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Association Studies of Regional Scientific and Technology Talent Coupled with the High-Tech Industry

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Abstract

Based on the theory of coupled systems, we use gray relational analysis to build a complex system that regional technology talent coupled with regional high-tech industry. We examine coupling relations of regional technology talent with the high-tech industry and analyze the law of the coupling of them. Results indicated (1) the degree of coupling of the regional technology talent and the high-tech industry system is relatively high, which has much close relationship. (2) China's central and western provinces are mostly classified to low-level coupling and antagonistic stage, the degree of coupling of each regional technology talent and high-tech industry interact is significantly different, and we found that regional distribution has corresponding relationship with the level of economic development.

Key words: Technology talent; High-tech industry; Coupling degree; Coupling

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INTRODUCTION

High-tech industry is very important in science and technology competition as well as competition between countries, which characterizes in high intelligence, high value-added, highly competitive, high-return and high risk. Moreover, high-tech industry also plays an irreplaceable role in upgrading industrial structure and improving labor productivity and economic benefits, thus has extremely important strategic significance to the development of social and economic. Based on the strategic position of the high-tech industry in the national economy, the development of high-tech industry is not only valued by the government, meanwhile academia has done a lot of research of the high-tech industry from all aspects, resulted in some achievements.

Technology talent is the creator and inventor of new knowledge and new technology, to lead and open up the development and breakthrough of science and technology, also the main driving force in the development of high-tech industry.

Through searching for relative literatures, we found that the main research direction of the existing literature focus on innovation evaluation of the high-tech industry, Influencing factors, regional differences, industrial agglomeration and personnel training, etc. Zhang Xixi (2010) used quantitative analysis method to build a regression model to examine the interaction between China's high-tech industry concentration and high-tech talent gathering. By using statistical data, Shi Dan and Li Xiaobin (2004) analyzed the factors which has an influence on the development of high-tech industry, such as enterprise system, enterprise scale, level of economic development and investment in science and technology, including capital investment and investment in human capital, they found whether the talent has ability of outstanding innovation involved success or failure of the high-tech enterprises and the development of the industry.

Sun Yutao, Bao Guangping and Liu Pingping (2008) used range method and standard deviation to analyze the regional distribution difference of scientific and technical personnel in Chinese high-tech industry. In perspective of developing high-tech industry personnel policy, Fan Bonai (2000) made a suggestion on how to improve the high-tech industry personnel policy. Shen Chunguang, Chen Wanming and Pei Lingling (2010) built an evaluation index system and used a multi-level Gray System Theory to explore the innovation capability evaluation index system of regional scientific and technology talent.

Searching relative literature of foreign language, there is not much literature on the high-tech industry and technology talent. Chen-Fu Chien (2008), taking high-tech industry as an example, studied how to improve personnel selection mechanism to enhance the human capital, they thought that the quality of human capital is the key to high-tech enterprises which maintain a competitive advantage in the knowledge economy era. Jean M. Johnson (2001) illustrated the contribution of human resources for science and technology, which explains the importance of talent for the development of an industry indirectly. Ortega-Argilés (2010) studied the relationship between R&D investment and productivity in the industrial and service sectors throughout Europe, and found that corporate R & D investment is more effective in the field of high-tech industry. Tebaldi (2011) examined the panel data from 1980 to 2008 and found that human capital, foreign investment and open international trade is a major factor in the performance of a country's high-tech industry in the global market.

Through studying the literature, we found scholars' research provided us a theoretical basis, however, existing research, or focused on the study of human capital investment, personnel training for the high-tech industry, or few studies, especially empirical research. Studying the influence on high-tech industry based on the research of the level and structure of technology talent, just like not viewing technology professionals and high-tech industries in matching perspective.

In view of this, the paper will commence from technology talent investment and refine it into four sub-index which are investment of quantity structure, quality structure, scientific research funds and configuration structure respectively (Figure 1), then we focused on this 4 sub-index and used Coupling theory and gray relational analysis to explore the coupling law of technology talent and high-tech industry. Moreover, the influence that technology talent on the development of high-tech industry will be analyzed, and then we will put forward policy recommendations of how to improve the matching degree of scientific and technology talent and high-tech industries.

SELECTION OF INDICES

From the coupling point, selecting the appropriate index is the basis of studying the matching degree of technology talent and high-tech industry, abide by the principles of purpose and the availability of data, we built index system of technology talent and the high-tech industry, which based on the intrinsically link of them.

According to the principle of selecting index, we counted the literatures about technology from 2002 to 2012 and made frequency statistics, then we chose those indices which frequently used by researchers in recent years, moreover, according to the paper and data availability and reliability of indices, we made initial screening. As for indices of high-tech industry, we chose what has been researched as well as selecting principle of index.

Index System of Technology Talent

Technology talents are those who both possess vocational skills and cultural knowledge. Considering the availability of data, we didn't take the connotation of technology talents in the political and moral aspects into account, and employed technology human resources which could be unified with technology talent in the statistical. From the knowledge and professional point of view, they are highly unified. According to the definition of technology human resource of Frascati Books-technology human resource manual which published by Organization for Economic Cooperation and Development (OECD) in cooperation with Eurostat, technology human resource is laborer who complete a college education or higher education (Du Qian, & Song Weiguo,2004).

For a more comprehensive study of the coupling relationship between technology talents and high-tech industries, in the technology talent system, we analyzed and selected index system (Figure 1) from the perspective of inputs in general.

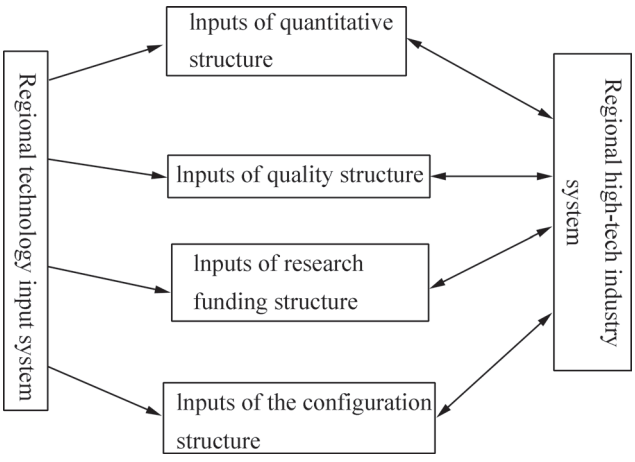

Figure 1
Regional Technology Talent Coupling with the High-Tech Industry

Index System of High-Tech Industry

The paper adopted the classification method of OECD to make definition and statistics of high-tech industry, scholars has made some achievements in study of the

indices that reflect the development of the high-tech industry. Wang Xiaojing (2007) decomposed the indices in the point of two aspects of economic activities and technology activities which reflects the development of high-tech industry. Zou Yan (2012) employed indices of economic, technology activities and fixed-assets investment, and then refined the indices. In order to guarantee scientific, skopos and data availability, we took evaluation index system of existing scholars for reference and built the index system of high-tech industry, then we will decomposed into three aspects of economic index, technology activities index and fixed-assets investment index (Table 1).

Table 1
Index System of Investment of Technology Coupling With High-Tech Industry

Coupling system	Type of indices	Indices
Inputs system of technology talent	Quantitative structure	Personnel of technology activities(X1)、scientist and engineer(X2)
	Quality structure	undergraduate(X3)、master(X4)、doctor(X5)
	Inputs structure of research funds	government(X6)、enterprise(X7)、overseas(X8)、other(X9)
	Configuration structure	Basic research(X10)、application research(X11)、R&D(X12)
High-tech industry system	Indices of economic activities	Enterprise number(Y1)、Annual average employment(Y2)、The gross output value of price(Y3)、sales revenue(Y4)、profits(Y5)
	Indices of technology activities	Internal expenditure of R&D(Y6)、expenditure for new products(Y7)、revenue from new products(Y8)、revenue from new products(Y9)、expenditure of technical renovation(Y10)、patents(Y11)
	Indices of fixed-assets investment	Fixed investment(Y12)

THEORETICAL MODELS AND RESEARCH METHODS

Coupling is belong to physics areas, but now is widely used in the field of social sciences research. From a physical point of view, coupling refers to two or more system or movement which through interaction, mutual influence so as to achieve a kind of collaborative phenomenon. In the coupling condition, each subsystem coordinate, rely on even promote each other. Under the condition of positive interaction, system will go from disorder to order, which lies in the synergy of the system internal order parameter, the law and characteristics of phase changing is influenced by this synergy, the degree of coupling is measured by this synergy (Wu & Zhang, 2008). Based on the theory above, the paper defined the degree of interaction, mutual influence of technology talent and high-tech industry which coupled as "technology talent - high-tech industry coupling degree" and this coupling degree will be described by Gray correlation analysis method. Gray correlation analysis method measured the correlation degree according to the similarity or dissimilarity of development trend of two or more factors, this method has few requirements about sample size, even can be used for erratic data, moreover, it doesn't appear inconsistent of quantitative results with qualitative analysis results. Gray correlation analysis method is now applied to the social sciences and natural sciences in various fields, especially in the field of socio-economic, such as regional economic advantage analysis and adjustment of industrial structure, etc., and effect of application is better, that is also why we choose this method.

The paper will introduce the coupling model for working out the coupling degree of technology and high-tech industry in consideration of the relevance and complexity of technology talent and high-tech industry, pursuant to characterize the degree of coupling between the two coordination, concrete steps are as follows (Bi, Bao & Li, 2007):

(1) Make analysis sequence. The paper make analysis sequence into two groups respectively, the technology talents sequence group (Xi) and the sequence of high-tech industry group (Yi), detailed reference to Table 1.

(2) Dimensionless processing. Given different dimensions of the original data of indices, we used the experience of previous studies for reference and employed interval standardized method to make data dimensionless.

$$X_i^{'} = (X_i - X_{\min}) / (X_{\max} - X_{\min})$$
$$Y_i^{'} = (Y_i - Y_{\min}) / (Y_{\max} - Y_{\min}) \quad (1)$$

(3) Grey correlation coefficient

$$\xi_{ij}(t) = \frac{\min\limits_i \min\limits_j \left|X_i'(t) - Y_j'(t)\right| + \rho \max\limits_i \max\limits_j \left|X_i'(t) - Y_j'(t)\right|}{\left|X_i'(t) - Y_j'(t)\right| + \rho \max\limits_i \max\limits_j \left|X_i'(t) - Y_j'(t)\right|} \quad (2)$$

The formula above, $X_i^{'}(t), Y_j^{'}(t)$ are standardization value of relate index for the analysis of the sequence group, ρ is resolution ratio, the general value is 0.5, t is for time value in general, but the paper value for a certain point space dynamic value, as a result, t is on behalf of provinces in this paper, $\xi_{ij}(t)$ is correlation coefficient.

(4) Association degrees and coupling degree. In order to discuss the main association degree and coupling characteristics of technology talent and high-tech industry, this article used the association and coupling model of technology talent coupled with the high-tech industry. We made correlation coefficient $\xi_{ij}(t)$ average in number n, then we can got a correlation matrix γ, γ can reflect the coupling relationship between technology talent and high-tech industry. Association degree is calculated using the following formula:

$$\gamma_{ij} = \frac{1}{n}\sum_{j=1}^{n}\xi_{ij}(t) \qquad (n=1, 2,...) \qquad (3)$$

The above formula, n is the number of samples that indices selected of technology talent or high-tech industry. By comparing the association degree, we can analyze the relationship between each index of system. Associate degree (γ_{ij}) ranges from 0 to 1, the value of γ_{ij} associated positively with relevance, the value of γ_{ij} is larger, the greater relevance accordingly. When $0<\gamma_{ij}\leq 0.35$, the association degree is weak, and also the coupling of the system indices. When $0.35<\gamma_{ij}\leq 0.65$, the association degree is in medium strength. When $0.65<\gamma_{ij}\leq 0.85$, the association degree is higher, so as to the coupling of the indices. When $0.85<\gamma_{ij}\leq 1$, the association degree is absolutely highest, in a similar way, relative change of indices almost consistent, so the coupling of the two system is strong.

Then we would averaged the γ_{ij} according to the row or column based on the correlation matrix, in this way, we can get an association model of coupling system.

$$D_i = \frac{1}{k}\sum_{j=1}^{k}\gamma_{ij} \qquad (i=1,2\ldots m; j=1,2\ldots k) \qquad (4)$$

$$D_i = \frac{1}{m}\sum_{j=1}^{m}\gamma_{ij} \qquad (i=1,2\ldots m; j=1,2\ldots k) \qquad (5)$$

In the formula above, D_i is the average association degree of number I index of technology talent with high-tech industry. D_j is the average association degree of number j index of high-tech industry with technology talent. K and m are number of indices of technology talent and high-tech industry respectively. We can decide the most important system factor that influences each other according to average association degree that can be obtained from the formula on the above. In order to further research on the coupling degree of technology talent with high-tech industry system overall, we employed coupling model, computation formula is as follows:

$$C(t) = \frac{1}{k\times m}\sum_{i=1}^{k}\sum_{j=1}^{m}\xi_{ij}(t) \qquad (6)$$

In the formula above, k and m are number of indices of related analysis sequence group respectively.

EMPIRICAL ANALYSIS

Due to the lack of data of Tibet and Ningxia, the paper only selected Chinese 29 provinces and cities as an analysis sample, all related data needed by constructing the analysis system indices are from the China Science and Technology Statistics Yearbook (2010).

The Coupling Main Factors Analysis

Through employing each index of regional technology talent and high-tech industry as index system of coupling analysis based on the data above, using the grey correlation analysis method introduced before, we can calculate and receive a association matrix (Table 2) of China regional technology talent coupling with high-tech industry in 2010 through MATLAB.

We can see directly that the most correlation is over 0.6 between the indices from the two systems from Table 2, which suggested that technology talent has closely relationship with high-tech industry. Consequently, analyzing the main factor of coupling between these two systems is meaningful. In addition, we will figure out the main factors which interact and influence each other between regional technology talent and high-tech industry through analyzing data from Table 2 for the sake of further revealing that which is the main driving force.

(1) The scientific research funds do have relatively obvious effect on the development of high-tech industry when technology talent influences the high-tech industry, the average correlation is the highest, is 0.6889, which obtained from coupling correlation matrix of China regional technology talent and high-tech industry in 2010, that is to say scientific research funds have significant impact on the high-tech industry. Secondly, culture structure of technology talent is highly correlated with high-tech industry; the average correlation degree is 0.6834, among them, technology talent who has rich cultural level such as master or doctor is much highly correlated with high-tech industry, the correlation reached to 0.7089 and 0.7419 respectively, but the correlation of bachelor degree and high-tech industry is obviously lower than the correlation of having high cultural level, which means the cultural level of technology talent has great influence on the development of high-tech industry. As we all know, high-tech industry has distinguishing feature of high intelligence and high investment, which is consistent with the data above. From another Angle, that scientific research funds and cultural structure of technology talent are important factors that differentiate and limit the development of high-tech-industry in Chinese various province and cities.

Table 2
Correlation Coefficient of Technology Talent and High-Tech Industry

Indices	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Average value	
X1	0.486	0.4297	0.4412	0.4429	0.4569	0.4251	0.4310	0.4608	0.4607	0.5062	0.3958	0.5387	0.4564	0.4749
X2	0.5326	0.4718	0.4797	0.4801	0.4993	0.4612	0.4663	0.4824	0.4876	0.5456	0.4334	0.5819	0.4935	
X3	0.6537	0.6037	0.5952	0.5894	0.6061	0.5925	0.5994	0.5718	0.5675	0.6130	0.5722	0.6281	0.5994	
X4	0.7047	0.7475	0.7215	0.7191	0.7443	0.7341	0.7433	0.7045	0.6937	0.6651	0.7258	0.6032	0.7089	0.6834
X5	0.6879	0.7766	0.7686	0.7665	0.7270	0.7917	0.7790	0.7578	0.7558	0.6771	0.8338	0.5812	0.7419	
X6	0.7152	0.7100	0.7043	0.6970	0.7192	0.6927	0.6932	0.677	0.6692	0.6821	0.6731	0.6331	0.6889	
X7	0.6940	0.6024	0.5995	0.5994	0.6251	0.5898	0.6053	0.6348	0.6287	0.6348	0.5442	0.7040	0.6218	0.6889
X8	0.6905	0.7702	0.8108	0.8163	0.7361	0.7808	0.7756	0.7948	0.8076	0.6408	0.8578	0.5852	0.7555	
X9	0.7145	0.7115	0.7042	0.6995	0.7235	0.7059	0.7082	0.6736	0.6684	0.6697	0.6358	0.6562	0.6893	
X10	0.5851	0.5357	0.5420	0.5434	0.5768	0.5407	0.5475	0.5308	0.530*	0.5901	0.4851	0.6516	0.5550	
X11	0.5239	0.4870	0.4883	0.4879	0.5186	0.4965	0.5025	0.5152	0.5131	0.5253	0.4439	0.5892	0.5076	0.5548
X12	0.6776	0.5751	0.5877	0.5898	0.6294	0.5661	0.5780	0.5936	0.5965	0.6296	0.5196	0.6796	0.6019	
Average value	0.6390	0.6184	0.6202	0.6193	0.6302	0.6147	0.6191	0.6165	0.6150	0.6149	0.5934	0.6193		
			0.6254					0.6123				0.6193		

(2)The development of high-tech industry also has significant influence and effect on technology talent, the correlation degree of economic activities, technology activities and fixed-assets investment of high-tech industry coupled with technology talent is above 0.6 overall, which means closely relationship, but whether the influence of various elements of high-tech industry on the technology is leading or not is not very obvious.

Space Function Characteristics of Coupling

Analyzing the coupling degree from the view of space can reveal the space function characteristics of regional technology talent and high-tech industry. Through calculating the statistics data from Chinese 29 provinces and cities in 2010, we can work out the coupling degree of each province respectively (Table 3). According to the coupling degree and the proportion that high-tech industry accounted for the industrial enterprises above designated size (percentage for short below), we generally divide Chinese 29 provinces and cities into following 4 types (Liu Yaobin,2006) in line with existing literature and research.

(1) Low coupling degree-high percentage (Ⅰ). Including Beijing, Guangdong, Shanghai, Jiangsu and Shanxi province, it also complies with the regional distribution of Chinese high-tech industry. At present, China has initially formed three Economic Rim of Yangtze River Delta, Pearl River Delta and Bohai Economic Rim like Beijing, Shanghai, Shenzhen and Xi'an city as the center of high-tech industry area, the percentage that high-tech industry accounted on the industrial enterprises above designated size in these provinces and cities is the highest, the development of high-tech industry is better than other provinces and cities. Benign development of high-tech industry produced positive influence on technology talent, they just gradually move towards the harmonious, so smaller degree of coupling performance.

Table 3
Regional Distribution of Technology Talent Coupled with High-Tech Industry

Province/city	Coupling degree	Percentage	Type	Province/city	Coupling degree	Percentage	Type
Beijing	0.47	16.69%	Ⅰ	Henan	0.612	3.66%	Ⅲ
Tianjin	0.632	12.63%	Ⅱ	Hubei	0.601	5.27%	Ⅳ
Hebei	0.611	3.32%	Ⅳ	Hunan	0.612	4.53%	Ⅳ
Shanxi	0.646	3.83%	Ⅲ	Guangdong	0.597	10.74%	Ⅰ
Inner Mongolia	0.568	2.44%	Ⅳ	Guangxi	0.678	5.42%	Ⅲ
Liaoning	0.632	4.28%	Ⅲ	Hainan	0.622	10.61%	Ⅱ
Jilin	0.619	7.53%	Ⅲ	Chongqing	0.631	4.48%	Ⅲ
Heilongj iang	0.616	4.76%	Ⅳ	Sichuan	0.637	6.39%	Ⅱ
Shanghai	0.61	9.09%	Ⅰ	Guizhou	0.633	6.01%	Ⅲ
Jiangsu	0.603	7.47%	Ⅰ	Yunnan	0.573	4.22%	Ⅳ
Zhejiang	0.595	5.12%	Ⅲ	Shanxi	0.602	8.42%	Ⅰ
Anhui	0.602	4.58%	Ⅳ	Gansu	0.546	4.03%	Ⅳ
Fujian	0.595	4.42%	Ⅳ	Qinghai	0.626	6.75%	Ⅲ
Jingxi	0.765	6.66%	Ⅱ	Xinjing	0.617	1.55%	Ⅳ
Shandong	0.667	4.19%	Ⅲ	average value of year	0.618	6.18%	

(2) High coupling degree-high percentage (Ⅱ). Including Tianjin, Jiangxi, Hainan and Sichuan, the development of high-tech industry in these four provinces and cities is higher, which is just in the accelerated development stage, the demand for talent is gradually increasing, because of industry development promoting talent structure adjustment, the demand for talent roughly can be satisfied. Generally, technology talent and high-tech industry in these provinces and cities are gradually adjusted, but sometimes there will be strong fluctuations, as a result, the coupling degree is the largest.

(3) Medium coupling degree-low percentage (Ⅲ). Including Shanxi, Liaoning, Jilin, Zhejiang, Shandong, Henan, Guangxi, Chongqing, Guizhou and Qinghai, the

economic development of these provinces and cities is relatively backward except for Zhejiang province, due to much more private small commodity economy and always for intermediary processing in Zhejiang province, whose economic model is two lower and one medium, one of the lower two is research. Consequently, Zhejiang province possesses good conditions to attract talents and investment, but still in industrial structure adjustment and transformation phase. The percentage of high-tech industry is fairly low, even these provinces and cities are actively developing high-tech industry and has obtained some certain achievement in recent years, however, owing to the limitation itself, these provinces and cities can't compete with big cities like Beijing, Shanghai and Guangdong in investment of research funds and attracting talents, which made these provinces and cities are in antagonism, limit stage, and the coupling degree is compared larger.

(4) Low coupling degree-low percentage (Ⅳ). Including Hebei, Inner Mongolia, Heilongjiang, Anhui, Fujian, Hubei, Hunan, Yunnan, Gansu and Xinjiang province, which is economically backward, among them most are agricultural provinces, industrialization can't compete against developed provinces and cities, thus the development of high-tech industry is slowly and low. Although these provinces are actively developing high-tech industry at present, the development of high-tech industry is still in a beginning stage, the demand for technology talent temporarily doesn't appear larger gap; in contrast, the coupling degree appeared smallest.

CONCLUSION AND SUGGESTION

The coupling of technology talent and high-tech industry not only appears complex of interaction between elements of two systems, also reflects the regularity of spatial evolution. By constructing the index system, using grey correlation technology, we analyzed the main factor of Chinese technology talent coupled with high-tech industry and the regional characteristic of the coupling degree; finally we came to a conclusion:

First of all, the coupling mechanism of technology talent and high-tech industry is complicated; the relationship between them appears mutual stress and constraint. Analysis shows that cultural structure of technology talent and research funds, especially government investment and oversea investment are main factor which constraint the development of the high-tech industry. But whether the influence of various elements of high-tech industry on the technology is leading or not is not very obvious.

Secondly, the coupling degree distribution of China regional technology talent and high-tech industry is basically in agreement with the law of difference between economics of eastern and western China. Regional distribution of coupling degree reveals a fact that development of high-tech industry in eastern coastal provinces and cities is better than Midwest of China, the coupling degree generally goes from low level coupling to antagonistic and running-in, and finally to coordinate. At present, antagonism and low coupling are main embodiment of technology talent and high-tech industry, which suggest the task of developing high-tech industry and coordinating the relationship of technology talent and high-tech industry is still very difficult.

Finally, analyzing the coupling degree, most of the Midwest provinces of China are at a low coupling and antagonistic stage, which suggest that either the development of high-tech industry in Midwest of China is in a low stage or the demand for technology talent or research funds of developing high-tech industry can't be satisfied. Thus, provinces and cities in Midwest should make great efforts to develop the economy, strengthen the investment of the high-tech industry, and at a same time improve infrastructure and policy, environment investment and attract investment actively. In addition, government should value higher education, especially the graduate student education, so as to improve the local high-level talent reserve.

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