

Spatial linkage of manufacturing industries in China: based on interregional input-output analysis

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Abstract:

Analysis on spatial pattern of industrial linkages may provide insights on economic interaction across regions. This paper examined spatial pattern of forward and backward linkages for manufacturing sectors in China based on China interregional input-output model 2002. All the manufacturing sectors are divided into three types: Foods, textile and light industries, Raw material sectors, Processing and manufacturing sectors. There are stronger intra-provincial linkages of Foods, textile and light industries in Henan, Jiangxi, Hebei and Henan of Central China. Jiangsu, Shanghai and Shandong of coastal areas are characterized by inter-provincial linkages of Foods, textile and light industries. Significant inter-provincial forward linkages and intra-provincial backward linkages of Raw material sectors can be observed in some central and west provinces such as Shanxi, Henan and Sichuan. It probably results from their rich mineral resources and relatively rare processing and manufacturing sectors. For Processing and manufacturing sectors, higher forward and backward linkages lie in same province or between neighbor provinces, especially in Shanghai, Jiangsu, Zhejiang and Shandong of coastal areas. The relatively complete industrial system that can provide sets of equipments and accessories locally may be the reasons of higher intra-provincial linkages in coastal provinces.

Key words: spatial industrial linkage, forward and backward linkage, manufacturing industries, interregional interaction, China interregional IO model,

Analysis on spatial pattern of industrial linkages may provide insights on economic interaction across regions. Generally, forward and backward linkages encourage enterprises to get spatial agglomerated to decrease transportation coast. However, for different industries, the relationship between industry linkages and spatial concentration is different. For Processing and manufacturing industries the intermediate input of which are relatively high, the sectors with close input-output linkages tend to have high inter-industry concentration degrees; but for resource-based industries, industry linkages and spatial concentration are not significantly related (Guoxia Ma and Minjun Shi). In the 1960s, the Three-line Construction under planned economics system transferred part of the manufacturing enterprises to inland, which caused industry linkages and spatial concentration not definitely correlative. This paper examined spatial patterns of forward and backward linkages of manufacturing sectors in China based on China interregional

input-output model 2002.

1. Data source and methods

1.1 Data source

All the calculations in this paper are based on China interregional input-output model 2002 (China IRIO2002). China IRIO2002 is a 30- region, 60-sector interregional input-output table which is compiled based on Chenery-Moses model, using non-survey approach. This model is an effective tool to quantitatively study industry linkages, regional disparities and regional interactions.

1.2 Methods

In this paper, direct consumption coefficient a_{ij} and distribution coefficient b_{ij} are selected to represent the input-output relationships among sectors. Considering spatial patterns of forward and backward linkages are related to specific industry characteristics, all the manufacturing sectors are divided into three types: Foods, textile and light industries, Raw material sectors, Processing and manufacturing sectors.

Three types	Sectors
Foods, textile and light industries	Food processing; Textiles; Wearing apparel and Leather; Sawmills and Furniture; Paper, printing and stationary related ,toys products;
Raw material sectors	Petroleum processing and Coking ; Chemicals ; Cement, Glass and Pottery; Steel, Nonferrous metal smelting and pressing
Processing and manufacturing sectors	Metal products; Boiler and other special purpose machinery ; Railroad transport equipment; Motor vehicles; Parts and accessories for motor vehicles and their engines ; Ship building ; Other transport equipment ; Generators and Household electric appliances ; Telecommunication and electronic computer equipment; Instruments, meters and other measuring equipment; Cultural and office equipment

For each type and each region, direct consumption coefficients and distribution coefficients are calculated to examine the intra-province industry linkages and then the 30 regions are divided into four types according to their industry linkage patterns. The direct consumption coefficients and distribution coefficients of neighbor regions are calculated to further observe the spatial linkage pattern of each type of sectors.

2. Results and analysis

2.1 Foods, textile and light industries

For Foods, textile and light industries, the direct consumption coefficients and distribution coefficients of intra-province, neighbor province and non-neighbor province are calculated.

Table2.1.1 direct consumption coefficients and distribution coefficients for Foods, textile and light industries

Region	Direct consumption coefficient			Distribution coefficient		
	Intra -province	neighbor province	non-neighbor province	Intra -province	Neighbor province	non-neighbor province
Beijing	0.65	0.17	0.15	0.50	0.07	0.11
Tianjin	0.68	0.02	0.09	0.42	0.13	0.25
Hebei	0.62	0.06	0.10	0.55	0.10	0.09
Shanxi	0.92	0.01	0.01	0.52	0.03	0.04
Inner Mongolia	0.80	0.05	0.04	0.53	0.12	0.12
Liaoning	0.89	0.02	0.06	0.46	0.12	0.13
Jilin	0.73	0.10	0.06	0.60	0.09	0.06
Heilongjiang	0.68	0.02	0.04	0.519	0.07	0.14
Shanghai	0.64	0.03	0.05	0.49	0.10	0.19
Jiangsu	0.68	0.05	0.05	0.53	0.07	0.18
Zhejiang	0.69	0.08	0.10	0.63	0.07	0.08
Anhui	0.758	0.04	0.03	0.49	0.15	0.11
Fujian	0.78	0.03	0.06	0.55	0.07	0.10
Jiangxi	0.81	0.07	0.04	0.61	0.11	0.09
Shandong	0.64	0.05	0.04	0.53	0.05	0.13
Henan	0.88	0.03	0.03	0.60	0.04	0.12
Hubei	0.88	0.03	0.06	0.59	0.04	0.07
Hunan	0.78	0.08	0.03	0.57	0.09	0.09
Guangdong	0.67	0.06	0.12	0.63	0.05	0.08
Guangxi	0.56	0.08	0.04	0.46	0.13	0.14
Hainan	0.87	0.06	0.07	0.32	0.10	0.25
Chongqing	0.84	0.04	0.06	0.61	0.06	0.13
Sichuan	0.78	0.14	0.06	0.60	0.02	0.07
Guizhou	0.55	0.08	0.01	0.41	0.12	0.11
Yunnan	0.90	0.08	0.01	0.35	0.03	0.08
Shanxi	0.67	0.07	0.19	0.49	0.09	0.14
Gansu	0.87	0.04	0.03	0.43	0.22	0.10
Qinghai	0.93	0.03	0.02	0.50	0.05	0.19
Ningxia	0.74	0.04	0.08	0.54	0.08	0.20
Xinjiang	0.78	0.02	0.04	0.67	0.04	0.10

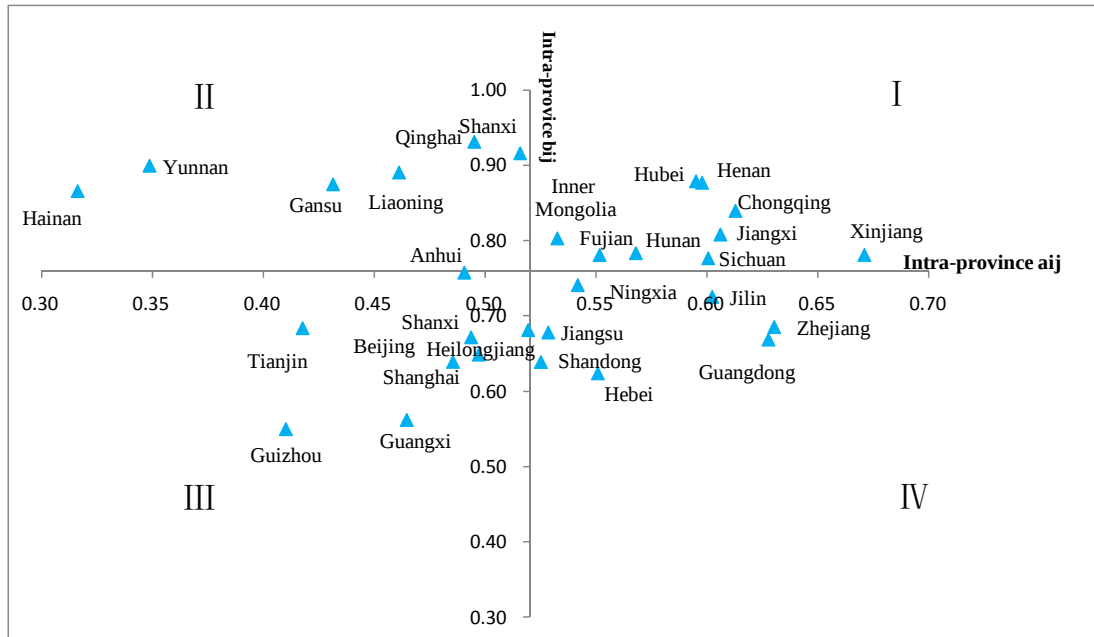


Fig 2.1 Forward and backward linkage patterns for food, textile and light industries

According to their different forward and backward linkage patterns, 30 regions are divided into four types (Fig2.1): I forward introvert and backward introvert: Fujian, Hunan, Hubei, Chongqing, Sichuan, Jiangxi, Henan, Inner Mongolia, and Xinjiang; II forward introvert but backward extrovert: Liaoning, Shanxi, Anhui, Yunnan, Hainan, Gansu and Qinghai; III forward extrovert and backward extrovert: Beijing, Tianjin, Shanghai, Heilongjiang, Shanxi, Guangxi and Guizhou; IV forward extrovert but backward introvert: Zhejiang, Jiangsu, Guangdong, Shandong, Hebei, Jilin and Ningxia.

By comparing the coefficients of neighbor province, it is observed that. Jiangsu, Fujian, Chongqing, Heilongjiang, Henan, Hubei, Shanxi, Qinghai, Ningxia and Xinjiang do not have close forward and backward linkages with neighbor provinces; Hebei, Inner Mongolia, Jilin, Hainan, Shaanxi, Jiangxi, Hunan, Guangxi, and Guizhou have close forward and backward linkages with neighbor provinces; Shanghai, Tianjin, Liaoning, Anhui, and Gansu have close backward linkages with neighbor provinces; Beijing, Guangdong, Zhejiang, Shandong, Sichuan, and Yunnan have close forward linkages with neighbor provinces.

Table2.1.2 shows the comprehensive Result including forward and backward linkages of both intra-province and neighbor province (the items with strong linkages are highlighted with marks). It is observed that provinces in Central region such as Henan, Jiangxi, Hubei, Hunan, Chongqing and Sichuan, have comparatively closer intra-province linkages. Their good agriculture condition but limited product competitiveness make local region not only raw material providers but also product markets; The industry linkages of coastal provinces such as Shanghai, Jiangsu and Shandong are not limited within provinces, which shows that the motivation of agglomeration in coastal regions is not purely local demand, but also the demand of neighbor provinces and even more distant provinces.

Table2.1.2 comprehensive Result including forward and backward linkages of intra-province and neighbor province (Foods, textile and light industries)

Backward linkage	Intra-province			Neighbor province			Non-neighbor province		
Forward linkage	Intra -province	Neighbor province	Non -neighbor province	Intra -province	Neighbor province	Non -neighbor province	Intra -province	Neighbor province	Non -neighbor province
Beijing								★	
Tianjin						★			
Hebei		★			★				
Shanxi							★		
Inner Mongolia	★				★				
Liaoning				★					
Jilin		★			★				
Heilongjiang									★
Shanghai						★			
Jiangsu			★						
Zhejiang		★							
Anhui				★					
Fujian	★								
Jiangxi	★				★				
Shandong		★							
Henan	★								
Hubei	★								
Hunan	★				★				
Guangdong		★							
Guangxi					★				
Hainan				★	★				
Chongqing	★								
Sichuan	★	★							
Guizhou					★				
Yunnan									
Shanxi					★				
Gansu				★					
Qinghai							★		
Ningxia			★						
Xinjiang	★								

2.2 Raw material sectors

For Raw material sectors, the direct consumption coefficients and distribution coefficients of intra-province, neighbor province and non-neighbor province are calculated.

Table2.2.1 direct consumption coefficients and distribution coefficients for Raw material sectors

Region	Direct consumption coefficient			Distribution coefficient		
	Intra -province	neighbor province	non-neighbor province	Intra -province	Neighbor province	non-neighbor province
Beijing	0.71	0.15	0.09	0.44	0.13	0.21
Tianjin	0.74	0.03	0.16	0.48	0.11	0.20
Hebei	0.73	0.14	0.09	0.51	0.16	0.07
Shanxi	0.74	0.11	0.05	0.56	0.07	0.06
Inner Mongolia	0.70	0.16	0.07	0.46	0.18	0.07
Liaoning	0.69	0.09	0.14	0.58	0.04	0.15
Jilin	0.29	0.60	0.10	0.508	0.24	0.08
Heilongjiang	0.82	0.01	0.01	0.45	0.15	0.15
Shanghai	0.88	0.03	0.07	0.48	0.08	0.20
Jiangsu	0.84	0.07	0.09	0.63	0.07	0.09
Zhejiang	0.88	0.09	0.03	0.59	0.08	0.14
Anhui	0.71	0.12	0.08	0.41	0.19	0.15
Fujian	0.79	0.07	0.05	0.67	0.03	0.07
Jiangxi	0.76	0.10	0.03	0.46	0.17	0.13
Shandong	0.84	0.07	0.08	0.61	0.04	0.11
Henan	0.78	0.12	0.13	0.58	0.06	0.09
Hubei	0.85	0.06	0.09	0.51	0.07	0.11
Hunan	0.78	0.08	0.04	0.47	0.11	0.15
Guangdong	0.89	0.05	0.05	0.67	0.03	0.11
Guangxi	0.61	0.15	0.06	0.48	0.12	0.14
Hainan	0.81	0.03	0.02	0.39	0.17	0.18
Chongqing	0.87	0.04	0.09	0.59	0.08	0.11
Sichuan	0.85	0.09	0.06	0.55	0.03	0.12
Guizhou	0.56	0.08	0.07	0.46	0.13	0.16
Yunnan	0.83	0.05	0.08	0.53	0.08	0.16
Shanxi	0.56	0.16	0.15	0.44	0.20	0.12
Gansu	0.47	0.31	0.06	0.37	0.30	0.08
Qinghai	0.62	0.04	0.16	0.45	0.20	0.10
Ningxia	0.54	0.14	0.12	0.35	0.19	0.26
Xinjiang	0.74	0.04	0.04	0.64	0.05	0.08

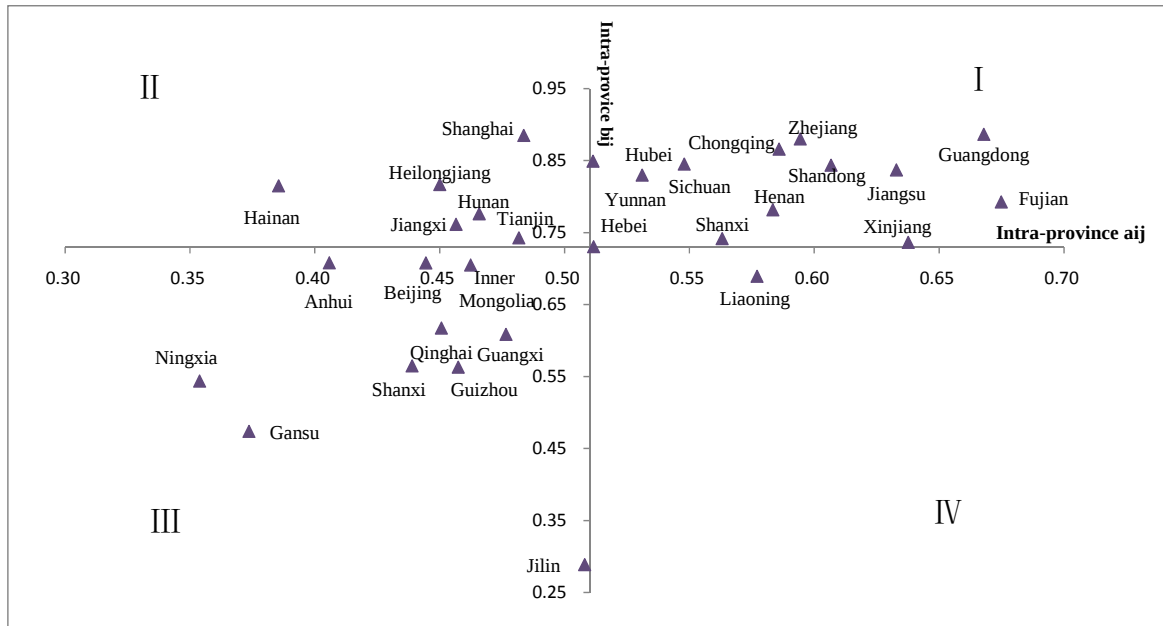


Fig 2.2 Forward and backward linkage patterns for Raw material sectors

According to their different forward and backward linkage patterns, 30 regions are divided into four types (Fig2.2): I forward introvert and backward introvert: Guangdong, Jiangsu, Zhejiang, Shandong, Fujian, Hebei, Chongqing, Sichuan, Henan, Shanxi, Hubei, Yunnan, and Xinjiang; II forward introvert but backward extrovert: Shanghai, Tianjin, Heilongjiang, Hunan, Jiangxi, and Hainan; III forward extrovert and backward extrovert: Beijing, Jilin, Anhui, Guangxi, Shaanxi, Guizhou, Inner Mongolia, Qinghai, Ningxia, and Gansu; IV forward extrovert but backward introvert: Liaoning.

By comparing the coefficients of neighbor province, it is observed that. Jiangsu, Shanghai, Guangdong, Shandong, Tianjin, Fujian, Chongqing, Yunnan, Hubei, and Xinjiang do not have close forward and backward linkages with neighbor provinces; Beijing, Hebei, Guangxi, Jiangxi, Anhui, Ningxia, Shaanxi, Gansu, Jilin, and Inner Mongolia have close forward and backward linkages with neighbor provinces; Heilongjiang, Qinghai, Hainan, Hunan, and Guizhou have close backward linkages with neighbor provinces; Zhejiang, Sichuan, Liaoning, Henan, and Shanxi have close forward linkages with neighbor provinces.

Table2.2.2 shows the comprehensive Result including forward and backward linkages of both intra-province and neighbor province (the items with strong linkages are highlighted with marks). It is observed that most central and western provinces like Shanxi, Henan and Sichuan have strong inter-provincial forward linkages and intra-provincial backward linkages, which may be caused by rich mineral resources but comparably weak industrial foundation, insufficient fund and limited processing level in these regions. Heilongjiang, Jilin and Liaoning of northeastern region are in close interaction with each other, which indicates the high collaboration level within the three northeastern provinces.

Table2.2.2 comprehensive Result including forward and backward linkages of intra-province and neighbor province (Raw material sectors)

Backward linkage	Intra-province			Neighbor province			Non-neighbor province		
Forward linkage	Intra -province	Neighbor province	Non -neighbor province	Intra -province	Neighbor province	Non -neighbor province	Intra -province	Neighbor province	Non -neighbor province
Beijing									✓
Tianjin							✓		
Hebei	✓				✓				
Shanxi	✓	✓							
Inner Mongolia					✓				
Liaoning		✓							
Jilin					✓				
Heilongjiang				✓					
Shanghai							✓		
Jiangsu	✓								
Zhejiang	✓	✓							
Anhui					✓				
Fujian	✓								
Jiangxi				✓	✓				
Shandong	✓								
Henan	✓	✓							
Hubei	✓								
Hunan				✓					
Guangdong	✓								
Guangxi					✓				
Hainan				✓					
Chongqing	✓								
Sichuan	✓	✓							
Guizhou						✓			
Yunnan	✓								
Shanxi					✓				
Gansu					✓				
Qinghai						✓			
Ningxia					✓				
Xinjiang	✓								

2.3 Processing and manufacturing sectors

For Processing and manufacturing sectors, the direct consumption coefficients and distribution coefficients of intra-province, neighbor province and non-neighbor province are calculated.

Table2.3.1 direct consumption coefficients and distribution coefficients for Processing and manufacturing sectors

Region	Direct consumption coefficient			Distribution coefficient		
	Intra -province	neighbor province	non-neighbor province	Intra -province	Neighbor province	non-neighbor province
Beijing	0.71	0.12	0.16	0.67	0.06	0.09
Tianjin	0.562	0.03	0.15	0.520	0.11	0.15
Hebei	0.69	0.06	0.07	0.49	0.11	0.09
Shanxi	0.90	0.02	0.02	0.57	0.05	0.08
Inner Mongolia	0.88	0.08	0.01	0.53	0.09	0.10
Liaoning	0.76	0.03	0.10	0.60	0.03	0.12
Jilin	0.68	0.11	0.09	0.53	0.09	0.09
Heilongjiang	0.85	0.03	0.09	0.32	0.14	0.27
Shanghai	0.771	0.07	0.11	0.52	0.09	0.16
Jiangsu	0.74	0.12	0.06	0.66	0.05	0.08
Zhejiang	0.60	0.09	0.07	0.58	0.08	0.12
Anhui	0.75	0.08	0.07	0.45	0.14	0.13
Fujian	0.81	0.04	0.04	0.67	0.03	0.05
Jiangxi	0.77	0.13	0.03	0.48	0.14	0.11
Shandong	0.80	0.06	0.08	0.61	0.05	0.14
Henan	0.79	0.07	0.09	0.53	0.06	0.12
Hubei	0.80	0.03	0.10	0.58	0.04	0.08
Hunan	0.78	0.08	0.02	0.50	0.12	0.10
Guangdong	0.71	0.05	0.17	0.69	0.02	0.09
Guangxi	0.82	0.06	0.05	0.53	0.12	0.13
Hainan	0.774	0.07	0.04	0.30	0.12	0.20
Chongqing	0.81	0.06	0.11	0.66	0.03	0.08
Sichuan	0.83	0.04	0.09	0.55	0.04	0.10
Guizhou	0.75	0.07	0.06	0.42	0.10	0.16
Yunnan	0.90	0.02	0.04	0.53	0.07	0.18
Shanxi	0.74	0.04	0.14	0.39	0.15	0.17
Gansu	0.64	0.04	0.22	0.37	0.15	0.23
Qinghai	0.76	0.02	0.12	0.41	0.09	0.22
Ningxia	0.73	0.11	0.16	0.33	0.10	0.25
Xinjiang	0.88	0.00	0.04	0.47	0.08	0.17

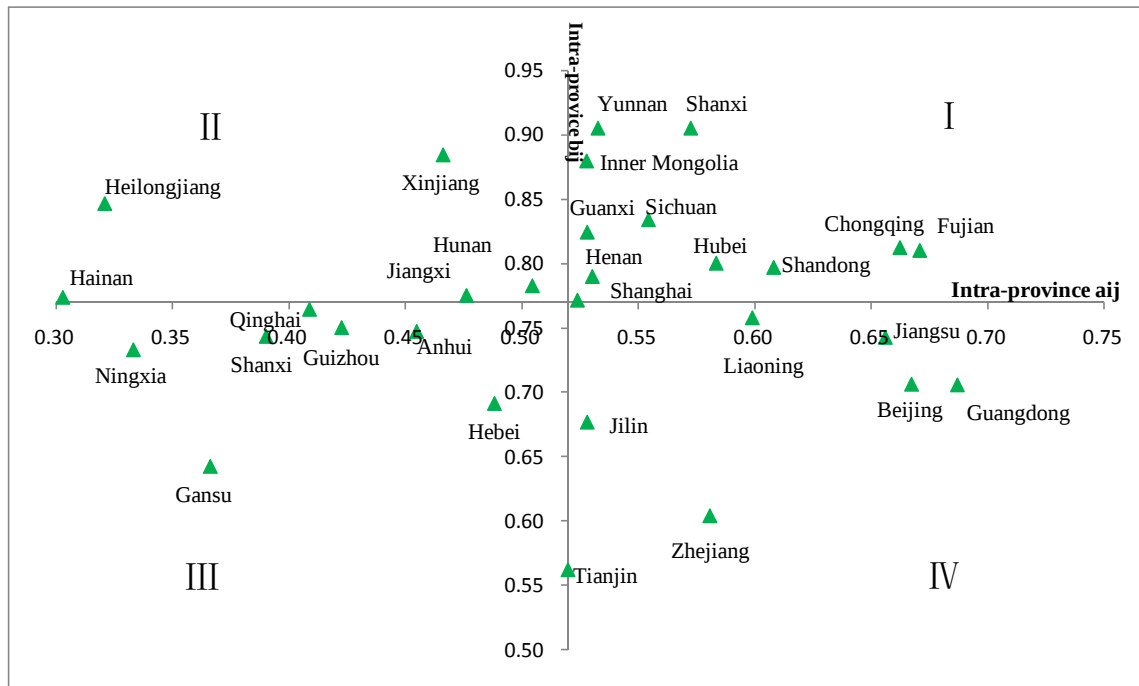


Fig 2.3 Forward and backward linkage patterns for Processing and manufacturing sectors

According to their different forward and backward linkage patterns, 30 regions are divided into four types (Fig2.3): I forward introvert and backward introvert: Shanghai, Shandong, Henan, Hubei, Chongqing, Sichuan, Fujian, Guangxi, Inner Mongolia, Yunnan, and Shanxi; II forward introvert but backward extrovert: Heilongjiang, Hunan, Jiangxi, Hainan, and Xinjiang; III forward extrovert and backward extrovert: Hebei, Anhui, Guizhou, Ningxia, Shaanxi, Qinghai, and Gansu; IV forward extrovert but backward introvert: Beijing, Tianjin, Jiangsu, Zhejiang, Guangdong, Liaoning, and Jilin. By comparing the coefficients of neighbor province, it is observed that Guangdong, Shandong, Fujian, Sichuan, Liaoning, Hubei, Shanxi, Yunnan, Qinghai, and Xinjiang do not have close forward and backward linkages with neighbor provinces; Shanghai, Guangxi, Hainan, Guizhou, Anhui, Hunan, Jiangxi, Ningxia, Inner Mongolia, and Jilin have close forward and backward linkages with neighbor provinces; Hebei, Tianjin, Heilongjiang, Gansu, and Shaanxi have close backward linkages with neighbor provinces; Beijing, Zhejiang, Jiangsu, Henan, and Chongqing have close forward linkages with neighbor provinces.

Table2.3.2 shows the comprehensive Result including forward and backward linkages of both intra-province and neighbor province (the items with strong linkages are highlighted with marks). It is observed that Processing and manufacturing industry linkages lie mainly in same province or between neighbor provinces, especially in Shanghai, Jiangsu, Zhejiang and Shandong of coastal areas. The relatively complete industrial system that can provide sets of equipments and accessories locally may be the reasons of higher intra-provincial linkages in coastal provinces. The significant high inter-provincial forward linkages in some eastern provinces like Tianjin, Liaoning, Guangdong may

caused by the developed processing level which make the products flow into inter-provincial markets. With the same situation as before, the three provinces of northeastern regions are also in strong linkages with each other.

Table2.3.2 comprehensive Result including forward and backward linkages of intra-province and neighbor province (Processing and manufacturing sectors)

Backward linkage	Intra-province			Neighbor province			Non-neighbor province		
Forward linkage	Intra -province	Neighbor province	Non -neighbor province	Intra -province	Neighbor province	Non -neighbor province	Intra -province	Neighbor province	Non -neighbor province
Beijing		●							
Tianjin			●			●			
Hebei						●			
Shanxi	●								
Inner Mongolia	●				●				
Liaoning			●						
Jilin		●			●				
Heilongjiang				●					
Shanghai	●				●				
Jiangsu		●							
Zhejiang		●							
Anhui					●				
Fujian	●								
Jiangxi				●	●				
Shandong	●								
Henan	●	●							
Hubei	●								
Hunan				●	●				
Guangdong			●						
Guangxi	●				●				
Hainan				●	●				
Chongqing	●	●							
Sichuan	●								
Guizhou					●				
Yunnan	●								
Shanxi						●			
Gansu						●			
Qinghai									●
Ningxia					●				
Xinjiang							●		

3. Conclusion

- (1) There are stronger intra-provincial linkages of Foods, textile and light industries in Henan, Jiangxi, Hebei and Henan of Central China. Jiangsu, Shanghai and Shandong of coastal areas are characterized by inter-provincial linkages of Foods, textile and light industries.
- (2) Significant inter-provincial forward linkages and intra-provincial backward linkages of Raw material sectors can be observed in some central and west provinces such as Shanxi, Henan and Sichuan. It probably results from their rich mineral resources and relatively rare processing and manufacturing sectors.
- (3) For Processing and manufacturing sectors, higher forward and backward linkages lie in same province or between neighbor provinces, especially in Shanghai, Jiangsu, Zhejiang and Shandong of coastal areas. The relatively complete industrial system that can provide sets of equipments and accessories locally may be the reasons of higher intra-provincial linkages in coastal provinces.
- (4) The situation of the three northeastern provinces is special. For all the three types of industries, they show strong forward and backward linkages with neighbor provinces, which indicate the high collaboration level within the three northeastern provinces.

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