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Empirical Analysis of the Economic Distance of Regional Industry Linkages in China's Manufacturing Industry

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Abstract

Promoting the coordinated development of regional economy and constructing a scientific and reasonable development layout is an important guarantee for promoting the high-quality development of regional economy. Based on the input-output table, the regional industry-linked economic distance model is used to study the industry-linked economic distance of manufacturing industries in China at different technology levels within and between regions. It was found that: (1) the high-end manufacturing industry has the greatest degree of association and the shortest economic distance from its own sector, and the high-end manufacturing industry or the mid-range manufacturing industry has the greatest degree of association and the shortest economic distance from its own to the mid-range manufacturing industry; (2) the number of sectors with the largest forward correlation economic distance index between the high-end manufacturing industry and the middle and low-end manufacturing industry has increased, indicating that the promotion role of high-end manufacturing on the manufacturing industry has become more obvious; (3) low-end manufacturing has the greatest degree of association with its own sector and the shortest economic distance, construction and mid-range manufacturing has the greatest degree of association with mid-range manufacturing and the shortest economic distance, mid-range manufacturing, high-end manufacturing, electricity and heat supply and construction constitute the greatest degree of association with high-end manufacturing and the shortest economic distance, and high-end manufacturing pulls more industries. However, manufacturing industries of different technology levels are more closely linked within regions than between regions; manufacturing industries in the eastern coastal region drive the development of other regions as upstream industries, spatially showing a spoke shape centered on the eastern coast; low- and mid-range manufacturing industries in Beijing, Tianjin or the eastern coastal region showing a spoke shape centered on Beijing, Tianjin or the eastern coast, and high-end manufacturing industries in the northwest or northern coastal region showing a spoke shape centered on the northwest or northern coastal region.

Keywords

Manufacturing Industry; Industry Association; Economic Distance.

1. Introduction

The manufacturing industry is the main body of the real economy and the key and driving force of high-quality economic development[1]. Paying attention to regional differences in industrial development, coordinating industrial policies, finance, human capital and science and technology and other factor resources, promoting the smooth evolution of the manufacturing industry's own growth[2] are the prerequisites and basis for the manufacturing industry to win its own high-quality development based on the common growth of many parties. The level of manufacturing industry association and economic distance is the inherent driving force of

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industrial restructuring and upgrading, thus the industrial association of manufacturing industry has gradually received wide attention.

From the existing studies, among the domestic studies on manufacturing industry linkages, Chen Xi et al. focus on the industrial association and spatial distribution within the manufacturing industry in China, pointing out that the high spatial association of industrial combinations is mostly distributed in the middle development level provinces and regions, while less distributed in the economically developed or less developed provinces and regions[3]. Deng Liang and Zhang Yuanyuan et al. studied the industrial correlation between science and technology service industry and manufacturing industry, and provided suggestions to promote the transformation and upgrading of manufacturing industry[4-5]. Yijun Yuan and Dianfan Yu et al. used input-output analysis to comprehensively measure and compare the characteristics of changes in industrial linkages between service and manufacturing industries[6-7]. Based on China's input-output data in 1997, 2002 and 2007, Li Xiaohui analyzed the industrial association between China's distribution industry and manufacturing industry by using input-output analysis[8]. Tang and Huili et al. analyzed and studied the degree of association between different subsectors of China's manufacturing industry or a particular manufacturing industry and productive service industry[9-10].Liu Tingting et al. analyzed the industrial association and spatial linkage of productive service and manufacturing industries in Beijing and Tianjin using methods such as geographic linkage rate, and provided suggestions for the optimization, upgrading and rational layout of Beijing-Tianjin industries[11]. Xu Yingying et al. used input-output models to study the industrial linkages of high-tech manufacturing industries in Beijing, Tianjin and Hebei, and the study found that there is a more obvious mismatch of resources in Beijing and Hebei[12]. Guan Wei et al. pointed out that in terms of economic effects, the driving effect of the manufacturing industry in Liaoning Province on the national economy weakened during 2002-2012, and the pulling effect of the manufacturing industry chain on the national economy has more room for improvement[13]. Based on the input-output tables of Tianjin in 1997 and 2002, Cao Yi et al. analyzed the industrial linkage between productive service industries and manufacturing industries in Tianjin, which helps to provide a scientific basis for formulating industrial development policies, promoting industrial structure upgrading and improving the service functions of the city[14]. Yang, Chengfeng et al. measured the industrial correlation status of each industry category in Beijing from the perspective of industrial correlation in the perspective of function deconstruction, in order to provide some reference for the deconstruction of non-capital functions[15].

Throughout the research, the existing research on manufacturing industry association in China is mainly carried out in three scales: national, regional and provincial-urban research on manufacturing industry subdivision, manufacturing industry and a certain industry, industrial association between a sub-industry of manufacturing industry and a certain industry, as well as the spillover effect of backward and forward association of manufacturing industry. Few studies have addressed the analysis of intra- and inter-regional industrial linkages and economic distances in manufacturing industries at different technology levels. In view of this, the industry-related economic distance indices are measured for different levels of manufacturing industries, and the intensity and economic distance of manufacturing industries at different technological levels within and between regions are analyzed, with a view to providing reference suggestions for coordinating the regional industrial division of labor and promoting the high-quality development of regional manufacturing industries.

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2. Research Methods and Data

2.1. Research Methodology

Using data from input-output tables to study the relationship between industry chains from the perspective of production chains, it is possible to avoid asking whether the link is a forward or backward link and to visualize the link between manufacturing regions at different levels. The Dutch input-output scholar Dietzenbacher et al. proposed the input-output based APL (average propagation lengths) model, which introduces the concept of economic distance between industries and uses different level numbers to represent the length of economic distance, the smaller the value, the shorter the economic distance[16-17], but the APL model fails to reflect the degree of sectoral association, so Tang et al. constructed an associated economic distance index[18]. Among them, association reflects the closeness of industrial linkage, and economic distance reflects the number of intermediate production links in the industry. Applying this model, we can calculate the associated economic distance index of different levels of manufacturing industries within and between regions, and the regional industry associated economic distance index includes backward associated economic distance index and forward associated economic distance index.

2.1.1. Backward Correlation Economic Distance Index

Take the demand-driven Leontief inverse matrix as an example:

$$L = (I - A)^{-1} = I + A + A^2 + \cdots + A^n \tag{1}$$

$$x = (I - A)^{-1} f = Lf = (I + A + A^2 + \cdots + A^n) f \tag{2}$$

Where L is the matrix of complete demand coefficient, and from the demand-driven point of view, A is the one-step indirect influence on all departments, A2 is the two-step indirect influence on all departments, An is the N indirect influence, and A is the direct consumption matrix.

Introducing the standard scale matrix model $\bar{A}$, the elements of the matrix are $(\bar{a})_{n\times n}$:

$$\bar{a} = \left(\frac{1}{n^2}\sum_{j=1}^{n}\sum_{i=1}^{n} x_{ij}\right) / \left(\frac{1}{n}\sum_{j=1}^{1} x_{ij}\right) \tag{3}$$

Construct a standard production chain:

$$[D]_{ij} = [\bar{A}]_{ij} + 2\left[\overline{A^2}\right]_{ij} + 3\left[\overline{A^3}\right]_{ij} + \cdots n[\overline{A^n}]_{ij} \ \ (i, j = 1,2,\cdots,n) \tag{4}$$

Then the backward correlation economic distance index W_{ij} for any two sectors in the unified economic system is measured as:

$$[W]_{ij} = [S]_{ij}/[D]_{ij} \tag{5}$$

Among them, $[S] = A + 2A^2 + 3A^3 + \cdots + nA^n \ \ (i, j = 1,2,\cdots,n)$, using formula (1), we can calculate $S = L(L - I)$.

2.1.2. Forward-Linked Economic Distance Index

Taking the Gaussian matrix of the initial push as an example:

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$$G = (I - B)^{-1} = I + B + B^2 + \cdots + B^n \tag{6}$$

where G is the Gaussian matrix and B is the direct assignment matrix.
Introducing the standard scale matrix model $\bar{B}$, the elements of the matrix are $(\bar{b})_{n\times n}$:

$$\bar{b} = \left(\frac{1}{n^2}\sum_{i=1}^{n}\sum_{j=1}^{n} x_{ij}\right) / \left(\frac{1}{n}\sum_{i=1}^{1} x_{ij}\right) \tag{7}$$

According to the input-output balance principle it is known that:

$$\bar{B}_{n\times n} = (\bar{b}_{ij})_{n\times n} = (\bar{a}_{ij})_{n\times n} = \bar{A}_{n\times n} \tag{8}$$

Then the backward correlation economic distance index for any two sectors in the unified economic system is measured as:

$$[V]_{ij} = [T]_{ij}/[D]_{ij} \tag{9}$$

Among them, $[T] = B + 2B^2 + 3B^3 + \cdots + nB^n$ $(i, j = 1,2,\cdots,n)$, using formula (1), we can calculate $T = L(L - I)$. After deducing the calculation, it is known that $[W]_{ij} = [V]_{ij}$, as detailed in [18].

2.2. Data Sources

China's 2012 inter-regional input-output tables for 31 provinces, autonomous regions and municipalities and China's 2007 inter-regional input-output tables for 30 provinces, autonomous regions and municipalities (excluding Hong Kong, Macao, Taiwan and Tibet Autonomous Region) [19]published by the Key Laboratory of Regional Sustainable Development Analysis and Simulation of the Chinese Academy of Sciences were used.

2.3. Data Processing

Table 1. Manufacturing at different technology levels

Technology levels	Manufacturing
High-end technology	General equipment; Special equipment; Transportation equipment; Electrical machinery and equipment; Communications equipment, Computers and other electronic equipment; Instrumentation; Chemical products
Mid-range technology	Petroleum, coking products and nuclear fuel processing products; Non-metallic mineral products; Metal smelting and rolling processing products; Metal products; Metal products, Machinery and equipment repair services
Low-end technology	Food and tobacco; Textiles; Textiles, clothing, shoes, hats, leather and down and their products; Woodworking products and furniture; Paper printing and stationery and sporting goods; Other manufactured products; Scrap waste

In order to focus on manufacturing industries at different technological levels in each region, with reference to the division criteria of existing studies[20]. Firstly, the inter-regional input-

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output tables of 2007 and 2012 were combined into eight regions, and secondly, drawing on the division of manufacturing industries based on the OECD manufacturing classification by Korean scholar Lee Hyun-ju, manufacturing industries were divided into three categories of high-end, mid-range, and low-end technology industries[21], and the 2012 inter-regional input-output tables of each specific industry in the manufacturing industry were classified into the above three categories, see table 1, and the remaining industries were combined according to the National Economic Classification of Industries (GB/T4754-2017).

3. China 2007 and 2012 Manufacturing Regional Correlation Analysis

To study the interdependence between industries in different regions, we used interregional input-output tables and calculated regional correlated economic distance indices for 2007 and 2012 for manufacturing industries at different technology levels in eight regions as shown in Tables 2 and 3.

3.1. Forward-linked Economic Distance Index Analysis

From the perspective of the initial input drive to examine the forward linkage economic distance index can be concluded: in 2007, the eight regions, whether intra-regional or inter-regional low-end manufacturing and high-end manufacturing to its own sector to promote the largest production chain forward linkage economic distance index; high-end manufacturing or mid-range manufacturing itself to the mid-range manufacturing sector to promote the largest production chain forward linkage economic distance index. The low-end manufacturing industry as an industrial sector with lower technical requirements, the high-end manufacturing industry as an industrial sector with higher technical requirements both have a large direct consumption of their own department, while the mid-range manufacturing industry as the main energy-consuming sector not only needs technology as support, but also the input of its own department, so the high-end manufacturing industry and the mid-range manufacturing industry as the most direct upstream industry of the mid-range manufacturing industry to promote its development.

In the region, the development of mid-range manufacturing in the northern coastal region, the central region, and the northwest region is mainly driven by the sector itself for its development, while the development of mid-range manufacturing in the northeast, Beijing and Tianjin, the eastern coast, and the southern coast is driven by the high-end manufacturing sector. Between regions, the largest economic distance of the forward linkage of the production chain, which is mainly driven by the low-end manufacturing industry in the eastern and southern coastal regions to the low-end manufacturing sector in the rest of the regions (except the northeast and Beijing-Tianjin regions), and the largest economic distance of the forward linkage of the production chain, which is driven by the high-end manufacturing industry in the eastern and southern coastal regions to the middle and high-end manufacturing sector in the rest of the regions (except the northeast region). By 2012 the 8 regions both intra-regional and inter-regional, it can be seen that the number of sectors with the largest manufacturing forward linkage economic distance index - the high-end manufacturing sector - is increasing.

From 2007 to 2012, the calculation results show a gradual increase in the number of sectors with the largest forward linkage economic distance index for low-end manufacturing and mid-range manufacturing to high-end manufacturing in the eight regions, reflecting the increasing reliance on technology for manufacturing at the low- and mid-technology levels.

3.2. Backward Linkage Economic Distance Index Analysis

The results of the calculation of the backward linkage economic distance index from the perspective of the final demand pull can be concluded that the backward linkage economic distance index of the production chain constituted by the pull of low-end manufacturing and

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high-end manufacturing to their own sectors is the largest in the eight regions in 2007, and the backward linkage degree of the production chain constituted by the pull of the construction industry to the middle manufacturing sector is the largest and the economic distance is the shortest. The construction industry is a large consumption between the mid-range manufacturing industry, but also the most direct downstream industry of the mid-range manufacturing industry. By 2012, the backward-linked sectors of manufacturing industries of different technology levels in the region were basically unchanged, and the backward-linked economic distance indexes all increased, indicating that the pulling effect of industrial sectors of different technology levels in the region on themselves was enhanced.

From the inter-regional point of view, in 2007, the low-end manufacturing industry has the largest degree of association with the production chain constituted by its own pull and the shortest economic distance, the construction industry or the mid-range manufacturing industry itself has the largest economic distance index associated with the production chain constituted by the mid-range manufacturing industry, and the mid-range manufacturing industry, high-end manufacturing industry, electricity and heat supply industry and the construction industry have the largest economic distance index associated with the production chain constituted by the high-end manufacturing industry. It can be seen that high-end manufacturing industry pulls the development of more industries, and the role of high-end technology in the manufacturing industry is becoming more and more important; as far as the mid-range manufacturing industry is concerned in 2012, in addition to the construction industry and the mid-range manufacturing industry itself, high-end manufacturing industry has also been added, and the pulling effect of technology on the mid-range manufacturing industry has been revealed; as far as the high-end manufacturing industry is concerned, the sectors with the largest backward correlation economic distance index, except for the electricity in the eastern region Heat supply industry and the central region and the northwest region of the high-end manufacturing industry constitute the shortest backward associated economic distance, the northwest region of the mid-range manufacturing industry and the southwest region of the high-end manufacturing industry constitute the largest degree of backward association and the shortest economic distance, the rest are the high-end manufacturing industry between different regions to the high-end manufacturing industry pull constitutes a large degree of association of the production chain, the economic distance is short. The sector with the largest backward correlation economic distance index of the Beijing-Tianjin region to the mid-range manufacturing industry in the northeast region changed from the mid-range manufacturing industry itself in 2007 to the construction industry in 2012, reflecting the rapid development of the construction industry in the Beijing-Tianjin region. The sector with the largest backward correlation economic distance index of the northwest region to the middle-end manufacturing industry in the eastern coastal region changes from the construction industry in 2007 to the high-end manufacturing industry in 2012, reflecting the rapid development of the high-end manufacturing industry in the northwest region.

Table 2. 2007 China manufacturing industry associated economic distance index

Region name	Sectors with the largest manufacturing forward linkage economic distance index				
	Manufacturing	In-region	Index	Inter-regional	Index
Northeast region	Low-end manufacturing	Low-end manufacturing	6.354	(Northern coast) Low-end manufacturing	2.062
	Mid-range manufacturing	High-end manufacturing	12.211	(Eastern coast) High-end manufacturing	4.510
	High-end manufacturing	High-end manufacturing	12.672	(Northern coast) High-end manufacturing	2.652

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Beijing-Tianjin region	Low-end manufacturing	Other services	4.264	(Eastern coast) High-end manufacturing	1.374
	Mid-range manufacturing	High-end manufacturing	7.207	(Eastern coast) High-end manufacturing	5.601
	High-end manufacturing	High-end manufacturing	4.808	(Eastern coast) High-end manufacturing	2.139
Northern coastal region	Low-end manufacturing	Low-end manufacturing	12.077	(Eastern coast) Low-end manufacturing	1.775
	Mid-range manufacturing	Mid-range manufacturing	15.041	(Eastern coast) High-end manufacturing	6.673
	High-end manufacturing	High-end manufacturing	16.487	(Eastern coast) High-end manufacturing	3.313
Eastern coastal region	Low-end manufacturing	Low-end manufacturing	10.841	(Southern coast) Low-end manufacturing	1.546
	Mid-range manufacturing	High-end manufacturing	17.103	(Southern coast) High-end manufacturing	1.869
	High-end manufacturing	High-end manufacturing	10.671	(Southern coast) High-end manufacturing	1.590
Southern coastal region	Low-end manufacturing	Low-end manufacturing	7.473	(Eastern coast) Low-end manufacturing	1.264
	Mid-range manufacturing	High-end manufacturing	9.464	(Eastern coast) High-end manufacturing	4.143
	High-end manufacturing	High-end manufacturing	7.292	(Eastern coast) High-end manufacturing	1.476
Central region	Low-end manufacturing	Low-end manufacturing	9.351	(Eastern coast) Low-end manufacturing	1.878
	Mid-range manufacturing	Mid-range manufacturing	11.903	(Eastern coast) High-end manufacturing	6.062
	High-end manufacturing	High-end manufacturing	7.537	(Eastern coast) High-end manufacturing	3.181
Southwest region	Low-end manufacturing	Low-end manufacturing	5.362	(Eastern coast) Low-end manufacturing	1.291
	Mid-range manufacturing	Construction	8.421	(Southern coast) High-end manufacturing	5.512
	High-end manufacturing	High-end manufacturing	10.153	(Southern coast) High-end manufacturing	2.943
Northwest region	Low-end manufacturing	Low-end manufacturing	3.071	(Eastern coast) Low-end manufacturing	3.290
	Mid-range manufacturing	Mid-range manufacturing	4.685	(Eastern coast) High-end manufacturing	7.562
	High-end manufacturing	High-end manufacturing	4.497	(Eastern coast) High-end manufacturing	3.803
Region name	Sectors with the largest manufacturing backward linkage economic distance index				
	Manufacturing	In-region	Index	Inter-regional	Index
Northeast region	Low-end manufacturing	Low-end manufacturing	6.354	(Beijing-Tianjin region) Low-end manufacturing	0.548
	Mid-range manufacturing	Construction	12.371	(Beijing-Tianjin region) Mid-range manufacturing	1.449
	High-end manufacturing	High-end manufacturing	12.672	(Northern coast) High-end manufacturing	1.387

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Beijing-Tianjin region	Low-end manufacturing	Low-end manufacturing	1.727	(Northeast region) Low-end manufacturing	0.157
	Mid-range manufacturing	Mid-range manufacturing	6.689	(Northeast region) Construction	0.683
	High-end manufacturing	High-end manufacturing	4.808	(Northwest region) High-end manufacturing	1.008
Northern coastal region	Low-end manufacturing	Low-end manufacturing	12.077	(Beijing-Tianjin region) Low-end manufacturing	2.165
	Mid-range manufacturing	Construction	17.192	(Beijing-Tianjin region) Construction	8.833
	High-end manufacturing	High-end manufacturing	16.487	(Beijing-Tianjin region) Construction	4.130
Eastern coastal region	Low-end manufacturing	Low-end manufacturing	10.841	(Southern region) Low-end manufacturing	2.232
	Mid-range manufacturing	Construction	10.154	(Northwest region) Construction	2.082
	High-end manufacturing	High-end manufacturing	10.671	(Northwest region) High-end manufacturing	2.982
Southern coastal region	Low-end manufacturing	Low-end manufacturing	7.473	(Beijing-Tianjin region) Low-end manufacturing	1.046
	Mid-range manufacturing	Construction	8.153	(Southwest region) Construction	2.112
	High-end manufacturing	High-end manufacturing	7.292	(Southwest region) High-end manufacturing	2.838
Central region	Low-end manufacturing	Low-end manufacturing	9.351	(Southern region) Low-end manufacturing	1.614
	Mid-range manufacturing	Construction	14.421	(Eastern region) Construction	3.771
	High-end manufacturing	High-end manufacturing	7.537	(Northern region) Electricity and heat industry	1.364
Southwest region	Low-end manufacturing	Low-end manufacturing	5.362	(Beijing-Tianjin region) Low-end manufacturing	0.604
	Mid-range manufacturing	Construction	8.421	(Southern region) Mid-range manufacturing	3.155
	High-end manufacturing	High-end manufacturing	10.153	(Southern region) Mid-range manufacturing	0.997
Northwest region	Low-end manufacturing	Low-end manufacturing	3.071	(Beijing-Tianjin region) Low-end manufacturing	0.877
	Mid-range manufacturing	Construction	6.084	(Beijing-Tianjin region) Mid-range manufacturing	1.522
	High-end manufacturing	High-end manufacturing	4.497	(Beijing-Tianjin region) Low-end manufacturing	0.596

Table 3. 2012 China Manufacturing Industry Associated Economic Distance Index

Region name	Sectors with the largest manufacturing forward linkage economic distance index				
	Manufacturing	In-region	Index	Inter-regional	Index
Northeast region	Low-end manufacturing	Low-end manufacturing	10.787	(Eastern coastal region) High-end manufacturing	1.665
	Mid-range manufacturing	High-end manufacturing	12.812	(Eastern coastal region) High-end manufacturing	4.222

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	High-end manufacturing	High-end manufacturing	14.097	(Eastern coastal region) High-end manufacturing	1.946
Beijing-Tianjin region	Low-end manufacturing	Other services	8.014	(Eastern coastal region) High-end manufacturing	2.709
	Mid-range manufacturing	High-end manufacturing	8.764	(Eastern coastal region) High-end manufacturing	6.563
	High-end manufacturing	High-end manufacturing	11.956	(Eastern coastal region) High-end manufacturing	2.785
Northern coastal region	Low-end manufacturing	Low-end manufacturing	23.089	(Southern coastal region) Low-end manufacturing	1.744
	Mid-range manufacturing	High-end manufacturing	23.219	(Eastern coastal region) High-end manufacturing	6.232
	High-end manufacturing	High-end manufacturing	25.474	(Eastern coastal region) High-end manufacturing	2.647
Eastern coastal region	Low-end manufacturing	Low-end manufacturing	12.204	(Southern coastal region) Low-end manufacturing	1.248
	Mid-range manufacturing	High-end manufacturing	23.281	(Eastern region) High-end manufacturing	1.675
	High-end manufacturing	High-end manufacturing	17.521	(Eastern region) High-end manufacturing	1.663
Southern coastal region	Low-end manufacturing	Low-end manufacturing	10.428	(Eastern coastal region) High-end manufacturing	0.963
	Mid-range manufacturing	High-end manufacturing	10.695	(Eastern coastal region) High-end manufacturing	2.808
	High-end manufacturing	High-end manufacturing	12.473	(Eastern coastal region) High-end manufacturing	0.987
Central region	Low-end manufacturing	Low-end manufacturing	14.184	(Eastern coastal region) High-end manufacturing	2.051
	Mid-range manufacturing	Mid-range manufacturing	14.628	(Eastern coastal region) High-end manufacturing	5.461
	High-end manufacturing	High-end manufacturing	13.248	(Eastern coastal region) High-end manufacturing	2.160
Southwest region	Low-end manufacturing	Low-end manufacturing	7.226	(Eastern coastal region) High-end manufacturing	1.329
	Mid-range manufacturing	Construction	10.672	(Eastern coastal region) High-end manufacturing	4.673
	High-end manufacturing	High-end manufacturing	12.292	(Eastern coastal region) High-end manufacturing	1.695
Northwest region	Low-end manufacturing	Low-end manufacturing	6.456	(Eastern coastal region) High-end manufacturing	1.907
	Mid-range manufacturing	Construction	7.701	(Eastern coastal region) High-end manufacturing	7.611
	High-end manufacturing	High-end manufacturing	7.256	(Eastern coastal region) High-end manufacturing	3.525
Region name	Sectors with the largest manufacturing backward linkage economic distance index				
	Manufacturing	In-region	Index	Inter-regional	Index
Northeast region	Low-end manufacturing	Low-end manufacturing	10.787	(Beijing-Tianjin region) Low-end manufacturing	0.850
	Mid-range manufacturing	Construction	13.039	(Beijing-Tianjin region) Construction	1.563

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	High-end manufacturing	High-end manufacturing	14.097	(Northwest region) High-end manufacturing	0.847
Beijing-Tianjin region	Low-end manufacturing	Low-end manufacturing	5.740	(Northwest region) Low-end manufacturing	0.229
	Mid-range manufacturing	Mid-range manufacturing	8.304	(Eastern coastal region) Mid-range manufacturing	0.681
	High-end manufacturing	High-end manufacturing	11.956	(Northwest region) High-end manufacturing	0.856
Northern coastal region	Low-end manufacturing	Low-end manufacturing	23.089	(Beijing-Tianjin region) Low-end manufacturing	2.838
	Mid-range manufacturing	Construction	22.646	(Eastern coastal region) Mid-range manufacturing	3.552
	High-end manufacturing	High-end manufacturing	25.474	(Beijing-Tianjin region) Construction	1.926
Eastern coastal region	Low-end manufacturing	Low-end manufacturing	12.204	(Beijing-Tianjin region) Low-end manufacturing	1.691
	Mid-range manufacturing	Construction	12.012	(Northwest region) High-end manufacturing	1.418
	High-end manufacturing	High-end manufacturing	17.521	(Northwest region) High-end manufacturing	4.487
Southern coastal region	Low-end manufacturing	Low-end manufacturing	10.428	(Beijing-Tianjin region) Low-end manufacturing	0.947
	Mid-range manufacturing	Construction	10.842	(Southwest region) Construction	0.899
	High-end manufacturing	High-end manufacturing	12.473	(Northwest region) High-end manufacturing	1.227
Central region	Low-end manufacturing	Low-end manufacturing	14.184	(Beijing-Tianjin region) Low-end manufacturing	1.879
	Mid-range manufacturing	Construction	16.935	(Eastern region) Construction	3.868
	High-end manufacturing	High-end manufacturing	13.248	(Eastern region) Electric power industry	1.797
Southwest region	Low-end manufacturing	Low-end manufacturing	7.226	(Beijing-Tianjin region) Low-end manufacturing	0.582
	Mid-range manufacturing	Construction	10.285	(Eastern region) Construction	1.085
	High-end manufacturing	High-end manufacturing	12.292	(Northwest region) Mid-range manufacturing	0.735
Northwest region	Low-end manufacturing	Low-end manufacturing	6.456	(Beijing-Tianjin region) Low-end manufacturing	0.387
	Mid-range manufacturing	Construction	10.340	(Eastern region) Mid-range manufacturing	1.757
	High-end manufacturing	High-end manufacturing	7.256	(Eastern region) Electric power industry	0.596

According to the calculation results of the associated economic distance index of manufacturing industry in eight regions of the country in Table 1 and Table 2, we further analyze the changes of the production chains between regions with the greatest degree of association and the shortest economic distance between manufacturing industry and upstream and downstream industries in different technology levels from 2007 to 2012, and the main regional distribution is shown in Figure 1 to Figure 6.

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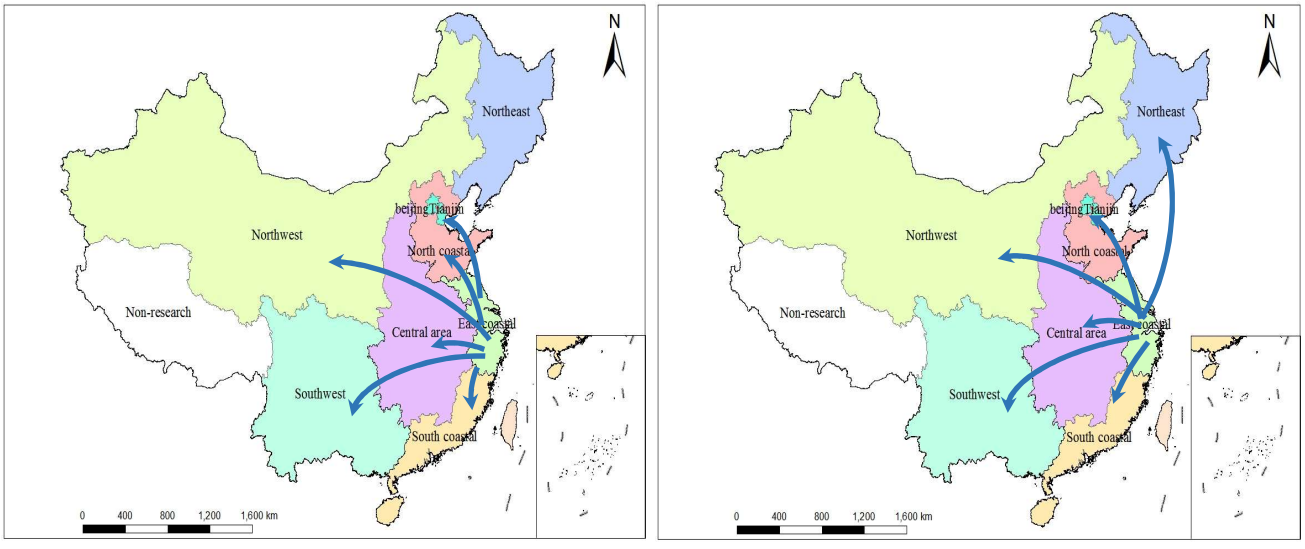
Analyzed from the perspective of initial input promotion, the low-end manufacturing industry in 2007 is mainly the low-end manufacturing industry itself constitutes the largest degree of association and the shortest economic distance in the production chain, and the high-end manufacturing industry and low-end manufacturing industry in the eastern coastal region become the main supply sectors in the Beijing-Tianjin region, the northern coastal region, the southern coastal region, the central region, the southwest region and the northwest region, and the spatial distribution is presented as a spoke dispersion centered on the eastern coast, as shown in Figure 1(a). In 2012, the high-end manufacturing industry in the eastern coastal region is the most connected and the shortest economic distance from the low-end manufacturing industry in the northeast region, Beijing-Tianjin region, southern coastal region, central region, southwest region and northwest region, and the east is still the main supply place, but the high-end manufacturing industry plays an increasingly important role, see Figure 1(b). Comparing the main regional spatial distribution characteristics of the upstream of low-end manufacturing in 2007 and 2012, it can be seen from Figure 1(a) and Figure 1(b) that the spatial radial expansion with the eastern center. In 2007 and 2012, the mid-tier manufacturing industry is mainly the high-end manufacturing industry constitutes the largest degree of association and the shortest economic distance in the production chain. Comparing the main regional spatial distribution characteristics of the upstream of the mid-tier manufacturing industry in 2007 and 2012, it can be seen from Figure 2(c) and Figure 2(d) that the radiation centered on the east spreads to the southwest, northwest and northeast. The high-end manufacturing industry in 2007 and 2012 is mainly its own composition of the production chain with the greatest degree of association and the shortest economic distance. Comparing the main regional spatial distribution characteristics of the upstream of the mid-range manufacturing industry in 2007 and 2012, it can be seen from Figure 3(e) and Figure 3(f) that the main regional spatial distribution characteristics of the upstream of the high-end manufacturing industry are the same as those of the mid-range manufacturing industry.



(a) (b)

Figure 1. 2007-2012 Change in low-end manufacturing forward linkage variable economic distance

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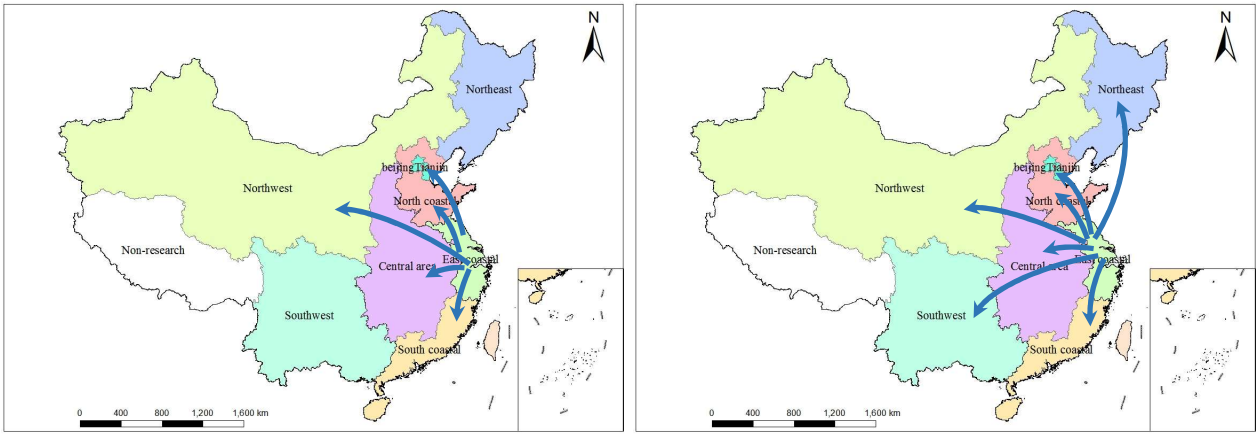
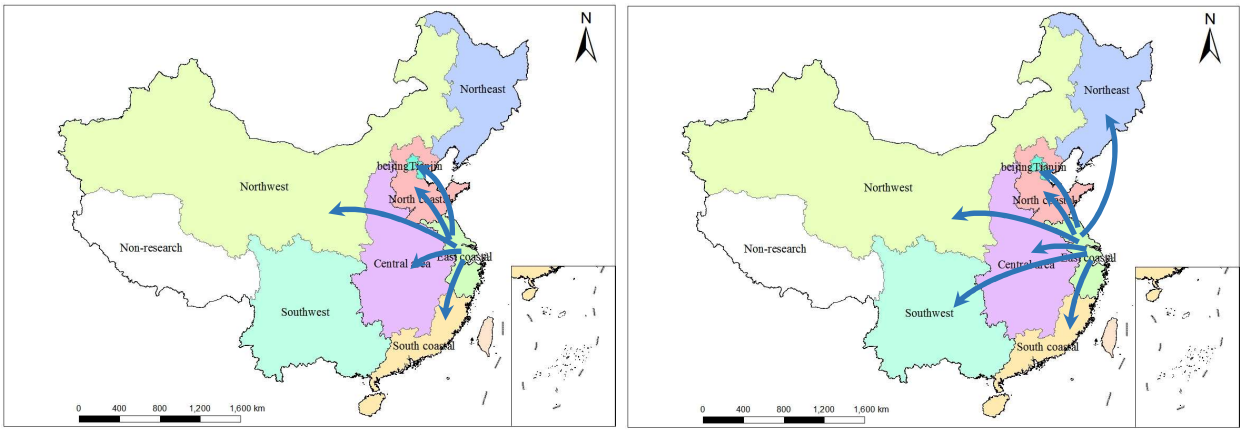


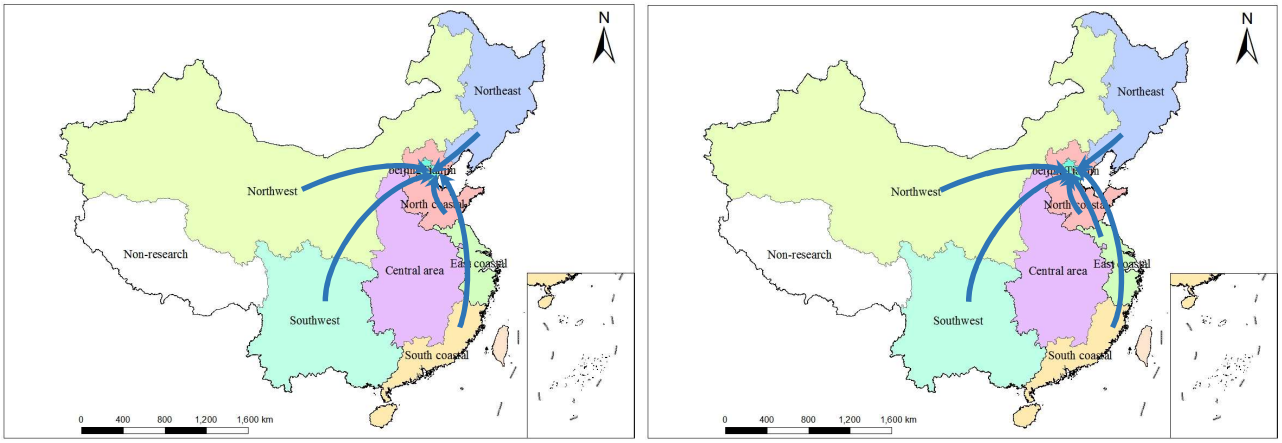
(c) (d)

Figure 2. 2007-2012 Change in mid-tier manufacturing forward linkage variable economic distance



(e) (f)

Figure 3. 2007-2012 Change in high-end manufacturing forward linkage variable economic distance



(g) (h)

Figure 4. 2007-2012 Change in low-end manufacturing backward linkage variable economic distance

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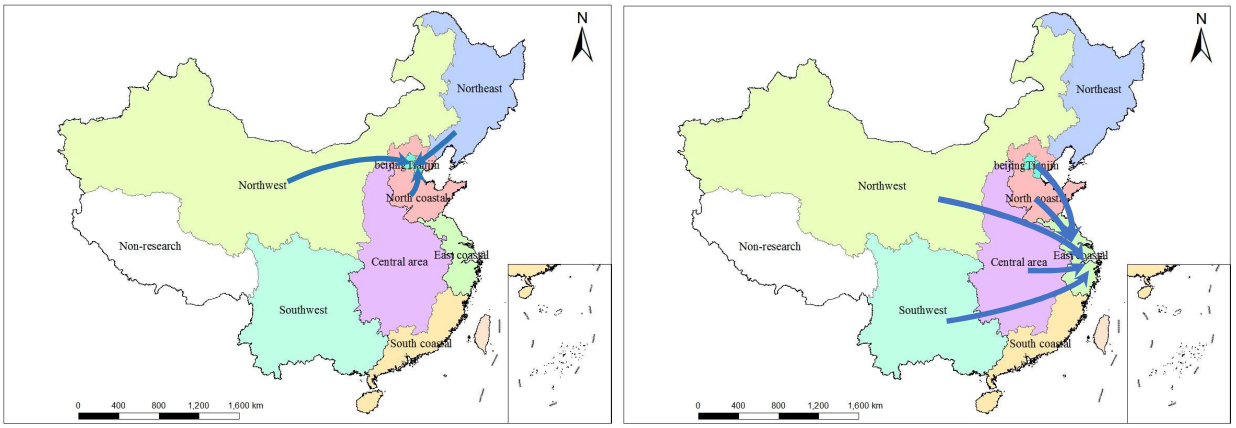
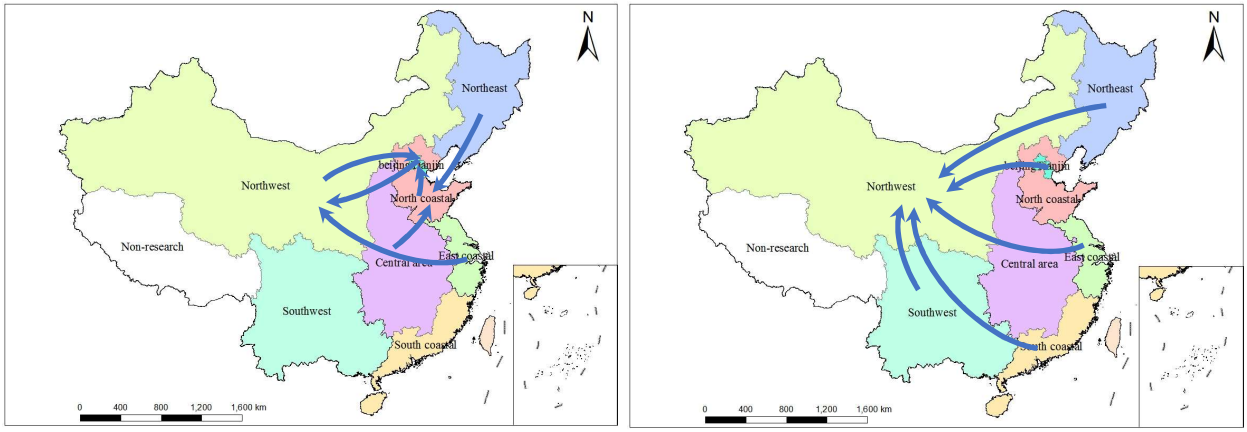


(i) (j)

Figure 5. 2007-2012 Change in mid-range manufacturing backward linkage variable economic distance



(k) (l)

Figure 6. 2007-2012 Change in high-end manufacturing backward linkage variable economic distance

Analyzed from the perspective of final demand pull, the low-end manufacturing industry is mainly its own, mid-range manufacturing industry is mainly with the construction industry mid-range manufacturing industry itself, high-end manufacturing industry is mainly with its own backward associated with the largest economic distance index. In 2007 and 2012, the low-end manufacturing industry of Beijing-Tianjin region as the downstream industry pulled the low-end manufacturing industry of northeast region, northern coastal region, eastern coastal region, southern coastal region, southwest region and northwest region to form the production chain with the greatest degree of association and the shortest economic distance, and these regions showed the distribution characteristics of spoke-like with Beijing-Tianjin region as the center, and the eastern coastal region was added in 2012, see Figure 4 (g) and Figure 4 (h). In 2007, the mid-range manufacturing industry was driven by the construction industry and mid-range manufacturing industry in Beijing-Tianjin region as the downstream industry, and the industry linkage of the production chain constituted by the mid-range manufacturing industry in the northeast region, the northern coastal region and the northwest region was the largest and the shortest economic distance, and these three regions showed the distribution characteristics of the Beijing-Tianjin region as the center in the form of spokes. In 2012, the middle-end manufacturing industry is pulled by the construction industry and middle-end manufacturing industry in the eastern coastal region as the downstream industry, and the

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industry of the production chain composed of the middle-end manufacturing industry in the Beijing-Tianjin region, the northern coastal region, the central region, the southwestern region and the northwestern region has the greatest degree of industrial association and the shortest economic distance, and the distribution characteristics of these three regions have changed to a spoke shape with the eastern coastal region as the center, and it can be seen from Figure 5(i) and Figure 5(j) that the confluence of the downstream industry of the middle-end manufacturing industry has shifted from the Beijing-Tianjin region to the eastern coastal region.

In 2007, the high-end manufacturing industry was driven by the high-end manufacturing industry in the northwest and the high-end manufacturing industry in the northern coastal region and the electric power and heat industry as the downstream industry, and the high-end manufacturing industry in the Beijing-Tianjin region, the eastern coastal region, the northeast region and the central region constituted the largest and shortest economic distance in the production chain. In 2012, the high-end manufacturing industry was pulled by the high-end manufacturing industry in the northwest and the mid-range manufacturing industry as a downstream industry in the northeast region, Beijing-Tianjin region, the eastern coastal region, the southern coastal region and the high-end manufacturing industry in the southwest region, which constituted the largest degree of industrial association and the shortest economic distance in the production chain, and these five regions showed the distribution characteristics of a convergence to the northwest region, see Figure 6(l).

In addition, the calculation results in Tables 1 and 2 further reveal that whether it is the forward linkage economic distance index or the backward linkage economic distance index, the intra-regional index values are much larger than the inter-regional index values in the eight regions from 2007 to 2012, indicating that the intra-regional industrial linkage is stronger than the inter-regional industrial linkage in 2007 and 2012.

4. Conclusion and Discussion

Linkage reflects the closeness of the degree of connection between industries, i.e., the strength of the connection between industry sectors; economic distance reflects the number of intermediate production links between industries, i.e., the length of the connection between industry sectors. To study the degree of linkage between two industries, the strength and length of the linkage are equally important. A standard production chain constructed using a standard scale determined in the same economic system is compared with a production chain composed of any two sectors to reflect the economic distance and degree of association between the two sectors, including the forward linkage economic distance index from the push perspective and the backward linkage economic distance index from the demand perspective. Using the empirical analysis of China's inter-regional input-output tables in 2007 and 2012, the calculation results show that in terms of regional spatial distribution, both intra-regional and inter-regional low-end manufacturing and high-end manufacturing industries have the largest forward correlation economic distance index to their own sectors, and high-end manufacturing or mid-range manufacturing industries have the largest forward correlation economic distance index to the mid-range manufacturing sector. The index is the largest, while the regional low-end manufacturing industry and high-end manufacturing industry to its own sector pull constitutes the largest production chain backward associated economic distance index, the construction industry to the middle manufacturing sector pull constitutes the largest production chain backward associated degree, and the shortest economic distance, the inter-regional construction industry or the middle manufacturing industry itself to the middle manufacturing industry constitutes the largest production chain associated economic distance index, the middle manufacturing industry, high-end The economic distance index of the production chain associated with the middle-end manufacturing industry, the high-end

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manufacturing industry, the electricity and heat supply industry and the construction industry to the high-end manufacturing industry is the largest.

From the perspective of the structure of upstream and downstream industries, low-end manufacturing and high-end manufacturing as their own industry supply industries, changes in the supply and demand of low-end manufacturing and high-end manufacturing will have a greater impact on their own. Similarly, as the upstream industry, changes in the supply of the middle-end manufacturing industry or high-end manufacturing industry will have a greater impact on the middle-end manufacturing industry, while as the downstream industry, changes in the demand of the construction industry and the middle-end manufacturing industry will have a greater impact on the middle-end manufacturing industry. It is also found that the backward and forward correlation economic distance index of manufacturing industries of different technology levels in 2007-2012 is larger in the region than in the inter-region, which indicates that the manufacturing industries of different technology levels in the region are more closely connected economically than in the inter-region. In addition, compared with the same region from 2007 to 2012, the middle and high-end manufacturing industries within the region have large associated economic distance indices, indicating that the middle manufacturing industries or high-end manufacturing industries are more closely linked within the region, and the majority of the regional middle manufacturing industries between regions have large associated economic distance indices, indicating that the middle manufacturing industries are more closely linked spatially across regions.

The economic distance index of economic linkages is not an absolute value, but a relative value, i.e. relative size is compared between sectors. In addition, the production structure of the existing national economic system, i.e., the direct consumption and distribution coefficients also determine the closeness of the links between industrial sectors, and the relative size of the total output of each sector determines the relative size of the sectoral correlation economic distance index. In the development of national economy, the high quality development of manufacturing industry plays a fundamental role, and the rationalization of industrial structure is an important way to realize the high quality development of manufacturing industry. The changes of production technology and industrial scale of manufacturing industry in any technical level will be passed to all industries in different regions through upstream and downstream. Therefore, the inter-regional input-output table is used to calculate the regional industry-linked economic distance of manufacturing industries to find the key production chains of manufacturing industries at different technology levels, which not only have fewer intermediate links and shorter economic distances, but also have a closer degree of industry linkage, which can bring more direct and effective impact. In order to provide a reference for the relevant departments in the development of industrial planning, limited to the timeliness of input-output data, the study is not more in-depth, and we hope that we can continue to study this area in depth later.

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