regions.

<Insert Table 3 about here>

Table 3. GMM regression results

	(1)	(2)	(3)	(4)	(5)
Inn	0.351***	0.161*	0.107	0.809***	0.139
	(0.000)	(0.081)	(0.248)	(0.000)	(0.130)
Ind	-1.968***	0.786***	0.619***	-0.214	0.766***
	(0.000)	(0.001)	(0.009)	(0.514)	(0.001)
Lab	3.391***	0.636	1.009**	0.315	0.683*
	(0.000)	(0.169)	(0.043)	(0.317)	(0.097)
Eco	-0.219	-1.816***	-1.830***	0.106	-1.710***
	(0.572)	(0.000)	(0.000)	(0.842)	(0.000)
For	0.609***	-0.0290	0.00391	0.0322	-0.0178
	(0.000)	(0.623)	(0.947)	(0.629)	(0.764)
Bas		0.140***	0.141	0.107**	0.132
		(0.009)	(0.263)	(0.017)	(0.251)
Fin		0.164***	0.159***	-0.00231	0.136**
		(0.001)	(0.003)	(0.959)	(0.011)
Inc		0.435***	0.360***	-0.0624	0.346***
		(0.000)	(0.006)	(0.576)	(0.005)
Inf		0.275***	0.0771	-0.0115	0.0335
		(0.001)	(0.460)	(0.902)	(0.749)
Bas_inf			0.105***		
			(0.002)		
Fin_inf				0.0593	
				(0.166)	
Inc_inf					0.108***
					(0.000)
AR(1)	0.500	0.227	0.213	0.007	0.251
AR(2)	0.266	0.758	0.807	0.244	0.865
Sargan	0.000	0.109	0.119	0.395	0.281
Observations	210	210	210	210	210
Number of regions	31	31	31	31	31

p-values in parentheses (* p < 0.1, ** p < 0.05, *** p < 0.01)

5. Discussion and conclusion

Business incubators as important homes to technology start-ups and entrepreneurs have developed dramatically in recent years, especially in emerging economies, such as China, because of the vast investment from the government and the industry. Despite the ongoing literature that have investigated the beneficial impact of investment activity on innovation performance in emerging economies (e.g. Fu, 2008), little is known about the effects of the development of business incubators on the regional innovation performance, particularly in the context of emerging economies.

The panel data analysis presented in this paper demonstrates the effects of business incubator capacities on regional innovation performance in 31 Chinese provinces over a ten-year period (2008–2017). The results suggest that the development of business incubators has a significant impact on regional innovation performance. Furthermore, this study identifies the communication infrastructure as an important moderator of the relationship between business incubator capacities and regional innovation performance. This result echoes recent calls for more attention to the effect of communication infrastructure construction on business incubators (Vedovello and Godinho, 2003; Fu, 2008; Meissner et al., 2016; Proskuryakova et al., 2017).

5.1 Contributions to theory

This study integrates the literature on business incubators and regional innovation performance and proves the important relationship between business incubators and regional innovation performance. Specifically, this study contributes to the regional innovation system theory by providing a better understanding of the specific mechanisms by which business incubators' three capacities (i.e., basic, finance and incubation) influence regional innovation performance. This study extends the use of regional innovation system theory that traditionally was based on singular organisations or firms (Cooke et al., 1997; Iammarino, 2005) to a national regional level.

Empirically, previous studies on the impact of business incubators upon regional innovation performance were unable to fully capture the impact of communication infrastructures (Fu and Xiong, 2011). As such, the role of the communication infrastructure remains unclear. This study, however, provides some evidences to verify the positive moderating effects of communication infrastructure development on business incubator capacities and regional innovation performance. Therefore, findings of this paper further add to the literature of knowledge management by conceptualizing the moderating effect of communication infrastructures and their roles in knowledge incubation activities of business incubators. This is particularly relevant in the context of emerging economies, such as China, because of the potential higher value added of knowledge sharing activities in emerging economies. Moreover, the traditional regional innovation systems theory highlights the interactions between various actors and institutions in the local network. Findings of this paper further indicate that the synergy between various entities in regional innovation ecosystems can be facilitated by the development of communication infrastructures.

5.2 Contributions to practice

Findings of this study also have important implications for practitioners and policy makers. This study shows that business incubators have positive effects to regional innovation performance through its basic, finance and incubation capacities. In this sense, managers of business incubators and policy makers should emphasize more on the cultivation of those specific capacities to develop business incubators further. Moreover, this study indicates that regional communication infrastructure investments are essential to facilitate the positive impacts of business incubators on regional innovation performance. Effective investments into the communication infrastructure would not only help improve the performance of business incubators, but also accelerate the transfer of outputs of business incubators into the wider regional innovation performance. Therefore, effective policies introduction and streamlined procedures to facilitate communication infrastructure development should be one of the

most important focus of policy makers.

5.3 Limitations and future research

This study is not without limitations which deserve better future works. First, this study used aggregate business incubator data, and did not differentiate types of business incubator. Future research may develop more fine-grained data to evaluate the development of different types of business incubators on the innovation performance of different regions. Second, this study cannot distinguish state-owned and non-state-owned business incubator due to the limited data availability. For instance, state-owned business incubator may have more support from the government, but non-state-owned business incubator may have more flexibility in operation. Therefore, future studies might wish to examine the roles of different ownership characteristics of business incubator in promoting regional innovation. Third, this study used the panel data of regional innovation to measure regional innovation performance. Future studies might employ longitudinal designs or survey questionnaires that go beyond archival input-output scores to capture more empirical evidence of the channels through which business incubators would facilitate regional innovation performance. Finally, this study used China as the main research context. Although China forms a good example of emerging economies, different emerging economies may have different policy and business environments for business incubators. Such differences may alter the relationship between business incubator capacities and regional innovation performance. Future research may extend our study to a multi-country context involving other emerging economies and even developed countries.

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