Studies on Interaction between Materials Manufacturing and Graduate Education

——Illustrated by Hubei Province

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Abstract: In this knowledge economy age, postgraduate education is closely related with regional materials manufacturing industry development, both of which interact with each other. As a big province of education and materials manufacturing, Hubei is of great theoretical and practical significance for the systematic study of its coordination between postgraduate education and materials manufacturing industry development. Taking advantage of related data about postgraduate education and economic development of material manufacturing industry in Hubei Province between 2005 and 2014, this paper uses maximum deviation and coordinated degree model to analyze the shortcomings of Hubei postgraduate education, and puts forward relevant proposals for adapting to regional materials manufacturing industry development.

1. Introduction

As the main body of national economy, materials manufacturing industry is the foundation of building the nation, instrument of rejuvenating the nation and basis of empowering the nation, whose rapid development depends on education support. Postgraduate education provides large amounts of talents for our country and plays a positive role in Chinese innovative development. Hubei province has great potentials in the economic development of materials manufacturing industry. By studying the coordination between postgraduate education and economic development of materials manufacturing industry in Hubei, we can help its postgraduate education to better adapt to the needs of materials manufacturing industry, and provide more talent reserves for materials manufacturing industry.

2. Literature Review

In the theoretical aspect, foreign scholars Austria Cui and Kirbach focus on knowledge and entrepreneurs' impact on economic growth. In empirical study, both knowledge capital and entrepreneur capital are regarded as the material capital and labor force factors for promoting economic growth. Wang Xianbin, starting from theories about coordinated development between postgraduate education and regional industrial economy, and based on related data about industrial economic development changes in Guangxi between 2011 and 2015, studies problems and shortcomings in the adaption process of postgraduate education in industrial structural transformation in Guangxi, and puts forward countermeasures in order to promote coordinated development. Yuan Bentao and other researchers point out that different coordination levels exist

between postgraduate education and economic development in different cities, and that the postgraduate education in Beijing and Shanghai has exceeded their economy. Huang Haijun and Li Liguo set up evaluation index system from four aspects of scale, structure, quality and benefit, and study the postgraduate development level as well as economic development level in 2012 in all Chinese provinces. The study has shown that Hubei's postgraduate education level is higher than regional economic development level.

Through literature analysis, we can find that the study of postgraduate education and economic development has extended from correlation analysis of single indicators towards the application of econometrics and comprehensive evaluating method. Based on existing literature and by using maximum deviations as well as coordinated degree model, this paper constructs a comprehensive evaluating system for postgraduate education and economic development in material manufacturing industry in Hubei province.

3. Model Building

3.1. Maximum Deviation Model

Suppose A = {A1，A2, ⋯ , An} to be the solution set of multi-index evaluation problem, G ={G1，G2，⋯，Gm}the index set, Yij (i= 1，2，⋯，n;j= 1，2，⋯，m) the index value of scheme Ai on index Gj, and matrix Y=(yij)n×m the "decision matrix" of program set A on index set G.

According to index natures, they are divided into four categories, namely efficiency-type, cost-type, fixed-type and interval-type. Generally speaking, different evaluation indexes usually have different dimensions and dimension units. To eliminate the differences between they two, firstly indexes should be processed without dimension. This paper includes efficiency-type index and cost-type index. The former refers to indexes which are better with bigger attribute values, such as per capita profit rate and average education funds proposed in this paper. The latter refers to indexes which are better with smaller attribute values, such as postgraduate student-teacher ratio in this paper.

For efficiency-type index, order:

$$Z_{ij}=\frac{y_{ij}-y_j^{min}}{y_j^{max}-y_j^{min}},\ i=1,2,\cdots n, j\in\Omega_1 \tag{1}$$

For cost-type index, order:

$$Z_{ij}=\frac{y_j^{min}-y_{ij}}{y_j^{max}-y_j^{min}},\ i=1,2,\cdots n, j\in\Omega_2 \tag{2}$$

Among it, y_j^{max}、y_j^{min} represent the the maximum and minimum of the index。

The decision matrix after dimensionless processing is $Z=(Z_{ij})_{n\times m}$, obviously, the big Z_{ij} is always better. The weighted vector between the evaluation indexes is $W=(W_1,W_2,\cdots,W_m)^T>0$, and achieve the premise of unit constraint:

$$\sum_{j=1}^{m} W_j^2 = 1 \tag{3}$$

After finding the weighted vector w, the evaluation matrix as follows is constructed：

$$c=\begin{array}{c} \\ A_1 \\ A_2 \\ \cdots \\ A_n \end{array}\begin{array}{c} \begin{array}{cccc} G_1 & G_2 & \cdots & G_m \end{array} \\ \begin{bmatrix} w_1z_{11} & w_2z_{12} & \cdots & w_mz_{1m} \\ w_1z_{21} & w_2z_{22} & \cdots & w_mz_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ w_1z_{n1} & w_2z_{n2} & \cdots & w_mz_{nm} \end{bmatrix} \end{array} \tag{4}$$

Then, based on the simple additive weighting method, the multi index comprehensive evaluation value of the Ai scheme is as follows：

$$D_i(w)=\sum_{j=1}^{m} Z_{ij}w_j \quad i=1,2,\cdots,n \tag{5}$$

Similarly, D_i (w) is always the bigger the better. If D_i (w) get better，the Ai scheme can be better. When the weight vector w is known, the scheme A_i can be evaluated and sorted according to the 5 formulas mentioned above.

Next is further analysis about the method in determining weight vector w. If the index has no difference to all decision plan A_i, then G_j index has no effects on plan decision and order, so that we can make this kind of index weight as 0.On the other hand, if G_j index can make great changes in the attribute value of all decision plans, then we should give this kind of index greater weight. For index G_j, the deviation between decision plan Ai and all other decision plans can be represented by V_{ij} (w),in that way:

$$V_{ij}(w) = \sum_{k=1}^{n} \left| W_j Z_{ij} - W_j Z_{ki} \right| \quad i = 1,2,\cdots,m \tag{6}$$

Set：

$$V_j(w) = \sum_{i=1}^{n} v_{ij}(w) = \sum_{i=1}^{n}\sum_{k=1}^{n} \left| Z_{ij} - Z_{kj} \right| w_j \quad j = 1,2,\cdots m \tag{7}$$

V_j (w) indicates the sum of deviations between all plan A_i and other plans under the index G_j. The selected weight vector w requires all indexes to maximize the sum of deviations among all plans, so the following objective function is constructed:

$$max\mathrm{F(w)} = \sum_{j=1}^{m} v_j(w) = \sum_{j=1}^{m}\sum_{i=1}^{n}\sum_{k=1}^{n} \left| Z_{ij} - Z_{kj} \right| w_j \tag{8}$$

Then, the method of weight vector W is equivalent to the method of nonlinear programming problem:

$$\begin{cases} max\mathrm{F(w)} = \sum_{j=1}^{m} v_j(w) = \sum_{j=1}^{m}\sum_{i=1}^{n}\sum_{k=1}^{n} \left| Z_{ij} - Z_{kj} \right| w_j \\ s.t. \sum_{j=1}^{m} w_j^2 = 1 \end{cases} \tag{9}$$

The nonlinear programming problem is solved and the w* is normalized to obtain the following result:

3.2. Coordinated Degree Model

According to existing research literature, and for the purpose of studying interaction between postgraduate education and economic development level of provincial materials manufacturing industry, this paper uses coordinated degree model to analyze coordination between them. Among them, E (x) and I (x) are used to represent the postgraduate education level and economic development level in materials manufacturing industry respectively, and C($0 \leqslant C \leqslant 1$) is used to represent coordinated degree. The coordinated degree model introduces systematic factors, using C_D to represent adjusted coordinated degree. The closer C is towards 1, the better coordinated degree is.

Coordinated Degree Model：$C=\left\{\frac{E(X)\times I(Y)}{\left[\frac{E(X)+I(Y)}{2}\right]^2}\right\}^2$

Adjusted Coordinated Degree：$C_D=\sqrt{C\times[0.5E(X)+0.5I(Y)]}$

4. Empirical Research

4.1. Data Processing

Each index has different sensing, so they can not keep pace in data unit. For this reason, we can only make dimensionless processing with evaluation indexes by maximum deviations, so as to

overcome the difficulty of different dimensions in all indexes. Among them, postgraduate student-teachers ratio is an inverse index. Then we should make weight assignment, specific weight assignments are as follows.

Table 1 The weight of each index of the graduate education level

The level of the graduate education	The proportion of graduate enrollment in the population aged 15 to 64	0.272
	The investment of graduate education	0.25
	The ratio of graduate teachers in graduate students	0.273
	The number of graduate degree award	0.205

Table 2 The weight of each index of the economic development level of the materials manufacturing sector

The level of the economic development level in materials manufacturing industry	Material manufacturing output share of total industrial output value	0.236
	Per capita profit rate of material manufacturing employees	0.24
	Labor productivity of material manufacturing employees	0.254
	Employee share in the material manufacturing industry of total regional employees	0.27

4.2. Empirical Results and Analysis

4.2.1. Economic Analysis of Material Manufacturing Industry in Hubei Province

The method of maximum deviation is used to normalize the data of material manufacturing industry, and then draw the charts of the four indexes in the material manufacturing industry. The specific chart is shown in figure 1.

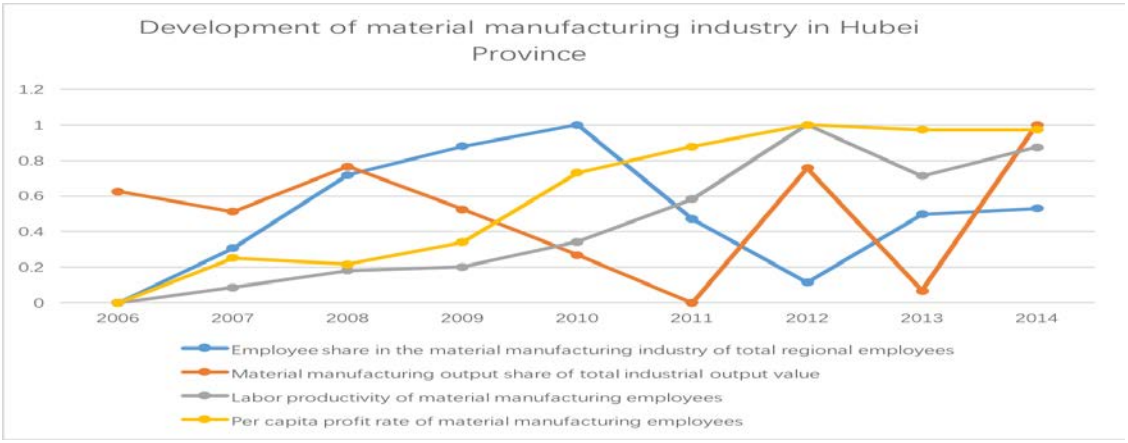

Figure 1

As we can see in figure 1, in terms of trend, labor productivity of material manufacturing employees and per capita profit rate have been steadily improving yearly, while material manufacturing employee share of total employees shows a dropping trend in two years from 2010 to 2012, then it increases gradually since 2012, but still below the level of 2010. This shows that materials manufacturing enterprises are accelerating their development speed significantly, and their total scale is constantly growing. Although material manufacturing employment proportion decreases, its labor productivity keeps rising, with enhanced technological innovation ability and steadily improved quality as well as efficiency.

4.2.2. Analysis of Postgraduate Education in Hubei

Integrating the data of postgraduate education, and draw a line figure 2.

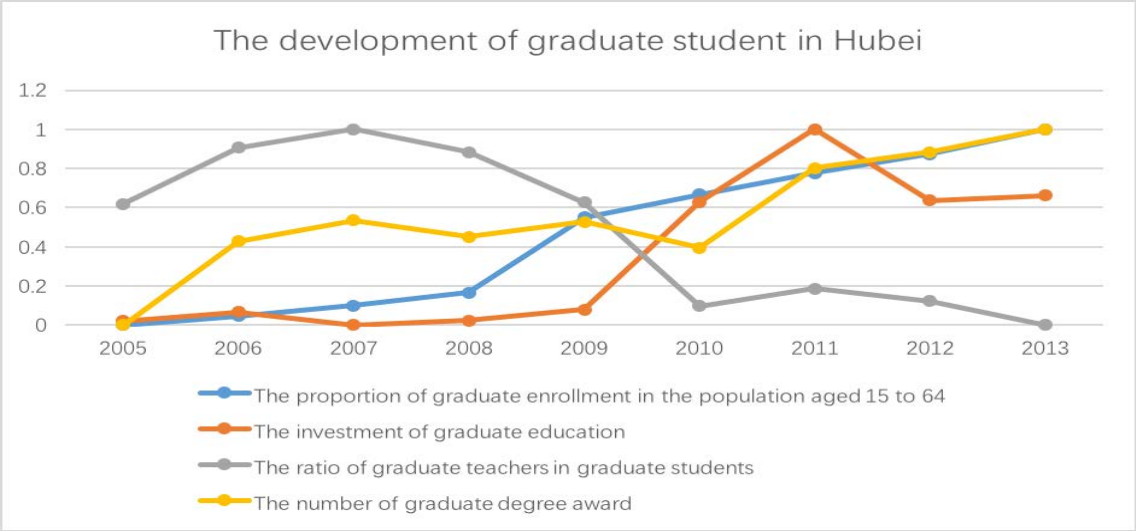

Figure 2

As we can see from figure 2, postgraduate enrollment, public funds and graduate numbers are presenting a rising trend year by year, while postgraduate student-teacher ratio shows an overall downward trend. The analysis of postgraduate student-teacher ratio can reflect the relationship between postgraduate education inputs and outputs to a certain extent, which indicates that postgraduate education quality is improving gradually, so that all postgraduate students have more opportunities to participate in study. Overall, both postgraduate education level and development speed in Hubei province are improving, which have been reflected in terms of training quantity and quality.

4.2.3. Analysis of Coordination Degree between Graduate Education and Economic Development of Materials Manufacturing Industry in Hubei

Using the method of maximum deviation to calculate the comprehensive index of graduate education and the economic index of material manufacturing industry. Then, using the coordination degree model to calculate the coordinated degree between the graduate education and the materials manufacturing industry in Hubei Province between 2006 and 2014. The results of the consolidated calculation are shown in Table 3:

Table 3 Coordinated Degree between Graduate Education and Economic development of Material Manufacturing Industry

Year	Index of Economic Development Level in Material Manufacturing Industry	Index of Postgraduate Education Development Level	Coordinated Degree	Adjusted Coordinated Degree
2014	0.849502316	0.893940469	0.961948839	0.847173942
2013	0.577227157	0.874956339	0.998352954	0.77026366
2012	0.732908233	0.805507711	0.996846073	0.838260994
2011	0.496224884	0.810518916	0.994358848	0.684488913
2010	0.584814285	0.711614142	0.965761038	0.706535233
2009	0.476829911	0.436729456	0.977585905	0.649156885
2008	0.458368885	0.266393847	0.993716842	0.65673115
2007	0.285765798	0.163711574	0.97051564	0.561988166
2006	0.149953383	0.249	0.988762619	0.400376197

According to data analysis above, we can see that postgraduate education level in Hubei shows a yearly growing trend, while its overall index value is low. By 2013, the postgraduate enrollment of people between 15 and 64 in Hubei is less than 9/1000, and its total postgraduate number is less than 40 thousand, whose lack of high-level talents has restricted economic development and

industrial transformation as well as upgrading of Hubei. In terms of economic development of materials manufacturing industry, Hubei's economy has maintained a rapidly growing momentum since the "12th Five-Year Plan", whose overall strength is enhanced significantly, industrial structure is optimized constantly, and people's living standards are further improved. Under the severe situation of sustained downward domestic economy, the economic development of material manufacturing industry in Hubei decreases a little, but still maintains a high rate of development, and its provincial economy has shown a trend of "steady progress". According to the coordination between economic development of material manufacturing industry and postgraduate education in Hubei, they two have shown a strong positive correlation and relatively high coordination. But the growth rate of postgraduate education is faster than that of material manufacturing industry, so that postgraduate educational changes in Hubei can not reflect economical changes and demands in time.

5. Conclusions

Taking advantage of related data about postgraduate education and economic development of material manufacturing industry in Hubei Province between 2005 and 2014, this paper uses maximum deviation and coordinated degree model to analyze the shortcomings of Hubei postgraduate education. The results of the calculation show the following conclusions. First, the level of graduate education in Hubei province has a strong correlation with the economic level of the material manufacturing industry. Second, in recent years, the level of graduate education in Hubei province and the economic growth of the material manufacturing industry have steadily improved, showing better coordination.

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References

[1] David Audretsch, Max Keilbach, Entrepreneurship Capital and Economic Performance, J. Regional Studies. 38 (2004) 949-959.

[2]Wang Xianbin, Research on Coordinated Development of Graduate Education and Industrial Economy in Guangxi, J. Journal of Guangxi University for Nationalities（Philosophy and Social Science Edition）. 6 (2016) 181-184.

[3]Wen Xiangli, Thought of upgrading the close degree between the postgraduate education and local socio-economic development——to take the postgraduate education of Guangxi Zhuang Autonomous Region for example, J. China Adult Education. 19 (2012) 51-53.

[4]Wang Zichen, Qi Wei, Measure study on postgraduate education and regional economic development coordination in China, J. Academic Degrees & Graduate Education. 4 (2015) 66-71.

[5]Yuan Bentao, Wang Chuanyi, On Coordination of Economy,Technology and Regional Structure of Graduate Education in China, J. Journal of Higher Education. 7 (2013) 39-44.

[6]Huang Haijun, Li Liguo, Coordination study on provincial postgraduate education and economic development of China, J. Jiangsu Higher Education. 3 (2015) 91-94.