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An Empirical Study on the Coordinated Development of the Service Industry and the Innovation of Science and Technology

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Abstract. The purpose of this paper is to make empirical research on the coordination between the service industry and science and technology innovation, and constructed theirs synergy degree measurement model, then made empirical analysis on the coordination using the data of China's service industry and the innovation of science and technology from 2005-2013. The results showed that the order degrees of service industry system and innovation system of science and technology are developing steadily, which showed that China's service industry and the innovation of science and technology are in the collaborative development state. But the order degree of technical innovation has become the main factor which restricts the rising of compound system coordination degree. Finally, put forward the policy suggestions to promote the coordinated development of compound system.

Introduction

2013, China’s production of the tertiary Industry reached 46.1% of GDP and firstly exceed second industrial output; 2014, The proportion of service sector output in the whole national economy further increased into 48.2%. But there is still a big gap compared with the West countries. Among world's major developed countries, the proportion of service sector has already reached about 70% of GDP, that rate of the middle-income also reached about 50%, however, the proportion in most developing countries is only about 45% in most developing countries (XU Guanhua et al., 2009) [1]. With the growth rate of China's imports and exports and fixed asset investment slowdown, two of the three drivers of the economy in China are in an unsustainable state, which highlights the importance of consumer-led economy. Service innovation undoubtedly improve consumer spending, In addition, the service industry not only involve the labor intensive industries, but also involve the technology intensive industries, which can be a very good to ease the current severe employment pressure. To promote the healthy and rapid development of the service industry can effectively optimize the industrial structure and promote the upgrading of the industrial structure and the operation of the economy more stable and healthy. After thirty years of reform and opening up, China has made great progress in economic development, which makes people get rid of poverty, solves the problem of food and clothing and makes China into the ranks of middle-income countries. Though china has made considerable achievement in economic development, many problems of economic development are exposed to the light: economic scale is big but not strong; economic growth is fast but not excellent.

There is a certain degree of interactive relationship between service industry and technological innovation. On the one hand, the development of service business can promote the progress of science and technology innovation. The process of scientific and technological innovation is a complex process that requires the intervention of the service industry to achieve the goal of ensuring the smooth progress of scientific and technological innovation. High investment in the process of technological innovation is bound to be accompanied by high risk and high income, which can provide the basis for the financial service industry; On the other hand, the progress of scientific and technological innovation can effectively promote the service industry in improve the quality of service and a more sophisticated division of labor. In the gradual differentiation and

personalized market competition, technological innovation plays an irreplaceable role in the process of supporting modern service enterprises to implement the differentiation strategy (YANG Shixin & ZOU Ziyun, 2009) [2]. Therefore, it has important practical significance to grasp the relationship between service industry and scientific and technological innovation for promoting the optimization and upgrading of China's industry and realizing the sustainable development of economy.

Haken (1984) pointed out that the collaborative degree can be used to indicate the amount of mutual connection and combination between subsystems within the composite system or the system and the environment [3]. In view of the construction and evaluation of the complex system coordination model, Experts and scholars from home and abroad have done a lot of researches from different perspectives .Beers (2008) research on the regional cooperative way of energy recovery about Kwinana area [4] .Tushman & O'Reilly (1997) proposed a tool to measure order degree that is a basic element of the composite system [5]. ZHANG Lingrong (2011) through the analysis of the supply chain coordination mechanism, from two perspectives: "five flow" sub system, node enterprise subsystem, researched the supply chain collaborative content, rebuilt supply chain collaboration model [6]. MENG Qingsong & HAN Wenxiu (2000) put forward the concept of coordination mechanism and composite factor from synergetics angle and made an empirical analysis of the complex system Consisted of science, technology, economy and education [7]. YANG ShiQi, etal. (2008) put forward the evaluation theory of coordination degree about regional agricultural system, which was used to do an empirical study on the order degree of Quzhou County in Hebei Province [8]. WU Yanyun (2012) constructed the regional economy and port logistics coordination model [9]. Hong Jin et al. (2013) studied the cooperative path of the technology transfer system in China and constructed a reasonable model [10].

The existing literature has done a lot of research on the service industry and the science and technology innovation. But the present research only pays attention to one aspect and lack of the two links to carry on the thorough analysis to the national industrial structure. Based on the theory of the synergy, this paper firstly establishes the cooperative degree evaluation system of the composite system. Then, setup the model of the service industry and the innovation of science and technology and the model of the complex system coordination degree. In the end of this paper, we use the date from "China Statistical Yearbook", "China Statistical Yearbook of science and technology" to analyze and evaluate the order degree of service industry and technology innovation respectively and Synergistic degree of composite system.

The Construction of the Synergy Degree Measurement Model

Establishing composite system of service industry and the innovation of science and technology $T=\{T_1, T_2\}$, Among them, T1 is the service industry subsystem, T_2 is the science and technology innovation subsystem. The order parameter during the n the development of T_j is expressed as $X_j=(X_{j1}, X_{j2},..., X_{jn})$, where $n>1$, $\beta_{ji}\le X_{ji}\le\alpha_{ji}, i\in[1, n]$, β_{ji},α_{ji} Respectively are the maximum and minimum values of the order parameters in the critical points of the system. In this paper, we assume that $(X_{j1},X_{j2},...X_{jk})$are a slow relaxation parameter, which is characterized by the higher values , the higher order of the subsystem. Contrarily, we assume that $(X_{jk+1},X_{jk+2},...,X_{jn})$ is a fast relaxation parameter, which is characterized by the opposite of slow relaxation parameter. So, there are the following definitions:

Definition 1: order degree of X_j-a component of subsystem' order parameter

$$\mu_j(X_{ji})=\begin{cases}\dfrac{X_{ji}-\beta_{ji}}{\alpha_{ji}-\beta_{ji}}, i\in[1,\ k]\\ \dfrac{\alpha_{ji}-X_{ji}}{\alpha_{ji}-\beta_{ji}}, i\in[k+1, n]\end{cases} \tag{1}$$

According to the Definition(1) ,$\mu_j(X_{ji})\in[0,1]$. In particular, the enlargement of this value can promote the improvement of the subsystem order degree.

Definition 2: Order degree of subsystem e_j

$$\mu_j(X_j) = \sum_{i=1}^{n} \lambda_i \mu_j(X_{ji}), \lambda_i \geq 0, \sum_{i=1}^{n} \lambda_i = 1 \tag{2}$$

By definition (2), $\mu_j(X_j) \in [0,1]$, the size of that affect the size of the system order degree. In particular, the enlargement of this value can promote the improvement of the system order degree. Conversely, reducing the order degree of system. And λ_i indicates the important degree of X_{ji} in the subsystem. This paper set the weight by entropy method.

Definition 3 composite system coordination of Service industry and scientific and technological innovation

$$c = \lambda \bullet \sqrt{\left|\mu_1^1(X_1) - \mu_1^0(X_1)\right| \times \left|\mu_2^1(X_2) - \mu_2^0(X_2)\right|}$$

in which,
$$\lambda = \begin{cases} 1, \left|\mu_1^1(X_1) - \mu_1^0(X_1)\right| \times \left|\mu_2^1(X_2) - \mu_2^0(X_2)\right| > 0 \\ -1, \left|\mu_1^1(X_1) - \mu_1^0(X_1)\right| \times \left|\mu_2^1(X_2) - \mu_2^0(X_2)\right| \leq 0 \end{cases} \tag{3}$$

By definition (3), there are three points as follows:

First, by the formula (3), we can know that the value of C (The synergy degree of the composite system) is [-1, 1], the size of that measure the size of the synergy degree of the composite system. In particular, the enlargement of this value can promote the improvement of the synergy degree of the composite system and vice versa. Second, if and only if$[\mu_1^1(X_1) - \mu_1^0(X_1)] \times [\mu_2^1(X_1) - \mu_2^0(X_1)] > 0$, the synergy degree of the composite system is positive, which indicates that the subsystems of the composite system are mutually promoted, and are in the state of coordinated development; when$[\mu_1^1(X_1)-\mu_1^0(X_1)] \times [\mu_2^1(X_1)-\mu_2^0(X_1)] \leqslant 0$, the synergy degree of the composite system is negative, which indicates that the subsystems of the composite system aren't mutually promoted, and aren't in the state of coordinated development.

The selection of the coordination index is the most important part of the effective measurement system. One side, too much index will result in excessive calculation, leading in too complex and redundant information; on the other hand, Improper selection will distort the real development evolution of the subsystem .Based on the time dimension, this paper measures the synergy degree of the composite system containing service industry and the innovation of science and technology. output cooperation of Service industry and scientific and technological is the result of synergy input between the two sides. Therefore, this paper base on input and output of the service industry and the scientific and technological innovation to build a cooperative measurement index system, which covers the collaborative state of input and output about service industry and technology innovation. From Mechanism analysis of cooperative development of service industry and scientific and technological innovation, the order degree parameter of service industry and scientific and technological innovation is the key parameter to realize the sustainable and rapid development of composite system.

Table 1. The Synergy measure index system of services and technological innovation system.

subsystem	primary indicators	secondary indicators
Service subsystem	service inputA1	the number of employeesA_{11}
	Service outputA2	the total output A_{21}
Science and technology innovation subsystem	innovation inputB1	new product development expensesB_{11}
		R&D staff B_{12}
	Innovation outputB2	he number of scientific papers publishedB_{21}
		the number of invention patentsB_{22}
		the ratio of new product sales revenue accounted for the main business income B_{23}

Select new product development expenses, R&D staff at the time of the year, the number of scientific papers published, the number of invention patents and the ratio of new product sales revenue accounted for the main business income as an indicator of technology innovation subsystem. The concrete index of the synergy degree between the service industry and the innovation of science and technology are as shown in Table 1.

Because of the different measurement units in this paper, it cannot be directly calculated. In order to compare the date directly, this paper processing the original data by the following formula.

$$X_{ij}' = \frac{X_{ij} - \min X_j}{\max X_j - \min X_j} (i = 1,2,..., n;\ j = 1,2,..., p) \tag{4}$$

On the formula, X_{ij} 'is the nondimensionalization data.

Table 2. The measurement index data about cooperative degree of service and technological innovation.

year	A11(Million people)	A21(Billion yuan)	B11(Billion yuan)	B12(Million people)	B21(Million articles)	B22	B23
2005	23439	74919.3	2449.97	136.48	94	171619	16.98%
2006	24143	88554.9	3003.1	150.25	106	223860	17.69%
2007	24404	111351.9	3710.24	173.62	114	301632	18.67%
2008	25087	131340	4616.02	196.54	119	352406	19.07%
2009	25857	148038	5802.11	229.1	136	501786	20.63%
2010	26332	173596	7062.58	255.4	142	740620	19.95%
2011	27282	205205	8687	288.3	150	883861	19.14%
2012	27690	231934.5	10298.4	324.7	152	1163226	16.28%
2013	29636	262203.8	11846.6	353.3	154.46	1228413	17.34%

Different index in the evaluation model needs to give a certain weight, which reflects the degree of the impact on the system. This paper uses the method of entropy to calculate the evaluation index weight of the two subsystems.

Table 3. The weight of index services and technological innovation.

Service index weight		Science and technology innovation index weight				
A11	A21	B11	B12	B21	B22	B23
0.4911	0.5089	0.2308	0.2095	0.1423	0.2584	0.1591

Through calculation, it is concluded that the order degree of two subsystems and the synergy degree of the composite system from2006 -2014, which are shown in Table 4.

Table 4. The order degree of the subsystem.

year	Service	innovation
2006	0.092842029	0.11650676
2007	0.175471057	0.22893152
2008	0.283910249	0.31138135
2009	0.390303973	0.50174552
2010	0.497394423	0.60602665
2011	0.658569801	0.70464451
2012	0.763533899	0.75310702
2013	1.00000	0.87754794

According to Table 4, the synergy degree of the composite system is obtained as shown in Table 5.

Table 5. The synergy degree of the composite system.

year	2006	2007	2008	2009	2010	2011	2012	2013
Synergy degree	0.09243	0.18940	0.28540	0.43159	0.53782	0.66928	0.74588	0.92362

Based on the results of the above calculations, the composite system synergy diagram (see Fig. 1) is drawn. From Fig. 1, we can see that there is the overall upward trend in the subsystem from 2006 to 2013 year, the synergy degree the composite system has also maintained a relatively stable upward trend. The main reason is that the growth trend in the two sub systems is completely synchronized. The order degree of scientific and technological innovation has keeping the overall rise trend, but that exists within big fluctuation.

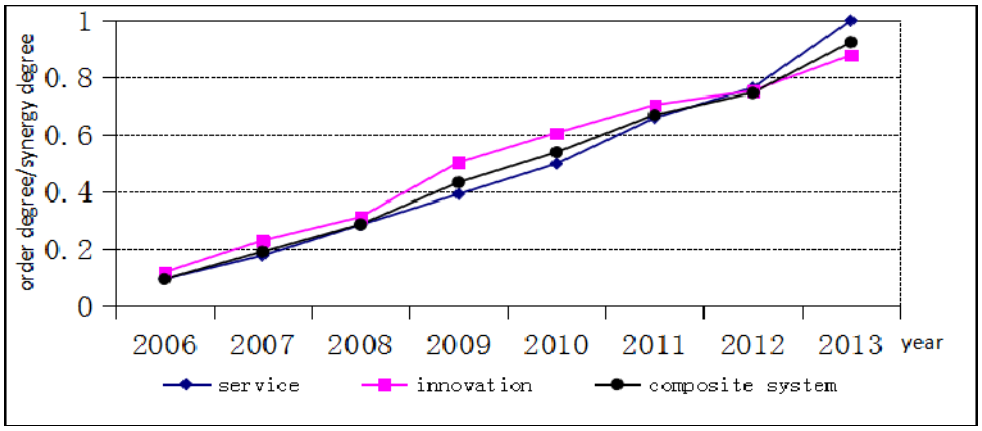

Fig. 1 The order degree change of services technological innovation and complex system.

Conclusions and Recommendations

Using the date of the service industry and t science and technology innovation system from 2006 - 2013 to make an empirical analysis. The results show that the service industry and science and technology innovation system has a strong mutual promotion relationship. (1) From the order degree of the two subsystems, the order degree of service industry is less than that of scientific and technological innovation, and in a low level before 2011, after 2011, which has a rapid recovery and surpassed the order degree of the scientific and technological innovation . In 2013, the output value of the tertiary industry exceeded that of the second industry in China's GDP for the first time. (2) In general, the overall coordination of the service industry and technology innovation in the 2003 - 2011 is relatively high, showing a relatively stable upward trend. However, the order degree of scientific and technological innovation is the main effect on the synergy degree of the composite system. (3) The government should accelerate the transformation of functions, provide a effectively policy service and environmental service that is needed for innovation. In addition, government should increases the support to the service industry, further perfect the scientific and technological innovation system and promote the coordinated development of service industry and scientific and technological innovation.

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References

[1] G. H. Xu, D. M. Liu, Q. Liu, The Development Trend of Modern Service Industry and Countermeasure, Bull. Chin. Acad. Sci. 3 (2009) 248-255.

[2] S. X. Yang, Z. Y. Zou, The Research on promoting the integration of modern service industry and science and technology innovation in Guangxi, Pioneer. Sci. Technol. Mon. 12 (2010) 20-22+24.

[3] Haken, The introduction of Synergy, Beijing Atomic Energy Press, 1984.

[4] D. Beers, W. K. Biswas, A regional synergy approach to energy recovery, case Kwinana industrial area, Western Australia, Energ. Convers. Manag. 49 (2008) 3051 -3062.

[5] M. L. Tushman, C. A. O'Reilly III, Winning through Innovation: A Practical Guide to Leading Organizational Change and Renewal, Boston: Harvard Business School Press, 1997.

[6] L. R. Zhang, The Study on Supply Chain Collaboration Degree Evaluation Model, Dalian University of Technology, 2011.

[7] Q. S. Meng, W. X. Han, Study of The Coordinating Measurement model With Respect to Composite System, J. Tianjin U. 33(4) (2000) 444-446.

[8] S. Q. Yang, Z. L. Yang, W. S. Gao, Harmony Coefficient of Regional Agro-osystem Assessment at both Local-and National-Scales—A case study of Quzhou County, Hebei Province, Chin. J. Eco-Agriculture, 1 (2008) 200-205.

[9] Y. Y. Wu, Dynamic Fleet Planning for Ship Corporation in Uncertain Circumstance, Dalian Maritime University, 2012.

[10] J. Hong, L. B. Wang, D. T. Zhao, Research on the Co-Evolution Path of Technology Transfer System in Self-Organization Perspective, Sci. Manag. S&T, 10 (2013) 77-84.