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# Spatial Evolution of Industrial Structure in Hebei Province

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**Abstract:** This study contributes to empirical literature concerning the spatial evolution of industrial structure. We use the GIS technology and the deviation range method to analyze the spatial evolution of industrial structure in 11 cities in Hebei province in the year 2002 and 2010. Our empirical analysis indicates four major problems: the industrial layout is too concentrated, the optimization of industrial structure is relatively low, the industrial structure is similar and diseconomies of scale and the industrial structure are similar and diseconomies of scale. Then we give specific recommendations to the above problems. Finally we discuss the implications of our findings for theory and practice and indicate avenues for future research.

**Keywords:** Deviation range method, industrial restructuring, industrial structure, spatial evolution

## INTRODUCTION

As the results of the past economic growth and the basis for future economic growth, the industrial structure is a fundamental factor in economic development. Many scholars have conducted extensive research on the evolution of industrial structure. Through the labor input and output data collation in three industries for different periods of more than 40 countries, Clark (1957) pointed out that with the improvement of per capita income level of the whole society, the workforce transferred from the first industrial to the secondary industry firstly; and when per capita income level was to further improve, the labor would transfer to the third industrial. On this basis, Kuznets (1985) used statistical regression methods to demonstrate the evolution of industrial structure from the perspective of the three industries accounted for a share of national income change. Got that throughout the process of industrialization, the proportion of industry in the national economy will experience a rise to a decline in the inverted U-shaped change. To Kuznets, research Rostow (1988) was from the perspective of supply, he took innovation as the starting point, examined the dominant sector to promote industrial conversion by diffusion effects, thus speeding up the status of economic growth.

Changes in industrial structure are interrelated with the urban development. There are four factors related to urbanization and the evolution of industrial structure. They are as shown below:

- The agglomeration economies
- Human capita
- Technological progress
- Policy

Davis and Henderson (2003) investigated the relationship between urbanization and changes in industrial structure from the perspective of agglomeration economies. They found that when the state-dominated industries transferred from agriculture to industry and modern service, the labor would also be transferred from agriculture to manufacturing and services, so that businesses and workers gathered in the city, in order to obtain the economies of scales, so to promote the development of urbanization.

Huge accumulation of human capital was powerful for a country or region's economic growth (Lucas, 1988). The main factors like human capital, regional information and knowledge spillovers promoted economic activity gathered in the city. By affecting the cities' agglomeration economies, the human capital became a bridge to connect the changes in industrial structure and urbanization (Black and Henderson, 1999).

In the process of industrialization in developing countries, higher technical level made labor absorption capacity and rapid by the manufacturing sector decline, which caused the transfer of labor from agriculture would be a substantial shift to tertiary industry afterward (Moir, 1976). Technological advances improved agricultural productivity, resulting releasing large amounts of labor in the agricultural sector, it was this part of the labor force which transferred to industry and services in the city, prompted the city develop fast (Murata, 2002).

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In addition, political and policy factors, such as infrastructure investment, pricing policies and trade policies will affect the composition of share to various industrial sectors, thereby indirectly affecting the urbanization (Garza, 1999; Davis and Henderson, 2003).

Previous studies show that constant adjustment and upgrading of industrial structure is the main feature and motivation of regional development. But a number of key issues, such as spatial development perspective, the unique features of the typical types of regional and so on, also need to be deepen and complemented.

In this study, we take the industrial structure of Hebei province as case study; use the GIS technology and the deviation range method. We expect to expand the research perspective of regional economics and urban geography scientifically.

## DATA AND METHODOLOGY

**Sample and data collection:** The sample of our study is 11 cities in Hebei province. We choose it with three issues in mind. Firstly, we work and live in Hebei province; we are so familiar with everything here. Secondly, we have done a lot of research on ecomomic development in Hebei province, including on-spot investigation, questionnaires issued, convening seminarsand conferences and so on. These studies laid the foundation for this study. Thirdly, we use a single-province sample in order to control for potential economic and cultural variations.

We choose the year 2002 and 2011 as the study objects, because during this decade the industrial structure changes a lot and the economic development grows faster. These two time points can effectively reflect the spatial transfer of the industrial structure.

For data collection, we use gross domestic product, promary industry product, secondary industry product, tertiary industry product and the employed persons of each industries of the 11 cities in the year 2002 and 2011. These data can be obtained from the Hebei Province Bureau of Statistics Web sites. (http://www.hetj.gov.cn/col1/col69/index.htm1?id= 69)

**Measures:**

**Cluster analysis:** It is the task of assigning a set of objects into groups (called clusters), so that the objects in the same cluster are more similar (in some sense or another) to each other than to those in other clusters. In this study, we use K-means algorithm. The specific steps are as follows:

- Select k elements from D randomly, as the k-th cluster center of each
- Calculate the dissimilarity of the remaining elements to the k-th cluster center; classify these elements to the lowest cluster
- According to the clustering results, re-calculate k cluster center by the arithmetic mean of all the elements to take the cluster dimension
- Re-cluster all elements of D in accordance with the new center
- Repeat step 4 until the clustering results does not change
- Outputs the results

Take sample $\vec{x}_i$, $\vec{x}_j$ for example, the distance between them is $d_{ij}$, the smaller the distance the more similar. We use Euclidian Distance formula:

$$d_{ij} = \sqrt{\sum_{k=1}^{p} \left(x_{ik} - x_{jk}\right)^2} \tag{1}$$

The SPSS software defaults the Squared Euclidian Distance formula:

$$d_{ij} = \sum_{k=1}^{p} \left(x_{ik} - x_{jk}\right)^2 \tag{2}$$

The formula of similarity coefficient $S_{ij}$ is:

$$s_{ij} = \frac{\sum_{k=1}^{p} \left(x_{ik} - \vec{x}_i\right)\left(x_{jk} - \vec{x}_j\right)}{\sqrt{\sum_{k=1}^{p} \left(x_{ik} - \vec{x}_i\right)^2} \cdot \sqrt{\sum_{k=1}^{p} \left(x_{jk} - \vec{x}_j\right)^2}} \tag{3}$$

**Deviation range method:** Structure deviation degree refers to the result of the proportion of industry in GDP/proportion of employment in the industry subtracts one (4). In general, the structure deviation degree is inversely proportional to the labor productivity. Moreover, if the structure deviation degree is greater than zero (positive deviation), i.e., the proportion of industry outputs is greater than the proportion of employment in the industry that means higher labor productivity in the industry. Conversely, the negative means lower labor productivity in the industry. From another point of view, there is the possibility for labor turn out in an industry if the result is negative. On the contrary, there is the possibility of labor transferred when the structure deviation is positive. When the national economy are open to all industries and there are no administrative barriers in the industry, that is the perfect competition, in this situation, the market will reallocate of labor resources, the productivity of the industry will gradually converge, the industry structure deviation degree will also tend to zero gradually. The formula of structure deviation degree is:

$$E_i = \frac{Y_i}{X_i} - 1 \qquad i = 1,2,3 \tag{4}$$

## RESULTS

After calculation of the data, we find that the industrial structure changed little since 2002 in Hebei. The province's industrial output value of the overall

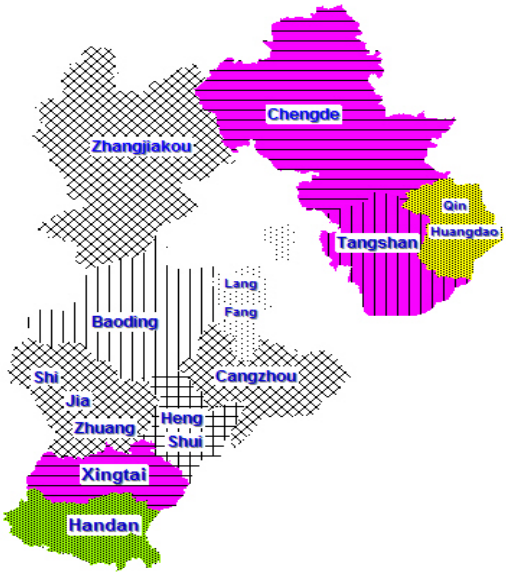


Fig. 1: Spatial distribution of leading industry in Hebei province in 2002

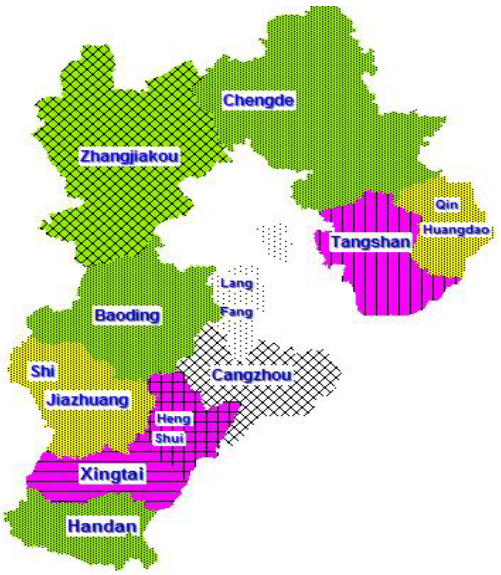


Fig. 2: Spatial distribution of leading industry in Hebei province in 2011

point of view in three industries are respectively 4.43, 52.55, 43.02% in 2002, 2.68, 51.44, 45.88%, respectively in 2011. It is obvious that the first industry decreased by 1.75%, the secondary industry decreased by 1.11% and the tertiary industry rose 2.86%. The industrial structure in Hebei Province is gradually shifted from the first and second industries to the tertiary industry, currently dominated by second and tertiary industries. Although the total percentage of the industry structure changes little, but each city's industrial structure has changed very obvious. We use mapinfo software to mark industrial structure of Hebei Province in the year 2002 and 2011 on the map in different colors, the same industrial structure of cities use the same color.

Fig. 1 and 2 show the significant changes in industrial structure in the 11 cities. In these two figures, the four colors representing the four types. The white color represents the proportions of the secondary and tertiary industries are relatively close. The pink color represents the proportions of the secondary industry are about twice of the tertiary industry. The yellow color represents the proportions of the tertiary industry are about twice of the secondary industry. There is a little difference between Fig. 1 and 2 for the green color. The green color in Fig. 1 represents the proportion of the secondary industry is very large, more than twice of the tertiary industry. While in Fig. 2 the green color represents the proportion of the secondary industry is more than doubled less than twice of the tertiary industry.

The characteristics of the spatial evolution of industrial structure in Hebei Province are as follows:

- **The development trend of regional integration is enhanced:** Comparing the spatial distribution of the leading industries of two different points in time, we found that visually, relatively clear regions of the leading industries are limited to the periphery of several cities in 2002, they are Qinhuangdao, Tangshan, Chengde, Xingtai and Handan, in which Qinhuangdao's leading industry is the tertiary industry and the other four's is the second industry; while in 2011, except Langfang and Cangzhou, the others are all have their own leading industries.
- **The leading industries are symmetric in Beijing-Tianjin axis:** The two parts with no marked character in the figure are Beijing and Tianjin. In Fig. 2 Shijiazhuang and Qinhuangdao are symmetric distribution, Tangshan and Hengshui are symmetric distribution, Baoding and Chengde are symmetric distribution, there are all in Beijing-Tianjin axis.
- **The spatial evolution of the industrial structure is accelerated:** Compared to Fig. 1 and 2 are changing a lot. The second industry in Zhangjiakou, Baoding and Hengshui develop fast, the tertiary industry in Chengde, Shijiazhuang and Handan develop fast, although in the other five cities, we can't find the change significantly, but the output value of the three industries all develops fast.
- **The transport conduction mechanism is working:** The main task of the comprehensive transportation construction in the "12$^{th}$-five year" in Hebei Province is to build two systems, namely, the province's integrated transport network system (referred to within the network) with the center

Shijiazhuang City, this system covers both urban and rural areas; and the "open transport channel system (referred to as the external network) is for the adjacent provinces. After the completion of the comprehensive transport system in Hebei Province, with in and out the province's transportation environment will bring great convenience for the development of the industry, what's more the city that has convenient transportation will get the opportunity of rapid development of industry.

- **The government's regulation is significantly:** In recent years, the Hebei Municipal Government is through the application of policies to guide the preparation of planning, implementation, control and other means to promote industrial structure. With the guide of the government, the industrial structure is further optimized, the steel, equipment manufacturing and petrochemical growth as the three pillar industries increased significantly. Industrial technology innovation capability was strengthened and energy conservation, the elimination of backward production capacity of enterprise was solid progress.

The problems in industrial structure spatial evolution are as follows:

- The industrial layout is too concentrated. The secondary industry is mainly concentrated in Tangshan, the tertiary industry is mainly concentrated in Shijiazhuang and Tangshan, the primary industry is relatively balanced distribution, but the overall strength is weak.
- The optimization of industrial structure is relatively low, the overall level of industrial structure is low and the proportion of tertiary industry is low. The proportion of three industries in Hebei Province by the year 2002 was 4:52:43 evolution 2011 with 2:51:45, indicating that the overall level of Hebei Province's industrial structure is still low, the tertiary industry the proportion is still below the national average, it should increase its efforts to development of tertiary industry and further promote the industrial structure in Hebei Province.
- The industrial structure is similar and diseconomies of scale. The industrial structure in Hebei Province is of fragmenting enterprise, the enterprises are low degree of specialization, which decentralized capabilities to improve product quality and product specifications, elongated new product cycle, the professional level of technology can't timely improve and increased costs caused by diseconomies of scale.
- The emerging industries develop slowly in Hebei province. From the internal point of view of industrial structure, iron and steel, building materials, coal and petroleum chemical industry accounts for a large proportion in the secondary industry in Hebei Province. These industries will result in over-exploitation of natural resources, leading to the gradual depletion of non-renewable resources and resource-based industries such as steel, petrochemical and pharmaceutical, textile and other industries are likely to cause environmental pollution, environmental pollution will undoubtedly increase the economic costs for society as a whole. In addition, compared with other provinces, there is industry-specific development of convergence, not yet formed its own characteristics.

The structure deviation degree of Hebei province is shown in Table 1. We can see that nearly all the cities have positive deviation in the first industry. From the actual situation in Hebei Province, the occurrence of this situation is not because of the agricultural modernization, but rather the slow pace of agricultural development, the majority of rural workers transfer to other industries engaged in labor productivity. For Langfang, there is no deviation in the first industry; it is because there are no farmers, all the people are engaged in other industries. Why there is no? Because Langfang is adjacent to Beijing. The structure deviation degree of the second industry has improved in 2011than in 2002. That means the space evolution of industrial structure is mature. The structure deviation degree of the tertiary industry is generally low, indicating that the tertiary

Table 1: Structure deviation degree of industries

| | Structure deviation degree of the first industry | | Structure deviation degree of the second industry | | Structure deviation degree of the tertiary industry | |
|---|---|---|---|---|---|---|
| City | 2002 | 2011 | 2002 | 2011 | 2002 | 2011 |
| Shijiazhuang | 2.80 | 0.75 | -0.07 | -0.26 | 0.05 | 0.17 |
| Chengde | 1.47 | 4.04 | 0.21 | 0.59 | -0.25 | -0.37 |
| Zhangjiakou | 2.10 | 33.45 | -0.11 | 0.19 | 0.13 | -0.21 |
| Qinhuangdao | 2.48 | 1.61 | -0.18 | 0.02 | 0.12 | -0.02 |
| Tangshan | 6.38 | 7.55 | -0.06 | 0.02 | -0.15 | -0.12 |
| Langfang | 12.29 | - | 0.17 | -0.25 | -0.25 | 0.17 |
| Baoding | 5.71 | 9.83 | -0.09 | 0.12 | 0.04 | -0.16 |
| Cangzhou | 4.72 | -0.76 | 0.07 | 0.33 | -0.08 | -0.16 |
| Hengshui | 17.16 | 23.03 | 0.39 | 1.08 | -0.34 | -0.56 |
| Xingtai | 21.38 | 15.92 | 0.14 | 0.23 | -0.22 | -0.27 |
| Handan | 4.03 | 4.46 | 0.13 | 0.05 | -0.29 | -0.08 |

industry's labor productivity is low and the tertiary industry needs further development and improvement.

## DISCUSSION

The evolution of industrial structure in Hebei Province is similar to organism's natural growth process of its space to grow by regional terrain conditions, traffic location and resource endowments. We discuss the strategy for space evolution of industrial structure adjustment in Hebei Province through this study.

**Constructing the network of industrial space associated with system:** The associated system of the network of industrial space refers to the central counties (districts) for the node, relying on the accessibility of the transportation routes, the gradient of the industrial division of labor system.

**Adjust the layout of the industrial structure:** Strengthen agricultural infrastructure construction, accelerate the progress of agricultural science and technology, improve grain yield, grain production to further improve the technical service system, increase the training of farmers and take the road of developing agriculture through science and technology, improve the effectiveness of the application of agricultural science and technology. What’s more, make innovations in agricultural production and management system. Strengthen the traditional pillar industries, promote industrial upgrading.

**Accelerate the development of high-tech industries:** Through these efforts to achieve the transition from resource-based economy to innovation-based economy. Hebei Province is around Beijing and Tianjin and Beijing and Tianjin have a lot of high-level talent and scientific research institutions, it’s better for Hebei to use the Beijing-Tianjin scientific and technological achievements, for high-tech achievements into the conditions and to create the conditions for the adjustment of industrial structure.

**Change the low-cost competitive strategy:** First, focus on upgrading the industrial structure. Second, strengthen the construction of the "location brand" to enhance the image of the industry cluster. The third is to nurture the industry leader, promoting industrial development.

## CONCLUSION

Our study shows space evolution of the industrial structure of Hebei province, the overall point of view, the various cities in Hebei province have been rapid development in the decade from 2002-2011, policy and geographical location affect the industrial structure most and the city's industrial development and have not been effective optimization.

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