Measuring the Generalized Global Industry Relocation

-Based on World Input-Output Model

Xiang Gao[1,2,3]

[1] Academy of Mathematics and Systems Science, CAS

[2] University of Chinese Academy of Sciences

[3] Key Laboratory of Management, Decision and Information Systems, CAS

January 2018

***Abstract*:** The financial crisis in 2008 prompted the restructuring of the world economic and trade pattern. The global value chain began to restructure, and global industry relocation presented more diversified features. Therefore, the researches on the measurement and mechanism of industry relocation become increasingly important. This paper put forward a new approach to measuring the value of generalized industry relocation based on world input-output model. In the approach, we subdivided the generalized industry relocation into industry relocation driven by intermediate inputs, by final products, and indirect intermediate industry relocation driven by final products. In the empirical part, this paper first measured the value of generalized industry relocation during the periods 2000-2007 and 2007-2014. The results revealed the features about industry relocation in these two periods, some of which are consistent over time, such as the global industry relocation obeys the Pareto Principle; the others present the heterogeneity between these two periods, for example the industry relocation of India and Germany. Furthermore, this paper focused on the global manufacture relocation. The results reveal that, in 2000-2007, the features of manufacture relocation of China and Brazil were similar; in 2007-2014, there were some similarities between China and India.

***Key word*:** Generalized Industry relocation; Manufacture relocation; Input-output technique

1. Introduction

Industry relocation is a common economic phenomenon. It happens with a part of capacity for a certain industry transferred from a location to another through the approach such as trade and foreign direct investment, in the course of economic development. There are usually two perspectives of industry relocation (Guo, 2016), i.e. narrow sense and generalized sense. In the narrow sense, industry relocation denotes the enterprises rearrange their capacity among different locations, then the capacity for a certain industry in different locations changes. In its generalized sense, industry relocation reflects that the evolutions of the comparative advantages for each economy lead to the adjustment of the shares of each location for a certain industry.

Since the end of the World War Ⅱ, there happened four large-scale global industry relocations, which benefited some developed and emerging economies. The industry relocations accelerated the process of industrialization for those economies, and so was their economic development. After entering the 21st century, the global division of labor has been subdividing, vertical specialization has been a distinctive feature of the world economy (Hummels et al., 2001; Chen et al., 2005; Dean, 2009), and the global value chain has been a popular topic in the past couple decades (Antràs & Chor, 2013). The scale of industry relocation has been growing. The financial crisis in 2008 prompted the restructuring of the world economic and trade pattern. Faced with the impact of the financial crisis, each economy adopted various economic policies. The United States and other developed economies have re-attached the importance of real economy. The moving back of manufactures has become a major approach to boosting the domestic economic development, in particular for the high-end manufactures. The developing economies in Africa, South America and Southeast Asia have been more involved in the world economy than ever. Their adequate labor resources, loose investment environment and desire for rapid development have made them the potential destination for industry relocation. At the same time, China has been gradually stepping into a new normal of economic growth. With the background of supply-side structural reform, the rapid increase in domestic prices of production factors and the tightening of the domestic policies for environmental protection, China will play a more active role in the global industry relocation. Therefore, the global industry relocation will present more diversified features, and the researches on the measurement and mechanism of industry relocation will become increasingly important.

The famous literatures on industry relocation mostly focus on the mechanism,

driving factors and realization approaches for the industry relocation. For example, Arthur Lewis (1984), Nobel Prize in Economics in 1979, put forward the industry relocation theory for labor-intensive industries, the U.S. economics Raymond Vernon (1982) put forward the product life cycle model, the Japanese economics Kaname Akamatsu (1937) put forward the flying geese paradigm, and the Japanese economics Kiyoshi Kojima (1978) put forward the marginal industrial expansion theory. In addition, there are some researches on the destination selection for the industry relocation (Shi, 2004; Zhang, 2009), and some researches on the impact of industry relocation (Pan, 1994; Wei, 2003; Song, 2005).

The empirical researches on industry relocation require first and foremost the measurement method for the industry relocation. To deal with this issue, almost all the researches adopted or constructed ratio indicators, such as locational quotient. For example, Maria Svona (2004) constructed an indicator for international relocation of production, and based on which, did an empirical research on the relationship between the international relocation of production and the industrial development of Italy. Chen (2007) constructed a coefficient of regional industrial competitiveness, and evaluated the degree of China's industry relocation based on the change of such coefficient. Zhang and Liang (2010) measured the degree of China's industry relocation based on the Herfindahl-Hirschman Index, locational quotient and the shares of industries. These indicators are more focused on the change of the shares of each location in the production of a certain industry, thus, the industry relocation embodied in these indicators are all generalized industry relocation. However, although these ratio indicators for the industry relocation can reflect the in or out of relocation and reveal the relative degree of industry relocation, these indicators fail to denote the exact value of industry relocation. The absence of the measures for the value of industry relocation will weaken the empirical researches on the industry relocation.

There are very few researches on the measure for the value of industry relocation. Among which, Liu et al (2011) put forward a measure for the value of generalized industry relocation based on the input-output technique. In that paper, generalized industry relocation is defined as the rise (decline) of production for a location driven by the rise (decline) of final demand for the other locations. That is different from the traditional recognized definition of generalized industry relocation, which reflects change of the shares of each location for a certain industry. For example, assuming that there are two locations, A and B, and two industries, agriculture and manufacture of food products (the products of agriculture are the raw material for the manufacture of food products), location A is only involved in the agriculture and the manufacture

of food products is the only industry in location B (thus, the raw material are supplied by the location A). In the measure of Liu et al (2011), the rise of final demand for the location B will increase the production of the agriculture in location A, and the industry relocation between will happen. But, actually, after the rise of final demand for the location B, location A is still only involved in the agriculture and the manufacture of food products is still the only industry in location B. The share of each location for agriculture and the manufacture of food products don't change. Therefore, the measure of Liu et al cannot be the measure for the traditional recognized generalized industry relocation.

This paper put forward a new approach to measuring the value of generalized industry relocation based on world input-output model. In the approach, we subdivided the generalized industry relocation into industry relocation driven by intermediate inputs, by final products, and indirect intermediate industry relocation driven by final products. Developed in the late 1930s, the input–output analysis is the name given to an analytical framework developed by Professor Leontief (Leontief, 1941, 1986; Miller & Blair, 2009). By far, the input–output model has been the most widely used in numerous fields, such as international trade, regional economics, environment, policy making, and others (Trefler & Zhu, 2010; Johnson & Noguera, 2012; Koopman et al., 2014; Los et al., 2016). Meanwhile, the world input-output table can show the shares of each economy both in aspect of input and output, which make it possible for measuring the value of generalized industry relocation.

The paper is organized as follows: Section 2 put forward the approach to measuring the value of generalized industry relocation in the case of the simplified world input-output table with two economies, and presents the proof of the consistency of the industry relocation driven by intermediate inputs and final products. Section 3 presents the empirical analysis; in this section, there is first an analysis of global generalized industry relocation during the periods 2000-2007 and 2007-2014, by using the new-released world input–output table (WIOT) (Dietzenbacher et al, 2013). Then, this paper will focus on the global manufacture relocation. The summary and conclusion are in section 4.

2. Measurement method of Generalized Industry Relocation

The generalized industry relocation reflects the change of the share of industry scale among different locations, which is caused by the evolution of comparative advantage among these locations. This paper presents the idea and approach for measuring the

generalized industry relocation. We start our model from the case of the simplified world input-output table with two economies[1].

Tab1e 1: Simplified World Input-Output Table with Two Economies

		Intermediate use		Final demand		Total output
		Economy r	Economy s	Economy r	Economy s	
Intermediate inputs	Economy r	Z_{rr}	Z_{rs}	f_{rr}	f_{rs}	x_r
	Economy s	Z_{sr}	Z_{ss}	f_{sr}	f_{ss}	x_s
Value added		V'_r	V'_s			
Total input		x'_r	x'_s			

In table 1, Z_{rs} is the matrix of intermediate deliveries from economy r to economy s. Also, f_{rs} denotes the column vector of the final demands for economy s which is provided from economy r. V_r denotes the column vector of the value added for economy r while $'$ denotes the transposition of a vector. x_r is the column vector of the total output for economy r, where the output value of each industry equals its total input.

Based on the Leontief input-output model, we can calculate the direct input coefficients form economy r to economy s as $A_{rs} = Z_{rs}\hat{x}_s^{-1}$, where A_{rs} denotes the matrix of the input from each industry in economy r for per unit output of each industry in economy s. We record the $A = \begin{pmatrix} A_{rr} & A_{rs} \\ A_{sr} & A_{ss} \end{pmatrix}$ as the global direct input coefficients and $f = \begin{pmatrix} f_{rr} + f_{rs} \\ f_{sr} + f_{ss} \end{pmatrix}$ as the column vector of total final demand for each economy.

2.1 The Industry Relocation Driven by Intermediate Inputs

The industry relocation driven by intermediate inputs reflects the value of output transfer caused by the change of shares of each economy for the total intermediate inputs.

Denoting 0 as the start year and 1as the end year of the period. If the final

[1] In the Appendix, this paper gives a calculation example of the measurement method we put forward, which can help understanding the idea of this measurement.

products of the end year (f_1) are produced under the technical level of the start year, then the total intermediate inputs can be calculated as the following on the basis of Leontief input-output model.

$$c_0 = ((I - A_0)^{-1} - I)\,\hat{f}_1 \tag{1}$$

Here, $c_0 = (c_{ij}^0), c_{ij}^0$ denotes the total intermediate inputs from industry i for producing the final products for industry j in f_1 with the technical coefficients A_0. Similarly, we have:

$$c_1 = ((I - A_1)^{-1} - I)\,\hat{f}_1 \tag{2}$$

Here, $c_1 = (c_{ij}^1), c_{ij}^1$ denotes the total intermediate inputs from industry i for producing the same final products for industry j in f_1 with the technical coefficients A_1. Then, $c_1 - c_0$ denotes the change of total intermediate inputs for the production of f_1, which is because of the evolution of technical coefficients from year 0 to year 1.

The evolution of technical coefficients may come from two aspects. The first is the technology advancement. Technology advancement leads to for example lower energy consumption for steel-making industry. The second is the change of supplier for a certain intermediate inputs, for example the coal supplier for the steel-making industry in economy r changed from the coal industry in economy r to that in economy s. The second aspect leads to the industry relocation driven by intermediate inputs. Therefore, what we need to do is to distinguish the part of $c_1 - c_0$ that caused by the second aspect.

In the case of the simplified world input-output table with two economies, $c_0 = \begin{pmatrix} c_{0r} \\ c_{0s} \end{pmatrix}$. Here, marix c_{0r} denotes the intermediate inputs from economy r for producing the final products f_1 with the technical coefficients A_0. Similarly, we denote $c_1 = \begin{pmatrix} c_{1r} \\ c_{1s} \end{pmatrix}$. We then can calculate $c_0^* = c_{0r} + c_{0s}$ and $c_1^* = c_{1r} + c_{1s}$, where c_0^* denotes the total intermediate inputs from each industry for the whole world to each certain industry for a certain economy in year 0 (for example the total coal input for the output of the steel-making industry in economy r, which is the sum of that

supplied by economy r and economy s. c_0^* is a $n \times 2n$ matrix, here n is the number of industries for a certain economy.). Then, we can deduce that:

$$r_{1r} = c_{1r}./\, c_1^*; r_{1s} = c_{1s}./\, c_1^{*\,2} \tag{3}$$

Here, r_{1r} denotes the shares of the intermediate inputs supplied by economy r in world total for each industry in the year 1, $r_1 = \begin{pmatrix} r_{1r} \\ r_{1s} \end{pmatrix}$ denotes the shares of each economy in the whole world.

Then, $c_1 - c_0$ can be decomposed by the following equation[3]

$$c_1 - c_0 = \begin{pmatrix} (c_1^* - c_0^*) \circ r_{1r} \\ (c_1^* - c_0^*) \circ r_{1s} \end{pmatrix} + \left[\begin{pmatrix} c_0^* \circ r_{1r} \\ c_0^* \circ r_{1s} \end{pmatrix} - c_0 \right] \tag{4}$$

Expanding the first part of equation 4, we can get $\begin{pmatrix} (c_1^* - c_0^*) \circ r_{11} \\ (c_1^* - c_0^*) \circ r_{12} \end{pmatrix}$ $= \begin{pmatrix} c_1^* \circ r_{11} \\ c_1^* \circ r_{12} \end{pmatrix} - \begin{pmatrix} c_0^* \circ r_{11} \\ c_0^* \circ r_{12} \end{pmatrix}$. This part is caused by the advancement of technology, the total intermediate inputs from each industry for the whole world are different, while the shares of each economy are the same, which are $\begin{pmatrix} r_{11} \\ r_{12} \end{pmatrix}$. As for the second part of the equation 4, we can deduce that $\left[\begin{pmatrix} c_0^* \circ r_{11} \\ c_0^* \circ r_{12} \end{pmatrix} - c_0 \right] = \begin{pmatrix} c_0^* \circ r_{11} \\ c_0^* \circ r_{12} \end{pmatrix} - \begin{pmatrix} c_0^* \circ r_{01} \\ c_0^* \circ r_{02} \end{pmatrix}$. This part is caused by change of supplier for a certain intermediate inputs, similarly, the total intermediate inputs from each industry for the whole world are the same, while the shares of each economy change over time.

Therefore, the measurement of the industry relocation driven by intermediate inputs are calculated as $r1 = \left[\begin{pmatrix} c_0^* \circ r_{11} \\ c_0^* \circ r_{12} \end{pmatrix} - c_0 \right] = (r1_{ij})_{2n \times 2n}$. Here, $r1_{ij}$ denotes the value of relocation for industry i driven by the change of intermediate inputs shares for each economy in the production of industry j.

---

[2] In equation (3), by employing the form of Hadamard product, $./$ denotes the elementwise division for two matrixes with the same dimensions, which means the quotient for the elements in the same location in those two matrixes

[3] In equation (4), $\circ$ denotes the Hadamard product of elementwise multiplication for two matrixes with the same dimensions.

2.2 The Industry Relocation Driven by Final Products

The industry relocation driven by final products reflects the value of output transfer caused by the change of shares for each economy in the final product market in a certain economy.

Denoting $ff = \begin{pmatrix} ff_r \\ ff_s \end{pmatrix}$ as the demand vector for each economy, here, ff_r denotes the final products demanded by the economy r. In ff_r, there are not only the final products produced by economy r itself, but also the final products produced in other economies and consumed by or invested into economy r. In the case of the simplified world input-output table with two economies, we have $ff_r = f_{rr} + f_{sr}$. Meanwhile, we define Fc as the share of the final products supplied by each economy in ff. In the case of the simplified world input-output table with two economies, we have $Fc = \begin{pmatrix} f_{rr}\widehat{./ff_r} & f_{rs}\widehat{./ff_s} \\ f_{sr}\widehat{./ff_r} & f_{ss}\widehat{./ff_s} \end{pmatrix}$[4].

The industry relocation driven by the changes of final products share are measured as $r2 = (Fc_1 - Fc_0) * \hat{ff}_1 = (r2_{ij})_{2n\times 2n}$. Here, $r2_{ij}$ denotes the value of relocation for the industry i driven by the change of final products shares for each economy in the final products market of industry j. Obviously, when industry i and industry j are not the same, $r2_{ij} = 0$.

2.3 The Indirect Intermediate Industry Relocation Driven by Final Products

The measurement of the industry relocation driven by final products is given in section 2.2. At the same time, taking the heterogeneity of the technical coefficients among different economies into consideration, the industry relocation driven by final products is always achieved with the indirect intermediate industry relocation that driven by final products.

Define $e = (1,1,...,1)'$ as the summation vector, the industry relocation driven by final products leads to the change of final products vector is given as $\Delta f = (Fc_1 - Fc_0) * \hat{ff}_1 * e = r2 * e$. Based on the Leontief input-output model, the change of final demand vector will lead to the change of intermediate input as

[4] Hereinafter, Λ is used to indicate the diagonal matrix.

$r3 = ((I - A_1)^{-1} - I) * (\Delta \hat{f}) = (r3_{ij})_{2n \times 2n}$, which is the measurement of the indirect intermediate industry relocation driven by final products. Here, $r3_{ij}$ denotes the relocation for industry i driven by the industry relocation for industry j due to the final products changes.

2.4 The Consistency of the Industry Relocation Driven by Intermediate Inputs and Final Products

The consistency of the industry relocation driven by intermediate inputs and final products means that: the sum of values of relocation-in for the corresponding economies must be equal to the sum of values of relocation-out for the other economies in a certain industry. In other words, if there is an economy achieved industry relocation-in for a certain industry, then there must be some economy experienced relocation-out for the same industry, and the value of the relocation-in and relocation-out are equal.

The proof of that consistency is shown in appendix in the case of the simplified world input-output model with two economies. The proof of the case with more than two economies is similar.

3. Empirical Analysis

On the basis of the approach proposed in the previous section, we use the new-released WIOT in WIOD database to measure the value of generalized industry relocation during the periods 2000-2007 and 2007-2014[5]. WIOD contains annual time series multi-regional input–output tables covering the time frame from 1995 to 2014, and each table gives the value of transactions among 56 industries in 43 economies plus the "rest of the world" (Timmer et al., 2015; Timmer et al., 2016).

The reasons we choose the periods 2000-2007 and 2007-2014 are as following. First, as shown in figure 1, during the period 2000-2007, the global exports boomed, especially after China's accession to the WTO in 2001. During the period 2003-2007, the average annual growth rate for global exports was 16.61%, higher than any other five consecutive years. The share of China's exports in world total was 3.85% in year 2000, and increased to 8.71% by year 2007, which highlights the increasing importance of China in global trade. During the period 2000-2007, globalization took over more and more countries, the production was fragmented into a series of

[5] Available at www.wiod.org

processes where different economies specialize in one process. The increasing production fragmentation promoted the global industry relocation. Second, the financial crisis in 2008 dragged down both the global economy and global trade. The world exports experienced a sharp fall in year 2009, with the growth rate dropped sharply from 15.7% in 2008 to -22.2% in 2009. Faced with the impact of the financial crisis, each economy adopted various economic policies. World economy and trade pattern began to restructure, and global industry relocation presented more diversified features. Finally, in consideration of the equal time-span as well as the fact that some omen for financial crisis may have been embodied in global trade before 2008, this paper chooses the periods 2000-2007 and 2007-2014 for empirical analysis.

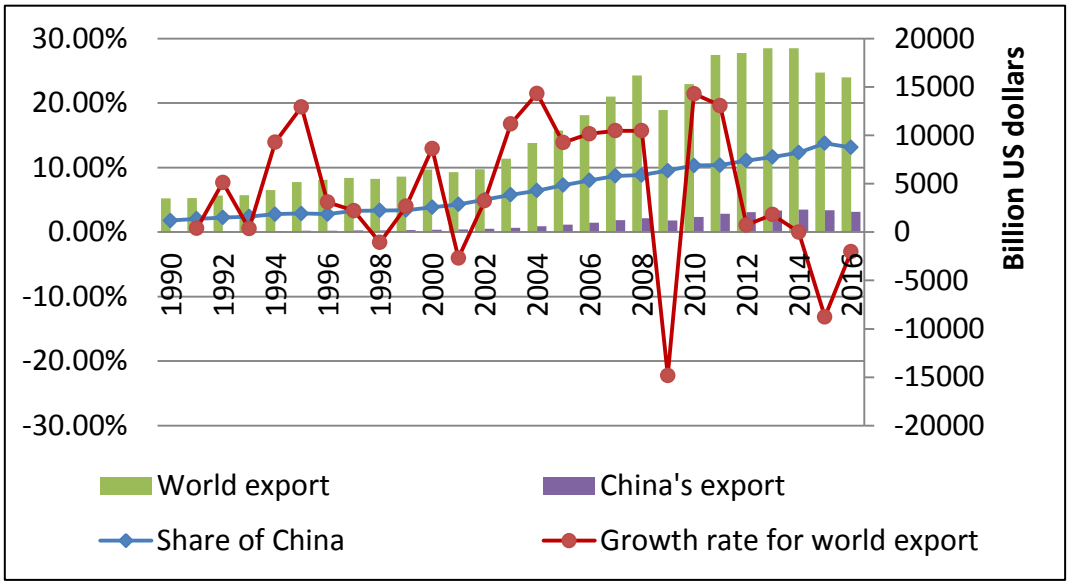


Figure 1: Global commercial exports during 1990-2016

(Left axis: Share of China, Growth rate for world export;

Right axis: World Export, China's Export)

3.1 Global Industry Relocation Analysis for World and Selected Economies

As for the value of industry relocation for the whole world, on the one hand, as proved in appendix, for the global industry relocation driven by intermediate inputs and by final products, their consistency can guarantee the equality between the total values of global relocation-in and global relocation-out for these two types of industry relocation. Therefore, we can obviously get the value of these two types of industry relocation for the whole world in periods 2000-2007 and 2007-2014. On the other hand, for the indirect intermediate industry relocation driven by final products, the values of its relocation-in and relocation-out are not equal. Thus, we define the average of its relocation-in and relocation-out as the value of the indirect intermediate industry relocation for the whole world.

Figure 2 and figure 3 present the values of three types of industry relocation for

the whole world in the two periods and the proportions of them in the total output for the whole world. As shown in figure 2, the values of the industry relocation driven by final products and indirect intermediate industry relocation driven by final products in 2007-2014 remained flat compared with that in 2000-2007. But the value of the industry relocation driven by intermediate inputs in period 2007-2014 was evidently higher than that in period 2000-2007. In period 2000-2007, the value of the industry relocation driven by intermediate inputs was 17170.7 trillion US dollar. Such value increased by 88.5% in period 2007-2014, reached 32359.7 trillion US dollar.

As for the proportion of industry relocation compared with total world output, the percentage of the total value of all types of industry relocation in 2007-2014 remained flat compared with that in 2000-2007, reached 2.97% in 2000-2007 and 3.05% in 2007-2014, respectively. But the proportions of different types of industry relocation changed over time. In 2000-2007, the percentage of the value of industry relocation driven by intermediate inputs in total world output was 1.51%. Such proportion grew to 2.01% in the period 2007-2014. Meanwhile, the percentages of the other 2 types of industry relocation fell from 0.73% and 0.73% in 2000-2007 to 0.49% and 0.55% in 2007-2014, respectively. The result reveals that the global location structure for intermediates had experienced a greater level of change than that for final products after the financial crisis.

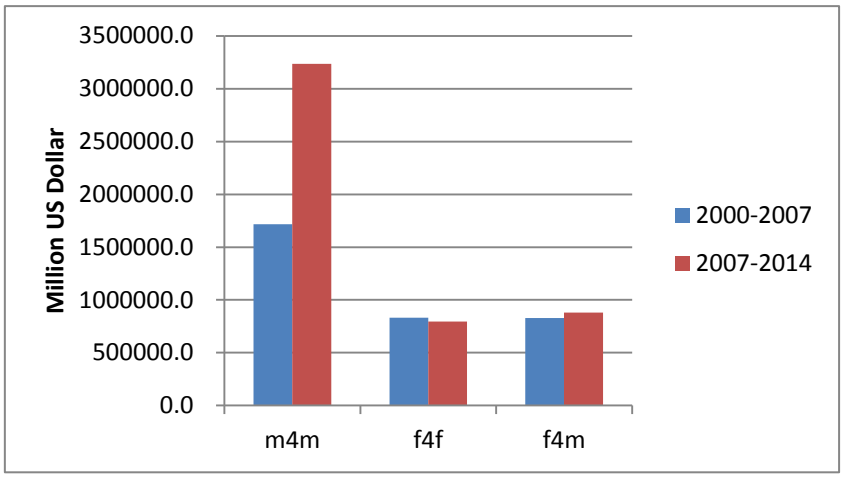


Figure 2: Values of three types of industry relocation for the whole world in two periods[6]

[6] Hereinafter, m4m represents the industry relocation driven by intermediate inputs, f4f represents the industry relocation driven by final products, and f4m represents the indirect intermediate industry relocation driven by final products.

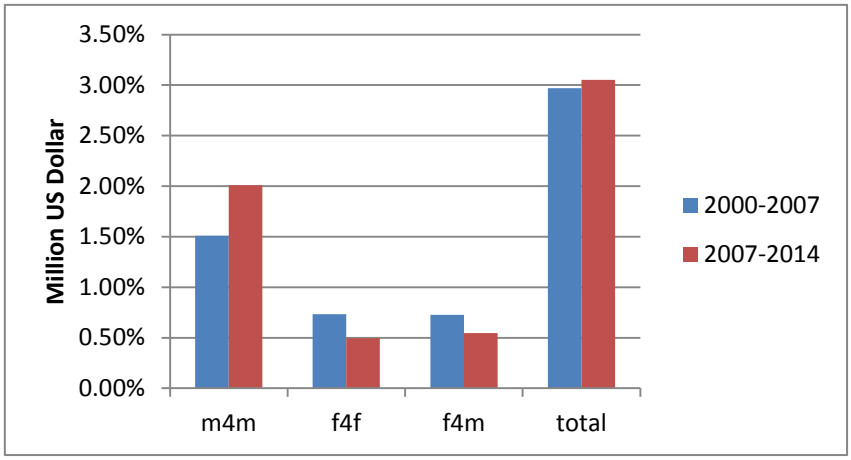


Figure 3: Proportions of three types of industry relocation in the total output for the whole world in two periods

The analysis on industry relocation for each certain economy can help us look into more details, as shown in tables 2-5.

Table 2: The top 5 and bottom 5 economies in terms of value of industry relocation, and their share in world total in 2000-2007(Unit: Million US dollars)

	Industry relocation driven by intermediate inputs				Industry relocation driven by final products				Indirect intermediate industry relocation driven by final products			
	Rankings	Economies	Value	Share	Rankings	Economies	Value	Share	Rankings	Economies	Value	Share
Top	1	China	615978	35.9%	1	China	450196	54.1%	1	China	709849	68.2%
	2	ROW	192688	11.2%	2	ROW	122710	14.7%	2	ROW	99858	9.6%
	3	Russia	190209	11.1%	3	Germany	47235	5.7%	3	Germany	61042	5.9%
	4	Spain	109452	6.4%	4	Brazil	25504	3.1%	4	Brazil	30984	3.0%
	5	Germany	85398	5.0%	5	Ireland	21771	2.6%	5	Korea	20330	2.0%
Bottom	1	USA	-814182	47.4%	1	USA	-387647	46.6%	1	USA	-314119	51.1%
	2	Japan	-503247	29.3%	2	Japan	-168119	20.2%	2	Japan	-138941	22.6%
	3	UK	-149279	8.7%	3	UK	-79174	9.5%	3	UK	-45276	7.4%
	4	France	-89620	5.2%	4	France	-67871	8.2%	4	France	-43414	7.1%
	5	Turkey	-48957	2.9%	5	Taiwan	-33801	4.1%	5	Italy	-13496	2.2%

Note: If it is industry relocation-out, we entered it as a negative number, the same as in other tables.

Table 3: The top 5 and bottom 5 economies in terms of value of manufacture relocation, and their share in the total value of industry relocation for the corresponding economy in 2000-2007(Unit: Million US dollars)

	Industry relocation driven by intermediate inputs				Industry relocation driven by final products				Indirect intermediate industry relocation driven by final products			
	Rankings	Economies	Value	Share	Rankings	Economies	Value	Share	Rankings	Economies	Value	Share
Top	1	China	530921	86.2%	1	China	419923	93.3%	1	China	448494	63.2%
	2	ROW	114530	59.4%	2	ROW	49567	40.4%	2	ROW	51433	51.5%
	3	Russia	51221	26.9%	3	Germany	48156	102.0%	3	Germany	35309	57.8%

	4	Spain	41145	37.6%	4	Brazil	24957	97.9%	4	Korea	17162	84.4%
	5	Korea	40991	40.6%	5	Chech	19225	74.9%	5	Brazil	12217	39.4%
	1	USA	-416543	51.2%	1	USA	-279846	72.2%	1	USA	-140715	44.8%
	2	Japan	-287598	57.1%	2	Japan	-136122	81.0%	2	Japan	-63142	45.4%
Bottom	3	UK	-112256	75.2%	3	UK	-85953	108.6%	3	UK	-12665	28.0%
	4	France	-78291	87.4%	4	France	-60249	88.8%	4	France	-9865	22.7%
	5	Turkey	-50714	103.6%	5	Taiwan	-27339	80.9%	5	Canada	-6420	60.0%

Table 4: The top 5 and bottom 5 economies in terms of value of industry relocation, and their share in world total in 2007-2014(Unit: Million US dollars)

	Industry relocation driven by intermediate inputs				Industry relocation driven by final products				Indirect intermediate industry relocation driven by final products			
	Rankings	Economies	Value	Share	Rankings	Economies	Value	Share	Rankings	Economies	Value	Share
	1	China	2322029	71.8%	1	China	439264	55.2%	1	China	754400	68.8%
	2	ROW	789102	24.4%	2	ROW	82301	10.3%	2	ROW	128057	11.7%
Top	3	Poland	34685	1.1%	3	India	67930	8.5%	3	India	56604	5.2%
	4	Romania	22013	0.7%	4	USA	40473	5.1%	4	Korea	41061	3.7%
	5	Switzerland	21187	0.7%	5	Switzerland	25221	3.2%	5	Switzerland	16801	1.5%
	1	Japan	-715180	22.1%	1	Japan	-222636	28.0%	1	Japan	-235134	35.4%
	2	USA	-430336	13.3%	2	France	-93068	11.7%	2	France	-68428	10.3%
Bottom	3	Germany	-347388	10.7%	3	UK	-83592	10.5%	3	Italy	-61995	9.3%
	4	France	-222549	6.9%	4	Germany	-75188	9.4%	4	UK	-53820	8.1%
	5	UK	-214311	6.6%	5	Italy	-55486	7.0%	5	Germany	-53659	8.1%

Table 5: The top 5 and bottom 5 economies in terms of value of manufacture relocation, and their share in the total value of industry relocation for the corresponding economy in 2007-2014(Unit: Million US dollars)

	Industry relocation driven by intermediate inputs				Industry relocation driven by final products				indirect intermediate industry relocation driven by final products			
	Rankings	Economies	Value	Share	Rankings	Economies	Value	Share	Rankings	Economies	Value	Share
Top	1	China	1638069	70.5%	1	China	407277	92.7%	1	China	481651	63.8%
	2	ROW	317233	40.2%	2	ROW	50615	61.5%	2	ROW	70687	55.2%
	3	India	38336	-222.6%	3	India	47431	69.8%	3	Korea	33453	81.5%
	4	Poland	17458	50.3%	4	Turkey	21556	157.2%	4	India	26730	47.2%
	5	Switzerland	12616	59.5%	5	Korea	20796	120.4%	5	Turkey	9167	56.7%
Bottom	1	Japan	-448505	62.7%	1	Japan	-190811	85.7%	1	Japan	-138819	59.0%
	2	USA	-358731	83.4%	2	UK	-71581	85.6%	2	Italy	-27153	43.8%
	3	Germany	-203739	58.6%	3	France	-67677	72.7%	3	Brazil	-21269	47.1%
	4	Taiwan	-128473	82.5%	4	Germany	-62815	83.5%	4	Germany	-20443	38.1%
	5	Italy	-114546	53.8%	5	Italy	-51708	93.2%	5	Germany	-17693	25.9%

Table 2 and table 4 present the economies whose values of industry relocation ranked at the top 5 and bottom 5 in the world, and their share in world total, respectively. Table 3 and table 5 present the economies whose values of manufacture relocation ranked at the top 5 and bottom 5 in the world, and their share in the total value of industry relocation for the corresponding economy, respectively. We have the following findings.

1) The global industry relocation obeyed the Pareto Principle. China was the most representative economy for the global industry relocation-in.

As shown in table 2, in period 2000-2007, for the industry relocation driven by intermediate inputs, the sum of the value for the top 5 relocation-in economies[7] accounted for 69.5% of the whole world. As for the industry relocation driven by final products and indirect intermediate industry relocation driven by final products, such shares reached 80.2% and 88.6%. In period 2007-2014, those shares grew to 98.5%, 82.3% and 91.0%, respectively. The shares indicate that the global industry relocation-in obeyed the Pareto Principle, which means the small part of the economies in the world achieved most part of global industry relocation-in. Furthermore, China was the most representative economy for the global industry relocation-in. In both of the two periods, the values of three types of industry relocation for China were the highest in the world, accounting for more than 50% of world total. Taking the values in 2007-2014 as an example, the values of three types of industry relocation for China accounted for 71.8%, 55.2% and 68.8%, respectively.

The global industry relocation-out also obeyed the Pareto Principle. In period 2000-2007, the values of three types of industry relocation for the sum of top 5 relocation-out economies accounted for 93.5%, 88.5% and 90.4% of the whole world respectively. In the period 2007-2014, such shares fell to 59.6%，66.6% and 71.3% respectively. The shares verified that the small part of the economies in the world also achieved most part of industry relocation-out, but during the period 2007-2014, the global relocation-out distributed smoother than that in period 2000-2007

2) The typical developed economies were the representative economies for the global industry relocation-out. In period 2000-2007, the most representative one was the United States; while in period 2007-2014, the most representative shifted to Japan.

As shown in table 2, in period 2000-2007, the top 4 economies for the value of every types of industry relocation-out were the United States, Japan, the United Kingdom and France, among which, the United States led with an obvious gap. In period 2000-2007, the values of three types of industry relocation-out for the United

[7] There are 44 economies in the WIOT.

States were 1.6 times, 2.3 times and 2.3 times than that for Japan. In period 2007-2014, as shown in table 4, Japan became the economy ranking at the first place for every types of industry relocation-out with an obvious gap. The values of three types of industry relocation-out for Japan were 1.7 times, 2.4 times and 3.4 times than that for the economies at the second place.

The industry relocation driven by final products for the United States changed sharply in the period 2007-2014. In 2000-2007, the value of the industry relocation-out driven by final products for the United States accounted for 46.6% of world total. However, in the period 2007-2014, not only did the situation of the industry relocation driven by final products for the United States transfer to relocation-in, but also rose to the fourth place in the world. The change of the industry relocation driven by final products for the United States came from its non-manufacture industries of the secondary industry. From the measurement results for every industry in the United States in 2007-2014, we can find that the value of industry relocation driven by final products for its secondary industry accounted for 148% of industry total. That means the relocation-in driven by final products for the United States was totally supported by its secondary industry. Furthermore, the value of industry relocation-in driven by final products for manufacture only accounted for 10% of that for the secondary industry, indicating that the relocation-in driven by final products for the secondary industry was almost supported by its non-manufacture industries.

3) The industry relocation for Germany and India changed sharply in the period 2007-2014, Germany shifted from the top 5 of industry relocation-in to the top 5 of industry relocation-out. Meanwhile, India became the representative economy for industry relocation-in.

As shown in table 2, during the period 2000-2007, Germany was a top 5 industry relocation-in economy, the values of three types of industry relocation-in for Germany ranked in the fifth, third and third place in the world respectively, accounting for 5.0%, 5.7% and 5.9% of the world total. However, as shown in table 4, in period 2007-2014, Germany was involved in top 5 industry relocation-out economies. The values of three types of industry relocation-out for Germany ranked at the third, fourth and fifth place in the world respectively, accounting for 10.7%, 9.4% and 8.1% of the world total.

India became the representative economy for industry relocation-in in period 2007-2014. In 2000-2007, India wasn’t listed in the top 5 economies in any of the three types of industry relocation. But in 2007-2014, India ranked at the third place for the industry relocation driven by final products and indirect intermediate industry

relocation driven by final products, accounting for 8.5% and 5.2% of the world total, respectively.

4) Small developing economies were also achieving the industry relocation-in from the typical developed economies.

As shown in table 2 and table 4, in each type of industry relocation-in, the values for ROW (rest of world) ranked at the second place. The most likely explanation for the result is: the ROW is constituted by a lot of small developing economies located in the Africa, South America and Southeast Asia. Those small developing economies also achieved some industry relocation-in because of its adequate labor resources and the loose investment environment. Due to the great quantity of these small developing economies, ROW played an increasingly important role in global industry relocation. However, there are too many economies involved in ROW, and too much heterogeneity in politics, economy and culture among these small developing economies, the features of the industry relocation for ROW varied over time. Therefore, this paper doesn't give a detailed analysis for the industry relocation for ROW, only presented the measurement in the tables.

5) The two types of direct industry relocation were mainly driven by manufacturing industry. China's manufacturing relocation was the major part of its highest value of industry relocation-in among the world. The manufacturing relocation for Germany and India contributed a lot for their sharp changes in industry relocation.

Hereinafter, we define the industry relocation driven by intermediate inputs and by final products as two types of direct industry relocation.

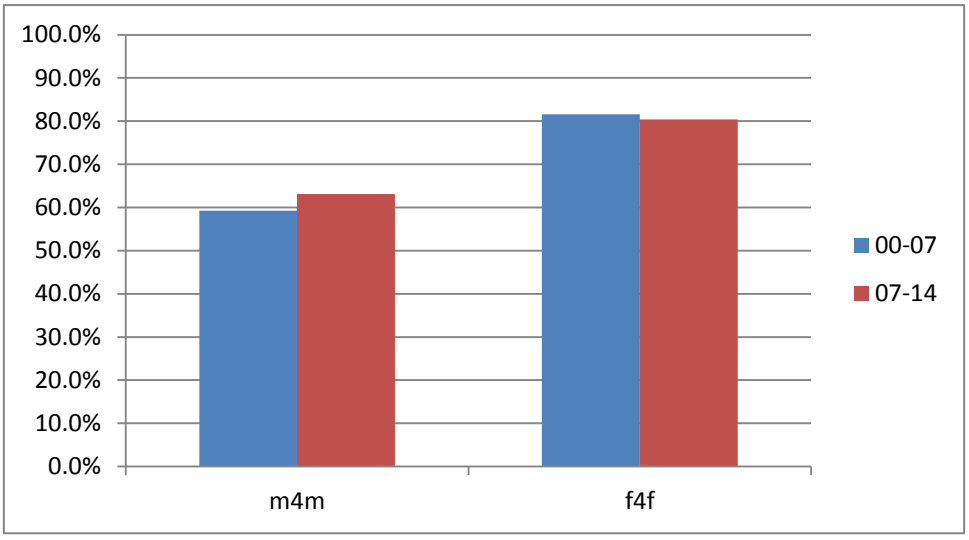


Figure 4: The shares of manufacture relocation for two types of direct industry relocation in two periods

As shown in figure 4, in both of the two periods, for the industry relocation

driven by intermediate inputs, the value of global manufacture relocation accounted for about 60% of the value for all industries. For the industry relocation driven by final products, such share reached about 80% in both of the two periods. Therefore, the two types of direct industry relocation were mainly supported by manufacture relocation

As we concluded in section 3.1, the global industry relocation obeyed the Pareto Principle, which means the top 5 relocation-in(out) economies achieved most part of the global industry relocation. Figure 5 below shows the shares of manufacture relocation in total industry relocation for the top 5 economies in the period 2000-2007.

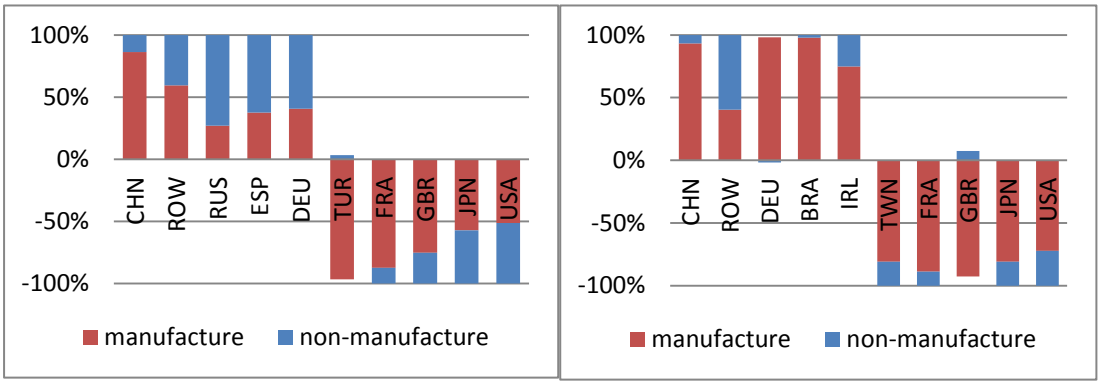


Figure 5: The shares of manufacture relocation in total industry relocation for the top 5 and bottom 5 economies

(Left-side figure：Industry relocation driven by intermediate inputs;

Right-side figure：Industry relocation driven by final products)

As we can see in figure 5, for the industry relocation driven by intermediate inputs, the shares of manufacture relocation in total industry relocation for the top 5 relocation-out economies were more than 50% in the period 2000-2007, among which, the shares for Turkey, France and the United Kingdom (accounted for 16.8% of the global relocation-out) were even more than 75%. As for the top 5 relocation-in economies, though only the shares for China and ROW were more than 50%, the value of relocation-in for these two economies accounted for almost half (47.1%) of the global relocation-in. Furthermore, the value of relocation-in for China accounted for 35.9% of the global relocation-in, and share of manufacture relocation in total industry relocation for China reached 86.2% in 2000-2007. For the industry relocation driven by final products, the shares of manufacture relocation in total industry relocation for all top 5 economies, except ROW, were more than 75%. Meanwhile, the values of relocation-in and relocation-out for the top 5 economies accounted for 80.2% and 88.5% of the whole world.

China’s manufacture relocation was the major part of its highest value of

industry relocation-in among the world. As shown in table 3 and table 5, in 2000-2007, for each of the three types of industry relocation, the share of manufacture relocation in total industry relocation for China reached 86.2%, 93.3% and 63.2% respectively. In 2007-2014, such shares reached 70.5%, 92.7% and 63.8% respectively.

The manufacture relocation for Germany and India contributed most for the sharp changes of their industry relocation. In section 3.1, we have pointed out that the industry relocation for Germany and India changed sharply in the period 2007-2014. For the two type of direct industry relocation for Germany, as shown in table 5, in 2007-2014, the share of manufacture relocation-out in total industry relocation-out for Germany reached 58.6% and 86.5%. As for India, for the industry relocation driven by final products, such share reached 69.8%. For the industry relocation driven by intermediate inputs, such share was -222.6%, which indicates that the industry relocation for India's non-manufacture achieved relocation-out during period 2007-2014, and offset the industry relocation-in for India's manufacture. After we rank the value of manufacture relocation in period 2007-2014, India took the third place, which confirms the contribution of manufacture relocation for India.

6) Processing trade promoted the industry relocation-in for China

Table 6: The top 5 industries in terms of values of industry relocation in China in period 2000-2007(Unit: Million US dollars)

Type	Rank	Sector	Value	Share
Industry relocation driven by intermediate inputs	1	Manufacture of computer, electronic and optical products	82831.86	13.45%
	2	Manufacture of basic metals	74727.58	12.13%
	3	Manufacture of textiles, wearing apparel and leather products	68369.37	11.10%
	4	Manufacture of chemicals and chemical products	57952.3	9.41%
	5	Manufacture of electrical equipment	43046.87	6.99%
Industry relocation driven by final products	1	Manufacture of computer, electronic and optical products	158673.9	35.25%
	2	Manufacture of textiles, wearing apparel and leather products	98713.37	21.93%
	3	Manufacture of machinery and equipment n.e.c.	39963.65	8.88%
	4	Manufacture of electrical equipment	37931.77	8.43%
	5	Manufacture of furniture; other manufacturing	30818.69	6.85%
Indirect intermediate	1	Manufacture of basic metals	63578.91	8.96%
	2	Manufacture of computer, electronic	63323.62	8.92%

industry relocation driven by final products		and optical products		
	3	Manufacture of textiles, wearing apparel and leather products	62652.96	8.83%
	4	Manufacture of chemicals and chemical products	49211.49	6.93%
	5	Wholesale trade, except of motor vehicles and motorcycles	45928.31	6.47%

Table 6 presents the top 5 industries in terms of values of industry relocation-in in China in period 2000-2007, and their share in the total industry relocation-in for China. It can be found that, for the two types of direct industry relocation, the top 5 relocation-in industries in China in 2000-2007 were all manufacture industries, among which the "Manufacture of computer, electronic and optical products" led with an obvious gap. For the industry relocation driven by intermediate inputs, the value of the industry relocation-in for the "Manufacture of computer, electronic and optical products" accounted for 13.5% of that for all industries in China during the period 2000-2007. For the industry relocation driven by final products, such share reached 35.3%, with 13.32 percentage points higher than the industry ranked at the second place.

This observation is consistent with the feature about processing trade in China. As calculated from China's input–output tables capturing processing trade for the year 2007 (abbreviated as DPN tables; Chen et al., 2012; Yang et al., 2015), the share of processing exports in total exports for the "Manufacture of Telecommunication equipment, computer and other electronic equipment" in China reached 88.3% in 2007, which was the highest among all industries. Meanwhile, the share of processing exports for "Manufacture of Telecommunication equipment, computer and other electronic equipment" in total processing exports of China reached 45.7%, while such share for the industry ranked at the second place was only 7.0%. Therefore, we can deduce that: during the period 2000-2007, the booming of the processing trade in China promoted the expansion of China's computer and other electronic products in the global market, which led to the great industry relocation-in for China's "Manufacture of computer, electronic and optical products".

Also, the measurement of the industry relocation for each industry can reveal some interesting and significant information. For example, the "Manufacture of basic metals" and the "Manufacture of chemicals and chemical products" ranked at the second and fourth place for the industry relocation-in driven by intermediate inputs in 2000-2007. But they weren't listed in the top 5 industries for the industry relocation-in driven by final products. For "Manufacture of basic metals", it is due to the industry characteristics that such industry is more involved in the processing of

raw materials. While for "Manufacture of chemicals and chemical products", it reveals that the chemical products of China were more recognized by the global intermediate market rather than final product market during the period 2000-2007. The "Manufacture of chemicals and chemical products" in China achieved their industry relocation-in mostly depend on its intermediate products.

Table 7: The top 5 industries in terms of values of industry relocation in China in period 2007-2014(Unit: Million US dollars)

Type	Rank	Sector	Value	share
Industry relocation driven by intermediate inputs	1	Manufacture of computer, electronic and optical products	440071.028	18.9%
	2	Manufacture of chemicals and chemical products	260491.2708	11.2%
	3	Manufacture of basic metals	160430.4724	6.9%
	4	Wholesale trade, except of motor vehicles and motorcycles	142988.373	6.1%
	5	Manufacture of electrical equipment	129765.9627	5.6%
Industry relocation driven by final products	1	Manufacture of machinery and equipment n.e.c.	112300.2119	24.6%
	2	Manufacture of computer, electronic and optical products	73867.45113	16.2%
	3	Manufacture of electrical equipment	69627.53491	15.2%
	4	Manufacture of other transport equipment	30475.32393	6.7%
	5	Wholesale trade, except of motor vehicles and motorcycles	26339.70792	5.8%
Indirect intermediate industry relocation driven by final products	1	Manufacture of basic metals	124154.895	16.5%
	2	Electricity, gas, steam and air conditioning supply	63397.34629	8.4%
	3	Manufacture of machinery and equipment n.e.c.	53459.06915	7.1%
	4	Mining and quarrying	44999.27016	6.0%
	5	Manufacture of chemicals and chemical products	44591.84585	5.9%

Table 7 presents the top 5 industries for each type of industry relocation in period 2007-2014. Compared with the period 2000-2007, the manufacture industries still dominated. But, for each type of industry relocation, the top 5 industries changed.

In 2007-2014, the "Manufacture of computer, electronic and optical products" still took the first place for the industry relocation-in driven by intermediate inputs. But for the industry relocation-in driven by final products, the value of industry relocation-in for "Manufacture of computer, electronic and optical products" dropped

sharply, and its share in the total value of industry relocation-in for China dropped from 35.35% to 16.2%. On the contrary, the value of industry relocation-in for "Manufacture of machinery and equipment n.e.c." rose by 181.0% in 2007-2014, and took the first place for the industry relocation-in driven by final products.

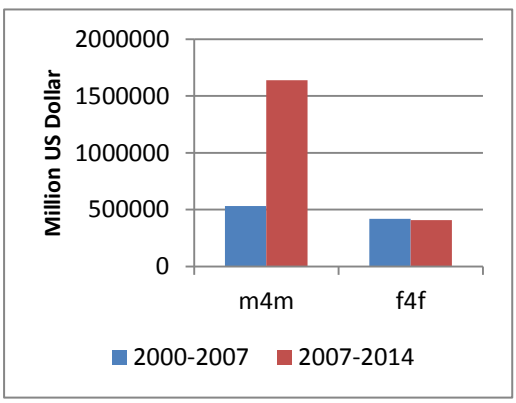
In 2000-2007, "Manufacture of textiles, wearing apparel and leather products" was listed in the top 5 industries for each type of industry relocation. While in 2007-2014, it was out of the top 5 list for any type industry relocation. This result indicates that the industry relocation-in for "Manufacture of textiles, wearing apparel and leather products" slowed down during the period 2007-2014, which is in line with the truth that the "Manufacture of textiles, wearing apparel and leather products" of China began to investing overseas.

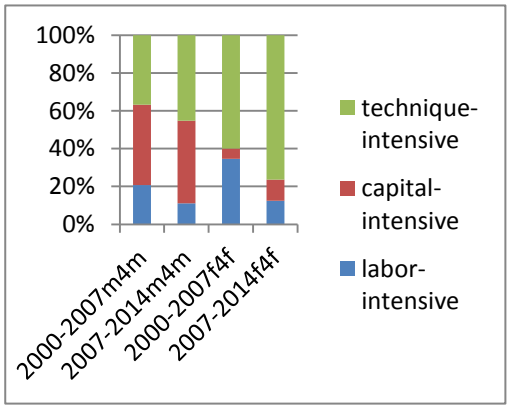
3.2 Global Manufacture Relocation Analysis Capturing Different Factor Inputs

As revealed in part 3.1, the two types of direct industry relocation were mainly driven by manufacture industries. Meanwhile, the manufacture industries can be classified into three groups depending on their factor inputs, that is, labor-intensive manufactures, capital-intensive manufactures, and technology-intensive manufactures. With a deeper analysis for these three types of manufacture relocation[8], more detailed features about the manufacture relocation for each economy, as well as greater level of the heterogeneity between these economies will be revealed.

3.2.1 Manufacture relocation analysis for China

As mentioned in part 3.1, China was the most representative economy for the global industry relocation-in during both of the two periods. Meanwhile, China's manufacture relocation was the major contributor to its highest value of industry relocation-in. After capturing different factor inputs for the manufacturing industry, the features about the manufacture relocation for China are presented in figure 6.





[8] Hereinafter, the three types of manufacture relocation denote the manufacture relocation for labor-intensive manufactures, capital-intensive manufactures and technology-intensive manufactures, and strictly in this order.

Figure 6: The shares of three types of manufacture relocation in China in two periods

As shown in figure 6, for China, compared with the period 2000-2007, the value of manufacture relocation-in driven by final products remained flat in 2007-2014. But the value of manufacture relocation-in driven by intermediate inputs grew sharply. In 2007-2014, China's value of manufacture relocation-in driven by intermediate inputs reached 16380.1 trillion US dollars, up 208.5% over the period 2000-2007. The right-side figure presents the shares of each type of manufacture relocation in the total manufacture relocation for China. As we can see, in both of the manufacture relocation driven by final products and intermediate inputs, during the period 2007-2014, the share of technology-intensive manufactures grew sharply while the share of labor-intensive manufactures dropped dramatically, which is in line with the rise of labor remuneration and overseas investment of labor-intensive manufactures for China.

Figure 7 and figure 8 present the values of manufacture relocation-in for each manufacture industry in China. For the manufacture relocation-in driven by intermediate inputs, the values for all industries grew over time, among which the technology-intensive manufactures achieved the highest rise, and the rise of labor-intensive manufactures were the lowest. For the manufacture relocation-in driven by final products, the values for technology-intensive manufactures, except for "Manufacture of Telecommunication equipment, computer and other electronic equipment", achieved a sharp increase during the period 2007-2014. On the contrary, the values for labor-intensive manufactures experienced a sharp drop compared with that in 2000-2007. The values of capital-intensive manufactures remained flat.

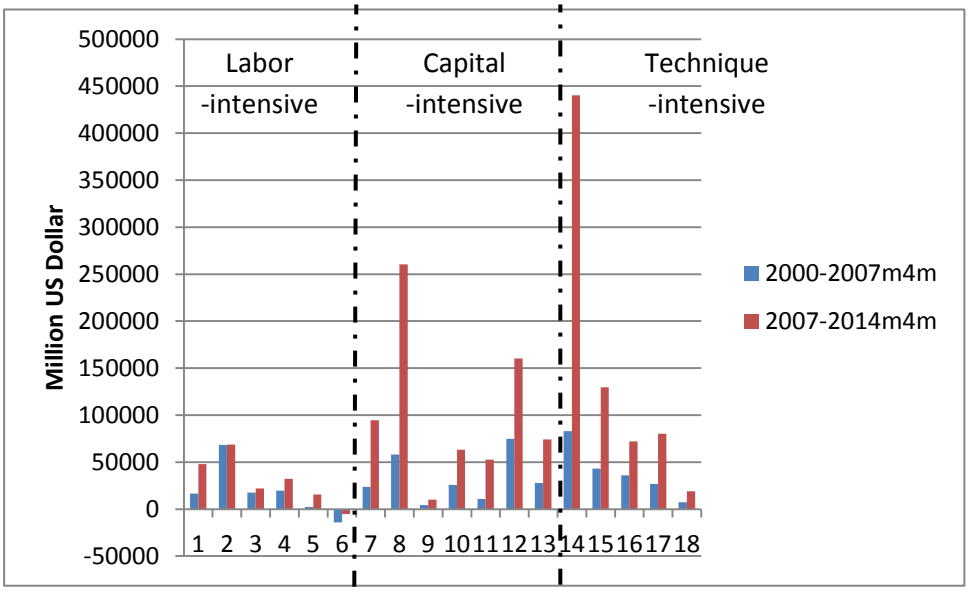


Figure 7: The values of manufacture relocation-in driven by intermediate inputs for

each manufacture industry in China

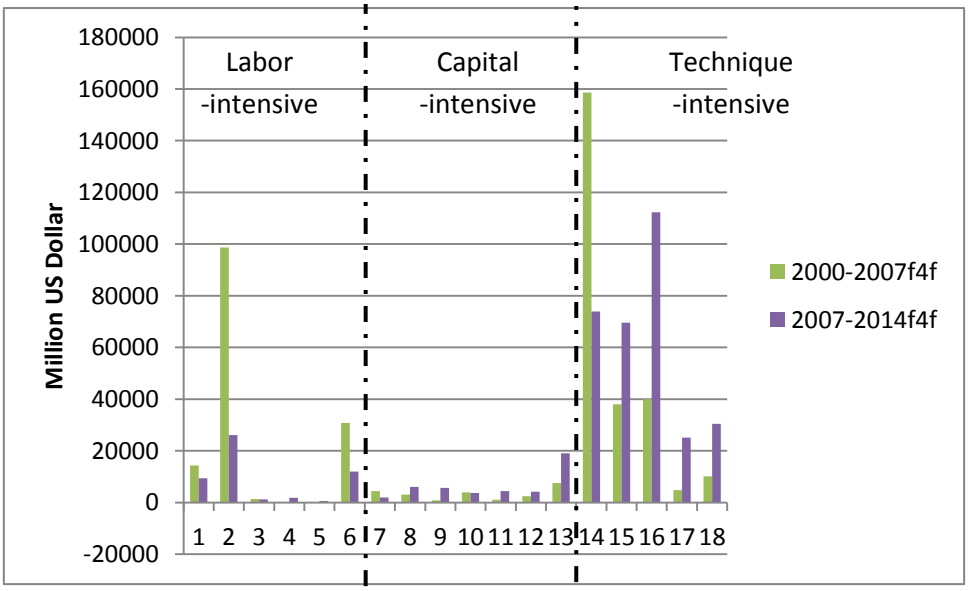


Figure 8: The values of manufacture relocation-in driven by final products for each manufacture industry in China

3.2.2 Manufacture relocation analysis for emerging economies

What about the features of manufacture relocation for other economies, especially other emerging economies?

Figure 9 is the scatter plots presenting the shares of different types of manufacture relocation in the total manufacture relocation for each economy in 2000-2007. In figure 9, the red points represent the economies achieving manufacture relocation-in during the period 2000-2007, while the green points mean the economies experiencing manufacture relocation-out. The first column and the second column are based on the value of manufacture relocation driven by intermediate inputs and by final products, respectively. The abscissas of each row denotes the shares of manufactures relocation from labor-intensive, capital-intensive and technology-intensive manufactures, respectively.

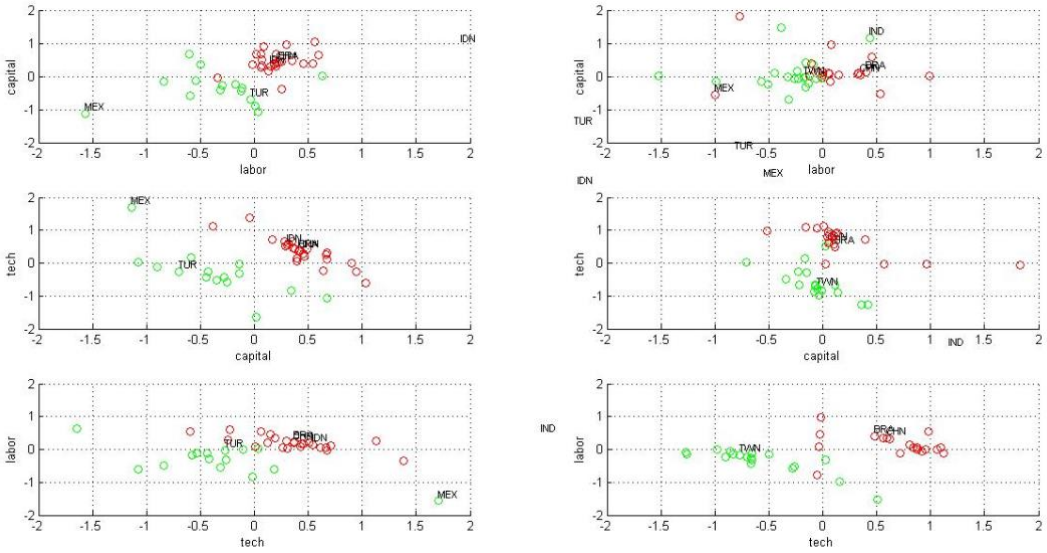


Figure 9: Scatter plots of the shares of different types of manufacture relocation in the total manufacture relocation for each economy in 2000-2007

As shown in figure 9, for most economies, the shares of each type of manufacture relocation in the total manufacture relocation fall into the range (-2, 2). During the period 2000-2007, for the manufacture relocation driven by intermediate inputs, the outliers only came from Switzerland, India, The Netherlands, Norway and Taiwan. These outliers were caused by some types of manufacture relocation achieved relocation-in while the others experienced relocation-out for a certain economy, then the value of total manufacture relocation was relatively small. Therefore, the small denominator made the share outlier.

As also shown in figure 9, in 2000-2007, in both of the manufacture relocation driven by final products and intermediate inputs, the in or out of each type of manufacture relocation were almost in line with that of total manufacture relocation for a certain economy, which is defined as the consistency of manufacture relocation in this paper. Such consistency was relatively weak when it comes to the capital-intensive manufacture relocation driven by final products. That is because the capital-intensive manufactures are mainly involved in the processing of raw materials. Therefore, the value of capital-intensive manufacture relocation driven by final products is much lower than the other types of manufacture relocation, which lower its consistency with the total manufacture relocation driven by final products.

This paper selects seven representative emerging economies to investigate the heterogeneity or homogeneity of the manufacture relocation between these emerging economies, and mark them in figure 9.According to the manufacture relocation driven by intermediate inputs, those emerging economies can be classified into 5 groups.

Table 8: The Classification of 7 emerging economies for the manufacture relocation driven by intermediate inputs in 2000-2007(Unit: Million US dollars)

	Labor-intensive	Capital-intensive	technology-intensive	Total manufacture
China, Indonesia, Brazil	↑	↑	↑	↑
Taiwan	↓	↑	↑	↓
Mexico	↓	↓	↑	↓
India	↑	↓	↑	↑
Turkey	↓	↓	↓	↓
↑ denotes the relocation-in，↓ denotes the relocation-out				
China	20.8%	42.3%	36.9%	530920.9
Brazil	22.4%	40.9%	36.6%	31986.3
Indonesia	15.3%	30.4%	54.3%	15293.6
Taiwan	3861.9%	-1280.2%	-2481.6%	-407.9
Mexico	156.7%	113.9%	-170.6%	-2641.1
India	969.5%	323.0%	-1192.5%	905.4
Turkey	3.3%	69.7%	27.0%	-50714.3

As shown in table 8, in 2000-2007, for the manufacture relocation driven by intermediate inputs, we have the following observations. First, the features for China, Indonesia and Brazil were similar, each type of manufacture relocation for these economies achieved relocation-in, while China and Brazil had the similar share for each type of manufacture relocation. Second, the features for the other four emerging economies were different from each other, and there were at least one type of manufacture relocation-out for these four emerging economies. Third, except for Turkey, all these emerging economies achieved technology-intensive manufactures relocation-in, which is consistent with the booming of processing trade and the rapid development of the global value chain during the period 2000-2007.

Table 9: The Classification of 7 emerging economies for the manufacture relocation driven by final products in 2000-2007(Unit: Million US dollars)

	Labor-intensive	Capital-intensive	technology-intensive	Total manufacture
China, Brazil	↑	↑	↑	↑
Indonesia, Turkey, Mexico	↓	↓	↑	↑
India	↑	↑	↓	↓
Taiwan	↓	↓	↓	↓
↑ denotes the relocation-in，↓ denotes the relocation-out				
China	34.6%	5.5%	59.9%	419923.1

Brazil	40.2%	11.6%	48.2%	24957.5
Indonesia	-226.4%	-335.3%	661.7%	391.0
Turkey	-81.1%	-230.3%	411.4%	5023.9
Mexico	-100.2%	-54.6%	254.8%	3981.0
India	-44.1%	-117.0%	261.2%	-3095.5
Taiwan	17.8%	4.8%	77.4%	-27338.6

According to the manufacture relocation driven by final products, in 2000-2007, those emerging economies can be classified into 4 groups. From table 9, we have the following findings: first, China and Brazil still had the similar features of relocation, each type of manufacture relocation for these economies achieved relocation-in, and share of each type of manufacture relocation were close. Second, the features for Indonesia, Turkey and Mexico were similar. Those emerging economies achieved total manufacture relocation-in, with the great relocation-in for technology-intensive manufactures and the relocation-out for labor-intensive and capital-intensive manufactures. Third, India had the opposite features compared with the second group, and Taiwan had the opposite features compared with the first group.

The pattern of manufacture relocation for the whole world in 2007-2014 was different from that in 2000-2007. For the manufacture relocation-in driven by intermediate inputs, as shown in figure 10, first, the number of economies achieving relocation-in sharply declined, more economies experienced relocation-out. Second, the share of labor-intensive manufacture decreased during the period 2007-2014. For the manufacture relocation-in driven by final products, the features for different economies became more distinct. For the consistency of manufacture relocation we mentioned in this section, the consistency for labor-intensive manufacture relocation driven by intermediate inputs was weaken, while the consistency for capital-intensive manufacture relocation driven by intermediate inputs was strengthen. The consistency for capital-intensive manufacture relocation driven by final products was still weak in 2007-2014.

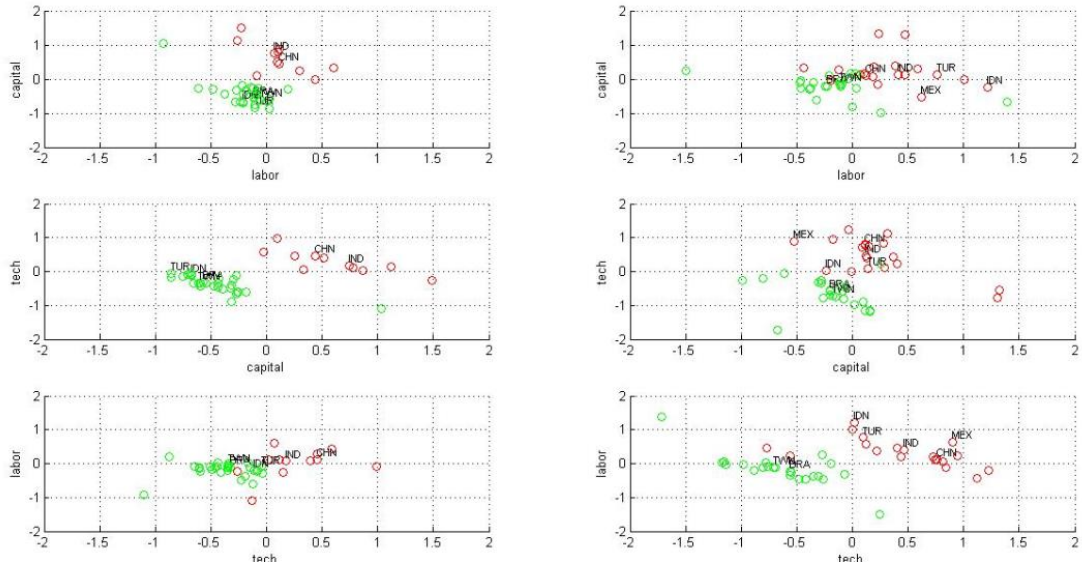


Figure 10: Scatter plots of the shares of different types of manufacture relocation in the total manufacture relocation for each economy in 2007-2014

As for the heterogeneity or homogeneity of the manufacture relocation between these emerging economies, it also changed a lot during the period 2007-2014. According to manufacture relocation driven by intermediate inputs in 2007-2014, those emerging economies can be classified into 3 groups. But there was still a great level of heterogeneity among the economies that belonged to the same group. As shown in table 10, first, China and India achieved relocation-in for all types of manufacture in 2007-2014. But China was more involved in technology-intensive manufactures, while India more focused on labor-intensive manufactures. Second, Brazil, Indonesia, Turkey and Taiwan experienced relocation-out for all types of manufacture in 2007-2014, and the shares of capital-intensive manufactures were more than 50% for all of them. The differences were as follows: for Turkey, its relocation-out were almost supported by capital-intensive manufactures (the share reached 85.5%); for Taiwan and Brazil, their labor-intensive manufactures also reached a great share of relocation-out (more than 30%); for Indonesia, its labor-intensive manufactures reached a great share of relocation-out (about 20.9%). Third, Mexico made up the third group by itself. In period 2007-2014, Mexico's large relocation-in for technology-intensive manufactures and little relocation-in for labor-intensive manufactures offset its great relocation-out for capital-intensive manufactures. Mexico achieved total manufacture relocation-in in the period 2007-2014.

Table 10: The Classification of 7 emerging economies for the manufacture relocation driven by intermediate inputs in 2007-2014(Unit: Million US dollars)

	Labor-intensive	Capital-intensive	technology-intensive	Total

				manufacture
China, India	↑	↑	↑	↑
Mexico	↑	↓	↑	↑
Brazil, Indonesia, Turkey, Taiwan	↓	↓	↓	↓
↑ denotes the relocation-in，↓ denotes the relocation-out				
China	11.1%	43.7%	45.2%	1638068.9
India	7.3%	74.8%	17.9%	38336.1
Mexico	70.4%	-1005.5%	1035.1%	658.0
Indonesia	20.9%	67.8%	11.4%	-44525.0
Taiwan	5.1%	60.8%	34.0%	-128472.8
Brazil	11.0%	56.5%	32.6%	-107913.0
Turkey	10.1%	85.5%	4.5%	-13839.2

As for the manufacture relocation driven by final products, in 2007-2014, those emerging economies reflected more distinct features. As shown in table 11, we also classify those emerging economies into 3 groups according to the manufacture relocation driven by final products. First, China, India and Turkey achieved relocation-in for all types of manufacture in 2007-2014. The differences were: China was more involved in technology-intensive manufactures (the share reached 76.4%); India was more focused on labor-intensive and technology-intensive manufactures. (both of the share reached more than 40%); and Turkey only focused the labor-intensive manufactures (the share reached 76.3%). Second, Brazil and Taiwan experienced relocation-out for all types of manufacture in 2007-2014, and both of them were mainly involved in technology-intensive manufactures (the share reached 71.1% for Taiwan and 56.4% for Turkey). Third, Mexico and Indonesia achieved relocation-in for labor-intensive and technology-intensive manufactures, and experienced relocation-out for capital-intensive manufactures. The relocation-in for Indonesia was almost supported by its labor-intensive manufactures (with the share reached 98.3%), while the relocation-in for Mexico was achieved more smoothly with the share of labor-intensive manufactures reached 40.9% and the share of technology -intensive manufactures reached 59.1%.

Table 11: The Classification of 7 emerging economies for the manufacture relocation driven by final products in 2007-2014(Unit: Million US dollars)

	Labor-intensive	Capital-intensive	technology-intensive	Total manufacture
China, India, Turkey	↑	↑	↑	↑
Mexico,	↓	↓	↑	↑

Indonesia				
Brazil, Taiwan	↓	↓	↓	↓
↑ denotes the relocation-in, ↓ denotes the relocation-out				
China	12.5%	11.0%	76.4%	407277.4
India	40.9%	12.4%	46.7%	47430.7
Turkey	76.3%	13.8%	9.8%	21555.5
Mexico	62.4%	-52.4%	90.0%	5578.3
Indonesia	121.6%	-23.7%	2.1%	9656.2
Brazil	23.1%	20.6%	56.4%	-38442.5
Taiwan	11.8%	17.1%	71.1%	-20585.5

In the end, in two periods, China was the only emerging economy with the stable feature of manufacture relocation. In 2000-2007, the features of manufacture relocation of China and Brazil were similar; in 2007-2014, there were some similarities between China and India.

4 Conclusion

The industry relocation has been a hot topic in both academia and governmental agencies, and it has attracted a great deal of interest in economic and trade literature. The financial crisis in 2008 prompted the restructuring of the world economic and trade pattern. The global industry relocation will present more diversified features, and the researches on the industry relocation will become increasingly important. The empirical researches on industry relocation require first and foremost the measurement method for the industry relocation. To address this issue, most researches adopted or constructed ratio indicators to evaluate the degree of industry relocation. Although these ratio indicators for the industry relocation could reflect the in or out of relocation, they couldn’t denote the exact value of industry relocation, which would weaken the empirical researches on the industry relocation. This paper put forward a new approach to measuring the value of generalized global industry relocation based on world input-output model. We subdivided the generalized industry relocation into industry relocation driven by intermediate inputs, by final products, and indirect intermediate industry relocation driven by final products, respectively. This approach will provide a clearer picture of global industry relocation.

Our major findings from the empirical analysis of global industry relocation based on the proposed approach in this paper in period 2000-2007 and 2007-2014 are summarized as follows. The value of the industry relocation driven by intermediate inputs in period 2007-2014 was evidently higher than that in period 2000-2007, while the value of the industry relocation driven by final products and indirect intermediate

industry relocation driven by final products in 2007-2014 were remain flat compared with that in 2000-2007. The percentage of the total value of industry relocation in the world total output in 2007-2014 remained flat compared with that in 2000-2007, while the share of the industry relocation driven by intermediate inputs grew sharply.

The global industry relocation obeyed the Pareto Principle, which means the small part of the economies in the world achieved most part of global industry relocation-in or experienced most part of global industry relocation-out. China was the most representative economy for the global industry relocation-in, while the typical developed economies were the representative economies for the global industry relocation-out, among which the United States and Japan took the first place in 2000-2007 and 2007-2014. The industry relocation for Germany and India changed sharply in the period 2007-2014. Small emerging economies also achieved the industry relocation-in from the typical developed economies.

The two types of direct industry relocation were mainly supported by manufacture relocation. The manufacture relocation for Germany and India contributed a lot for the sharp changes of their industry relocation. Manufacture relocation was also the main force making China achieve its highest value of industry relocation-in among the world.

For China, in period 2000-2007, processing trade promoted the industry relocation-in for China; in the period 2007-2014, the industry structure of China's industry relocation-in changed a lot over time and the results were in line with the truth about the overseas investment of China.

The following findings are focused on the manufacture relocation. As the most representative economy for the global industry relocation-in, China was more occupied by the manufacture relocation-in driven by intermediate inputs and the manufacture relocation-in for technology-intensive manufactures in period 2007-2014, compared with the period 2000-2007. Meanwhile, among all the emerging economies in WIOT, China was the only emerging economy with the stable feature of manufacture relocation, that is, China achieved relocation-in in each type of manufacture relocation. In 2000-2007, the features of manufacture relocation of China and Brazil were similar; in 2007-2014, there were some similarities between China and India.

References

Akamatsu, K., 1937. Synthetic dialectics of industrial development of Japan. Journal of Nagoya Commercial High School (15).

Antràs, P., Chor, D., 2013. Organizing the global value chain. Econometrica 81(6), 2127-2204.

Chen, H., Kondratowicz, M., and Yi, K. M., 2005. Vertical specialization and three facts about U.S. international trade. North American Journal of Economics & Finance 16(1), 35-59.

Chen, J.J., 2007. The development of industrial and spatial structures in the yangtze river delta. Journal of Zhejiang University (Humanities and Social Sciences)(*in Chinese: Zhe Jiang Da Xue Xue Bao Ren Wen She Hui Ke Xue Ban*) 37(2), 88-98.

Chen, X.K., Cheng, L. K., Fung, K. C., Lau, L. J., Sung, Y. W., Zhu, K.F., Yang, C.H., Pei, J.S., and Duan, Y. W., 2012. Domestic value added and employment generated by Chinese exports: A quantitative estimation. China Economic Review 23(4), 850-864.

Dean, J. M., 2009. How vertically specialized is Chinese trade? Social Science Research Network(SSRN) Electronic Journal 1, 71-94.

Dietzenbacher, E., B. Los, R. Stehrer, M. Timmer and G. de Vries (2013) The construction of world input-output tables in the WIOD project. Economic Systems Research, 25, 71-98.

Guo,W., 2016. The study on China's outward typical industry relocation in new era. Beijing, China Development Press.

Hummels, D., Ishii, J., and Yi, K. M., 2001. The nature and growth of vertical specialization in world trade. Journal of International Economics 54(1), 75-96.

Johnson, R. C., Noguera, G., 2012. Accounting for intermediates: Production sharing and trade in value added. Journal of International Economics 86(2), 224-236.

Kojima, K., 1978. Foreign trade theory. Tianjin, Nankai University Press.

Koopman, R., Wang, Z., and Wei, S. J., 2014. Tracing value-added and double counting in gross exports. The American Economic Review 104(2), 459-494.

Leontief, W. W., 1941. Structure of the American economy, 1919–1929. Cambridge, MA: Harvard University Press.

Leontief, W. W., 1986. Input-output economies. New York, NY: Oxford University Press.

Lewis, A., 1984. The evolution of the international economic order. Beijing, The Commercial Press.

Liu, H.G., Liu, W.D., Liu, Z.G., 2011. The quantitative study on inter-regional industry transfer. China Industrial Economics(*in Chinese: Zhong Guo Gong Ye Jing Ji*) (6), 79-88

Los, B., Timmer, M. P., and Vries, G. J.D., 2016. Tracing value-added and double counting in gross exports: Comment. The American Economic Review 106(7), 1958-1966.

Miller, R. E., Blair, P. D., 2009. Input-output analysis: Foundations and extensions. Cambridge, MA: Cambridge University Press.

Pan, W.M., 1994. The impact on "industry holowing" in the home country due to the overseas production of multi-national enterprise. Journal of International Trade(*in Chinese: Guo Ji Mao Yi Wen Ti*) (12), 14-18.

Savona, M., Schiattarella, R., 2004. International relocation of production and the growth of services: the case of the" made in italy" industries. Transnational Corporations 13(2), 57-76.

Shi, Q., 2004. Compositive economy theory and industrial migration. China Industrial Economics(*in Chinese: Zhong Guo Gong Ye Jing Ji*) (10), 5-12.

Song, Q., 2005. Analysis of the sdvantages and fisadvantages of undertaking international industry relocation -- the positive influence and the ;imitations. Intertrade(*in Chinese: Guo Ji Mao Yi*) (8), 17-20.

Timmer, M. P., Dietzenbacher, E., Los, B., Stehrer, R., and Vries, G. J. D., 2015. An illustrated user guide to the world input–output database: The case of global automotive production. Review of International Economics 23(3), 575–605.

Timmer, M. P., Los, B., Stehrer, R., and Vries, G. J.D., 2016. An anatomy of the global trade slowdown based on the WIOD 2016 release. Available at: http://www.wiod.org/home.

Trefler, D., Zhu, S. C., 2010. The structure of factor content predictions. Journal of International Economics 82(2), 195-207.

Vernon,R., 1982. International investment and international trade in the product vycle. International Economics Policies and their Theoretical Foundations 80(2),307-324.

Wei, H.K., 2003. The development trend of industrial relocation and its influence on competitiveness. Academic Review(*in Chinese: Xue Shu Ping Lun*) (4), 11-15

Yang, C. H., Dietzenbacher, E., Pei, J. S., Chen, X.K., Zhu, K. F., and Tang, Z. P., 2015. Processing trade biases the measurement of vertical specialization in China. Economic Systems Research 26, 60-76.

Zhang, G.W., Liang, Q., 2010. The study of industry transfer and the spatial allocative effect of resources. Review of Industrial Economics(*in Chinese: Chan Ye Jing Ji Ping Lun*) 9(3), 7-27.

Zhang, S.J., Liu, Z.B., 2009. Industry transference of GVC mode- force, influence and inspiration for China's industrial upgrading and balanced development of areas. China Industrial Economics(*in Chinese: Zhong Guo Gong Ye Jing Ji*) (11), 5-15.

Appendix.A

The proof of the consistency of the industry relocation driven by intermediate inputs and final products

1) The consistency of the industry relocation driven by intermediate inputs

In the case of the simplified world input-output model with two economies, the industry relocation driven by intermediate inputs is measured as $r1 = \left[\begin{pmatrix} c_0^* \circ r_{11} \\ c_0^* \circ r_{12} \end{pmatrix} - c_0 \right]$, where the upper submatrix of $r1$ is the value of industry relocation driven by intermediate inputs for the economy 1, and the lower submatrix is that for economy 2. Summing the upper half and the lower half of $r1$, we have

$$c_0^* \circ r_{11} + c_0^* \circ r_{12} - c_{01} - c_{02} = c_0^* - c_0^* = 0 \tag{5}$$

Therefore, the value in the upper half and the lower half of $r1$ are opposite numbers with each other for each element. The value of relocation-in(out) for any industry in economy 1 is equal to the value of relocation-out(in) for the same industry in economy 2. The consistency of the industry relocation driven by intermediate inputs is proved.

2) The consistency of the industry relocation driven by final products

In the case of the simplified world input-output model with two economies, the industry relocation driven by final products is measured as $r2 = (Fc_1 - Fc_0) * \hat{ff}_1$. Similarly, the upper half of $r2$ is the value of industry relocation driven by final products for the economy 1, and the lower half is that for economy 2.

In the same way, the next step is summing the upper half and the lower half of $r2$, which equals that first summing the upper half and the lower half of $Fc_1 - Fc_0$ and then multiplied the $\hat{ff}_1$. Considering that $Fc = \begin{pmatrix} f_{11}\widehat{./ff}_1 & f_{12}\widehat{./ff}_2 \\ f_{21}\widehat{./ff}_1 & f_{22}\widehat{./ff}_2 \end{pmatrix}$, the sum of the upper half and the lower half of Fc_i equals

$$(f_{11}\widehat{./ff}_1 + f_{21}\widehat{./ff}_1 \quad f_{12}\widehat{./ff}_2 + f_{22}\widehat{./ff}_2) = ((f_{11} + \widehat{f_{21}})./ff_1 \quad (f_{12} + \widehat{f_{22}})./ff_2) \tag{6}$$

Because $ff_1 = f_{11} + f_{21}$, $ff_2 = f_{12} + f_{22}$, the equation(6)equals$(I \quad I)$. Thus, the sum of the upper half and the lower half of $Fc_1 - Fc_0$ equals $(I \quad I) - (I \quad I)$=0. Then the sum of the upper half and the lower half of $r2$ equals 0. Therefore, the

value in the upper half and the lower half of $r2$ are opposite numbers with each other for each element. The value of relocation-in(out) for any industry in economy 1 is equal to the value of relocation-out(in) for the same industry in economy 2. The consistency of the industry relocation driven by final products is proved.

What needs to be pointed out is that, although there is the consistency of the industry relocation driven by intermediate inputs and final products, the indirect intermediate industry relocation driven by final products doesn't obey such consistency. That is because the heterogeneity of the technical coefficients among different economies.

Appendix.B

The calculation example in the case of the world input-output table with two economies, economy A and economy B, and each economy has two industries, the steel-making industry and the coal-making industry.

Denoting table 12 and table 13 as the world input-output table in the start year and end year, respectively.

Table 12: the world input-output table in the start year

		Economy A		Economy B		A	B	
		coal	steel	coal	steel	f		x
Economy A	coal	12.03	2.04	6.02	0.00	15.00	5.00	40.09
	steel	0.00	6.11	0.00	4.26	7.00	3.00	20.37
Economy B	coal	4.01	0.00	24.09	2.13	5.00	25.00	60.23
	steel	0.00	2.04	0.00	4.26	5.00	10.00	21.30
	v	24.05	10.19	30.12	10.65			
	x	40.09	20.37	60.23	21.30			

Table 13: the world input-output table in the end year

		Economy A		Economy B		A	B	
		coal	steel	coal	steel	f		x
Economy A	coal	11.48	2.90	6.55	0.00	20.00	5.00	45.93
	steel	0.00	7.25	0.00	1.76	15.00	5.00	29.02
Economy B	coal	2.30	0.00	19.64	3.53	10.00	30.00	65.46
	steel	0.00	1.45	0.00	8.82	5.00	20.00	35.27
	v	32.15	17.41	39.28	21.16			
	x	45.93	29.02	65.46	35.27			

It can be calculated that the global direct input coefficients in start year is $A_0 = \begin{pmatrix} 0.3 & 0.1 & 0.1 & 0 \\ 0 & 0.3 & 0 & 0.2 \\ 0.1 & 0 & 0.4 & 0.1 \\ 0 & 0.1 & 0 & 0.2 \end{pmatrix}$, the global direct input coefficients in end year is $A_1 = \begin{pmatrix} 0.25 & 0.1 & 0.1 & 0 \\ 0 & 0.25 & 0 & 0.05 \\ 0.05 & 0 & 0.3 & 0.1 \\ 0 & 0.05 & 0 & 0.25 \end{pmatrix}$, and the column vector of total final demand in end

year is $f_1 = \begin{pmatrix} 25 \\ 20 \\ 40 \\ 25 \end{pmatrix}$. On the basis of the approach proposed in the section 2, the value of **industry relocation driven by intermediate inputs** is calculated as the following:

$$c_0 = ((I - A_0)^{-1} - I)\,\hat{f}_1 = \begin{pmatrix} 11.6 & 4.4 & 9.8 & 2.1 \\ 0 & 9.6 & 0 & 9.3 \\ 6.1 & 1.4 & 28.3 & 5.8 \\ 0 & 3.7 & 0 & 7.4 \end{pmatrix} = \begin{pmatrix} c_{0A} \\ c_{0B} \end{pmatrix}$$

$$c_1 = ((I - A_1)^{-1} - I)\,\hat{f}_1 = \begin{pmatrix} 8.7 & 3.6 & 7.7 & 0.9 \\ 0 & 6.8 & 0 & 2.2 \\ 2.4 & 0.5 & 17.7 & 4.9 \\ 0 & 1.8 & 0 & 8.5 \end{pmatrix} = \begin{pmatrix} c_{1A} \\ c_{1B} \end{pmatrix}$$

$c_0^* = c_{0A} + c_{0B} = \begin{pmatrix} 17.7 & 5.8 & 38.0 & 7.9 \\ 0 & 13.3 & 0 & 16.7 \end{pmatrix}$, denotes the total intermediate inputs from each industry for the whole world to each certain industry for a certain economy, in order to producing the final products f_1 with the technical coefficients A_0. For example, 17.7 in c_0^* denotes that, in order to producing 25 unit coal final product in economy A with the technical coefficients A_0, the global total intermediate inputs from coal-making industries (both from economy A and economy B) is 17.7 unit. Similarly, we have $c_1^* = c_{1A} + c_{1B} = \begin{pmatrix} 11.1 & 4.2 & 25.4 & 5.8 \\ 0 & 8.6 & 0 & 10.7 \end{pmatrix}$. Then, the shares of the intermediate inputs supplied by economy A in year 0 is $r_{0A} = c_{0A}./c_0^* = \begin{pmatrix} 0.66 & 0.77 & 0.26 & 0.27 \\ 0 & 0.72 & 0 & 0.56 \end{pmatrix}$. For example, the 0.66 in r_{01} denotes the share of economy A in 17.7 unit global total intermediate inputs from coal-making industries is 66%. Similarly, we have $r_{0B} = c_{0B}./c_0^* = \begin{pmatrix} 0.34 & 0.23 & 0.74 & 0.73 \\ 0 & 0.28 & 0 & 0.44 \end{pmatrix}$;

$r_{1A} = c_{1A}./c_1^* = \begin{pmatrix} 0.78 & 0.88 & 0.30 & 0.16 \\ 0 & 0.79 & 0 & 0.21 \end{pmatrix}$; $r_{1B} = c_{1B}./c_1^* = \begin{pmatrix} 0.22 & 0.12 & 0.70 & 0.84 \\ 0 & 0.21 & 0 & 0.79 \end{pmatrix}$。

It can be found that the shares of each economy in the total intermediate inputs are

changed. For example, in the global total intermediate for coal-making industries to steel-making industry in economy A, the share of economy A raises from 77% to 88%. And that is what we called the generalized industry relocation driven by intermediate inputs.

According to the measurement method we put forward in section 2, the value of industry relocation driven by intermediate inputs is

$$r1=\left[\begin{pmatrix} c_0^* \circ r_{1A} \\ c_0^* \circ r_{1B} \end{pmatrix} - c_0\right]=\begin{pmatrix} 2.3 & 0.6 & 1.8 & -0.9 \\ 0 & 0.9 & 0 & -5.8 \\ -2.3 & -0.6 & 1.8 & 0.9 \\ 0 & -0.9 & 0 & 5.8 \end{pmatrix}$$

As we can see, the values of relocation-in(out) for economy A equal the values of relocation-out(in) for economy B in each corresponding industry, which is what we called the consistency of the industry relocation driven by intermediate inputs.

The value of **industry relocation driven by final products** is calculated as the following:

As shown in table 12 and 13, the demand vector for each economy in year 0 is $ff_0=\begin{pmatrix}20 & 12 & 30 & 13\end{pmatrix}$, for example the 20 in ff_0 denotes that the demand of economy A for the coal final products is 20 unit, which is not only supplied by economy A itself, but also the coal final products produced in economy B but consumed by or invested into economy A. Then, the share of the final products supplied by each economy in ff_0 at year 0 is $Fc_0=\begin{pmatrix} 0.75 & 0 & 0.17 & 0 \\ 0 & 0.58 & 0 & 0.23 \\ 0.25 & 0 & 0.83 & 0 \\ 0 & 0.42 & 0 & 0.77 \end{pmatrix}$. For example, 0.75 in Fc_0 denotes that, in the 20unit coal final products demand for economy A, economy supplies 75%. Similarly, we have $ff_1=\begin{pmatrix}30 & 20 & 35 & 25\end{pmatrix}$ and $Fc_1=\begin{pmatrix} 0.67 & 0 & 0.14 & 0 \\ 0 & 0.75 & 0 & 0.2 \\ 0.33 & 0 & 0.86 & 0 \\ 0 & 0.25 & 0 & 0.8 \end{pmatrix}$. It can be found that the shares for each economy in the final product market in a certain economy are changed. For example, in the coal final products demand for economy A, the share of economy B raises from 25% to 33%. And that is what we called the generalized industry relocation driven by final products.

According to the measurement method we put forward in section 2, the value of industry relocation driven by final products is

$$r2 = (Fc_1 - Fc_0) * \hat{ff}_1 = \begin{pmatrix} -2.5 & 0 & -0.8 & 0 \\ 0 & 3.3 & 0 & -0.8 \\ 2.5 & 0 & 0.8 & 0 \\ 0 & -3.3 & 0 & 0.8 \end{pmatrix}$$

And we can also observe the consistency of the industry relocation driven by final products.

The following is the calculation of **the indirect intermediate industry relocation driven by final products**. Summing the matrix r2 in row, we have the change of final products vector due to the industry relocation driven by final products

$$r2 * e = \begin{pmatrix} -3.3 \\ 2.5 \\ 3.3 \\ -2.5 \end{pmatrix}$$

Then the value of indirect intermediate industry relocation driven by final products is

$$r3 = (I - A_0)^{-1} - I) * (\hat{f}_1 - \hat{f}_0^{'}) = (I - A_0)^{-1} - I) * \widehat{\mathrm{r2} * \mathrm{e}} = \begin{pmatrix} -1.5 & 0.6 & 0.8 & -0.2 \\ 0 & 1.2 & 0 & -0.9 \\ -0.8 & 0.2 & 2.4 & -0.6 \\ 0 & 0.5 & 0 & -0.8 \end{pmatrix}$$

As we can see, in matrix r3, the elements in the same column are all in the same sign, which means they are both nonnegative or both nonpositive. That is because the increase (decline) of a certain final products will lead to the increase (decline) for all the intermediates. Meanwhile, it also can be found that the indirect intermediate industry relocation driven by final products doesn't obey the consistency