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# Research on the Development of the Manufacture of Medicine Based on Gray CorrelationAnalysis： Analysis of Yangtze River and Pearl River Deltas in China

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# Research on the Development of the Manufacture of Medicine Based on Gray Correlation Analysis: Analysis of Yangtze River and Pearl River Deltas in China

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**Abstract:** Giving the fact that manufacturing industry is still the engine of economic development in developing countries, China pays special attention to the development of manufacturing industry, especially the hi-tech industry. This paper takes the manufacture of medicine as an example, aiming to investigate the development status of the manufacture of medicine in Yangtze River and Pearl River Deltas, which are China's major manufacturing centers. In this context, the dynamic index system composed of R&D Stage, Production Stage and Output Stage is established and the Gray Correlation Analysis Model is applied in evaluating. The results indicate that there is a gap between Yangtze River and Pearl River Deltas. The capacity of turning R&D and innovation input into output is important to promote the development of the manufacture of medicine and the synergy effect of the industry value chain can't be ignored.

**Keywords:** Manufacture of Medicine, Development, Gray Correlation Analysis

## 1. INTRODUCTION

Economists have for a long time discussed the causes of economic growth and the mechanisms behind it. According to Kaldor (1966) [1], an important stylized fact in the growth trajectory of developed economies in the postwar period is the relationship between industrial growth and the performance of the economy as a whole.(Gilberto Libanio, 2005)[2] Even in recent years, a large number of empirical studies confirmed the "manufacturing is the engine of growth" hypothesis both in developed countries and developing countries. [3][4][5]The dynamic forces of globalization and the emergence of the knowledge based economy have made the manufacturing industry, especially the hi-tech industry the leading sector and the engine of growth. Taking the manufacture of medicine as an example, it has been one of the top three industries in developed countries such as the USA and Japan. The manufacture of medicine got the highest margin (17.2%) of all the industries, significantly higher than the telecommunication industry (8.1%) and computer industry (7.3%).[6] Some developing countries also realize the importance of hi-tech industries and set up strategies to promote the development of hi-tech industries. For example, the manufacture of medicine belongs to China's one of nine strategic emerging industries, which are proposed in 2009.

The Yangtze River Delta (YRD) and the Pearl River Delta (PRD) in China are two of the most dynamic manufacturing regions. The YRD mainly includes Shanghai, Jiangsu Province and Zhejiang Province while the PRD mainly includes Guangzhou, Shenzhen and Zhuhai. This paper aims at investigating the development status of the manufacture of medicine between the YRD and the PRD.

The rest of the study is organized as follows: the index based on value chain network is set about in Section 2. Section 3 set about evaluation using Grey Correlation Analysis followed by this study while in section 4 empirical findings are provided. Section 5 concludes the articles.

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## 2. INDEX SYSTEM OF THE DEVELOPMENT OF THE MANUFACTURE OF MEDICINE

According to the Value chain, originally proposed by Michael Porter[7] in 1985, the article has established an evaluate index system of the Development of the Manufacture of Medicine. Porter believes that the enterprises' value creation process can be divided into several parts: design, production, distribution, delivery and those different but interrelated supporting economic activities. According to the characteristics of value chain, the index system is composed of R&D Stage, Production Stage and Output Stage based on the science and the reality principle, the systematic principle, the comparable principle, the operational principle and the dynamic principle of continuity. (As shown in table 1)

**Table 1. The index system**

| First grade Index | Second grade Index | Description of Second grade Index |
|---|---|---|
| R&D Stage | Number of R&D Personnel | R&D Scale in R&D Stage |
| | R&D Internal Expenditure | R&D Investment in R&D Stage |
| | Number of New Products | Effects of R&D in R&D Stage |
| Production Stage | Fixed Asset Investment by year end | Asset Size in Production Stage |
| | New Fixed Asset Value | Asset Investment in Production Stage |
| | Average Number of Employees | Employment Scale in Production Stage |
| Output Stage | Market Share | Market Share in Output Stage |
| | Total Profit | Level of Profitability in Output Stage |
| | Export delivery value | Export Scale in Output Stage |
| | Total Output | Sales Volume in Output Stage |

Note: Market Share=Local Sales Revenue/ State Sales Revenue

In this study, the manufacture of medicine is classified based on the state's Statistics Catalogue of High-technology Industry Classifications (Version 2002). Table below shows the sector group numbers for related sectors that were taken into account for analysis. The indices mentioned above were used to compare the Yangtze River Delta (YRD) and the Pearl River Delta (PRD)'s development status in the manufacture of medicine.

**Table 2. The catalogue of Manufacture of Medicine**

| NO. | Name | Code |
|---|---|---|
| 1 | Manufacture of Medicine | 27 |
| 2 | Manufacture of Chemical Medicine | 2710+2720 |
| 3 | Manufacture of Finished Traditional Chinese Herbal Medicine | 2730+2740 |
| 4 | Manufacture of Biological and Biochemical Chemical Products | 2760 |

## 3. GRAY CORRELATION ANALYSIS MODEL

The basic concept of grey correlation analysis is to determine whether a relationship among a series of data is close, based on the degree of similarity among the geometric shapes of the data series' curves.[8][9][10] When the method of grey correlation analysis was first proposed by Deng(1982), it has been used by hundreds of experts in many research fields. The strength of grey correlation is that it can improve the accuracy of modeling, decision-making and control systems, especially those systems which have incomplete information and unclear operating mechanism.

### 3.1 Selection of optimal value

Assume i as the serial number of the i-th evaluation unit, i＝1，2，…，m；k as the index number of the k-th evaluation indicator, k＝1，2，…，n, $V_{ik}$ as the evaluation value. Select $V_{0k}$ ＝Optimum($V_{ik}$)，where k＝1，2，…n,

$$V_{0k} = (v_{01}, v_{02}, \ldots, v_{0n}) \qquad (1)$$

Get the candidate region m valuate matrix V with evaluation indicator n.

$$V = V_{ik} = \begin{bmatrix} V_{11} & V_{12} & \cdots & V_{1n} \\ V_{21} & V_{22} & \cdots & V_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ V_{m1} & V_{m2} & \cdots & Vmn \end{bmatrix} \qquad (2)$$

### 3.2 Standardization of the index value

Dimensionless is important for us to compare the various index value for each indicator, the formula is

$$X_{ik} = \frac{V_{ik} - \min V_{ik}}{\max V_{ik} - \min V_{ik}} \qquad (3)$$

### 3.3 Calculate the grey relational coefficient

Use $X_0=(x_{01}, x_{02}, \ldots, x_{0n})$ as the reference series and

$X_i=(x_{i1}, x_{i2} \ldots x_{in})$ (n=1,2…n) as the comparison series, we can calculate the grey relational coefficient, that is:

$$S_{ik} = \frac{\min_i \max_k |X_{0k} - X_{ik}| + \rho \max_i \max_k |X_{0k} - X_{ik}|}{|X_{0k} - X_{ik}| + \rho \max_i \max_k |X_{0k} - X_{ik}|} \qquad (4)$$

i=1,2,…,m  k=1,2,…,n

where $\rho$ =0.5, $\rho \in [0,1]$

Then we can get the relational matrix E

$$E = S_{ik} = \begin{bmatrix} S_{11} & S_{12} & \cdots & S_{1n} \\ S_{21} & S_{22} & \cdots & S_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ S_{m1} & S_{m2} & \cdots & Smn \end{bmatrix} \qquad (5)$$

### 3.4 Calculate the grey relational degree

Take the weight of the second grade index as wk=0.1, k=1,2,…10, and the weight of the first grade index as wk'=1/3, k'=1,2,3, we can calculate the grey relational degree, the formula is

$$R = (r_i)_{1\times m} = (r_1, r_2, \cdots r_m) = WE^T \qquad (6)$$

## 4. EMPIRICAL FINDINGSWHAT

This section is to measure the correlations of the Manufacture of Medicine for Yangtze River and Pearl River Deltas in mainland China, date are from latest China High-tech Industry Statistics Yearbook 2012.

In order to select the relative optimal value more accurately, we calculated the grey relational coefficient of 31 economic zones in mainland China first as follows: First, select the relative optimal value as the optimal reference vector use formula 1 $V_{0k}$ =(9019，206358，201，1018，142，183720，20.323，184，215，1616). Then, Calculate the grey relational coefficient by formula from 2 to 5 $s_{ik}$ ( i =1,2… m k=1,2…n) . Table 3 shows the grey relational coefficient of 31 economic zones in mainland China. After that, we calculate the grey relational degree of the Manufacture of Medicine for Yangtze River and Pearl River Deltas by formula 6.

Figure1 below shows the grey relational coefficient of the second grade index of the Manufacture of Medicine for Yangtze River and Pearl River Deltas in mainland China. And Table 4 shows the grey relational degree of the first grade index.

The results indicate that Yangtze River Delta has a comparative advantage in R&D Stage and Production Stage as well as Output Stage. Because of the locational advantages, Pearl River Deltas used to be the frontier of undertaking industrial transfer from Taiwan. But now Manufacture of Medicine develops faster in Yangtze River Delta as the talent aggregation and the FDI investment, especially in Shanghai and Jiangsu. Therefore R&D stage is one of the important factors influencing the development of industries,( Lan et al. 2008)[12] The score of R&D stage is 0.688 in Yangtze River Delta and 0.647 in Pearl River Delta respectively.

However, of all the three stages, Output Stage owns the highest score both in Yangtze River and Pearl River Deltas. The grey relational degree was found to be greater than 0.8, which reveals that it is particularly important to turn R&D and innovation input into practical output.[13]

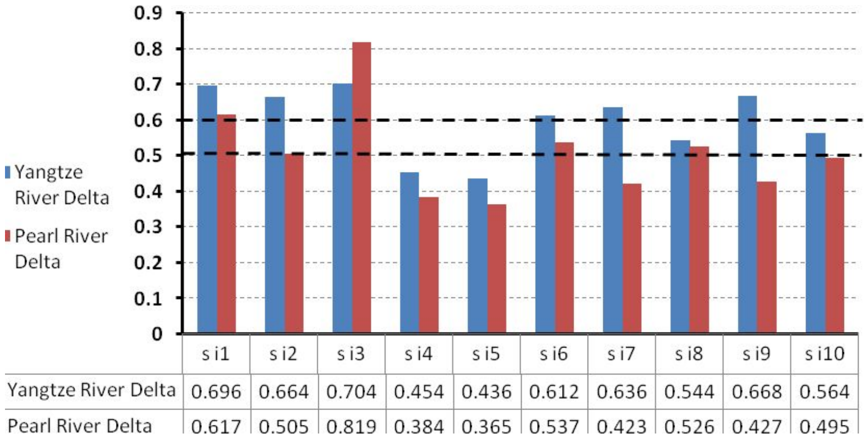


**Figure 1. The grey relational coefficient for the third index (*$S_i$*)**

**Table 4. The grey relational degree for the third index**

| | Yangtze River Delta | Pearl River Delta |
|---|---|---|
| R&D Stage | 0.688 | 0.647 |
| Production Stage | 0.501 | 0.429 |
| Output Stage | 0.805 | 0.624 |

The grey relational coefficient in figure 1 also indicates that synergy of all aspects in the industry value chain can't be ignored. Synergy can create effect within industry cluster to gain stronger profitability than single enterprise. That is"1+1>2" effect. [14]Thus competitive advantage can be achieved and sustained. Five out of ten grey relational coefficients in Pearl River Delta are below 0.5, while the grey relational coefficients of Fixed Asset Investment by year end and New Fixed Asset Value are below 0.4.

**Table 3. The gray relational coefficient Sik in manufacture of medicine for 31 provinces in China**

| | $s_{i1}$ | $s_{i2}$ | $s_{i3}$ | $s_{i4}$ | $s_{i5}$ | $s_{i6}$ | $s_{i7}$ | $s_{i8}$ | $s_{i9}$ | $s_{i10}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| Beijing | 0.4132 | 0.3704 | 0.5051 | 0.3472 | 0.3425 | 0.4132 | 0.3817 | 0.4202 | 0.3401 | 0.3937 |
| Tianjin | 0.4000 | 0.3968 | 0.4950 | 0.3876 | 0.3571 | 0.3937 | 0.3846 | 0.3876 | 0.3650 | 0.3788 |
| Hebei | 0.5155* | 0.4237 | 0.5319* | 0.5263* | 0.5102* | 0.4717 | 0.3704 | 0.4167 | 0.4348 | 0.4132 |
| Shanxi | 0.3597 | 0.3448 | 0.3472 | 0.3650 | 0.3497 | 0.3759 | 0.3356 | 0.3448 | 0.3378 | 0.3472 |
| Inner Mongolia | 0.3401 | 0.3378 | 0.3401 | 0.3817 | 0.3546 | 0.3623 | 0.3333 | 0.3676 | 0.3401 | 0.3597 |
| Liaoning | 0.3846 | 0.3597 | 0.3876 | 0.6098** | 0.4348 | 0.4032 | 0.3448 | 0.3817 | 0.3571 | 0.3968 |
| Jilin | 0.3650 | 0.3448 | 0.3759 | 0.8929** | 1.0000** | 0.4673 | 0.3497 | 0.4032 | 0.3378 | 0.4425 |
| Heilongjiang | 0.4098 | 0.3817 | 0.4274 | 0.4202 | 0.4310 | 0.4000 | 0.3425 | 0.3906 | 0.3425 | 0.3676 |
| Shanghai | 0.4098 | 0.4310 | 0.4545 | 0.3497 | 0.3597 | 0.4167 | 0.4000 | 0.4202 | 0.3731 | 0.4000 |
| Jiangsu | 0.9091** | 1.0000** | 1.00** | 0.6173** | 0.5556* | 0.8197** | 1.0000** | 0.7143** | 0.6329** | 0.8065** |
| Zhejiang | 0.7692** | 0.5618* | 0.6579** | 0.3968 | 0.3937 | 0.6024** | 0.5102* | 0.5000* | 1.000** | 0.4854 |
| Anhui | 0.3788 | 0.3597 | 0.3817 | 0.4505 | 0.4032 | 0.4098 | 0.3521 | 0.3597 | 0.3472 | 0.3704 |
| Fujian | 0.3571 | 0.3546 | 0.3906 | 0.3623 | 0.3497 | 0.3623 | 0.3472 | 0.3546 | 0.3546 | 0.3546 |
| Jiangxi | 0.3788 | 0.3623 | 0.4000 | 0.6579** | 0.6329** | 0.4630 | 0.3597 | 0.3788 | 0.3497 | 0.4132 |
| Shandong | 1.00** | 0.9804** | 0.9804** | 1.00** | 0.7143** | 1.00** | 0.7143** | 1.00** | 0.6173** | 1.00** |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Henan | 0.4505 | 0.3817 | 0.4348 | 0.7937** | 0.6329** | 0.5618* | 0.3876 | 0.4902 | 0.3497 | 0.4808 |
| Hubei | 0.4310 | 0.3704 | 0.4673 | 0.5263* | 0.5747* | 0.4545 | 0.4065 | 0.3906 | 0.3817 | 0.4000 |
| Hunan | 0.3788 | 0.3650 | 0.3817 | 0.4348 | 0.4032 | 0.4202 | 0.3546 | 0.3846 | 0.3401 | 0.3937 |
| Guangdong | 0.6173** | 0.5050* | 0.8197** | 0.3846 | 0.3650 | 0.5376* | 0.4237 | 0.5263* | 0.4274 | 0.4951 |
| Guangxi | 0.3546 | 0.3425 | 0.3759 | 0.3817 | 0.3704 | 0.3846 | 0.3448 | 0.3650 | 0.3378 | 0.3571 |
| Hainan | 0.3401 | 0.3401 | 0.3650 | 0.3333 | 0.3333 | 0.3448 | 0.3333 | 0.3497 | 0.3333 | 0.3425 |
| Chongqing | 0.3817 | 0.3650 | 0.4505 | 0.3846 | 0.3650 | 0.3759 | 0.3650 | 0.3497 | 0.3497 | 0.3597 |
| Sichuan | 0.3571 | 0.3546 | 0.3546 | 0.4630 | 0.4545 | 0.5208* | 0.3597 | 0.4310 | 0.3650 | 0.4464 |
| Guizhou | 0.3497 | 0.3425 | 0.3846 | 0.3425 | 0.3356 | 0.3650 | 0.3425 | 0.3571 | 0.3333 | 0.3597 |
| Yunnan | 0.3597 | 0.3472 | 0.3472 | 0.3546 | 0.3472 | 0.3597 | 0.3448 | 0.3546 | 0.3356 | 0.3521 |
| Tibet | 0.3333 | 0.3333 | 0.3333 | 0.3333 | 0.3333 | 0.3333 | 0.3333 | 0.3356 | 0.3333 | 0.3333 |
| Shaanxi | 0.3817 | 0.3497 | 0.3521 | 0.3731 | 0.3650 | 0.3846 | 0.3425 | 0.3571 | 0.3356 | 0.3676 |
| Gansu | 0.3425 | 0.3546 | 0.3401 | 0.3497 | 0.3472 | 0.3472 | 0.3356 | 0.3425 | 0.3333 | 0.3401 |
| Qinghai | 0.3333 | 0.3333 | 0.3356 | 0.3356 | 0.3356 | 0.3378 | 0.3333 | 0.3333 | 0.3333 | 0.3356 |
| Ningxia | 0.3448 | 0.3401 | 0.3448 | 0.3356 | 0.3333 | 0.3378 | 0.3448 | 0.3378 | 0.3425 | 0.3356 |
| Xinjiang | 0.3333 | 0.3333 | 0.3333 | 0.3356 | 0.3356 | 0.3356 | 0.3333 | 0.3333 | 0.3333 | 0.3333 |

Note: “**”means $S_{ik} > 0.6$; “*”means $0.5 < S_{ik} < 0$.

## 5. CONCLUSIONS

This study was conducted by focusing on development of the Manufacture of Medicine for Yangtze River and Pearl River Deltas in mainland China. The empirical studies show that there is a competitiveness gap between Yangtze River and Pearl River Deltas. There is a comparative advantage of the Manufacture of Medicine in Yangtze River Delta. Although the development of the Manufacture of Medicine as well as the other hi-tech industries could not leave without R&D input and innovation, it is more important to turn R&D and innovation input into practical output. Also, the synergy effect of the industry value chain can't be ignored.

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