ATLANTIS PRESS

Advances in Economics, Business and Management Research, volume 190

Proceedings of the 2021 International Conference on Financial Management and Economic Transition (FMET 2021)

The Empirical Analysis of the Influence of Urban Innovation Ability on the Economic growth Based on the Least Square Regression Model (OLS)

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ABSTRACT

At present, economic development has entered the stage of "new normal", which has been gradually transformed from the factor-driven development to the innovation-driven development. Then, will the improvement of the urban innovation level have an impact on the urban economic development? In this paper, through the establishment of measurement model validation, the effect of city innovation ability level on economic growth is investigated. In particular, 209 cities are selected across the country, the city's Research and Development and patent number are collected as indicators of innovation ability, and GDP, per capita GDP, as well as the GDP growth rate are used as a measure of economic growth. In addition, the ordinary least squares regression model is set up, and the results are as follows: First, the increase of urban R&D investment can indeed promote the economic development. Second, an increase in the total number of patents in cities can indeed boost the economic growth. Finally, this paper explains how the improvement of innovation level affects the economic development through economic logic and puts forward corresponding policy suggestions on how to improve urban innovation level.

Keywords: *Urban Innovation Ability, Economic growth.*

1. INTRODUCTION

According to the Global Innovation Index 2020, GII, China ranked 14th out of 131 economies in the annual innovation ranking, ranked among the world's top 15 for two years in a row, led in several fields, and was the only middle-income economy to enter the overall top 30. In The thirteenth Five-Year Plan, Chinese government proclaimed the core position of innovation in China's modernization. In recent years, 17 Chinese innovation clusters have ranked among the world's top 100, and two of them are among the world's top four (Shenzhen, Hong Kong, Guangzhou, Beijing). The scientific research funds have been constantly increasing during the period of the thirteenth Five-Year Plan. The total expenditure on the scientific research of the entire society increased from 1.42 trillion Yuan in 2015 to 2.21 trillion Yuan in 2019 (amount of increase: 55.6%). China has made a lot of progress in basic research and breakthroughs in core technologies. Regarding the reserve of talents, the rate of China's R&D personnel is emergingly increased from 3.76 million per year in 2015 to 4.8 million per year in 2019. For the situation of the Chinese high-end innovative talents, according to Clarivate's the List of Highly Cited Scientists, the number of selected Chinese scientists reached 770 (total: 6167) and ranked number 2. The development situation of pioneering enterprises in China is really promising. The number of entrepreneurship incubation carriers in China reached 13206. Huge amount of new innovative enterprises are supported by these carriers.

The innovation level of Chinese provinces is increasing year by year, and the degree of spatial aggregation is obvious. The innovation ability of Chinese provinces decreases gradually from the east to the west (refer to Hu's line). There is relatively great difference of the innovation ability of cites in China. According to the research, the spatial distribution of innovation in China shows polarization characteristics.

The innovation outputs are mostly from a few costal developed cites. The cites with similar innovation ability are spatially clustered, such as the Yangtze River Delta, Pearl River Delta, and Beijing-Tianjin-Hebei Region (the core cites of innovation). There are abundant innovation resources inside these core cities, such as many new high-tech enterprises, which employ many high-tech talents; many institutions of higher learning, which can offer innovative talents to the society; and high-quality human capital storage, which is the foundation of the innovation ability of cites. There are also great differences within the same region and within the same province. The scientific and technological innovation development level of regional central cities such as provincial capital cities and cities above deputy provincial level is often much higher than that of other prefecture-level cities. According to our results, firstly, the increase of urban R&D investment can indeed promote the economic development; secondly, an increase in the total number of patents in cities can indeed boost the economic growth.

In recent years, China's economy has entered a stage with medium-high speed and high-quality growth. As an important driving factor, what effect will the innovation have on the urban economic growth in China? This paper attempts to study the impact of the comprehensive capacity of the urban innovation on the economic development in China, and quantitatively describes the impact of the change of the urban innovation ability level on the urban GDP through the establishment of the least square regression model (OLS).

The main innovative points of this paper are as follows: firstly, the impact of innovation and entrepreneurship on economic development is studied from the urban level. Previous studies focused more on the national level. Secondly, through the division of urban areas, this paper examines the strength of the relationship between innovation and economic growth from the eastern, western and central regions, which is convenient for subsequent policy suggestions.

The structure of this paper is as follows: the second section is literature review, the third section is the descriptive statistics of variables and data, the fourth section is quantitative analysis model, and the fifth section is result analysis and policy recommendations.

2. LITERATURE REVIEW

In regard to urban innovation ability, a series of studies have been carried out by many scholars.

Based on the data of 286 prefecture-level cities in China from 2006 to 2017, Xing Zhao and Linhui Wang (2020) (data [3]) investigated the spatial evolution trend and causes of innovation agglomeration in China with a spatial econometric model, focusing on the influence of knowledge spillover on innovation agglomeration and the spatial characteristics of radiation effect. It was found that: firstly, the urban innovation agglomeration in China presents a significant polarization phenomenon, with Beijing, Tianjin, Shanghai, Guangzhou, and Shenzhen as the innovation core cities. It depends on the richness of innovation resources within the cities, among which the R&D investment of R&D institutions plays a key role. Secondly, Knowledge spillover leads to the radiation effect, which leads to the evolution of urban innovation agglomeration in China from polarization to multicentric network. Thirdly, there is inconsistency in the spatial characteristics of radiative effect from different knowledge of city circle. Fourthly, knowledge spillover has a strong dependence on city properties. The role of leading cities, central cities, and large cities in research and development are more significant.

Based on data of 289 cities' cooperative patents, Lei ye, et al. (2019) (data [2]) have made a comparison about the innovation efficiency of different innovation network models. The results showed: firstly, China’s innovation capacity is strong in the east and weak in the west. Secondly, there are four types of urban innovation network models in China: network innovation city, external innovation city, local innovation city, and isolated innovation city. Thirdly, network innovation cities at the core of the innovation network have the highest innovation efficiency, followed by external innovation cities and local innovation cities, and isolated innovation cities have the lowest innovation efficiency.

Yiman Chen, et al. (2020) (data [8]) researched the factors influencing the innovation capacity of Chinese cities and their spatial differences based on the data from 286 Chinese cities: firstly, influencing factors in descending order are financial input, talent factors, economic basis, economic extroversion, financial environment and in formalization level. Secondly, there are spatial differences in the influencing factors of urban innovation capability in China. The innovation ability of south-eastern cities is greatly affected by the economic base, while that of north-eastern and western cities is greatly affected by the financial environment.

Chenghua Guan and Zhao Zheng (data [1]) concluded that: firstly, the vast majority of the top cities in the comprehensive ranking have obvious weaknesses in the development of science and technology innovation. Secondly, the level of urban economic development is positively correlated with the level of scientific and technological innovation. Thirdly, increasing residents' disposable income is conducive to promoting urban science and technology innovation. Fourthly, a compact urban form is conducive to improving the innovation capacity of cities.

Through summarizing the characteristics of China's technological innovation and development in recent years, Yunjie Sun and Yu Chen (2019) (data [7]) proposed several issues of the Chinese innovation situation: There are problems of imbalance and inadequacy in the development of scientific and technological innovation. The stock and intensity of investment in scientific and technological innovation still need to be improved. The quality and efficiency of scientific and technological innovation output need to be improved; the allocation structure of science and technology innovation elements needs to be optimized; the opening of scientific and technological innovation to the outside world needs to be strengthened; the overall ability of science and technology to support social development needs to be further enhanced.

From an international perspective, Kangning Xu (2019) (data [6]) analysed and compared China's national innovation ability and summed up the problems that restrict China's innovation ability: firstly, the long-term extensive economic development model blindly pursues scale expansion, making it difficult for innovation to become the leading role. Secondly, the disadvantages of the innovation system and mechanism lead to the emphasis on quantity and neglect of quality in the field of innovation, and the hard original innovation work and achievements cannot be encouraged. Thirdly, for a long time, the positioning of innovation strategy has been inaccurate, the innovation resources are too concentrated in universities and research institutes, the scientific research output is seriously out of line with the actual demand, and the enterprises have not become the real innovation subjects. Fourthly, the foundation of innovation culture is weak, the lack of entrepreneurship is serious, and the innovation ecological environment has not really formed.

Based on GII, Su Qi and Lichun Liu (2018) (data [4]) proposed the important factors affecting the improvement of China's innovation ability: Institutional environment, creative output, market maturity, infrastructure, and higher education.

However, there are few studies on the impact of innovation capacity on economic growth from the urban level.

Nan Su and Laisheng Song (2016) （data [9]） used the panel data of 17 cities in Hubei Province from 2000 to 2014 to conduct an empirical study on the influence of innovation and entrepreneurship on regional economic growth and found that the promotion effect of entrepreneurship and innovation factors on the competitiveness of Hubei Province was generally weak.

3. DATA AND MODEL

3.1. Data resources

In order to study the impact of urban innovation capacity on economic development, this paper selects the relevant data of cities across the country in 2018 for quantitative analysis according to the relevant databases of China City Statistical Yearbook and China Regional Innovation and Entrepreneurship Index. The innovation capacity is measured by R&D input and patent filings, respectively. Indicators of economic growth include gross domestic product (GDP), gross domestic product per capita (per GDP), and GDP growth. Due to the lack and unavailability of relevant data, the relevant data of 209 cities in China can be obtained according to the results of data screening. These cities belong to different regions, including Central China, South China, East China, Northeast China, North China, Northwest, and Southwest China.

3.2. Data resources

Before the establishment of the quantitative analysis model, descriptive statistics should be conducted on the variables, and the results are shown in Table 1.

Table1. Descriptive statistics.

variable	Obs	Mean	Std.Dev	Min	Max
City	209	105	60.47727	1	209
GDP	209	2.65E+07	3.64E+07	1356700	3.27E+08
Per GDP	209	56771.32	31815.15	12656	191942
GDP growth	208	7.091538	1.909787	0.44	13
Patent	206	10277.49	20114.2	2	150233
R&D	208	522327.7	1235799	98	1.36E+07

In order to further observe the relationship between variables, this paper draws the scatter plots of the economic growth index and innovation ability index respectively.

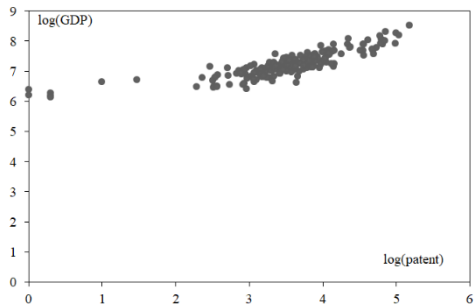

Figure1 Relationship between GDP and patent

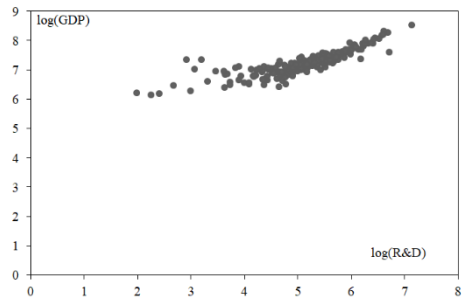

Figure2 Relationship between GDP and R&D

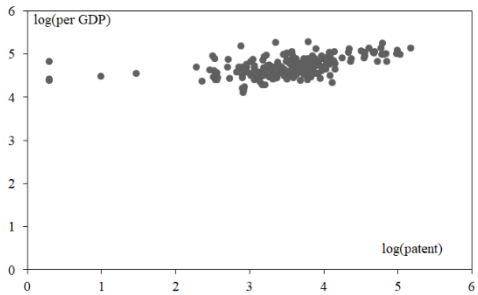

Figure3 Relationship between per GDP and patent

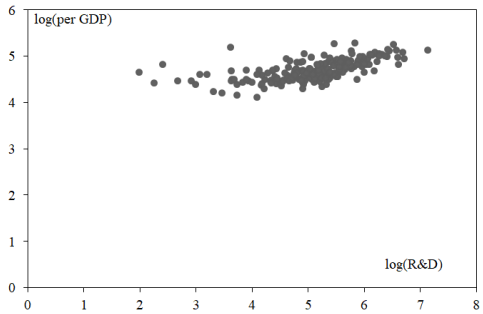

Figure4 Relationship between per GDP and R&D

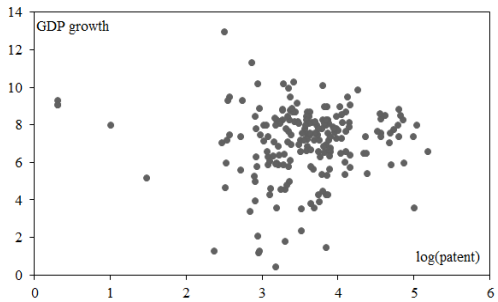

Figure5 Relationship between GDP growth and patent

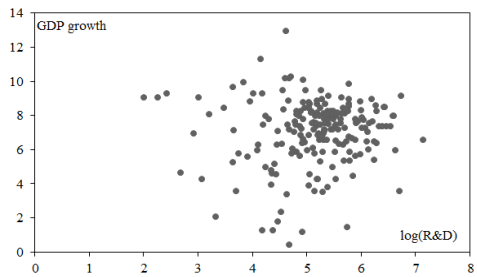

Figure6 Relationship between GDP growth and R&D

Figure 1 is a scatter plot of GDP and the number of patent applications. According to the distribution of the scatter points, it is not difficult to see that the growth rate of patent applications is positively correlated with the growth rate of GDP. Figure 2 is a scatter plot of GDP and patent R&D investment. According to the distribution of the scatter plot, it is not difficult to see that the growth rate of R&D investment is positively correlated with the growth rate of GDP. Figure 3 is a scatter plot of per capita GDP and the number of patent applications. According to the distribution of the scatter points, it is not difficult to see that the growth rate of patent applications is positively correlated with the growth rate of per capita GDP. Fig. 4 is a scatter plot of per capita GDP and patent R&D investment. According to the distribution of the scatter plot, it is not difficult to see that the growth rate of R&D investment is positively correlated with the growth rate of per capita GDP. Fig. 5 is a scatter plot of the number of patent applications and GDP growth rate. From the perspective of scattering distribution, the relationship between the two is not obvious. Figure 6 is a scatter plot of R&D investment and GDP growth rate. From the point of view of the scatter distribution, the relationship between the two is not obvious.

According to the results of the scatter chart, it is not difficult to find that both the R&D investment and the number of patent applications have a strong positive impact on GDP and GDP per capita. Although the trend of impact on GDP growth rate is not obvious, it is still positive. On this basis, this paper further explains the phenomenon through the construction of the model.

3.3. Model

Based on the introduction of data sources and descriptive statistics of variables, this paper establishes a simple least square regression model to quantitatively analyse the economic growth effect of innovation capability. Considering that the orders of magnitude of explanatory variables and explained variables are different, the explained variables GDP and per capita GDP are logarithmized, and the regression models of urban innovation capacity and economic growth are established as follows.

$$\ln(GDP)_i = \alpha_1 + \beta_1 \ln(patent)_i + \varepsilon_i \quad \text{NO.1}$$

$$\ln(GDP)_i = \alpha_2 + \beta_2 \ln(R\&D)_i + \mu_i \quad \text{NO.2}$$

$$\ln(perGDP)_i = \alpha_3 + \beta_3 \ln(patent)_i + \gamma_i \quad \text{NO.3}$$

$$\ln(perGDP)_i = \alpha_4 + \beta_4 \ln(R\&D)_i + \theta_i \quad \text{NO.4}$$

$$GDPgrowth_i = \alpha_5 + \beta_5 \ln(patent)_i + \kappa_i \quad \text{NO.5}$$

$$GDPgrowth_i = \alpha_6 + \beta_6 \ln(R\&D)_i + \eta_i \quad \text{NO.6}$$

The above models are regression equations of GDP, per capita GDP and GDP growth rate on the number of patent applications and R&D investment respectively. In this paper, the least square regression principle is used to expand and estimate the above models. The regression results of the above model can be obtained as follows:

Table2: the regression results of model above

Dependent variable	lnGDP	lnGDP	lnperGDP	lnperGDP	GDP_growth	GDP_growth
lnRD	0.408***		0.161***		0.055	
	) -0.027 (		) -0.0193 (		) -0.072 (	
lnpatent		0.469***		0.149***		0.0253
		) -0.0351 (		) -0.0243 (		) -0.0832 (
Constant	11.82***	12.82***	8.917***	9.600***	6.443***	6.853***
	) -0.331 (	) -0.295 (	) -0.236 (	) -0.206 (	) -0.906 (	) -0.735 (
Observations	208	206	208	206	207	205
R-squared	0.727	0.725	0.387	0.24	0.003	0.001

4. RESULTS

In this paper, through the establishment of measurement model validation city innovation ability level effect on economic growth, we find that, firstly, the increase of urban R&D investment can indeed promote economic development; secondly, an increase in the total number of patents in cities can indeed boost economic growth.

Specifically, every 1% increase in R&D will significantly increase GDP by 0.408 percent and per capita GDP by 0.161%. If the number of patents increases by 1%, GDP increases by 0.469% and per capita GDP significantly increases by 0.149%. All results passed the test at the 1% significance level. In addition, R&D and patents have no impact on GDP growth, which means only the level value can be affected.

In order to explain this result, we elaborate the relationship between innovation ability and the economic growth from the perspective of economy as follows. The innovation of technology can bring significant changes in the production of society. To begin with, certain technological improvements can reduce the average total cost of suppliers and in the long-term effect, can shift the supply curve to the right. Moreover, urban innovative ability, which includes the average GDP of citizens, would become higher when the average GDP of people increases. In a way, the innovation would stimulate people to achieve higher GDP. Not only in the sphere of technology and production, but may innovation also happen in the operational level. The improvement and innovation of the managing level of a firm or business may bring huge effects.

5. CONCLUSION

The city innovation level mainly includes two dimensions: the abilities of technology and receiving. The first one is mostly reflected in creative ideas and expertise while the latter refers to the knowledge structure of the city that is capable of receiving and transforming cutting-edge thoughts and technologies. Based on the characteristics of modern technology, most of the creative thoughts and expertise belong to some specific talent. That is the reason for most cities to scramble for talent in all kinds of ways. However, the main differences in innovation capacity of each city have something to do with the taking root of these talents and the overall facilities of receiving ability. Furthermore, to create a fundamental change in the creativity of the city needs to maintain a high level of knowledge density. However, the important question has to be that why the talents choose to go to this city instead of the others. Therefore, to attract enough talent and maintain a big knowledge density, many cities choose to show enough respect for intellectual property and take the initiative to break all kinds of obstacles restricting the accumulation of knowledge, even if some necessary costs are paid. After doing so, more talents will be willing to move to these cities as they see the market spirit of openness, inclusiveness, and sharing. In addition to these large quantities of talents, by examining the leading innovation cities, there has been shown that the cultivation of the intellectual middle class plays a decisive role in the progress of the development of innovation. The majority of the intellectual middle class is mainly made up of college graduates, and that is the main reason for some first-tier cities to lower the threshold of household registration

and actively attract college students to their cities to start businesses and obtain employment. Once these talents gather in specific cities, the market of ideas will form, and the producers and consumers of knowledge can exchange information freely which eventually leads to a higher level of innovation. In all, a city with a prosperous idea market will naturally attract intellectual middle class which then brings the increase of knowledge density, thus forms knowledge and resources and eventually promotes the probability of innovation. What's more, cities must ensure a legal environment, provide fair opportunities, and acquire free access to knowledge to create a prosperous idea market.

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