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Research article

Entrepreneurial ecosystem and urban economic growth-from the knowledge-based view

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ABSTRACT

The purpose of this paper is to explore the relationship between the development of entrepreneurial ecosystems and economic growth at the urban level from the knowledge-based view. This paper also scrutinizes the moderating roles of industrial diversities and digital technology service. Based on the data of 32 cities in China from 2008 to 2018, the findings show that entrepreneurial ecosystems' development promotes municipal economic growth significantly via knowledge creation and knowledge flow. Moreover, industrial diversity and digital technology service are found to positively moderate the relationship between entrepreneurial ecosystems' development and the urban economic growth. This study extends the literature on entrepreneurial ecosystems and regional economic development at the urban level from the perspective of knowledge-based view. The findings also provide policymakers and stakeholders a different mentality when forming strategies and policies on entrepreneurship.

1. Introduction

Entrepreneurship can bring new business opportunities for regions and invigorate the market (Acs et al., 2017; Dorado and Ventresca, 2013). Policy makers around the world have gradually recognized the importance of entrepreneurship, and have initiated numerous policies and devoted considerable resources to promote entrepreneurship (Biru et al., 2020; Mason and Brown, 2014; Sternberg, 2012). For example, in China, the national policy of "Mass Entrepreneurship and Innovation" was proposed in 2015, aiming to invigorate the market and encourage the regional development,[1] and myriad resources have been allocated under it afterwards. Against this background, China, as an emerging economy, has gained wide attention due to its remarkable development in entrepreneurship. The modern and innovative cities, such as Beijing, Hangzhou, Shenzhen and Shanghai, have become global hubs for entrepreneurship and innovation. Many entrepreneurial start-ups have also achieved catch-up or even become the leading companies in corresponding fields. For example, Douyin, also known in abroad as Tiktok, which was launched in 2016 in Beijing, has been listed in the top of video-hosting service companies. The Nio Inc., founded in Shanghai, has gained remarkable achievements in the electric vehicle industry and occupied a large market share around the world.

Entrepreneurship is not acting in isolation (Boschma, 2015; Ryan et al., 2020), rather, it requires supports from different actors and

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[1] Stata Council. http://www.gov.cn/zhengce/content/2015-06/16/content_9855.htm.

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stakeholders, such as individuals, organizations, and institutions in the region (Chen et al., 2020; Spigel and Harrison, 2018). Thus, the notion of "entrepreneurial ecosystem" (EE) has been gradually employed to depict the level and status of entrepreneurship (Cohen, 2006; Roundy et al., 2017; Shi and Shi, 2022), which is defined as *"a dynamic interaction between interdependent actors and other factors embedded in institutional environments of a particular region, one which drives the allocation of resources through the creation and operation of new ventures"* (Harima et al., 2021, p82). The entrepreneurial ecosystem is thereby also valued by the governments with the expectation of improving regional development through the ecosystem. Although extant studies have emphasized the role of entrepreneurial ecosystem's development in regional development (Audretsch et al., 2019), few of them have explored its role in regional economic performance. In practice, policymakers are also provided limited information of whether the development of entrepreneurial ecosystem has promoted regional economy, which are not beneficial for the future policy making.

In addition, the regional development in some countries such as China is extremely unbalanced and varies differently among cities due to historical and cultural issues (Liu et al., 2018), requiring analysis at the urban level. For example, Jinan and Qingdao, two cities in Shandong Province, have presented different development paths and entrepreneurial levels, with the former enjoying sufficient resources and convenient transportation, and thus being more active in entrepreneurship. As can be seen, even cities in a same province are much varied from each other, calling for more micro analysis. However, previous studies focus more on the country, provincial or state level, the results of which may be biased or even inaccurate in terms of the urban level.

Thus, it is pending a comprehensive investigation on the relationship between the development of entrepreneurial ecosystem and urban economic growth, which is of great significance in terms of both the theory and practice. In this research, we will resort to the knowledge-based view (KBV), since knowledge is not only regarded as a key factor underlying the competitiveness of firms (Grant, 1996), but also in sectors or regions (Huggins, 2008; Yigitcanlar, 2009; Huggins and Strakova, 2012). For example, Lerro and Schiuma (2009) have illustrated the regional development from the knowledge-based perspective and hold that creation and diffusion of knowledge has contributed much to the economy. Since the entrepreneurial ecosystem is the carrier of knowledge creation and knowledge flow, we hold, the KBV could provide us an opportunity to the explore the relationship between entrepreneurial ecosystem's development and regional economy.

Several regional contingency factors may also moderate the effects of entrepreneurship ecosystems' development on urban economy. According to the KBV, knowledge, especially idiosyncratic knowledge, is a strategic determinant of superior organization's performance (DeCarolis and Deeds, 1999; Felin and Hesterly, 2007; Grant, 1996). Regions with diverse industries can thus improve the capability of entrepreneurial ecosystems to create more heterogenous and cross-industrial knowledge, which may exert an influence on the relationship between entrepreneurship ecosystems' development and urban economic growth. In addition, under the knowledge-based view, the knowledge flow is also an essential mechanism. Thus, we hold regional digital technology service may also affect the relationship between entrepreneurship ecosystems' development and urban economy by improving the efficiency of knowledge flow within the entrepreneurship ecosystems (Autio et al., 2018; Yoo et al., 2010). However, the potential impacts of the industrial diversity and digital technology service are also underexplored in the existing entrepreneurial ecosystem research. What's more, the development of digital technology service has been emphasized by Chinese government in the past several years and many policies have been enacted, among of which, the *New Infrastructure Construction* is the most influential one with the aim of establishing a comprehensive digital infrastructure system and stimulating the development of regions and the nation. Therefore, it is also of great significance to examine whether the policies have taken effect in promoting regional development.

To address the research gaps, we propose two research questions: *1) What's the relationship between the development of entrepreneurship ecosystems and urban economic growth? and 2) How do the industrial diversity and digital technology service moderate the relationship between the development of entrepreneurship ecosystems and urban economic growth?* Based on a panel data of 32 major cities in China from 2008 to 2018, which covers a wide range of development situations of China, we find that entrepreneurship ecosystems' development can promote urban economic growth significantly via knowledge creation and knowledge flow. To avoid the potential endogeneity problem that economic growth may also facilitate the development of entrepreneurship ecosystems, we employ the fixed effects Generalized Method of Moments (GMM) regression technique, and our argument is still supported. Furthermore, the industrial diversity and the digital technology service are found to have strengthened the effects of entrepreneurship ecosystems' development on urban economic growth. The findings of this study contribute to extant entrepreneurship ecosystem research from the knowledge-based view and expands the understanding of the role of digitalization and industrial diversification in entrepreneurship ecosystems. Our findings also shed lights on entrepreneurship policies and practices.

2. Theoretical development and hypotheses

Originating from the resource-based view, the knowledge-based view treats the knowledge as the critical resource in capturing value and gaining competitiveness (Barney, 1991; Grant, 1996). Creating new knowledge to gain more value thus becomes a pivotal strategy (Håkanson, 2010; Kodama, 2006), especially in the knowledge-intensive era. Within the entrepreneurship ecosystems, actors, especially those from academia, can provide or create knowledge, which enables the value creation and influence regional development accordingly.

Besides, from the KBV, the flow and spread of knowledge is also validated as an essential mechanism in the value creation process, especially the knowledge from external sources (Hayter, 2016; Johanson and Vahlne, 2003). Previous studies have also figured out the role of knowledge flow in entrepreneurship ecosystems. For example, Chen et al. (2020) have summarized the extant research of China's entrepreneurial ecosystem from multiple dimensions, and hold that the absorption and flow of knowledge play an essential role in the innovation dimension. Thus, this research will mainly focus on these two mechanisms in the following analysis, namely knowledge creation and knowledge flow.

2.1. Entrepreneurial ecosystems and urban economic growth

As stated above, according to the knowledge-based view, knowledge is regarded as the primary resource that underlies value creation (Audretsch and Keilbach, 2008; Barney, 1991; Grant, 1996; Kogut and Zander, 1992; Romer, 1990). The new knowledge creation, as well as knowledge flow and reconfiguration are regarded as the key mechanisms (Galunic and Rodan, 1998). First, in the entrepreneurship ecosystems, universities and research institutes can create new knowledge and cutting-edge outcomes during the research (Adams, 2020; Hayter, 2016). Different types of actors, including the universities, enterprises and other supporting organizations, are usually interconnected and interwoven with each other in the entrepreneurship ecosystems (Mason and Brown, 2014) , which can speed up the new knowledge creation process due to the knowledge creation atmosphere. For example, the enterprises may be encouraged to create more new knowledge and technologies in the entrepreneurship ecosystems. In this situation, more entrepreneurial activities would be carried out, and thus stimulate the economic development (Agarwal et al., 2008, 2010; Zahra et al., 1999). Therefore, as the carrier of new knowledge creation, the entrepreneurship ecosystem may have a positive influence on regional economic development.

Second, different kinds of actors in the entrepreneurial ecosystems can usually transfer or share pivotal knowledge and technologies through communication and collaboration. The knowledge flow and spillover among these actors can facilitate the new venture creation by improving the entrepreneurship and innovation efficiency, and hereby improve economic growth (Audretsch et al., 2008; Audretsch and Keilbach, 2008; Harima et al., 2021; Horvath and Rabetino, 2019; Romer, 1986). Take the Silicon Valley as an example, a distinguished entrepreneurial ecosystem, the universities and research institutes have contributed much to the local economic growth by providing enterprises with new knowledge and brainpower (Adams, 2020). Moreover, the flow and spillover of advanced knowledge, including the cutting-edge process and production knowledge, management experience or international quality standards, can also help the incumbents upgrade the knowledge base, create more entrepreneurial opportunities, and thus improve regional economic growth (Ryan et al., 2020).

Based on the above discussion, we propose the following hypothesis.

Hypothesis 1. The entrepreneurial ecosystems' development can promote urban economic growth via knowledge creation and knowledge flow.

2.2. The moderating effect of industrial diversity

Due to the imbalance among different regions, the local governments have autonomy of formulating industrial policies in China (Zhou et al., 2017), and thus the industrial diversity also varies across regions. From the knowledge-based view and industrial economics, cross-industrial and multidisciplinary knowledge, including various technologies and ideas, is more important than that from a monopoly or the similar sector (Beaudry and Schiffauerova, 2009; Glaeser et al., 1992). A classical research of Jacobs also indicates that, '*the greater the sheer number of and variety of division of labor, the greater the economy's inherent capacity for adding more kinds of goods and services*' (Jacobs, 1969).

Specifically, a region with more diverse industries could provide more heterogeneous and multidisciplinary knowledge (Audretsch, 2007), which may accelerate the new knowledge creation process by increasing recombination opportunities of various knowledge during the entrepreneurship, and thus stimulate more entrepreneurial opportunities in ecosystems (Audretsch, 2007; Driessen et al., 2013; Wang et al., 2016). The regional economic growth can hereby be accelerated. Thus, some high-tech enterprises tend to locate in cities with diverse industries to enjoy the benefits (Liang and Goetz, 2018). Besides, when a region is equipped with diversified industries, the interaction between multilateral actors in the entrepreneurship ecosystem will be more frequent and effective, since almost every actor requires components or complements from others (Adner and Kapoor, 2010). More new knowledge and entrepreneurial opportunities could thus be generated in the interaction process. Therefore, we hold that the industrial diversity can strengthen the positive effect of entrepreneurship ecosystems' development on urban economic performance by improving the new knowledge providing capability of entrepreneurship ecosystems.

Based on the above discussion, we propose.

Hypothesis 2. Industrial diversities may strengthen the positive effect of the development of entrepreneurship ecosystems on urban economic growth.

2.3. The moderating effect of digital technology service

Nowadays, digitalization plays an increasingly important role in technological innovation, sustainable development, as well as economic growth, which is defined as "*the sociotechnical process of applying digitizing techniques to broader social and institutional contexts that render digital technologies infrastructure*" (Tilson et al., 2010). Organizations have made great effort in the digitalization with the purpose of grasping entrepreneurial opportunities in the new era and accelerating value creation (Nambisan, 2017; Yoo et al., 2010). From the KBV, the knowledge flow is an essential mechanism in the value creation process (Hayter, 2016). We suggest that digital technologies and related services can speed up the knowledge flow and spillover in the entrepreneurial process (Nambisan, 2017; Zammuto et al., 2007), and thus strengthen the positive influence of the entrepreneurship ecosystems' development on urban economic growth.

From one hand, the digital technology service enables the speeding up of the knowledge spillover and knowledge sharing across organizational and industrial boundaries (Goswami et al., 2018; Thompson et al., 2018). Actors in entrepreneurship ecosystems can thus have more opportunities to participate in the value cocreation process, and the regional development can also hereby be promoted.

From another hand, digital technologies can change the trajectory of entrepreneurs in searching for entrepreneurial opportunities and realizing new value propositions by speeding up knowledge sharing and spillover in the entrepreneurial ecosystems (Autio et al., 2018; Nambisan, 2017; Nambisan et al., 2019; Tilson et al., 2010; Yoo et al., 2010). For example, digital technologies have promoted the construction of many new operational structures (Malone, 2018), such as the digital platforms, which provides more channels and opportunities for entrepreneurs to create and capture value. The regional economic growth can thus be improved.

Based on the above discussions, we hypothesize.

Hypothesis 3. Digital technology service may strengthen the positive effect of the development of entrepreneurship ecosystems on urban economic growth.

The conceptual model is depicted in Fig. 1.

3. Research context

In China, both the central government and local governments have put great emphasis on entrepreneurship in the past decades, and have enacted myriad policies to encourage entrepreneurship since the 1980s. Many entrepreneurship ecosystems are thereby established. The frequency of keywords may demonstrate the logic and tendency of organizations' behaviors (Dunn and Jones, 2010; Jeong and Kim, 2019). Thus, we selected the representative economic heavyweights in our sample and searched for the formal governmental documents whose titles contain the keyword "entrepreneurship" from 2007 to 2017. Fig. 2 exemplifies documents from municipal governments that are related to entrepreneurship. The selected sample cities include traditional developed cities (e.g., Beijing, Shanghai, and Jinan), emerging cities with advanced innovation and manufacturing industries (e.g., Xiamen, Foshan, and Wuxi), and the hub of the national program of "The Development of the Western Region in China" (e.g., Chongqing). Owing to the proposal of "Mass Entrepreneurship and Innovation", we have witnessed a sharp increase of entrepreneurship and innovation-oriented policies after 2014. This national initiative was put forward by Premier Li Keqiang at the Annual Meeting of the New Champions in September 2014 and this concept was promoted and adopted widely since then. In response to this major initiative, both relevant national ministries (such as the Ministry of Science and Technology, Ministry of Finance, Ministry of Industry and Information Technology, and The People's Bank of China) and local governments have issued many documents to further encourage entrepreneurship, aiming to promote regional development and economic growth. Entrepreneurship has become the consensus of various cities afterwards, regardless of the geographical location and developing situation. The development of entrepreneurial ecosystems has gradually entered an era of

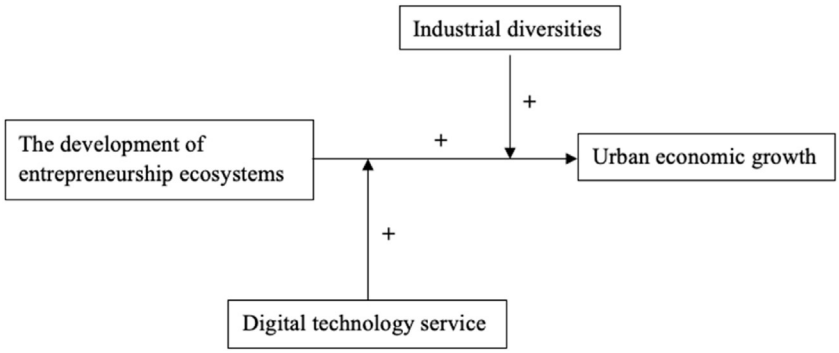

Fig. 1. The conceptual model.

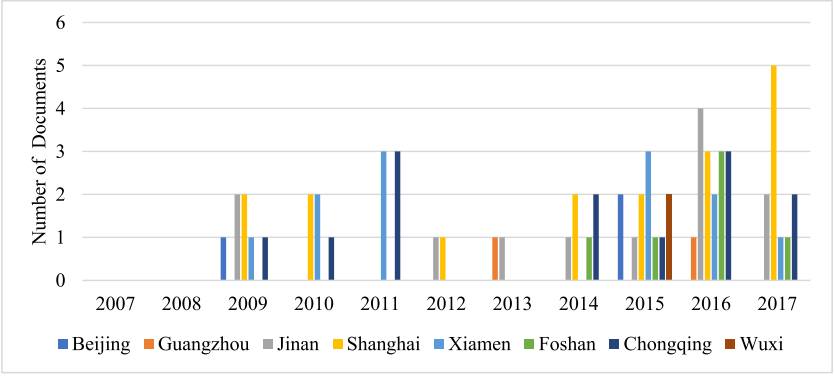

Fig. 2. Number of formal documents containing "Entrepreneurship" in the title.
Note: Documents in the figure are released by the general office of each municipal government.

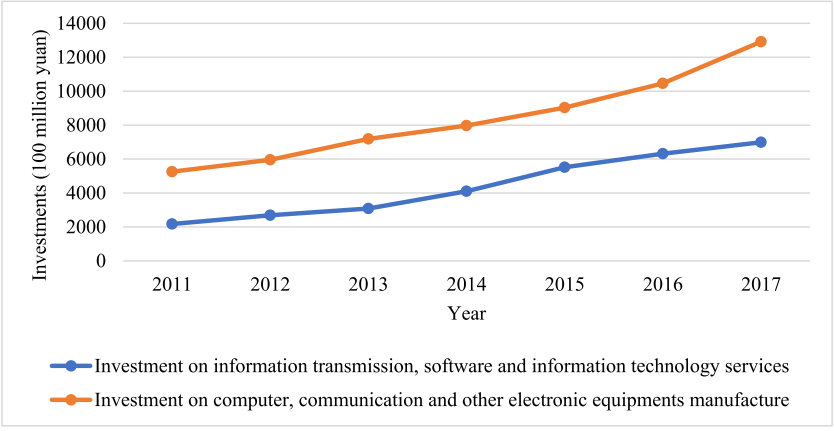

Fig. 3. Investments on digital technology services and manufacturing.
Source: National Bureau of Statistic, accessed via http://www.stats.gov.cn/tjsj/ndsj/.

unprecedented rapidity and prosperity. However, under this situation, the effect of the development of entrepreneurial ecosystems on regional economic performance is still underexplored.

Due to different historical, cultural, geographical, and natural factors, institutional developments of regions are also unbalanced in China. Following the general strategic guidance of the central government, local governments can formulate their own policies according to the region's comparative advantages and resource endowments with autonomy (Chen and Yang, 2019; Zhou et al., 2017). Different policies and initiatives have nurtured different industrial clusters among regions. For example, Shijiazhuang, the capital of Hebei Province and an economic hub in central China, has cultivated nearly 40 industrial clusters, covering equipment manufacturing, biological medicine, electronic information, chemical industry, textile, food processing, leather, ceramics, calcium and magnesium, building materials, etc. While in Changchun, the capital of Jilin Province and a manufacturing hub in Northeastern China, the automobile, information technology, as well as medicine industrial clusters are in dominance and with strategic priority. The emergence of diversified industries can facilitate the cross-industrial knowledge flow and spillover within the region, which could nurture more entrepreneurial and innovation opportunities (Audretsch and Keilbach, 2004; Baptista and Swann, 1998).

Other than industrial diversification, another critical driving force in the entrepreneurial process is digitalization. In the past decade, the development of digital technologies has been booming, and both the central government and local governments have allocated much resource to support the development of digital technology services and manufacturing (see Fig. 3). Digital technology services enable new businesses and focus more on the transforming and upgrading of industries. For example, the live commerce, virtual education, virtual signing of contract, telemedicine, and so on, have gradually occupied people's life and work, especially during the period of COVID-19. It is the digital technology service that ensures the recovery of China's economy in the outbreak, just as what the Guangming Daily (founded by the Central Committee of the Communist Party of China) said that "*digital technology service has been fully involved in the social operation and guides the enterprises to recover from the epidemic*".[2]

Overall, in such an era when entrepreneurship is booming in almost every corner and is valued by both the governments and urban citizens, it is meaningful to explore whether the development of entrepreneurial ecosystems can improve urban economic growth. Moreover, we argue, in nations like China with huge differences in institutional development, governmental orientation, resource endowments, and culture across different regions (Liu et al., 2018), it is necessary to explore the mechanisms of entrepreneurial ecosystems on a small footprint region. For example, In Qingdao, a coastal city of Shandong Province, lots of stat-ups have gradually established due to the attractive entrepreneurial policies and huge amount of loans provided for entrepreneurs. Some well-developed firms have also cultivated a good entrepreneurial atmosphere. The digital platform established by Haier, a famous manufacturing firm in China, has provided abundant resources and opportunities to those who want to start a new business. In comparison, Jinan, the capital of Shandong Province, enjoys less advantages and is lack of entrepreneurship. Therefore, if we analyze the mechanism of entrepreneurial ecosystems from a more macro level, such as the provincial level and national level, we may overlook some important mechanisms. Our work also attempts to investigate the mechanisms of contingencies that may affect the relationship between entrepreneurial ecosystems' development and urban economic growth, hoping to provide some specific suggestions to both policymakers and managers.

4. Data and measurement

4.1. Data

Our panel sample mainly covers 32 cities in China from 2008 to 2018 (Beijing, Dalian, Guangzhou, Ha'erbin, Hangzhou, Jinan,

[2] Guangming Daily. https://epaper.gmw.cn/gmrb/html/2020-03/05/nw.D110000gmrb_20200305_2-16.htm.

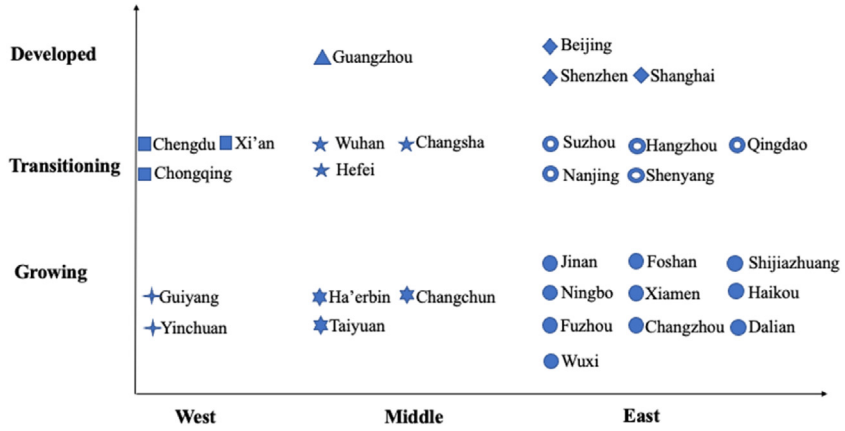

Fig. 4. The distribution of selected cities.

Nanjing, Qingdao, Shanghai, Shenzhen, Shenyang, Shijiazhuang, Suzhou, Taiyuan, Tianjin, Wuhan, Xi'an, Changchun, Ningbo, Xiamen, Fuzhou, Chengdu, Haikou, Hefei, Changsha, Chongqing, Yinchuan, Changzhou, Wuxi, Foshan, Tangshan, Guiyang). The dataset does not cover all the cities in China, and the sample cities are selected for the following reasons. Data accessibility is a primary concern, as comprehensive annual statistical data for many cities is lacking. To fulfill our research objectives, cities included in the sample have well-documented annual statistics that are public and available. Second, our sample has covered almost all the representative cities in different regions with different developing situations to avoid selection bias (see Fig. 4). Regions in China are divided into three parts, namely, the east part, the middle part and the west part (Liu et al., 2018). The eastern coastal regions have been enjoying the advantage of rich resource endowments stimulated by FDI and the opening door policy. In contrast, the western areas have been lagged behind due to their weak connections to the global market and the underdeveloped infrastructures (Liu et al., 2018). The development of middle regions is between the east and west regions. As can be seen in Fig. 4, the horizontal axis representing the geographical distribution has covered all the three areas in China. Besides, according to the economic development status, resident living standard and lifestyle diversity, concentration of resources, and future development potential, the selected cities can be divided into three categories: developed city, transitioning city, and growing city, which are shown in the vertical axis. Overall, the sample has covered a wide range of geographical and development situations of China's cities, which can avoid the selection bias to some degree (see Fig. 4).

It's worth noting that the multi-level administrative system of China is divided into nation, province, and city in sequence. Generally speaking, cities are subordinates of provinces. Yet, four municipalities, i.e., Beijing, Tianjin, Shanghai, and Chongqing, are equal to provinces in terms of their administrative authorities, and they are named as "Municipality Directly Under the Central Government" in China. In the robust check, we dropped out these four municipalities to avoid selection bias.

We gather information of these cities from various sources. We firstly collect data from the China City Statistical Yearbook (2008–2018) published by the National Bureau of Statistics of China, as well as each city's statistical yearbook (2008–2018) published by each Municipal Bureau of Statistics. These databases contain detailed information about the social and economic development of cities in China, such as GDP, total registered population, permanent population, deposits and loans, university student enrollment, urban employment, gross output value of industrial enterprises above the designated size, investment in information transmission, software and information technology, length of highways, total passenger and freight traffic, and land area. Using *TianYanCha* database (www.tianyancha.com), we then search for each city's newly registered companies with registered capital of more than 1 million in each year to track the entrepreneurship status. We also collect patent data of each city from the *incoPat* database (www.incopat.com). Besides, we also search for the science and technology business incubators of each city registered in the China Torch Statistical Yearbook (2008–2018).

4.2. Measurement

4.2.1. Dependent variable

To evaluate urban economic growth, we calculate the GDP growth rate, *GDPR*, which reflects an urban region's economic development. In the robustness test, the growth rate of GDP per capital is also employed to measure the regional economic growth. The information of the growth rate of GDP and GDP per capital is collected from the China City Statistical Yearbook (2008–2018) and each city's statistical yearbook (2008–2018).

4.2.2. Independent variable

To construct a comprehensive measurement for entrepreneurial ecosystems' development, we adopt the entropy weight method (EWM) to synthesize several sub indicators into one index, *EE*. The sub indicators contain several vital dimensions that are measured by previous entrepreneurial ecosystem studies. Vedula and Kim (2019) have concluded five pivotal dimensions from other studies when measuring the entrepreneurial ecosystem in the regional level, namely, a supportive entrepreneurial culture, access to finance, access to

human capital, innovation capacity, and formal support organizations for entrepreneurs. Thus, in this paper, we resort to this framework to measure the entrepreneurial ecosystem in the urban level in China, and some specific indicators were replaced due to the unavailability of the data. The specific dimensions and indicators are concluded in Table 1.

The following steps and formulas present the calculation of entrepreneurial ecosystem index for each city in each year through the EWM, which is extended to measure the weight of panel data in recent years (Yang and Sun, 2015).

(1) Select indicators: X_{tij} is designed as the value of indicator j of city i in year t, where r, n

And m represent that our data set contain r years, n cities and m indicators respectively($i = 1,2 \ldots, n$; $j = 1,2 \ldots, m$).

(2) Standardize indicators since the measurement units of each indicator are not unified,

Standardization is carried out before calculating the comprehensive index. Because the indicators in this paper are all positive indicators, the standardization method of positive indicators is adopted:

$$X'_{tij} = \frac{X_{tij} - X_{min}}{X_{max} - X_{min}}$$

(3) Calculate indicators' weight: $P_{tij} = \frac{X'_{tij}}{\sum_t \sum_i X'_{tij}}$.

(4) Calculate the entropy value of indicator j: $E_j = -k \sum_t \sum_i P_{ij} \ln(P_{tij})$, where $k > 0$, $k = 1/\ln(Q)$ (since the data in this paper is unbalanced, Q is the total number of observations)

(5) Calculate information entropy redundancy: $G_j = 1 - E_j$.

(6) Calculate the weight of each indicator: $W_j = \frac{G_j}{\sum_j G_j}$.

(7) Calculate the comprehensive score of each city: $S_{ti} = \sum_j (W_j X_{tij})$ (City with high score demonstrates that entrepreneurial ecosystem is well developed in this area.)

4.2.3. Moderating variables

Industrial diversity, *Diversity*, is computed following the Hirschman–Herfindahl index (Wang et al., 2016):

$$D_i = 1 - \sum_{j=1}^{n} \alpha_{ij}^2$$

where D_i is the diversity index,and $\alpha_{ij} = \gamma_{ij}/\gamma_i$ denotes industry j's share of gross value of industrial output (γ) in region i.

The digital technology service, *Digitalization*, is measured by the ratio of investment in information transmission, software, and information technology service to the total fixed assets investment of each city.

4.2.4. Control variables

We include several control variables that may influence urban economic performances. First, we control for the length of highways

Table 1
The indicators of entrepreneurial ecosystem's development.

Dimensions	Indicator	Description	References
Entrepreneurial culture	Inflow of population Newly registered enterprises	Since supportive entrepreneurial environment could encourage openness of new ideas and processes, and also the collaboration, we try to depict cities' inclusiveness towards new businesses using these two indicators.	Vedula and Kim (2019)
Finance	Loans	It is especially important for startups to get access to finance, and we think more loans demonstrate easier access to the bank finance.	Robb and Robinson (2014); Stam (2018)
Human capital	Talents Employment	Human capital is also required in the startups to sustain the operations and make rapid development. We use the talents receiving higher education and the existing workforce of the city to measure it.	Stam (2018); Vedula and Kim (2019); Davidsson and Honig (2003)
Innovation capacity	Patents	In the knowledge-intensive society, the innovation capacity is also regarded as a significant factor in the entrepreneurial process. The number of patents has been widely used in the previous studies when measuring the innovation capacity.	Vedula et al. (2018); Vedula and Kim (2019)
Formal supporting organizations	Incubators	The business services given by supporting organizations could provide ventures with both tangible and intangible resources, thus increase the speed of new value creation. In this process, the incubators have played an important role in China.	Stam (2018); Vedula and Kim (2019); Goswami et al. (2018); Cohen (2013)

Table 2
Variables.

	Variable	Symbol	Measurement
Dependent Variable	Economic performance	GDPR	GDP growth rate
Independent Variable	Entrepreneurial ecosystem index	EE	The number of immigrants outside the city (Inflow of population) The number of newly registered enterprises with registered capital of more than 1 million per 10000 people (Newly registered enterprises) Total loans of the city (Loans) University student enrollment (Talents) Urban employment (Employment) The number of patent application per 10000 people (Patents) The number of science and technology business incubators (Incubators)
Moderating Variables	Industrial diversity	Diversity	Hirschman–Herfindahl index of regions' industrial diversity
	Digital technology service	InformationFAI	The ratio of investment in information transmission, software and information technology to total fixed assets investment
Control Variables	Length of highways	Road	Length of highways of each city
	Total passenger traffic	Passenger	Total passenger traffic of each city
	Total freight traffic	Goods	Total freight traffic of each city
	Population density	PopArea	Population density of each city
	Deposit	Deposit	Deposits of each city

(*Road*), which could reflect the basic infrastructure development level. Second, we control for a city's total passenger and freight traffic (*Passenger, Goods*) to capture possible differences between cities in resource mobilization. Third, we also control for population density (*PopArea*) with the ratio of population to land areas. Moreover, we use the deposits of people (*Deposit*) in a city to control for the possible differences of people's living standards. Finally, we include year fixed effects to control for any unobserved contextual changes that might affect economy performance of the cities.

A summary of all variables can be found in Table 2.

5. Results

5.1. Descriptive statistics and correlation analysis

The descriptive statistics and correlations for the variables are reported in Tables 3 and 4. In Table 4, the correlations are all less than 0.75, demonstrating that there is no high correlation between variables. To investigate any potential multicollinearity problems, we calculated variance inflation factors and found the highest to be 3.53, which is below the conservative threshold of 5, indicating that multicollinearity does not appear to be a problem. Besides, to reduce any endogeneity, the dependent variable is lagged for one year.

5.2. Empirical results

We model the effect of entrepreneurial ecosystems' development on economy using OLS models with fixed effects and time controlled. Table 5 shows the estimation results for the impact of entrepreneurial ecosystems' development on cities' economic growth, with the separate factors in Model 2–4 and the whole factors in Model 5. Model 1 in Table 5 includes only the basic variables, and Model 2 tests the effect of the development of entrepreneurial ecosystems on the economic growth. *H1* predicts that entrepreneurial ecosystems' development would exert a positive effect on urban economic growth. Consistent with this hypothesis, the coefficient of entrepreneurial ecosystems' development is positive and significant ($p < 0.05$), and *H1* is thus supported.

Model 3 adds the industrial diversity to test its moderating. *H2* suggests that industrial diversity would strengthen the effect of entrepreneurial ecosystems' development on economic growth. The result shows that industrial diversity has positively moderated the relationship between the development of the entrepreneurial ecosystem and economic performance (significant at the 1% level), in support of *H2*.

Table 3
Descriptive statistics.

Variable	Obs	Mean	Std.Dev.	Min	Max
GDPR	286	0.117	0.072	−0.240	0.661
EE	286	0.186	0.052	0.080	0.534
InformationFAI	286	0.000	1.000	−0.933	11.424
Diversity	286	0.000	1.000	−4.632	0.818
Road	286	14.785	22.914	0.872	147.881
Passenger	286	32.454	33.955	2.620	185.011
Goods	286	34.003	25.544	3.415	147.148
PopArea	286	0.796	0.413	0.173	2.295
Deposit	286	2.487	0.837	0.075	4.928

Table 4
Correlation matrix.

Variables	1	2	3	4	5	6	7	8	9
1. GDPR	1.000								
2. EE	−0.091	1.000							
3. InformationFAI	0.026	0.103*	1.000						
4. Diversity	0.029	−0.311***	0.029	1.000					
5. Road	0.061	−0.020	−0.056	0.091	1.000				
6. Passenger	0.142**	0.326***	0.096	−0.087	0.323***	1.000			
7. Goods	−0.103*	0.254***	0.006	0.118**	0.443***	0.233***	1.000		
8. PopArea	−0.061	0.617***	−0.063	−0.101*	−0.259***	0.052	0.315***	1.000	
9. Deposit	−0.241***	0.726***	0.136**	0.004	0.119**	0.395***	0.470***	0.489***	1.000

Table 5
Regression results.

	Model 1	Model 2	Model 3	Model 4	Model 5
EE		0.676** (0.286)	1.080*** (0.255)	0.601** (0.277)	1.029*** (0.246)
InformationFAI				−0.041* (0.023)	−0.048** (0.021)
Diversity			−0.031** (0.014)		−0.030* (0.015)
EE × InformationFAI				0.211* (0.112)	0.243** (0.101)
EE × Diversity			0.208*** (0.069)		0.226*** (0.069)
Road	−0.003*** (0.000)	−0.003*** (0.000)	−0.003*** (0.001)	−0.003*** (0.000)	−0.003*** (0.000)
Passenger	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)
Goods	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.0000 (0.000)	0.000 (0.000)
PopArea	−0.046 (0.049)	−0.131 (0.081)	−0.073 (0.066)	−0.150* (0.084)	−0.091 (0.067)
Deposit	−0.023 (0.021)	−0.025 (0.020)	−0.021 (0.017)	−0.026 (0.020)	−0.022 (0.017)
_cons	0.314*** (0.065)	0.268*** (0.057)	0.162** (0.069)	0.297*** (0.066)	0.187** (0.074)
Number of obs	286	286	286	286	286
Number of groups	32	32	32	32	32
Prob > F	0.000	0.000	0.000	0.000	0.000
R-squared	0.420	0.443	0.450	0.450	0.461

Notes:1) Standard errors in parentheses; 2)***p < 0.01, **p < 0.05, *p < 0.1.

Model 4 replaces the industrial diversity variable with the digital technology service to test *H3*, which suggests a stronger positive effect of entrepreneurial ecosystems' development on economic growth when digital technology service develops well. In line with our hypothesis, the result indicates that the more developed the digital technology service is, the more significant entrepreneurial ecosystems' development will be in promoting the urban economic growth. *H3* is hereby supported. The regression results reported in Model 5 include all variables simultaneously, and the result is also consistent with our hypotheses. Thus, all the hypotheses are supported.

5.3. Robustness test

We have performed several tests to validate the robustness of the results. In the previous analysis, we argue that entrepreneurial ecosystems' development has a positive effect on the urban economic growth. However, the development of a city's economy can also facilitate regional entrepreneurship (Audretsch and Keilbach, 2008). Thus, we apply the GMM to alleviate the possible endogeneity. As shown in Table 6, the result indicates that the development of entrepreneurial ecosystems is still positively and significantly related ($p < 0.05$) to the GDP growth rate of a region, with industrial diversity positively moderating this relationship. However, the results lose significance when considering the moderating effects of the digital technology service. One possible reason is that the digital technology service was booming for a short time and its function has not fully revealed.

We also perform an additional robustness check by changing the dataset since special cities with abundant resources and authority may increase the likelihood of urban economic growth. In our main analysis, we incorporated provincial capitals, municipalities with independent planning status, municipality directly under the central government, and some other cities. Then we dropped the four municipalities directly under the central government (Beijing, Tianjin, Shanghai, Chongqing) in the robustness check and the results is reported in Table 7. It can be seen that the results for the adjusted sample are still consistent with the total sample, indicating our findings are robust.

Besides, we have changed dependent variable, namely, replacing the GDP growth rate with growth rate of GDP per capital, yet all hypotheses are still supported (Table 8). Thus, we can conclude with confidence that the findings are robust, and all hypotheses are supported.

6. Discussion and conclusion

In this paper, we have examined the relationship between the development of entrepreneurial ecosystems and urban economic

Table 6
GMM results.

	Model 6	Model 7	Model 8	Model 9
EE	0.271** (0.132)	0.870*** (0.280)	0.274** (0.134)	0.854*** (0.282)
InformationFAI			0.013 (0.024)	0.008 (0.024)
Diversity		−0.014 (0.012)		−0.014 (0.012)
EE × InformationFAI			−0.047 (0.120)	−0.024 (0.118)
EE × Diversity		0.125** (0.063)		0.121* (0.064)
Road	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)
Passenger	0.000* (0.000)	0.000* (0.000)	0.000* (0.000)	0.000* (0.000)
Goods	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
PopArea	−0.012 (0.014)	−0.025* (0.015)	−0.010 (0.015)	−0.023 (0.015)
Deposit	−0.021*** (0.008)	−0.043*** (0.011)	−0.023*** (0.008)	−0.043*** (0.011)
_cons	0.107*** (0.022)	0.063** (0.028)	0.108*** (0.022)	0.065** (0.029)
Number of obs	245	245	245	245
Prob > F	0.000	0.000	0.000	0.000
Centered R-squared	0.329	0.352	0.332	0.355
Uncentered R-squared	0.828	0.834	0.829	0.835

Notes:1) Standard errors in parentheses; 2)***p < 0.01, **p < 0.05, *p < 0.1.

Table 7
Dropping municipality directly under the central government.

	Model 10	Model 11	Model 12	Model 13	Model 14
EE		0.626** (0.262)	1.085*** (0.277)	0.526** (0.250)	1.041*** (0.258)
InformationFAI				−0.055* (0.032)	−0.068** (0.028)
Diversity			−0.027* (0.015)		−0.030* (0.015)
EE × InformationFAI				0.283* (0.155)	0.340** (0.134)
EE × Diversity			0.234*** (0.074)		0.271*** (0.068)
Road	−0.001 (0.002)	−0.001 (0.002)	−0.000 (0.002)	−0.000 (0.002)	0.001 (0.002)
Passenger	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)
Goods	0.003 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
PopArea	−0.065 (0.060)	−0.129 (0.087)	−0.068 (0.062)	−0.162* (0.094)	−0.098 (0.065)
Deposit	−0.021 (0.021)	−0.023 (0.020)	−0.020 (0.018)	−0.024 (0.020)	−0.021 (0.018)
_cons	0.284*** (0.064)	0.230*** (0.055)	0.116* (0.068)	0.266*** (0.065)	0.140*** (0.072)
Number of obs	244	244	244	244	244
Prob > F	0.000	0.000	0.000	0.000	0.000
R-squared	0.394	0.414	0.424	0.424	0.438

Notes:1) Standard errors in parentheses; 2)***p < 0.01, **p < 0.05, *p < 0.1.

growth, as well as the contingency roles of industrial diversity and digital technology service from the KBV. Based on a unique panel dataset from 2008 to 2018 of 32 cities in China, the empirical evidence indicates that the development of entrepreneurial ecosystems can facilitate the regional economy significantly via knowledge creation and knowledge flow. Besides, industrial diversity and digital technology service can strengthen the facilitation effect. These findings provide novel insights into the role of entrepreneurial ecosystems and contribute to extant literature in several ways.

First, this study expands our understanding on the entrepreneurship ecosystem. In particular, a more comprehensive framework is provided to explore the relationship between entrepreneurial ecosystems' development and urban economic growth from the knowledge-based view. Extant studies claimed that the development entrepreneurial ecosystem is beneficial for regional development, while they provided little evidence of its influence on regional economic growth. Thus, in this research, we further scrutinize whether entrepreneurial ecosystems' development stimulates regional economic growth by considering both knowledge creation and knowledge flow to complement prior literature.

Second, this study provides an alternative perspective to analyze the regional economic development of emerging countries. When discussing the economic development and urban prosperity of developing countries, prior studies mainly resort to economic factors such as the investment of traditional capital and labor (Fu et al., 2011; Wong and Goh, 2015) and the domestic market demand. Some other studies also pay attention to international business-related factors. For example, FDI from developed economies, including the associated technological and market knowledge (Fu et al., 2011), is thought to be a stimulus of the economic growth (Grimes and Du, 2013). In China, government intervention and policy support are also regarded as crucial factors enabling the rise of China (Guan et al., 2009; Miao et al., 2018). However, although Chinese governments have enacted many policies related to the entrepreneurship which encourages the establishment and development of entrepreneurial ecosystems, few scholars have explored the effects of these policies. Thus, in this paper, we quantify the influence of entrepreneurial ecosystems' development on regional economy, which also complements extant studies.

In addition, extant studies about entrepreneurial ecosystem mainly focus on broader levels such as the national or provincial levels. However, for countries like China with high diversification and unbalanced development between cities, it is important to scrutinize the role of entrepreneurial ecosystems' development in the local economy at an urban level to get more accurate conclusions. For example,

Table 8
The effect of EEs on the growth rate of GDP per capita.

	Model 15	Model 16	Model 17	Model 18	Model 19
EE		0.629** (0.277)	1.167*** (0.271)	0.564** (0.271)	1.125*** (0.274)
InformationFAI				−0.037 (0.024)	−0.046** (0.020)
Diversity			−0.044*** (0.014)		−0.044*** (0.014)
EE × InformationFAI				0.187 (0.115)	0.228** (0.096)
EE × Diversity			0.278*** (0.078)		0.295*** (0.077)
Road	−0.002*** (0.000)	−0.002*** (0.001)	−0.001** (0.001)	−0.002*** (0.001)	−0.001** (0.001)
Passenger	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)
Goods	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	−0.000 (0.000)
PopArea	−0.013 (0.041)	−0.092* (0.051)	−0.016 (0.041)	−0.110* (0.055)	−0.032 (0.044)
Deposit	−0.039 (0.032)	−0.041 (0.031)	−0.036 (0.027)	−0.042 (0.031)	−0.037 (0.027)
_cons	0.261*** (0.062)	0.219*** (0.060)	0.075 (0.076)	0.243*** (0.068)	0.098 (0.080)
Number of obs	286	286	286	286	286
Prob > F	0.000	0.000	0.000	0.000	0.000
R-squared	0.366	0.393	0.416	0.400	0.426

Notes:1) Standard errors in parentheses; 2)***p < 0.01, **p < 0.05, *p < 0.1.

the advantageous industries or clusters vary across cities in China and thus the role of entrepreneurial ecosystems' development may also vary from each other. Therefore, setting the study on the urban level can avoid biased results and provide accurate insights.

Our findings also provide implications for policymakers and managers. Policymakers have long attempted to improve regional economic development. Our empirical results show that the development of entrepreneurial ecosystems can boost regional economy significantly. To facilitate the development of entrepreneurial ecosystems, policymakers should first create an entrepreneurial atmosphere and fully understand the comprehensive factors underneath an entrepreneurial ecosystem, such as the number of new ventures, regional employment, and the science and technology business incubators. Policymakers also need to recognize that industrial diversity could help entrepreneurial ecosystems operate more effectively. Further, the promoting effect of entrepreneurial ecosystems' development on regional economic growth becomes more significant where digital technology service is well established. Thus, policymakers should also pay attention to the development of digital services and digital infrastructures. Take the strike of the COVID-19 pandemic as an example, conducting entrepreneurship activities virtually has been booming with the support of digital technology service, which has demonstrated its necessity. Though the physical venture creation activities are largely confined due to the disruptive crisis, the virtual pillar of entrepreneurial ecosystems has gained unprecedented prosperity and greatly facilitated the recovery of regional economy. Accordingly, for managers and entrepreneurs, they should try to integrate their businesses into the digital environment and absorb knowledge from various industries.

This research also has its limitations. Though China has become a major emerging economy and global economic power, its governance and development mode may still have some uniqueness. Therefore, future research can take more emerging countries into account to expand the generality of the findings. Besides, when investigating the contingencies that may influence the relationship between the development of entrepreneurial ecosystems and urban economic growth, we only considered contextual factors such as industrial diversity and digital technology service. Firm-level factors can be further explored in future research. Finally, in the measurement of the development of entrepreneurial ecosystems, indicators can be refined and supplemented to fully depict the characteristics of entrepreneurial ecosystems.

Declaration of competing interest

No conflict of interest exits in the submission of this manuscript, and manuscript is approved by all authors for publication. I would like to declare on behalf of my co-authors that the work described was original research that has not been published previously, and not under consideration for publication elsewhere, in whole or in part. All the authors listed have approved the manuscript that is enclosed.

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