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Gray Correlation Analysis of Shanghai Input-output of Science and Technology Based on Grounded Theory

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Abstract: The input-output effects of science and technology are critical for the level of technological development while what was often overlooked is that the overall consistency of each individual input. In this study the large and medium-sized industrial enterprises' science and technology investments was the starting point, we analyzed data of all districts' inputs and outputs in Shanghai since 2003 by using the Grey correlation analysis and Grounded theory. As a conclusion according to evaluating the degree of consistency of each district with the overall scientific and technological development in Shanghai, some relevant policy recommendations were listed as follows: (1) To establish large-sized high-tech industrial parks, for instance, science and technology parks, high-tech development zone, etc. which can effectively promote the local science and technology development; (2) To adjust industrial layout which is the key issue for input-output effectiveness of science and technology; (3) To strengthen the constructions of traffic and road which contributes to the urban-rural integration.

Key words: Science and technology input, grounded theory, grey correlation analysis

INTRODUCTION

The influence of science and technology towards the development of economy and society is remarkable day by day. Whether the development is healthy or not has become the major standard to evaluate the overall level of economy and society's development in a certain country or a region. Shanghai, as the highly developed region in China respectively, must strongly promote the progress of science and technology, so as to remain the higher development level as a whole. Owing to Shanghai's unique features such as: Special administrative level, densely population, large area and pluralistic development, the districts and counties that belongs to Shanghai plays a key role in the overall development of Shanghai.

This study is based on the statistics of Shanghai since 2003 and analyzes the relations between Shanghai's scientific inputs and outputs. Theory-oriented method is employed and the input factors that are closely bound up with scientific inputs are coded to obtain the comprehensive influences and concepts that produce the most intimate effects on Shanghai's scientific inputs. On this basis, through selecting those most representative concepts among the comprehensive influences to carry out grey correlation analysis towards the scientific inputs and outputs of Shanghai's each region and county and then further getting the general view of the consistency between these areas and the whole city in regard of science and technology inputs and outputs, it can provide some useful advices and references for the direction and key point of future scientific investment.

RESEARCH PROCESS

Grey correlation analysis of S and T inputs-outputs of Shanghai

Grey correlation analysis of the inputs and outputs of the science and technology: The basic concept of Grey correlation analysis is determine the correlation by the degree of similarity of the sequence curve geometry, so the closer the shape of the curve, the closer relation between the corresponding sequence and vice versa (Liu, 1991; Liu *et al*., 2012).

In this study, Shanghai Scientific and Technological Activities output monitoring value was selected as the reference sequence and set comparison sequence as follows: The monitoring value of the proportion of corporate R and D scientists and engineers in the total social R and D scientists and engineers, the number of Million R and D scientists and engineers, the proportion of R and D share in GDP, the proportion of corporate R and D expenditure in product sales revenue, the proportion of expenditures in enterprises introduction,

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Table 1: Shanghai 2003-2010 scientific and technological input indicators for monitoring

Parameters	2003	2004	2005	2006	2007	2008	2009	2010
Proportion of corporate R and D scientists and engineers out of the total social R and D scientists and engineers	26.21	40.09	27.13	32.24	36.83	37.11	36.48	34.68
No. of million R and D scientists and engineers	27.69	27.86	28.57	32.05	37.53	41.08	42.12	37.00
Proportion of R and D share in GDP	2.04	2.06	2.30	2.28	2.5	2.52	2.59	2.81
Proportion of corporate R and D expenditure in product sales revenue	0.86	0.76	0.81	0.98	0.97	0.97	0.99	1.12
Digestion and absorption of technology in product sales revenue	6.27	11.30	14.78	11.27	0.66	0.5	0.49	0.77
Proportion of the local fiscal technology funding in the local financial allocations	1.74	1.80	2.82	4.78	5.23	4.85	4.42	7.20

Table 2: Shanghai 2003-2010 scientific and technological output indicators for monitoring

Parameters	2003	2004	2005	2006	2007	2008	2009	2010
Output of S and T activities	70.48	65.63	86.96	88.61	84.39	80.84	81.79	87.08

Table 3: Grey relative correlation degree of scientific and technological input and output indicators of Shanghai 2003-2010

	Input					
Output	Proportion of corporate R and D scientists and engineers out of the total social R and D scientists and engineers	No. of million R and D scientists and engineers	Proportion of R and D share in GDP	Proportion of corporate R and D expenditure in product sales revenue	Digestion and absorption in product of technology sales revenue	Proportion of the local fiscal technology funding in the local financial allocations
Monitoring indicators of science and technology (S and T) output	0.9547	0.9269	0.8212	0.6894	0.7809	0.6408

digestion and absorption of technology in product sales revenue, the proportion of the local fiscal technology funding in the local financial allocations (SSTC, 2004; SMBS, 2005). By comparing each factor in science and technology, it can get the result of the impact on scientific and technological output. Here to set the scientific and technological output indicators lag a year of investment in science and technology indicators which is usually the most reasonable, short for L = 1. Distinguishing coefficient $\zeta = 0.5$. It can get the Shanghai scientific and technological output in the lag year's time with the technology associated input factors grey, here to select the most obvious effect of the grey correlation degrees. In the following parts, the Grey correlation degree of the proportion of corporate R and D scientists and engineers of R and D scientists and engineers of the whole society is used to illustrate the calculation process.

$$(\gamma_{0i} = \frac{1+|s_0'|+|s_i'|}{1+|s_0'|+|s_i'|+|s_i'-s_0'|} \quad (1)$$

$$|s_0'| = \left|\sum_{k=2}^{n-1} x_0^{0'}(k) + \frac{1}{2}x_0^{0'}(n)\right| \quad (2)$$

$$|s_i'| = \left|\sum_{k=2}^{n-1} x_i^{0'}(k) + \frac{1}{2}x_i^{0'}(n)\right| \quad (3)$$

$$|s_i' - s_0'| = \left|\sum_{k=2}^{n-1} (x_i^{0'}(k) - x_0^{0'}(k)) + \frac{1}{2}(x_i^{0'}(n) - x_0^{0'}(n))\right| \quad (4)$$

In which $x_i^0(n)$ is $x_i(n)$ the starting point of zero initial value like.

First step: Initialization operation (sort out to be equal length temporal sequence)

Sequence [1]: 65.63, 86.96, 88.61, 84.39, 80.84, 81.79, 87.08
Sequence [2]: 26.21, 40.09, 27.13, 32.24, 36.83, 37.11, 36.48

Second step: Initial value like of sequence

Sequence [1]: 1.0000, 1.3250, 1.3501, 1.2858, 1.2318, 1.2462, 1.3268
Sequence [2]: 1.0000, 1.5296, 1.0351, 1.2301, 1.4052, 1.4159, 1.3918

Third step: The starting point of zero of sequence

Sequence [1]: 0.0000, 0.3250, 0.3501, 0.2858, 0.2318, 0.2462, 0.3268
Sequence [2]: 0.0000, 0.5296, 0.0351, 0.2301, 0.4052, 0.4159, 0.3918

Fourth step: Calculate|s0|,|s1|,|s1-s0||s0| = 1.6023; |s1| = 1.8118; |s1-s0|=0.2095

Conclusion: Relative correlation degree between sequence [1] and sequence [2]= 0.9547

Shanghai 2003-2010 scientific and technological input and output data are from the Yearbook as in Table 1 and 2.

From the data in Table 3, the correlated sequence between shanghai S and T output and the other six indicators can be drawed as follows: Proportion of corporate R and D scientists and engineers out of the

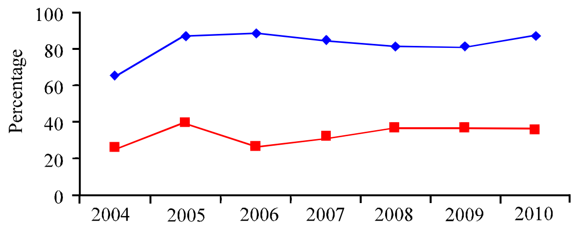

Fig. 1: Comparative curve between the proportion of corporate R and D scientists and engineers out of the total social R and D scientists and engineers (red curve) and output of science and technology activities (blue curve)

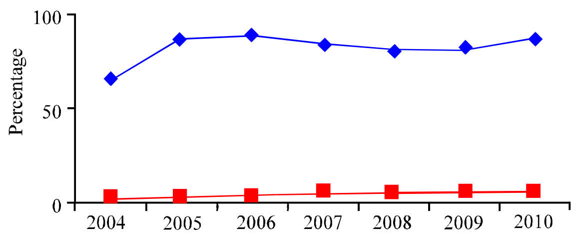

Fig. 2: Comparative curve between proportion of the local fiscal technology funding (red curve) and the local financial allocations (blue curve)

total social R and D scientists and engineers>number of Million R and D scientists and engineers>digestion and absorption of technology in product sales revenue> proportion of corporate R and D expenditure in product sales revenue>proportion of the local fiscal technology funding in the local financial allocations.

As Fig. 1 shows two curves are quite similar in overall shape. The curve mutation point and the position of the peak are nearly the same, so it is closely associated with a very high degree that the graph illustrates. Similarly, Fig. 2 obviously shows the two curves are not only different from the overall trend but also from turning point of view which illustrates the relationship between those two indicators not close at all.

Here select two types of higher and lower correlation degree which is representative of the case. The difference can clearly be seen from the graph and fully prove the reliability of the grey relational analysis (Benz *et al*., 2007; Vedung, 1997).

Grounded theory coding: Grounded theory was proposed by sociologists Glaser and Strauss in 1967 which is an empirical research method of bottom-up construction theory on the basis of empirical data (Fei, 2008). Exploratory analysis using grounded theory is to build comprehensive theoretical concepts by three programs: Open coding, axial coding and selective coding of data. In this study the grey relational analysis based on Grounded Theory is highlighted, so there is only a brief description of the grounded theory coding process (Xu and Huang, 2012).

Proportion of corporate R and D scientists and engineers out of the total social R and D scientists and engineers and the number of Million R and D scientists and engineers encoded as S and T activities human resource input; proportion of R and D share in GDP, proportion of corporate R and D expenditure in product sales revenue, digestion and absorption of technology in product sales revenue and proportion of the local fiscal technology funding in the local financial allocations encoded as S and T activities financial resources input (Zhang and Ma, 2009).

All districts of Shanghai S and T inputs and outputs grey relational analysis of large and medium-sized industrial enterprises: Shanghai is the gathering areas of large and medium-sized enterprises and scientific and technological benefits of them also well reflect the level of economic development of this region. So, in this study, the scientific and technological input and output is selected as research samples and choose the number of scientific and technological activities staff from investment in science and technology to behalf of the S and T activities input level indicators. And the output value of new products from the scientific and technological output indicator is selected to explain the enterprise level of economic development. The degree of the grey relational degree between the two sets of data is closely related to the degree of scientific and technological activities output and the level of science and technology human resource input which explaining the level of consistency between the direction of science and technology activities in each district and Shanghai overall and providing recommendations for future scientific and technological work.

The grey relational analysis also set the scientific and technological output indicat ors lag a year behind investment in science and technology indicators, L = 1(Input indicators selected data of 2008-2009, output indicators selected data of 2009-2010). Distinguishing coefficient $\zeta = 0.5$ (Table 4) (Wang and Zhang, 2006).

In Table 5. The most districts technological labor input is closely related to the scientific and technological output, up to more than 0.9, for example Huangpu District, Luwan District,Xuhui District, Changning District, Hongkou District, Yangpu District etc (Weidenbaum, 2003). We can see more directly from the Fig. 3 that Shanghai districts have consistent pace with the overall

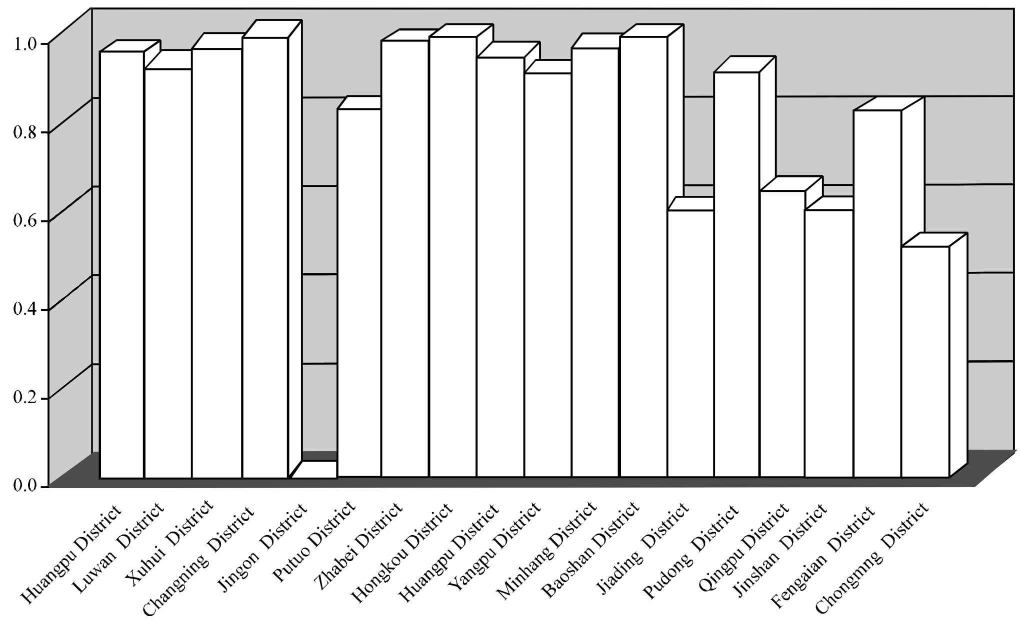

Fig. 3: Grey correlation degree between technological labor input and the scientific and technological output value of new products of the various districts of Shanghai in 2008-2010

Table 4: Human input of science and technology and the output value of new products in all districts and counties of Shanghai from 2008 to 2010

Investment in S and T manpower (District)	2008	2009	2010	The output value of new technology (District)	2008	2009	2010
Huangpu	1412	1275	818	Huangpu	3474225	3163683	3166463
Luwan	673	751	748	Luwan	1814682	1764959	2301225
Xuhui	5514	6355	5029	Xuhui	5467049	10753459	9914967
Changning	413	701	329	Changning	196790	1461829	444723
Jingan	55	0	0	Jingan	37691	0	0
Putuo	1785	1754	1719	Putuo	3085782	3844624	5887021
Zhabei	2623	3162	3655	Zhabei	2145165	3562234	4154544
Hongkou	889	851	677	Hongkou	1005577	1065862	1009807
Yangpu	3093	3881	3317	Yangpu	11730282	14861641	16839628
Minhang	12387	15198	15375	Miuhang	58195364	66666519	67109922
Baoshan	6286	7259	7692	Baoshan	43095499	30367915	37440977
Jiading	22363	12214	12501	Jiading	143362868	71252185	102429785
Pudong	7228	41795	44447	Pudong	50637860	203366324	240110551
Jinshan	4536	2807	2373	Jinshan	6519234	8269886	6949570
Songjiang	2588	10737	9585	Songjiang	3511555	20295841	16052895
Qingpu	742	4133	5587	Qingpu	2057827	8597167	9796267
Fengxian	7204	2861	3357	Fengxian	109803580	6465828	6862325
Chongming	1418	1354	2425	Chongming	3358077	947177	19967756

scientific and technological activities in Shanghai but some districts associates relatively weak (Wang *et al*., 2002; Hong *et al*., 2012).

The reasons differ from each other. Huangpu District, Luwan District and other main Districts have been through a long history of scientific development and formed a relatively large scale scientific system. In addition to that, these districts are close to the downtown area of Shanghai which provides many advantages, such as convenient transportation and easily accessible information which help rapidly and thoroughly understand the plans, directions and development trends of Shanghai's scientific development. As a result, these districts successfully keep a highly consistency with Shanghai's scientific activities. To some extent, the scientific activities of these main districts lead the scientific trend of Shanghai city as a whole. Pudong New District owns a high standard of scientific development but the scientific relevance of Pudong New District is not very high. The most important reason is scientific development of Pudong New District is in the forward position of Shanghai, moreover, the scientific level of

Table 5: Grey correlation degree between technological labor input and scientific and technological output value of new products of the various districts of Shanghai in 2008-2010

District	Grey correlation degree	District	Grey correlation degree
Huangpu	0.9562	Minhang	0.9103
Luwan	0.9279	Baoshan	0.9683
Xuhui	0.9677	Jiading	0.9944
Changning	0.9996	Pudong	0.6021
Jingan	0	Jinshan	0.9198
Putuo	0.8322	Songjing	0.6457
Zhabei	0.9837	Qingpu	0.6023
Hongkou	0.9953	Fengxian	0.8311
Yangpu	0.9515	Chongming	0.5248

Pudong New District is higher than the whole Shanghai. Jinshan District, though located in the suburban of Shanghai, keep a consistency of Shanghai for possessing large-scale industrial parks. Qingpu District and other Districts without large-scale scientific parks fail to attract high-qualified employees in the field of science and technology because of their inconvenient transportation to the downtown area and delayed information communication. Consequently, the scientific development of Qingpu District is behind Shanghai's overall standard. Furthermore, scientific and technological level of Chongming County is even far behind Qingpu District or any other areas. The development of Chongming District is more biased in favor of travel, vacation tour and other kinds of third industries.

CONCLUSION

Grey correlation degree analysis between the various districts' technology human input and technology output value of new products gets the following conclusions:

- First, technology development in the main city of Shanghai is relatively mature with that transportation and information is unobstructed which helps keep pace with the Shanghai Municipal overall and produce join forces to forward development. It ends up with the pillar of strength of Shanghai's science and technology progress. Pudong district takes the responsibility to lead the advanced direction of technology development for its high-tech intense; Jinshan, Qingpu and other outer suburbs own diverse technological development pacing because there exist large-sized science and technology parks in some districts to support the regional technological development while not in others Therefore, it is essential to establish large-sized high-tech industrial parks, for instance, science and technology parks, high-tech development zone, etc. which can effectively promote the local science and technology development
- Second with regard to the scientific development standard, generally speaking, the main districts perform better than suburban which has close relationship with the transportation and information communication. Traffic inconvenience may cause difficulties in the introduction of talent and access to technology policy information, thus affecting the level of technological development of the whole region. It is assumed that Qingpu is quite a typical example whose technological development is impacted by traffic and communication problems. So promoting urban-rural integration seems imperative and it can be accomplished by strengthen the constructions of traffic and road
- Last but not least, adjusting the structure of scientific industries is essential. Districts and counties which are close to other districts and counties highly developed in scientific industries can present a better development situation. In the case of Jiading District, it is known to be contiguous to Kunshan, a highly developed city in the field of science and technology having rarely high rapid of scientific development and increasing economic development. Taking advantage of this, Jiading district maintains a high degree of consensus with Shanghai's overall technological development pace and level. As a result, the reasonable arrangement of the scientific industries according to the location advantages of various districts and counties will largely promote the scientific development of Shanghai

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