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# Is there a causal relationship between knowledge capital and industrial enterprises added?

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## ABSTRACT

This paper explores the impact effects of different knowledge capital investment on the industrial enterprises added in China. Using 2007-2016 China's industrial enterprises panel data of 31 provinces, we analyze the space spilt effect of knowledge capital in different regions and explores the causal relationship between knowledge capital and industrial enterprises added by using the dynamic space Dubin model. The results show that: the knowledge capital investment of industrial enterprises has obvious spatial agglomeration ef-fect, and the agglomeration effect increases gradually with time. The results also show that: the estimated results under three kinds of spatial weight matrices show that the positive spillover effect of knowledge cap-ital on enterprise income is significant.

**Key words:** Industrial enterprises; Intellectual capital; Space overflow; Dynamic spatial durbin model

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## 1. Introduction

The development of industrial enterprises is one of the important research fields in China's modernization economic construction. The development of traditional industrial enterprises is mainly driven by the input of resource factors. Under the new normal of economic development, Chinese enterprises gradually shift from the original driven by the input of production factors to the driven by the accumulation of knowledge capital. According to the People's Daily, China's contribution rate to scientific and technological progress reached 57.5% in 2017. The total R&D expenditure of the whole society was 1.76 trillion, an increase of 70.9% over 2012. The proportion of R&D expenditure in GDP was 2.15%, higher than the average level of European Union. In 2004, the proportion of industrial enterprises with R&D activities was 6.2%, and the number of valid patents was 30,315. By 2016, the proportion of industrial enterprises with R&D activities was 23%, and the number of valid patents was 769847. Compared with 2004, it increased by 3.71 times and 25.39 times respectively. This shows that China has made great progress in scientific and technological innovation and the accumulation of knowledge capital in industrial enterprises has been constantly improved. Therefore, it is of far-reaching significance to study the influence mechanism of knowledge capital on the improvement of industrial enterprises' benefit.

In China, to what extent does knowledge capital promote the increase of industrial enterprises' income, how does the direction and timing change, and how does it affect industrial enterprises in surrounding areas? How to give full play to the role of knowledge capital? These questions are the focus of the following research.

## 2. Knowledge capital with spatial correlation

### 2.1 knowledge capital

American economist Galbraith put forward the concept of knowledge capital for the first time. In his opinion, knowledge capital is an intellectual activity, a dynamic capital rather than a fixed form of capital. Intellectual capital is an intangible asset which is characterized by high technology and based on infinite knowledge and can bring profits to enterprises. The productive forces of human society begin to enter such a stage. Knowledge is replacing the traditional capital such as land and material capital and playing a leading role in production. With the emergence of knowledge capital, the ownership of enterprises has changed, and the new enterprise system with knowledge management and knowledge distribution as the main content has begun to appear and profoundly affects the ownership structure of the future society.

The concept of knowledge capital integrates enterprises' production capacity, technological innovation capacity, market development capacity and other factors together to form the core competence and operating assets of enterprises.

### 2.2 Spatial correlation

The spatial correlation of economic factors is actually caused by the flow of economic factors in different regional units, which makes the traditional OLS test no longer applicable. The spatial dubin model can be used to solve the spatial overflow problem. Dynamic spatial durbin model can reflect the reality level better than static spatial durbin model in processing panel data. In this paper, the dynamic spatial dubin model is used to analyze the relationship between Chinese intellectual capital and enterprise income. Some Chinese scholars have used dynamic spatial durbin model to analyze practical problems. Su Yi (2017) et al. respectively used the static and dynamic spatial panel model to analyze the spatial effect of scientific and technological innovation, and believed that innovation has regional effect, and the spatial effect of innovation has a significant relationship with social and economic characteristics. Yang Yiwu (2018) calculated the spatial spillover effect of

agricultural scientific and technological innovation on farmers' income by using the static spatial panel model based on three spatial weights. In this paper, the dynamic spatial durbin model is used to analyze the impact of China's knowledge capital input on the income of industrial enterprises.

## 3. Research design

### 3.1 Hypothesis model

Referring to the research of Cheng Huifang et al. (2014), in addition to knowledge capital, the increase in income of industrial enterprises is also related to human capital, labor input, material capital input and other factors. Therefore, in order to avoid the problem of missing variables, relevant control variables are added into the research on the influence of knowledge capital on the income increase of industrial enterprises. The general form of the dynamic spatial durbin model introducing related control variables is as follows:

$$\ln Y_{it} = \vartheta \ln Y_{j,t-1} + \delta W \ln Y_{jt} + \rho W \ln Y_{j,t-1} + \beta \ln KC_{it} + \gamma \ln K_{it} + \lambda W \ln KC_{jt} + \theta W \ln K_{it} + \alpha_i + \mu_i + \varepsilon_{it}$$

$Y_{it}$ represents the industrial income, $KC_{jt}$ represents the knowledge capital, $\delta WY_{jt}$ represents the enterprise increases receives the space lag item, $\beta$, $\gamma$ represent the corresponding regression coefficient vector, $\delta$, $\lambda$, $\theta$ represent the corresponding space hysteresis coefficient, $\vartheta$ represents the lag the regression coefficient of industrial enterprise income increase of one period, $\rho$ represents the corresponding spatial hysteresis coefficient of the first lag period, $W$ represents the space weight matrix, $\delta W \ln Y_{jt}$ represents the dimensional lag item that industry enterprise increases income, $\lambda W \ln KC_{jt}$ represents the industrial enterprise intellectual capital space lag item, $\theta W \ln K_{it}$ represents the control space lag, $\alpha_i$ represents the provincial effect, $\mu_i$ represents the time effect, $\varepsilon_{it}$ represents the random error term.

### 3.2 Data sources and variable definitions

The data in this paper are panel data of 31 provinces and cities in China from 2007 to 2016. The data are from ***China statistical yearbook*** and ***China industrial statistical yearbook***.

The dependent variable is the main business income of industrial enterprises, and the core explanatory variable is knowledge capital. In this paper, the full-time equivalent index of R&D personnel is selected to represent the variable of knowledge capital. The control variables include human capital, labor input, financial support and fixed asset investment. The human capital variable is the average education level of employees in industrial enterprises (unit/year). The labor input variable is the number of employees in industrial enterprises (unit/person). Financial support is the expenditure of enterprises in various regions on scientific and technological innovation. The variable of fixed asset investment is fixed asset investment of the whole society (unit/hundred million yuan).

**Table 1 descriptive statistics of variables**

| Variables | Define | Sample size | Mean | Standard Deviation | Max | Min |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| *lnGIO* | Industrial enterprise main business income logarithm | 248 | 18.8532 | 1.4437 | 21.1717 | 13.0997 |
| *lnRD* | Logarithm of all time equivalent of R&D personnel | 248 | 10.2537 | 1.7054 | 13.0212 | 2.9484 |
| *lnH* | Human capital logarithm | 248 | 4.1715 | 0.7711 | 5.1120 | 1.7918 |
| *lnT* | Financial support logarithm | 248 | 13.0337 | 1.0970 | 15.821 | 10.2004 |
| *lnL* | Log of labor variable inputs | 248 | 14.3500 | 1.3550 | 9.6989 | 16.6510 |
| *lnFAI* | Fixed asset investment logarithm | 248 | 18.3625 | 0.9262 | 20.0945 | 15.146 |

### 3.3 Set the space weight

In this paper, adjacency matrix, geographic distance weight matrix and economic geographic weight matrix are used to estimate the dynamic spatial durbin model.

Adjacency matrix: It is set according to whether the geographical location is adjacent or not. If the two regions i and j are adjacent in space, the element on the row j column of the corresponding matrix i is 1, otherwise it is set to 0. Hainan province is set to border guangdong province.

Geographical distance matrix: The weight matrix of geographical distance is based on the longitude and latitude coordinates of each provincial capital (or city), and the geographical distance between cities is calculated according to the spherical distance of geography. Firstly, according to the longitude and latitude of M and Q as well as the radius of the earth, the longitude and latitude coordinates of M and Q are converted into the three-dimensional coordinates of the sphere. Then, according to the three-dimensional coordinates of M and Q, the length of MQ is calculated. According to the law of cosines, the Angle MOQ, MQ arc length =R* Angle MOQ, and the geographic spherical distance of MQ is obtained.

Economic weight matrix: It is a spatial matrix to measure the adjacency degree of economic development between provinces and cities. $W_{gdp} = 1/\left|Q_j - Q_i\right|$ , $i, j = 1 \cdots 31, i \neq j$ 。 $Q_I$ Is the arithmetic average of per capita GDP of each province from 2007 to 2016。The economic distance between the two regions reflects the similarity of economic development.

### 4. Spatial metrology inspection and result analysis

Both spatial and temporal effects were significantly tested by LR, suggesting the existence of spatial and temporal effects. Combined with the Hausman test results, this paper adopts the dynamic spatial durbin model with double fixed effect to estimate the results, as shown in table 2

**Table 2 spatial panel estimation results**

| variable | Adjacency matrix | Geographical distance weight matrix | Economic distance weight matrix |
|---|---|---|---|
| lnRD | 0.2184*** | 0.2779*** | 0.2966*** |
| | (3.25) | (3.11) | (2.89) |
| lnH | 0.1491** | 0.1756*** | 0.1865*** |
| | (2.44) | (2.64) | (2.59) |
| lnT | 0.1468*** | 0.1443** | 0.0944* |
| | (2.67) | (2.36) | (1.61) |
| lnL | -0.0351 | 0.1517* | -0.0244 |
| | (-1.26) | (1.73) | (-1.24) |
| lnFAI | 0.3256*** | 0.4137*** | 0.4656*** |
| | (3.51) | (4.42) | (5.16) |
| lnGIO_1 | 0.0982** | 0.1165** | 0.0801*** |
| | (-2.48) | (-2.19) | (-2.78) |
| W*lnGIO_1 | 0.1658* | -0.306 | -0.0094 |
| | (1.67) | (-1.28) | (1.06) |
| W*lnRD | 0.1395** | 1.329*** | 0.5156** |
| | (1.98) | (4.34) | (2.52) |
| W*lnH | 0.5538 | 1.0549** | 0.5757* |
| | (1.23) | (2.11) | (1.78) |
| W*lnT | -0.1969* | -0.7582 | -0.2757* |
| | (-1.71) | (-1.59) | (-1.75) |
| W*lnL | -0.7322*** | -0.5873 | -1.4348*** |
| | (-2.79) | (-0.33) | (-3.51) |
| W*lnFAI | -0.236 | 0.3191 | -0.2667 |
| | (-1.24) | (0.17) | (-1.28) |
| log-lik | 96.7273 | 97.3253 | 99.4111 |
| R2 | 0.9882 | 0.9884 | 0.9885 |

Note: *, ** and *** passed the significance level test of 0.1, 0.05 and 0.01 respectively. The Z value is in parentheses.

It can be seen that the economic distance weight matrix has the highest log-lik value. Therefore, the following part focuses on the analysis of the effect decomposition results of the dynamic spatial econometric model under the economic distance weight matrix.

Knowledge capital plays a positive role in increasing the income of industrial enterprises and has passed the significance level test of 1%. Among the control variables, human capital, financial support and fixed asset investment play a role in promoting the income increase of industrial enterprises, and all pass the significance level test. The estimated results of labor input factors did not pass the significance level test. Knowledge capital has significant spatial correlation effect, and the spatial spillover coefficient is 0.5156. This means that areas with high accumulation of knowledge capital also have a greater role in boosting the income of industrial enterprises in surrounding areas. The spatial spillover effect of human capital factors is positive, that of financial support and labor input factors is negative, and the spatial spillover of fixed asset investment fails the significance test.

## 5. Conclusions and Suggestions

In this paper, the spatial spillover effect of Chinese industrial enterprises' knowledge capital is evaluated by the dynamic spatial dubin model. Using panel data of 31 provinces and cities in China from 2007 to 2016, three different spatial weight matrices were constructed for spatial spillover effect analysis, and the conclusions are as follows: Through the test, the knowledge capital of Chinese industrial enterprises has obvious spatial agglomeration effect ; Knowledge capital plays a positive role in increasing the income of industrial enterprises; The areas with high accumulation of knowledge capital also have a greater role in boosting the income of industrial enterprises in surrounding areas.

Accordingly, we suggest that: Chinese industrial enterprises should increase the input of intellectual capital and promote the growth of enterprise income; The government should strongly support the accumulation of intellectual capital in industrial enterprises, stimulate the vitality of enterprises by increasing financial subsidies, and give full play to the improvement of income of enterprises by intellectual capital through the introduction of relevant laws and policies.

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