Measurement of the Matching Degree between the Structure of China's High-tech Industry and of Technological Resources Input

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Based on general principles of welfare economics, a structure deviation index is constructed for the industry structure and the technological resources input structure. Taking China's high-tech manufacturing and high-tech service industry from 2004 to 2013 as samples, the research measures the matching degree of the industry structure and the technological resources input structure between high-tech manufacturing and high-tech service industry, among high-tech manufacturing sub-industries, and between two high-tech service sub-sectors, respectively. Conclusions are (i) allocation of technological resources between high-tech manufacturing and high-tech service industry is basically efficient; (ii)technological resources efficiency of high-tech manufacturing sub-industries exhibits gradient-differences; (iii) information transfer, software and information technology services demonstrates long-term and absolute advantages.

INTRODUCTION

It has been difficult for China's economy to sustain rapid growth depending on factor inputs expansion. Under the background of "New Normal" that the economic development pattern is shifted and the growth momentum is transformed. Economic restructuring and upgrading is one of the most critical issues. Changes in the industrial structure must be accompanied by re-allocation of resources. Factors of production are allocated constantly from sectors with lower productivity or productivity growth rate to higher ones, which will release new growth potential. Therefore, the study on the matching between industrial structure and resources input structure is conducive to the adjustment of industrial layout and the release of "structural bonus".

The "matching" between industrial structure and resources input structure refers to the status when marginal input of resources produce theoretical marginal product. If it reaches the status of "matching", resources productivity would be the greatest. If not, there is "resources misallocation", which indicates that the region does not have such resources or the resources productivity is low. China has experienced nearly 40 years of reform and opening and the commodity market has basically broken the shackles of the planned economic system to achieve efficient allocation regulated by the price mechanism. China has not

yet fully completed the dual-track reform. Capital, labor and other production factors, markets still have a twist brought about by administrative intervention and market forces, which hinders efficient allocation of resources. Many of current structural problems of China's economy are essentially problems of "resources misallocation" [1]. The misplacement of resources causes the imbalance of industrial structure, thereby affecting growth [2].

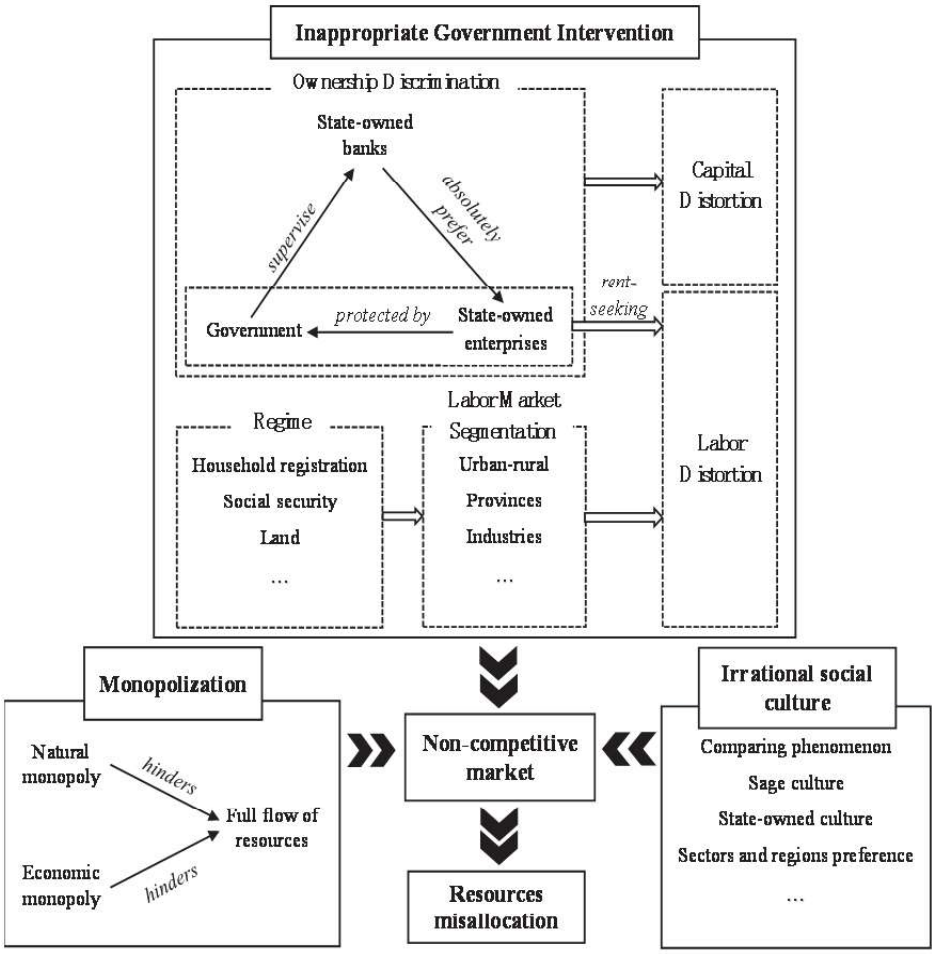
Vigorously developing high-tech industries has become a strategic consensus at both national level and local levels. This great enthusiasm across the country has caused deep thinking about the structure issues. Should China be ready to develop high-tech industries without considering structure issues, or invest in them selectively based on different conditions? This paper aims to figure out a better configuration of technological resources of China's high-tech industries from the perspective of the "matching" between the industrial structure and technological resources input structure. Based on the neoclassical economics hypothesis that there is a full flow of factors, this paper is going to construct a structure deviation index of the industry structure and the technological resources input structure, in order to analyze the "matching" issue of China's high-tech industries structure.

Factors Affecting the Resources Misallocation and the Formation Paths

Generally speaking, the underlying cause of resources misallocation is the non-competitive market and the non-competitive market can be formed in three ways: inappropriate government intervention, monopolies and irrational social culture. These three factors undermine sufficient resources competition in the market by different paths, thereby resulting in misallocation of resources. It is necessary to understand the resources misallocation mechanism first as shown in Figure 1.

The first factor is inappropriate government intervention, which is the most important one. Biased public policies make it a variable for resource acquisition costs of enterprises from different ownerships, regions or industries. Often, the government sets up high market entry barriers or sets certain price controls for non-state-owned enterprises in order to protect state-owned enterprises. State-owned enterprises, with their unique market power, can often obtain superior resources at lower cost, or seek protection from the government when they lack market competitiveness due to low operation efficiency. Being subject to the pressure of economic security risks, the government often protects nonviable state-owned enterprises, giving them preferential policies concerning taxes, subsidies and so on. The circular relationship between state-owned enterprises and the government "protecting - low operating efficiency - and protecting again" undermines the free movement of production factors in the market and distorts the price mechanism. In addition, supporting key industries by industrial policies and the market segmentation caused by local protectionism will bring about resources misallocation to some extent [3-4].

FIGURE 1
FACTORS AFFECTING RESOURCE MISALLOCATION AND FORMATION PATHS



Here are some further analyses in detail on capital distortion and labor distortion caused by inappropriate government intervention.. This has attracted much attention [2, 5-7]. Firstly, inappropriate government intervention causes ownership discrimination in the financial market. China's financial market is led by four major state-owned banks. Other medium and small-size commercial banks have a smaller share of the market. Bonds, funds and stocks also occupy limited market shares. At the same time, there is a subtle link among state-owned banks, the government and state-owned enterprises due to the inertia of China's planned economic system. Corporate finance comes mainly from state-owned banks, while state-owned banks show an absolute preference for state-owned enterprises due to government intervention. Therefore, there is a huge gap in the financing cost of enterprises from different ownership, resulting in a non-fully competitive capital market [8]. There are several kinds of ownership of China's high-tech enterprises, like state-owned, Hong Kong, Macao Taiwan-owned, and foreign-owned. Ownership discrimination caused by administrative intervention would bring about capital distortion of high-tech industries. Secondly, inappropriate government intervention undermines the full flow of labor resources. State-owned enterprises can easily do rent-seeking activities because of their market monopoly power. Economic outcomes that should have been owned by the public are often turned into additional revenue for state-owned enterprises. Rent-seeking behaviors make marginal returns of state-owned sector workforces are above the market equilibrium level, affecting the free movement of labor resources [9-10]. In addition, the household registration system, social security system and the land system bring about

urban-rural dual structure of labor resources [2], which restricts the full and free inter-urban-rural, inter-provincial and inter-industrial flow of labor resources, resulting in resources misallocation.

The second factor is monopolization, referring to natural monopoly and economic monopoly. Natural monopoly is common in industries of water, electricity, gas, telecommunications, and railway. In spite of the peculiarity of these industries that monopolization is more efficient and more conducive to secure resources than that of competition [11], the free flow and competition of resources will thus be limited. Economic monopoly is an exclusionary behavior implemented to other market players relying on the market competitiveness in order to obtain monopoly profits. With good business strategies, patents or joint organizations, enterprises obtain economic advantages, bring together industry resources, control the price of resources and restrict market competition. Natural monopoly and economic monopoly result in non-competitive markets and misallocation of resources.

The third factor is irrational social culture. The allocation of resources is influenced not only by administrative intervention and monopolization, but also by traditional social culture, ideas or trends of thought which to some extent are irrational. For example, firstly, regions' industrial selection decisions are often convergent because of the "comparing phenomenon". When a certain area has a quite good income due to investment in a certain industry, others often follow to do the same thing and even try to create "the most" within the country or even the world. It may cause blind investment without considering local resource conditions, resulting in misallocation of resources. Secondly, the allocation of resources is affected by the traditional "Sage culture". In China, personal will of the leader plays a critical role in the public decision-making because of the "Sage culture". So the uncertainty of personal leadership style is a kind of factor. Finally, folk decisions are also influenced by irrational cultural. For example, China has maintained top-down centralism for thousands of years, so people always have faith in "state-owned", "collective-owned" or "public-owned" sectors and then they are more inclined to choose those sectors when making investment or employment decisions. Another example is a folk idea of discriminatory attitudes to agriculture and rural areas, while advocating finance and internet industries or big cities, which will also affect folk decisions. In summary, irrational social culture would interfere with sufficient competition of resources and make resources allocations have a certain bias.

RESEARCH DESIGN

Construction of the Structure Deviation Index

According to the principle of welfare economics, when the production activity is Pareto optimal, isoquant curves of sector A and sector B have the same slope. The absolute value of the isoquant curve slope can be represented as marginal rate of technical substitution (MRTS) of production factors, and MRTS can be represented as the ratio of the marginal product of different factors. Therefore, in order to achieve optimal allocation of technological resources between two different high-tech industries, the marginal product of resources input of the two industries should be equal. When industry structures and resources input structures of sector A and sector B achieve the status of formula (1), the allocation of technological resources arrives at Pareto Optimality, where it is economically efficient and it reaches the status of "matching".

$$\frac{\Delta p_t^A}{\Delta k_t^A} = \frac{\Delta p_t^B}{\Delta k_t^B} \tag{1}$$

In formula (1), Δp is the marginal added value of the output, Δk is the marginal added value of technological resources input, A and B are two different industries, and t represents the time. Derived from formula (1), the result is

$$\Delta p_t^A \times \Delta k_t^B = \Delta p_t^B \times \Delta k_t^A \tag{2}$$

$$\frac{\Delta p_t^A \times \Delta k_t^B}{\Delta p_t^B \times \Delta k_t^A} = 1 \quad (3)$$

$$\alpha_t^{AB} = \frac{\Delta p_t^A \times \Delta k_t^B}{\Delta p_t^B \times \Delta k_t^A} - 1 \quad (4)$$

The definition of α_t^{AB} is the structure deviation index (SDI) between the industry structure and technological resources input structure of industries A and B. The closer α_t^{AB} and 0 are, the higher matching degree is and the more efficient the resources allocation between A and B. The index will be used to measure the allocation of financial, human and material technological resources between high-tech manufacturing and high-tech service industry, among high-tech manufacturing sub-industries, and between two high-tech service sub-sectors respectively, and give advice on better configuration

Industrial Classification, Indexes Selection and Data Source

Given the difficulties such as obtaining data, most of current researches related to high-tech industries take high-tech manufacturing sectors as the research object. This research will attempt to include both high-tech manufacturing and high-tech services industries. High-tech manufacturing is classified into 5 sub-sectors according to High-tech Industries (Manufacturing) Classification (2013) issued by National Bureau of Statistics of China, including Manufacture of Medicines, Manufacture of Aircrafts and Spacecrafts and Related Equipment, Manufacture of Electronic Equipment and Communication Equipment, Manufacture of Computers and Office Equipment, and Manufacture of Medical Equipment and Measuring Instruments. Based on High-tech Industries (Services) Classification (2013) and considering the availability of data, two industries were selected as representatives for high-tech service sectors, including Information Transfer, Software and Information Technology Services and Scientific Research and Technical Services. The classification and the short for sectors are shown in Table 1.

TABLE 1
THE CLASSIFICATION AND SHORT NAMES OF HIGH-TECH INDUSTRIES

High-tech Industries	Sub-sectors	Short Names
High-tech Manufacturing	Manufacture of Medicines	MM
	Manufacture of Aircrafts and Spacecrafts and Related Equipment	MASRE
	Manufacture of Electronic Equipment and Communication Equipment	MEECE
	Manufacture of Computers and Office Equipment	MCOE
	Manufacture of Medical Equipments and Measuring Instrument	MMEMI
High-tech Service Industry	Information Transfer, Software and Information Technology Services	ITSITS
	Scientific Research and Technical Services	SRTS

Technological resources refer to the required production factors in technological production and innovation activities. In general, from the perspective of input, technological resources include human, financial and material resources. There are various types of indicators representing technological resources. Considering the representativity and data availability, the following three are selected. Full-

time Equivalent of R&D Personnel for human resources, Intramural Expenditure on R&D for financial resources and R&D Equipment Expenditure for material resources.

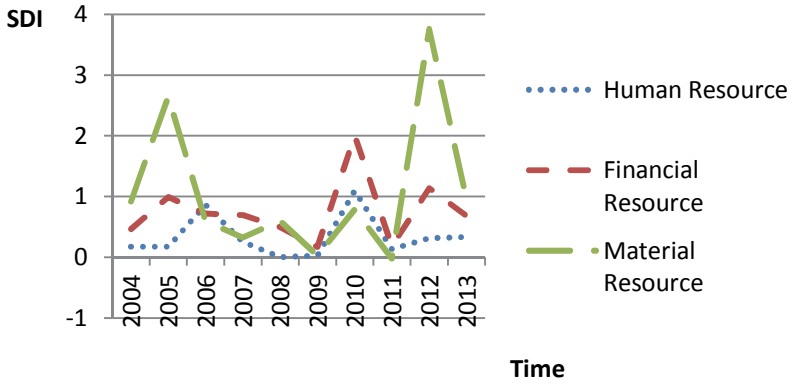
The data sources of high-tech manufacturing and high-tech services are different. Data of annual added value of high-tech manufacturing outputs and their technological resources input is available in China Statistics Yearbook on High Technology Industry. Annual added value of high-tech services outputs are collected from China Statistical Yearbook and data of technological resources input of service sectors comes from China Statistical Yearbook on Science and Technology.

EMPIRICAL ANALYSES ON STRUCTURAL MATCHING

High-tech Manufacturing and High-tech Service Industry

China's economy restructuring is an important feature of the change of the economic development mode. It is the servicing of manufacturing. Resources allocation between manufacturing and services will become the main determinant of China's economic growth [12]. For high-tech industries, it is necessary to focus on the efficiency of the allocation of technological resources between manufacturing and services. The evolution of the structure deviation index (SDI) between high-tech manufacturing and high-tech service industry is shown in Figure 2.

FIGURE 2
THE EVOLUTION OF SDI BETWEEN HIGH-TECH MANUFACTURING AND SERVICES



Overall, structure deviation indexes for three types of technological resources range stably and slightly higher than 0. The resources efficiency of manufacturing is slightly higher. The index fluctuates within a small range in most years during 2004--2013, indicating that the overall allocation of resources between manufacturing and services is efficient and stable. Combined with the original data, it was found that the resource efficiency of manufacturing shows slight advantages over services (the marginal product of manufacturing each year is slightly higher than services). Specifically, the index value of human resource fluctuates basically less than 1 and even within 0.3 in most years. Except for 2 in the year of 2010, the index value of financial resource hovers in the vicinity of zero in the rest of years, which is relatively stable. For material resource, in addition to 2.64 in 2005 and 3.76 in 2012, the index value fluctuates within 1 in other years. Thus, the overall resource allocation efficiency between China's high-tech manufacturing and services is relatively high and there is no large deviation.

High-tech Manufacturing Sub-sectors

In order to grasp overall the resource allocation efficiency among five manufacturing sub-sectors, the authors calculated and compared the variance of technological resources' marginal output, results of which are shown in Table 2. We know that when the marginal output of each kind of technological resource among sub-sectors is equal to each other, resources allocation arrives at the status of Pareto optimality. Since the variance reflects the degree of dispersion of the marginal product of sub-sectors, the closer the variance and 0 are, the lower degree of dispersion is and the higher resource allocation

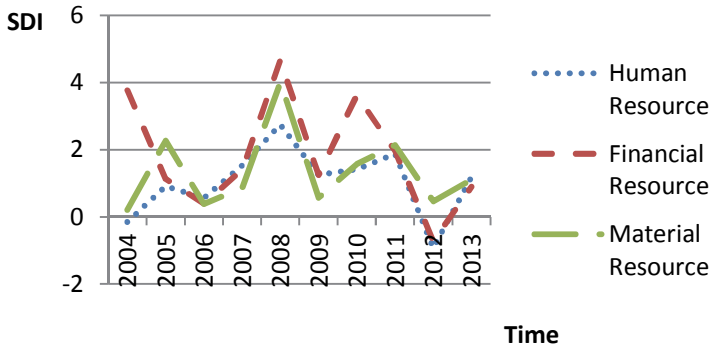
efficiency is. On the contrary, the greater the variance is, the higher degree of dispersion is and the lower efficiency is. According to Table 2, in most years, the variances of financial and material resources are closer to 0 and less volatile with respect to human resources. The fluctuation of human resource variance is relatively larger and the variance is far from 0 in some years, such as 3.37 in 2004 and 2.33 in 2010. Therefore, the allocation of financial and material resources is relatively efficient within high-tech manufacturing and the annual change is small. However there is somewhat imbalance of the allocation of human resource and the annual fluctuation of allocation efficiency is relatively large.

TABLE 2
VARIANCES OF RESOURCES' MARGINAL OUTPUT WITHIN HIGH-TECH MANUFACTURING

Time	Human Resource	Financial Resource	Material Resource
2004	3.3670565	0.0005903	0.0006154
2005	0.0258109	0.0002946	0.0062251
2006	0.3422070	0.0000245	0.0004546
2007	0.2706726	0.0000679	0.0003385
2008	0.2133789	0.0053370	0.0194634
2009	0.0007266	0.0000016	0.0000368
2010	2.3343746	0.0002450	0.0503402
2011	0.0043216	0.0000014	0.0001193
2012	0.2731284	0.0039638	0.0162261
2013	1.3446560	0.0002630	0.1050452

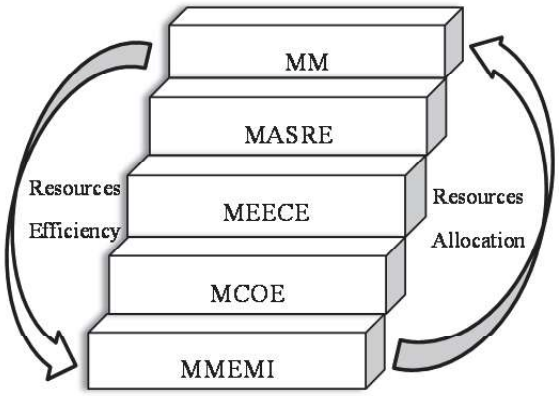
Further analyses using the structural deviation index and taking the comparison between MM and MMEMI for example, is shown in Figure 3. Structure deviation indexes for three kinds of resources have a similar trend. They have experienced "three ups and downs". During three stages 2004-2005, 2008 and 2010-2011, the resource efficiency of MM shows obvious advantages, and subsequently goes down three times. There is a reversal in the comparison in 2012, namely MMEMI exhibits a relative advantage on technological resource efficiency. Throughout the sample period, except in 2012, MM always has higher resource efficiency and higher matching degree between the industrial structure and technological resources input structure.

FIGURE 3
THE EVOLUTION OF SDI BETWEEN MM AND MMEMI



Making multiple comparisons among the five sub-sectors of manufacturing, ten groups of results can be achieved as shown in the appendix. Integrating ten groups of results, the results show that the utilizing efficiency of three kinds of technological resources of five sub-sectors can all be ranked in descending order as "MM-MASRE-MEECE-MCOE-MMEMI". The first ones are always more efficient in using resources than ones in the back in most years. This indicates that economic planners should try to make technological resources flow from low efficient sectors to high efficient ones, as shown in Figure 4.

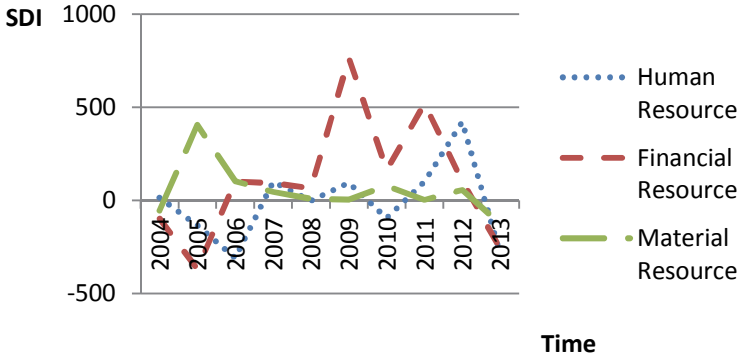
FIGURE 4
TECHNOLOGICAL RESOURCES EFFICIENCY RANK AND RECOMMENDED ALLOCATION DIRECTION



High-tech Service Industry

With the improvement of national per capita income, it highlights the growing importance of the service sector in the economy. Service-sectors and manufacturing-sectors have differences in industrial properties and study conclusions of manufacturing which cannot be copied on services [13]. There should be more focus on issues of resource allocation efficiency of services [14-15]. The evolution of the structural deviation index between two high-tech service sub-sectors ITSITS and SRTS is shown in Figure 5.

FIGURE 5
THE EVOLUTION OF SDI BETWEEN ITSITS AND SRTS



On the whole, the structural deviation index of inner service industry fluctuates greatly in the sample interval, being changeable and seriously deviating from 0. The huge swing is due to great annual changes of technological resources input of services, which indicates that the resource allocation efficiency of service industry is unstable. The large deviation from 0 shows, that there is a serious imbalance of allocation efficiency between ITSITS and SRTS. Investigating the original data, the research shows that

the efficiency in utilizing three kinds of technological resources of ITSITS is much higher than that of SRTS.

Firstly, human resources are examined. For volatility, the number of R&D Personnel of ITSITS showed negative growth during 2004-2006, 2010 and 2013, and SRTS in 2004 and 2008. Periodical negative growth makes mathematical symbols periodically change, suggesting that human resource of high-tech services is characterized by strong mobility. For deviation, the maximum of SDI's absolute value of human resource is 934, and furthermore the absolute value is far from 0 in most years, which indicates that there is a serious imbalance of allocation efficiency of R&D personnel. By calculating the marginal output of human resources over the years, ITSITS shows great efficiency advantages with respect to SRTS. Secondly, financial and material resources are examined. SDIs of these two kinds of resources are also characterized by strong volatility and deviation. Intramural expenditure on R&D and R&D equipment expenditure of both ITSITS and SRT have negative growth in some of the years, making the value of SDI fluctuate periodically. In addition, like human resource, the absolute values of SDI of financial and material resources are far from 0 for many years. By comparing the marginal output of resources of the two sub-sectors each year, we find that ITSITS is greatly superior to SRTS in efficiency of financial and material resources.

In summary, high-tech services are characterized by great mobility of human resource and big changes of annual input of financial and material resources. Technological resource efficiency of ITSITS is much higher than that of SRTS in the long-term. In the future allocation of high-tech services' technological resources, ITSITS should get more.

CONCLUSIONS

Based on general principles of welfare economics, this research constructed a structure deviation index. Taking China's high-tech manufacturing and high-tech service industry from 2004 to 2013 as samples, this research respectively studies the "matching" between industrial structure and technological resources input structure of high-tech manufacturing and services, among manufacturing sub-sectors and among service sub-sectors. The authors found that (i) the allocation of human, financial and material resources between high-tech manufacturing and services is basically efficient and manufacturing shows a slight advantage of resource efficiency than services; (ii) within the manufacturing sector, the utilizing efficiency of three kinds of technological resources of five sub-sectors can all be ranked in descending order as "MM-MASRE-MEECE-MCOE-MMEMI". So economic planners should try to make technological resources flow from low efficient sectors to high efficient ones; (iii) within the service sector, ITSITS exhibits long-term and absolute resource efficiency advantages than SRTS. And ITSITS should get more in the future resources allocation.

There are still some deficiencies in the research design. Firstly, the construction of the structural deviation index implies the hypothesis of neoclassical economics that production factors flow sufficiently. When the economic assumptions change, market equilibrium conditions will change. So taking non-full flow of factors into account in the index construction should be the future direction of research. Secondly, the structure deviation index is still insufficient to directly reflect the resource utilization efficiency between two industries, which needs to be improved.

ENDNOTES

[1] Of course, information is also required in technological activities. But due to the difficulties of indexes selection and data availability, this information will not be taken into account.

[1] High-tech manufacturing industry statistics are available in *China Statistics Yearbook on High Technology Industry*. The yearbook is compiled based on *High-tech Industries (Manufacturing) Classification (2013)* issued by National Bureau of Statistics of China and it only contains the manufacturing data. Currently there is no specific official statistics yearbook for high-tech services. The *China Statistical Yearbook was chosen* as the data source and classification reference for high-tech service sectors. The *China Statistical Yearbook* has made a major

adjustment from 2003 onward. Data of ITSITS before 2003 is not available, so the sample internal in this paper is set 2004-2013.

China Statistics Yearbook on High Technology Industry no longer published the output data of sub-sectors from 2012 onward so GM (1,1) was used. Gray Prediction Model to evaluate the output of high tech manufacturing sub-sectors in 2012 and 2013.

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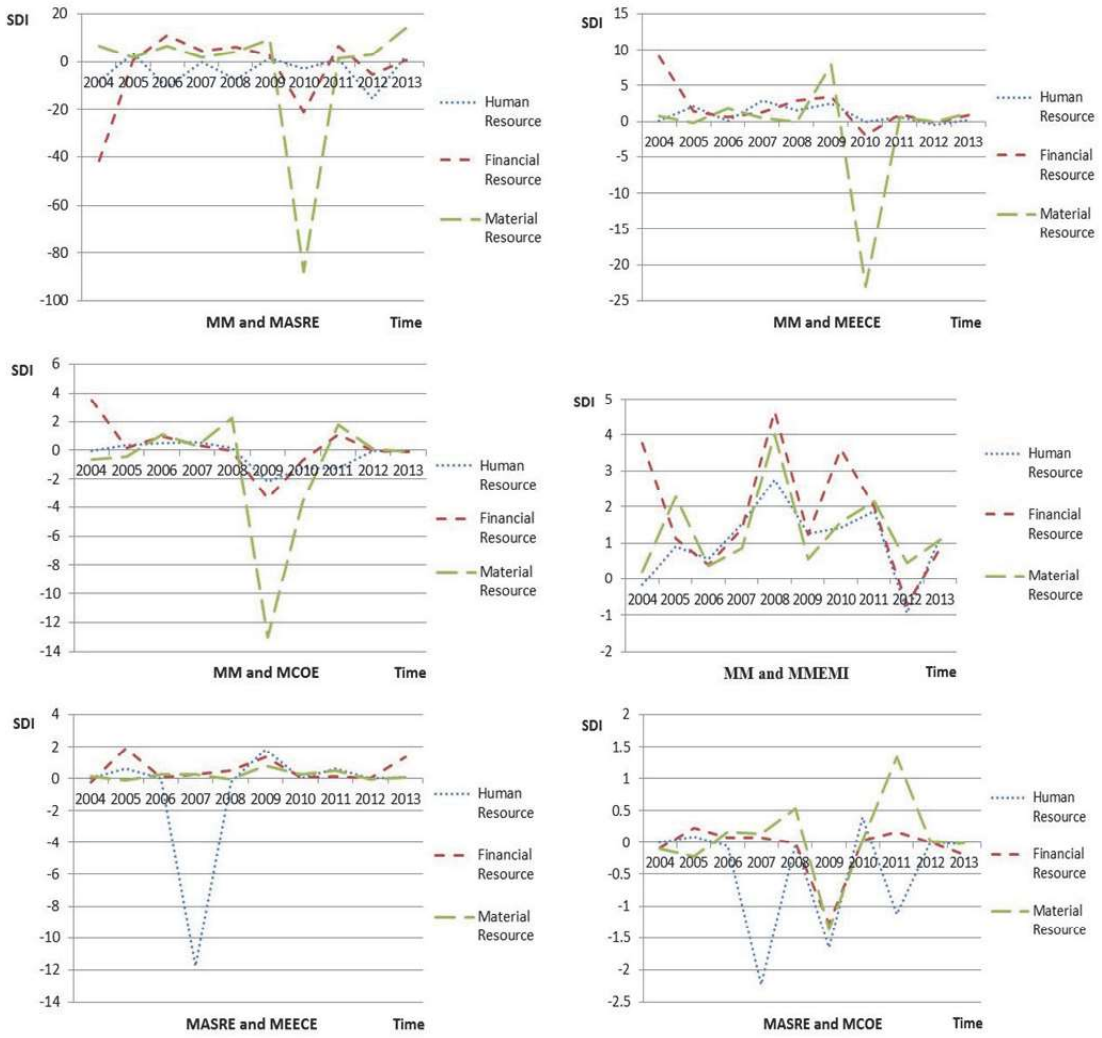
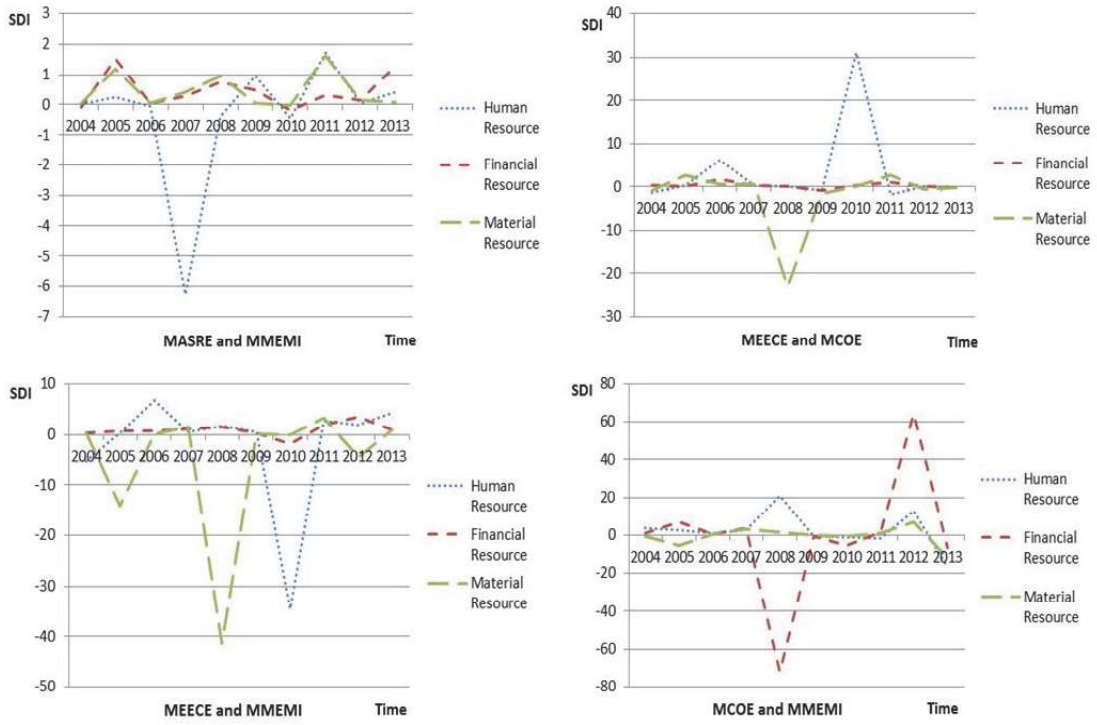
Appendix：The Evolution of SDI of High-tech Manufacturing Sub-sectors




SDI
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