Estimating the China Inter-Regional Trade Based on 2002 IO Tables

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Abstract:

Since China implemented its reform and open-door policy, its economy has kept fast growth and the trade dependency also increased significantly. At the same time, the inter-regional trade also kept fast growth and in many provinces, especially for the inland regions the inter-regional trade may play an even important role in driving the regional economy growth compared to the foreign trade. However, there is no official inter-regional trade data, this arises many difficulty in analyzing the regional economy and constructing the multiregional model and so on.

This paper estimats the China's 30-region trade for 42 sectors based on the 2002 regional Input-Output Tables and some other inter-regional trade data such as the trade through railway. In the procedure of estimating the inter-regional trade, the method of Cross-Entropy and gravity model was used.

Using the estimated inter-regional trade, this paper compared the volume for region's trade with foreign country and inter-region trade and found that in many regions the inter-regional trade out-weighted much than the foreign trade. We also analyzes the dividing of china's sub trade-region, ie, the provinces which trade most between each other. It was found that china has mainly three economic centers, that is the JingjingJi district, the Yangzi river delta and the Pearl river delta. Most inland provinces, no matter how far they are away from these economic centres, they often trade much commercial with these three economic centre regions than with the nearby regions.

According to these findings, we think the liberations of inter-regional market is an effective way to promote more balanced development for China. On the other hand, it had better to simulate the development of some inner regions and form another economic center, then the inland region can trade more with this economic inner center thus to cut down the overall transportation cost and enhance the economy efficiency.

Key Words: inter-regional trade, Cross-Entropy, Gravity model，sub-trade region

1. Introduction

Trade plays an important role in driving one region's economic growth. Regional trade includes foreign trade with other countries and internal trade with other regions within the country. The scale and importance of these two kinds of trade can be very different for different regions due to diverse factors such as economic development levels, geographical positions and degree of market integration. For example, in the eastern coastal areas of China, the scale of foreign trade is often very large, and foreign trade constitutes an important force which affects regional economic development; whereas in the inland regions, the scale of foreign trade is often smaller, but internal trade with other regions within the country is very large in scale. Therefore, compared with foreign trade, internal trade is usually more important for the economic growth of many regions.

Unlike foreign trade which has been recorded with detailed statistical data, the statistical data on internal trade is often not so complete because there is almost no inter-provincial trade customs statistics in most countries. Therefore, many techniques have to be employed to calculate inter-provincial trade based on the available data. This paper estimates China's inter-regional trade flows for 42 sectors based on the 2002 regional IO tables as well as the statistical data on inter-regional transportation by rail.

Inter-regional trade flow estimation methods can be divided into direct and indirect ones. Direct estimation, which is usually based on the survey data, is highly reliable but very expensive. Pierre A. Génereux and Brent Langen (2002) used the survey data regarding inter-regional trade of goods and services to construct the Canadian inter-regional input-output model. Carlos Llano Verduras used the transportation flow method to estimate the Spanish inter-regional trade flows. Therefore, many economists pay attention to how to make use of different basic data to conduct indirect estimation of inter-regional trade flows, and thus some inter-regional trade models come into existence.

Isard (1951) built the first inter-regional noncompetitive import-type input-output model, which is called IRIO model or Isard model. The basic form of this model is to divide all sectors by region, and then construct each sector's input-output structure for each region, respectively. This model is simple, but requires tremendous amount of basic data. Later, many researchers came up with various kinds of simpler input-output models that needed less data. One of the most influential models with highest precision was put forward by Chenery（1953）and then Moses（1955）independently, and thus it's called Chenery-Moses model. The feature of this model is to fix the percentages of one region's demand for certain product supplied by different regions (including the region itself) as the starting point of building up the model. Actually, row coefficient model and column coefficient model have a lot in common, and the former is usually considered as the reversed image of the latter. Their difference only lies in the fact that the column coefficient model fixes percentages of one region's demand for certain product supplied by different regions, while the row coefficient model fixes percentages of one region's supply of certain product to different regions.

Among inter-regional input-output models, the gravity model is the most important one and is widely used. This model, firstly put forward by Leontief and Strout in 1963, was derived from the concept of universal gravity in physics, holding that the gravitational pull between two celestial bodies is proportional to their mass and inversely proportional to their distance. Gravity model can be applied to inter-provincial trade, with the total supply and demand representing their mass and the distance between two provincial capitals standing for the distance between the two provinces. It can be formulated as below:

$$x_i^{gh} = \frac{x_i^{gO} x_i^{Oh}}{x_i^{OO}} q_i^{gh} \qquad (i = 1, 2, \cdots, m; g, h = 1, 2, \cdots, n; q_i^{gg} = 0)$$

x_i^{Oh} : Region *h*'s demand for product *i* supplied by all regions within the country;

x_j^{gO} : Region *g*'s supply of product *j* to all regions within the country;

x_i^{OO} : Total output (or consumption) of product *i* by all regions within the country;

q_i^{gh} : Trade parameter or friction coefficient.

Calculating inter-regional trade flows of certain product with gravity model depends on the selection of trade parameter estimation techniques and the data of each region's total output and demand, thus there is no need to include the inter-regional trade flow differentiated by region in the regional table. Estimation of the friction coefficient is crucial when using the gravity model, and Leontief and Strout put forward estimation techniques for different basic data conditions. If relatively complete base year statistics can be available, including both regional input-output data and data on inter-regional trade flows, the above equation can be directly used to calculate the friction coefficients, and then by assuming that the friction coefficients from the base year to planned year remain the same, the trade flow matrices in certain year can be directly estimated. This kind of method is called "single-point estimation". Otherwise, the friction coefficients have to be indirectly estimated based on the total base-year regional input and output. Polenske (1970) compared the empirical results of gravity model, column coefficient model and row coefficient model with Japan's input and output data of year 1963, and found that row coefficient model performed less well than the other two models.

Saikaku (1979; 1996) introduced the transportation distribution coefficient to calculate the trade coefficients of different products. The method assumed that the distribution ratios of transportation of all products from one region to other regions were similar to those of some important products. Therefore, the distribution coefficients can be regarded as the trade coefficient of inter-regional trade flows. Reed (1967) used rail and road transportation data to estimate the inter-regional trade flows between Bengal Bihar and other regions in India. With Britain's trade flow data of year 1962 and 1964, including 78 regions and 13 groups of goods, Chisholm and O'Sullivan (1973) also resorted to the gravity model and linear programming model to calculate the coefficients. Black (1971; 1972) estimated the power of the distance in the gravity model, based on 24 main US transport groups' data in 1967, and obtained the following results: (1) the larger market share of the manufacturers or the bigger total traffic volume of suppliers, the lower of the power; (2) The higher ratio of regional flow to the total flow, the higher of the power. In 1989, Brocker pointed out that all forms of gravity models can be simplifed by inter-regional trade Samuelson spatial price equilibrium, and then put forward spatial interaction matrix on inter-regional trade flows.

Under the cooperation with IDE and other Japanese experts, China's National Information Center (2001) used the gravity equation, combined with some survey data, to estimate the 8-region trade for 30 sectors for year 1997, on which the first China's regional Input-Output table combining sampling survey and no–survey data was based. After that, some Chinese experts started to put into practice the China's inter-regional Input-Output model and inter-country Input-Output model. For example, Liu Qiang and Taro (2002) calculated China's three-regional 10-sector trade flow matrix for year 1997 by direct linear regression models.

Under the framework of multi-regional economic accounting, Chen Xiushan and Zhang Ruo (2007) used mathematical programming model to estimate the inter-provincial trade flows of agricultural products, mineral products and manufactured products for six provinces in the central region of China. Xing Weibo (2008) studied inter-regional trade flows with monthly value added tax invoices of China's 31 provinces, cities and autonomous regions by State Administration of Taxation for year 2003, 2004 and 2005.

2. Estimation Method of Inter-regional Trade Flow

To get the 42-sector and 30-region trade flow matrix, we need to estimate the trade flow between region g and region *h* of sector *i*, that is x_i^{gh} $(i=1,2,\cdots,21; h=1,2,\cdots,30)$. There is no statistical data of the inter-regional trade flow in China, so we finally got the data by estimation. To use Isard model, we should know not only the trade flow of certain sector's product in all regions of China, but also the trade flow between different sectors among various regions, that is x_{ij}^{gh} . This model needs adequate original data as its base. However, the statistical data is not enough for us to use Isard model to estimate the trade flow among provinces. To use row-coefficient model and column-coefficient model, we need to know the distribution coefficient (the proportion of the volume of product *i* in region *g* exported to region *h* to the volume of the product exported to all regions of a country) and supply coefficient (the proportion of the volume of product *i* in region *g* exported to region *h* to the volume of product *i* of all regions exported to region *h*). Unfortunately, we have no ways to get the two coefficients based on current materials. The location quotient method requires the fewest data, as long as total output of each region and input coefficient matrix of national IO table are available. However, the accuracy of results is challenged by many researchers. Leontief model, which need output ratios of national sector products in each region as precondition, is appropriate to planning economy system. Further, the model assumes that direct consumption coefficient of any product is the same across different regions, which is totally different with real case. Pool-approach model use gravity equation to evaluate inter-regional flow of any product or service *i*. The gravity model supposes that the flow of the products of sector *i* from region *g* to any other region *h* is in direct ratio to its total output in region *g* and its total input in region *h*, whereas in inverse ratio to x_i^{OO} , that is $x_i^{gh} = \frac{x_i^{gO} x_i^{Oh}}{x_i^{OO}} q_i^{gh}$, and q_i^{gh} is called trade coefficient (which is also called friction coefficient). According to current data, we can put the factors that influence trade flow among regions into trade coefficients. Therefore, the gravity model is an estimation method which combined typical investigation and non-investigation method. The model makes the most of information in hand to estimate the trade flow among regions.

The trade matrix we get by way of gravity equation is only an elementary one. We should adjust the estimation results according to the row and column of IO table. The total out-flow of certain commodity in a region is equal to the total export of the commodity in the region. The total in-flow of certain commodity in a region is equal to the total import of the commodity in the region. We use the cross-entropy method to do the adjustment and get the final trade matrix.

2.1 Gravity Model

The gravity model comes from the universal gravitation in the physical world which considers that the gravity between two planets is in direct ratio to their mass and in inverse ratio to their distance. We apply the gravity model to inter-province trade. In this application, the GDP of the two provinces is taken for their mass and the distance between the two capitals of the provinces is taken for the distance between the two provinces.

According to the traits of inter-province data in our country, we try to construct the gravity model as follows:

$$x_i^{gh} = e^{\alpha} (x_i^{gO})^{\beta_1} (x_i^{Oh})^{\beta_2} \frac{(G^g)^{\beta_3} (G^h)^{\beta_4}}{(d^{gh})^{\beta_5}}$$

x_i^{gO} denotes the total volume of the products of sector *i* in region *g* exported to the whole country (including region *g*), that is, the total supply.

x_i^{Oh} denotes the total volume of the products of sector *i* in region *h* imported from the whole country (including region *h*), that is, the total demand.

G^g and G^h denotes the proportion of GDP of region *g* and region *h* to GDP of the whole country.

d^{gh} denotes the distance between region g and region h. In reality, we use the distance between the capitals of the two provinces to represent it.

x_i^{Oh} reflects the total demand of the sector in destination region. The bigger the total demand, the bigger the import volume and trade flow. x_i^{gO} reflects the total supply of the sector in origin region. The bigger the total supply, the bigger the export volume and trade flow. Through the construction of the model, we can analyze the influence of the factors such as distance on the inter-region trade flow. By way of regress analysis, we can get the estimation of $\alpha, \beta_1, \beta_2, \beta_3, \beta_4$ and β_5, thus calculate the original matrix of trade flow among 30 regions.

2.2 Minimum Cross Entropy Method

Shannon brought forward the concept of cross-entropy when he created information theory in 1948. Theil applied it into economics in 1967. Suppose there is a group of incidents $E_1, E_2, \cdots, E_n$ whose probabilities to happen are $q_1, q_2, \cdots, q_n$ (prior probability) respectively. Now we get additional message, which means that the prior probabilities should be adjusted into $p_1, p_2, \cdots, p_n$. According to Shannon's theory, the information we acquired from message is equal to $-\ln p_i$. However, each incident E_i has its own unknown probability p_i, so the extra information from q_i is determined by the following equation:

$$-\ln \frac{p_i}{q_i} = -(\ln p_i - \ln q_i)$$

Through the expected value of single information's price, we can get the expected value of a message's information value as following:

$$-I(p:q) = -\sum_{i=1}^{n} p_i \ln \frac{p_i}{q_i}$$

$I(p:q)$ is the cross entropy distance between the two probability distribution defined by Kullback-Leibler in 1951. The object function of cross entropy method uses all available information to minimize the cross entropy distance, and keep it in accordance with prior probability.

Golan, Judge and Robinson used cross entropy method to adjust the coefficients of IO table. Suppose the original coefficient matrix is $\overline{A}$, they estimated the final matrix A to minimize the cross entropy distance between the two matrixes.

$$\min(\sum_i \sum_j A_{ij} \ln \frac{A_{ij}}{\overline{A}_{ij}})$$

Subject to $\sum_j A_{ij} y_j^* = y_i^*$

$$\sum_j A_{j,i} = 1$$

$$0 \le A_{j,i} \le 1$$

y_j^* is the row sum or column sum of new information.

To solve the above problem, we can introduce the Lagrange multiplier

$$A_{ij} = \frac{\overline{A}_{ij} \exp(\lambda_i, y_j^*)}{\sum_{i,j} \overline{A}_{ij} \exp(\lambda_i, y_j^*)}$$

λ_i is the Lagrange multiplier of the information that relates to row sum and column sum, and the denominator is normalization factor.

In this paper, we construct the minimum cross entropy model as follows:

$$\text{Min} \sum_g \sum_h \frac{\overline{x}^{gh}}{OF^g} Ln(\frac{x^{gh}}{\overline{x}^{gh}})$$

Subject to $\sum_g x^{gh} = IF^h$ — g, h represents 30 different regions

$$\sum_h x^{gh} = OF^g$$

$$x^{gh} \ge 0$$

2.3 the steps to estimate the inter-regional trade in this research

The procedure for estimating the inter-region trade can be illustrated in table 1, which shows the inter-region trade for one kind of commodites. To get the estimated trade($A_{i,j}$), we first try to find the matrix of row sum (RS_i) and column sum (CS_j) as the control number. Then find an initial trade matrix $\bar{A}_{i,j}$ (mainly by estimating the gravity model), and finally we adjust the initial $\bar{A}_{i,j}$ to final $A_{i,j}$ controlled by the row sum and column sum by the method of CE.

Table 1: the inter-regional trade matrix for one kind of commodities

	Beijing	Tianjin	Hebei	…	Qinghai	Ningxia	Xinjiang	total export to ROMC
Beijing	$A_{1,2}$	$A_{1,3}$	$A_{1,4}$		$A_{1,28}$	$A_{1,29}$	$A_{1,30}$	RS_1
Tianjin	$A_{2,2}$	$A_{2,3}$	$A_{2,4}$		$A_{2,28}$	$A_{2,29}$	$A_{2,30}$	RS_2
Hebei	$A_{3,2}$	$A_{3,3}$	$A_{3,4}$		$A_{3,28}$	$A_{3,29}$	$A_{3,30}$	RS_3
…								…
Qinghai	$A_{28,2}$	$A_{28,3}$	$A_{28,4}$		$A_{28,28}$	$A_{28,29}$	$A_{28,30}$	RS_{28}
Ningxia	$A_{29,2}$	$A_{29,3}$	$A_{29,4}$		$A_{29,28}$	$A_{29,29}$	$A_{29,30}$	RS_{29}
Xinjiang	$A_{30,2}$	$A_{30,3}$	$A_{30,4}$		$A_{30,28}$	$A_{30,29}$	$A_{30,30}$	RS_{30}
total import from ROMC	CS_1	CS_2	CS_3	…	CS_{28}	CS_{29}	CS_{30}	

3. Data Base and the Estimation of Inter-region Trade Flow

3.1 Basic Data

To estimate the trade flow among regions, we need lots of detailed data. According to the data in hand, this research mainly used the data as follows.

3.1.1 IO Table of 30 provinces in China in 1997 and 2002

The IO table (basic table) in China is constructed every 5 years. In 1997 and 2002, the national bureau of statistics in China constructed integrated regional IO table. In regional IO table of 1997, the inter-region trade flow is systematically estimated and the total inter-province import and export volume of each region and each sector is calculated. However, the quality of the regional IO table of 2002 is not so good. For some regions, the import from outside province and the export to outside province are well estimated, and the import and export are also estimated separately. But for other regions, only total import (including import from foreign countries) and total export (including export to foreign countries) are estimated. For some exceptional provinces, only one column——the net export (including net inter-province export) is estimated.

Table 2: IO table of Beijing (with 4 column of trade) unit: 10000 yuan

	Agri	Coalmin	……	Pubadmin	consume, capital formation	export to ROMC	export	import from ROMC	import	ERR	total
Agri	740435	0	……	0	1739390	24893	270303	825100	122693	0	2465569
Coalmin	13965	288116	……	46279	115820	86548	0	616667	1006	0	575360
……	……	……	……	……	……	……	……	……	……	……	……
Pubadmin	85	5	……	3159	2398552	140	0	3905	0	0	2423506
total input	1457023	388550	……	1276428	42927056	32119535	8182706	34093690	8199308	0	40936299
wage	611595	93844	……	868439							
depreciate	69755	4848	……	260303							
adjtax	4856	22860	……	17017							
profit	322340	65259	……	1320							
value added	1008546	186810	……	1147078							
total	2465569	575360	……	2423506							

For these IO tables with 4 columns of trade, we can know the total volume of inter-region trade for every sector. For example, in table, the item in the row of sector “Agri”and column of “export to ROMC” indicates that Beijing export 24893 yuan commodities of agriculture to the other region in the Mainland of China. And the item in the same row and the column of “import from ROMC” indicates that Beijing import 122693 yuan of agriculture goods from the rest of mainland of china. There are 12 regions with this type of IO table in all of the 30 regions.

Table 3: IO table of Shannxi (with 2 column of trade) unit: 10000 yuan

	Agri	Coalmin	……	Pubadmin	consume, capital formation	export to ROMC	export	import from ROMC	import	ERR	total
Agri	942176	3930	……	0	1781659	1051845	0	184207	0	0	5224421
Coalmin	9626	1583	……	0	148007	235963	0	4183	0	0	702619
……	1449	1405	……	69725	111635	0	0	88214	0	0	261100
Pubadmin	0	0	……	0	1952800	0	0	0	0	0	1952800
total input	2107532	324893	……	659100	22773431	12068688	0	13835558	0	0	51196591
wage	204212	137254	……	7243	0						
depreciate	2468473	159646	……	1277871	0						
adjtax	149929	71805	……	8557	0						
profit	294275	9021	……	29	0						
value added	3116889	377726	……	1293700	0						
total	5224421	702619	……	1952800	0						

For these IO tables with 2 columns of trade, we can know only the total volume of inter-region trade plus export for every sector. For example, in table 2, the item in the row of sector “Agri”and column of “export to ROMC” indicates that Shannxi export 1051845 yuan commodities of agriculture to the other region in the Mainland of China and to foreign country. But in fact, we can get the inter-region trade by subtract this total trade by export and import, which can be get from the custom data. For the services sector, we just divide the total export according to the proportion in the accordingly 1997 IO table. So we can construct the 4 columns trade for these IO tables. There are 13 regions with this type of IO table in all of the 30 regions

And there are also anther type of IO table that there is only 1 column of trade column, that is only net export to outside the region. For these IO tables, we can first get the export and import from the custom data, and then we get the net inter-region trade.

3.1.2 China economic census yearbook 2004

The PRC implemented its first national economic census in 2004 and many index changed much after the census. For example, in 2004 GDP was considered to be 1.369 trillion yuan before the census, and was adjusted to 1.599 trillion based on the results of the census. The adjusted GDP was 17.8% higher than the non-adjusted figure. All regions made adjustments to their historical economic data in accordance with the result of this national economic census. For example, in 2004 GDP in Beijing, Shanxi, and Guangdong were adjusted upward by 41.5%, 17.4%, and 17.4%, respectively, and that in Heilongjiang, Hubei, and Guangxi were adjusted downward by 10.4%, 4.8%, and 10.7%, respectively. The adjusted data reflect the economic conditions of the regions more accurately.

3.1.3 Railway inter-region trade for 8 commodities

Based on the transport data of railway on 2002, we can get the inter-region trade of 8 commodities, that is grain, coal, coke, petroleum, metal ore, Nonmetal ore, Nonmetal Mineral Products (cement,glass,etc), Ferrous and nonferrous Metals (steel). For these 8 commodities, we can find the inter-region trade from one region to another region, so there is a trade matrix for every kind of commodities. This inter-region trade matrix is the base for us to estimate the gravity model.

3.2 Procedure of estimation of inter-region trade

3.2.1 Estimating the 4 columns trade in 2002 IO table for the 13 regions with 2 column trade and five regions with one column of net trade.

For these IO tables with only one column of net trade with the other regions and foreign, we first get the export and import from custom data. Then we just estimate the remain data by assume that the trade with the other regions and the export (import) are all proportionally with the sector’s output, and then adjust these proportionally so that the net-trade are identical with the 2002 IO table.

3.2.2 Balancing the inter-region trade

After construct the preliminary 4 column IO table, we can get rearrange the total inter-region trade for every sector in the form of table 4.

Table 4: the preliminary trade for agriculture goods in 2002 unit: 10 thousand yuan

	export to ROMC	import from ROMC	export	import
Beijing	24893	925100	122693	270303
Tianjin	717580	362208	219504	114432
Hebei	4545520	1722937	212264	173939
shanxi	0	321155	5586	76632
…	…	…	…	…
gansu	136145	130491	17659	72705
qinghai	17214	71727	415	7961
Ningxia	228199	58697	14325	3114
xinjiang	1089098	26991	376	114774
total	3965(100 million yuan)	2145(100 million yuan)		

We can see that for the preliminary trade, the sum of export to ROMC fore every region does not equal to the sum of import from ROMC. But in fact, these two numbers should be identical since every inter-region export from one region to the other is the other region's inter-region import. But since every IO table are constructed by every region and there is no statistical data on the inter-region trade. So there is always much difference between these 2 numbers and we have to balance the inter-region trade to get a consistently estimate.

Here we balance the inter-region trade for every sector using the CE method, that is, we solution the following problem (we balance every sector's inter-region trade one after one, so here we omit the subscript of the sector):

$$\min(\sum_i \sum_j A_{ij}(\ln A_{ij} - \bar{A}_{ij}))$$

Subject to

$$\sum_i A_{ij} y_j^* = y_j^* \quad (1)$$

$$\sum_i A_{i,j} = 1 \quad (2)$$

$$0 \le A_{i,j} \le 1 \quad (3)$$

$$A_{i1} y_1^* + \exp ort_i \le output_i \quad (4)$$

$$A_{i2} y_2^* + im\,\mathrm{p}\,ort_i \le demand_i \quad (5)$$

Where j= (1,2),1 stands for export to ROMC, 2 stands for import from ROMC), A_{ij} is the new estimated coefficient of region i's export to ROMC (/import from ROMC) to the column sums in table 3. $\overline{A}_{ij}$ is the prior coefficients. y_j^* is mean of two column sums, that is to say, we set the total inter-region export to the mean of total inter-region export and total inter-region import.

The constraint (4) just said that the estimated inter-region export plus export in region i should not large than total output in region i (for every sector). The constraint (5) indicate that the estimated inter-region import plus import should not larger than total demand in region i, total demand include the demand for Intermediate Input, household and government consumption, capital formation and inventory.

3.2.3 Revise the regional IO table

Since the regional IO table is constructed without the information of the first national economic census, and many index changed much, so we revised the regional IO table so that the regional GDP, sector output, consumption, capital formation as well as other index are identical to the adjusted data in the "china economic census yearbook". The methods used here is still the CE method (Robinson, Cattaneo, El-Said,1998), but we fixed the trade in the procedure.

3.2.4 Estimated the gravity model for 8 commodities

The data used in the gravity model include:

(1) the inter-region trade matrix for every commodities, which we get from the railway statistical data.

(2) total supply(x_i^{gO}),total demand (x_i^{Oh}), can be get from the revised regional IO tables, the total demand is just the sum of intermediate input, consumption of household, consumption of government, capital formation and inventory.

(3) Distance between every two regions. In theory, we should find out the economic center of gravity and use the distance between this regional economic centres as distance of two regions. Here we just simply set the distance of two regions equal to the railways distance between the regional capitals, which can be get from the national railway ticket system. Since the Hainan province is an island, there is no direct railway between its capital and other regions, we just set the distance between Hainnan and other regions equal to the distance of capital of other region to Nanning plus the distance of Nanning to Haikou.

Then we estimated the gravity model for the 8 commodities by simple OLS, the results are shown in table 5.

Table 5. The estimated gravity model for 8 commodities

Commodity	Estimated results
grain	$\ln x_i^{gO} = -0.838 + 0.738 \ln x_i^{gO} + 0.046 \ln x_i^{Oh} + 0.504 \ln G^h - 0.253 \ln d^{gh}$ (-0.358)(9.948***) (0.335) (3.820***) (-2.524***)
coal	$\ln x_i^{gh} = 6.602 + 0.681 \ln x_i^{gO} - 1.262 \ln d^{gh}$ (3.584***) (4.915***) (-5.997***)
coke	$\ln x_i^{gh} = 2.240 + 0.481 \ln x_i^{gO} + 0.039 \ln x_i^{Oh} - 0.539 \ln d^{gh}$ (1.559) (5.759***) (0.395) (-3.410***)
Petroleum	$\ln x_i^{gh} = 6.332 - 0.696 \ln d^{gh}$ (5.565***) (-4.090***)
metal ore	$\ln x_i^{gh} = 7.753 + 0.019 \ln x_i^{gO} + 0.025 \ln x_i^{Oh} - 0.967 \ln d^{gh}$ (3.035**)(0.195) (0.183) (-5.693***)
Nonmetal ore	$\ln x_i^{gh} = 7.410 + 0.099 \ln x_i^{gO} + 0.109 \ln x_i^{Oh} + 0.169 \ln G^h - 1.152 \ln d^{gh}$ (4.346***)(1.754*) (1.556) (1.450) (-11.084***)
Nonmetal Mineral Products (cement,glass,etc)	$\ln x_i^{gh} = 4.084 + 0.188 \ln x_i^{gO} + 0.031 \ln x_i^{Oh} - 0.884 \ln d^{gh}$ (2.241**) (2.460**) (0.427) (-8.925***)
Ferrous and nonferrous Metals (steel)	$\ln x_i^{gh} = -1.250 + 0.301 \ln x_i^{gO} + 0.332 \ln x_i^{Oh} - 0.877 \ln d^{gh}$ (－0.776) (4.882***) (5.642***) (-10.061***)

Note: * indicates significant at 0.1 level, ** indicates significant at 0.05 level, *** stands for significant at 0.01 level.

3.2.5 Calculated the initial inter-regional trade matrix

For the sectors with mainly products as the 8 commodities, we just use the initial railway trade matrix as the initial trade matrix. For other non-services sectors, we calculate the initial trade matrix using the selected estimated gravity equations. We don't use the same gravity equation for every industry; the mapping relation between sectors and 8 commodities is showed in table 6.

Table 6. mapping relation for sectors and the 8 commodities

8 commodities	Sectors in the IO table
Grain	Agriculture Food Processing, Manufacturing and Tobacco Processing
Coal	Coal Mining and Dressing
Petroleum	Petroleum and Natural Gas Extraction

<table>
<tr><td></td><td>Chemical Industry</td></tr>
<tr><td>metal ore</td><td>Metals Mining and Dressing</td></tr>
<tr><td>Nonmetal ore</td><td>Nonmetals Mining and Dressing</td></tr>
<tr><td>coke</td><td>Petroleum Processing and Coking</td></tr>
<tr><td>Nonmetal Mineral Products (cement,glass,etc)</td><td rowspan="2">Nonmetal Mineral Products
Textile Industry
Garment, Leather，Furs，Down and Related Products
Timber Processing and Furniture Manufacturing
Paper making, Printing and Record Medium products
Machinery(Ordinary and Special)
Transport Equipment
Electric Equipment and Machinery
Electronic, computer and Telecommunications
Instruments，Meters，Cultural and Office Machinery</td></tr>
<tr><td rowspan="2">Ferrous and nonferrous Metals (steel)</td></tr>
<tr><td>Smelting and Pressing of Metals
Metal Products
Other Manufacturing</td></tr>
</table>

For the service sector, the gravity model is not efficient since the trade for services different much from the non-service sector. So we just construct an initial trade matrix from the estimated total inter-region export and inter-region import. That is to say, $a_{i,j} = \frac{CS_j}{\sum_j CS_j} \times RS_i$ (see table 1 for denotation of CS and RS)

3.2.6 Estimate the final Inter-Region trade matrix

With the initial inter-region trade matrix and control number of total inter region export (RS) and total inter-region import (CS), we can estimate the final trade matrix by CE method, that is, we solution the following problem:

$$\min(\sum_i \sum_j A_{ij}(\ln A_{ij} - \overline{A}_{ij}))$$

Subject to

$$\sum_j A_{ij} CS_j = RS_i \qquad (1)$$

$$\sum_i A_{ij} RS_i = CS_j \qquad (2)$$

$$\sum_i A_{i,j} = 1 \qquad (3)$$

$$0 \le A_{i,j} \le 1 \qquad (4)$$

4、Analysis of inter-regional trade based on the estimated trade matrix

4.1 The comparison between domestic trade and foreign trade

In the nationwide, foreign trade is an important factor promoting economic growth. The ratio of the export to GDP is increasing year by year. In the year of 2002, the ratio has attained 22.4%. However, according to our estimation, the total amounts of domestic trade were RMB 5.67 trillion in the same year, more than two times as much as the ratio of the export to GDP, and accounted for 47.0% of GDP. From this point, we can infer that domestic trade also has important influence on the economic growth.

4.2 Domestic trade has much more important influence on some districts

Table 4 Ratio of Dependence on trade for different districts in China (%)

	Ratio of Inter-Regional Export Dependency	Ratio of Export Dependency	Ration of Inter-Regional Import Dependency	Ratio of Import Dependency
Beijing	78.3	18.9	80.3	18.9
Tianjin	96.1	48.5	95.1	45.6
Hebei	79.0	5.9	66.7	2.8
Shanxi	27.9	8.5	30.1	2.7
InnerMong	43.2	4.0	37.8	7.4
Liaoning	43.4	18.2	33.6	14.3
Jilin	104.1	6.6	109.9	9.0
Heilongjiang	44.3	5.5	35.8	5.5
Shanghai	58.4	55.5	40.3	67.5
Jiangsu	34.8	30.7	31.7	28.0
Zhejiang	64.0	31.3	68.6	13.2
Anhui	84.7	5.6	85.6	4.4
Fujian	21.7	29.8	32.7	15.6
Jiangxi	38.3	3.5	47.2	2.8
Shandong	33.7	16.3	31.7	14.3
Henan	29.3	3.2	28.9	2.0
Hubei	28.2	3.8	29.6	5.1
Hunan	32.8	3.5	29.1	3.2
Guangdong	37.1	68.1	36.8	61.5
Guangxi	54.6	5.9	65.9	3.1
Hainan	66.6	6.9	80.4	8.2
Chongqing	94.7	4.6	108.9	4.2
Sichuan	20.9	4.6	24.5	3.5
Guizhou	47.5	3.8	61.5	2.9
Yunnan	30.2	3.7	41.7	2.9
Shaanxi	51.1	0.2	57.9	4.9
Gansu	37.0	9.9	55.6	3.6

Qinghai	55.9	9.2	96.2	1.8
Ningxia	54.5	3.3	97.6	3.0
Xinjiang	45.1	5.8	52.2	6.5
whole country	47.0	22.2	47.0	19.3

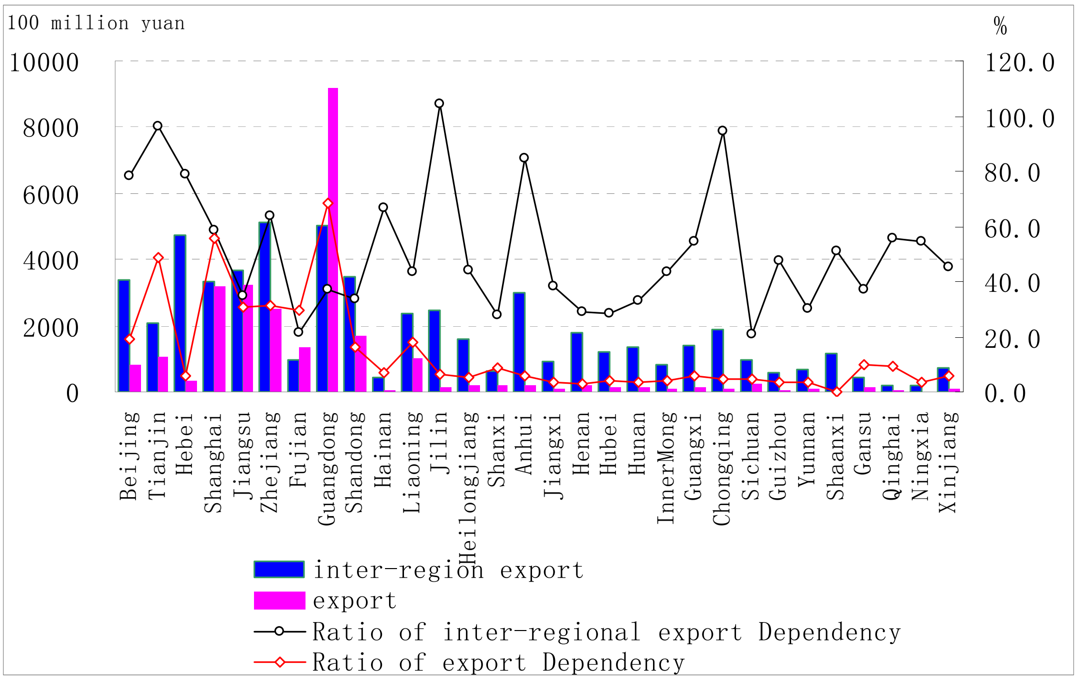

Figure 1: export, inter-region export and export dependency

Data Source: Calculation result

Figure 1 shows the volume and ratio of export and inter-region export for all 30 regions in China. In the year 2002, the export totaled 2.67 trillion RMB, among which, nine provinces of Beijing, Tianjin, Shanghai, Jiangsu, Zhejiang, Fujian, Guangdong, Shandong and Liaoning accounted for 90%, amounting to 2.4 trillion RMB. The ratio of export dependencyof those areas was also high. Shanghai, Jiangsu, Zhejiang, Fujian and Guangdong were 55.5%, 30.7%, 31.3%, 29.8% and 68.1%, respectively, while Shan Dong was 16.3%, the lowest ratio in those areas.

Among those nine provinces, the ratio of export dependency of Shanghai, Jiangsu, Fujian and Liaoning were the same as or more than that on the inter-region export. But the situation of Beijing, Tianjin,Zhejiang were just on the contrary, which implied that the development of domestic market is also important for these eastern areas.

Apart from these 9 provinces, total export amounts of the rest provinces accounted for less than 10% of the GDP. But the ratios of inter-region export dependency were higher than that on international export. Except Sichuan province whose ratio of inter-region export dependency was 20.9%, the rest were all above 30%, which suggested that the development of domestic trade is very important for the economic growth in inland areas.

4.3 division of trade area

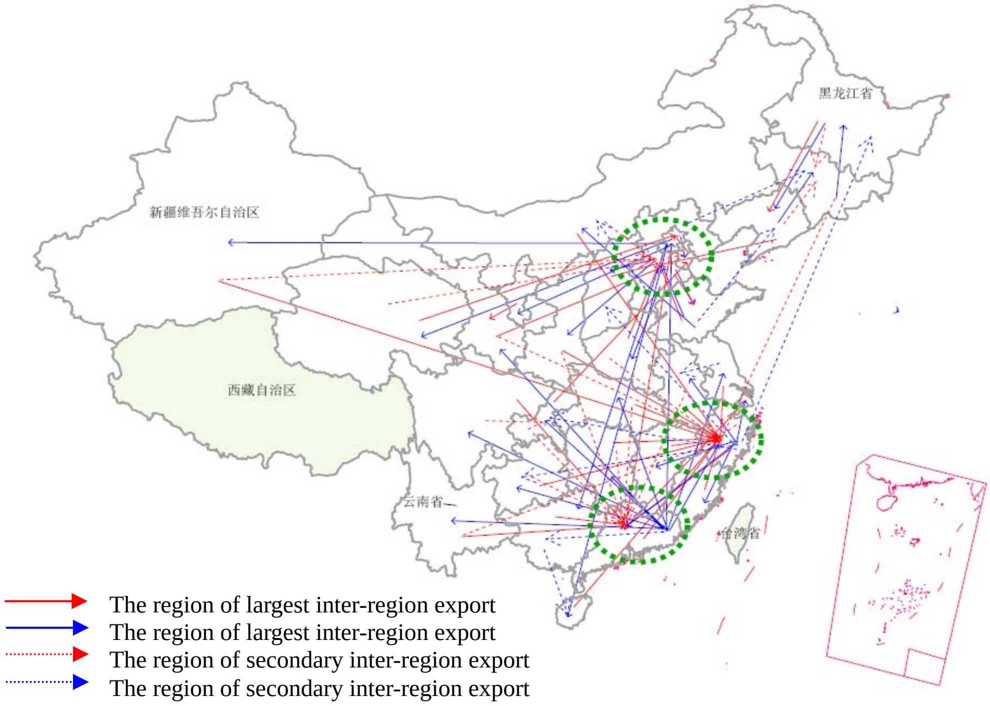

Figure 2: Sketch map of inter-regional trade in China

According to the sketch map, the pattern of inter-regional trade of China can be described as three centers:

The first centre is the Jing-Jin-Ji regions. The relationships between the provinces in the regions are strong. Besides that, these regions are main export destinations of Shanxi, Liaoning, Shandong, Henan, Chongqin, Gansu and Qinghai, and also main import sources for Shanxi, Shandong, Henan, Guangxi, Hainan, Qinghai and Xinjiang.

The second center is the Yangtza River Delta. Trade partners of the Yangtza Rive Delta distributed in large areas, including Inno Mongolia, Anhui, Fujian, Jiangxi, Hubei, Hunan, Guangdong, Hainan, Guizhou, Shanxi, Xinjiang, Anhui, Fujian, Jiangxi and Guangdong. Three provinces of Shanghai, Jiangsu and Zhejiang in the district also trade a lot.

The third center is Pearl River Delta regions. The Pearl River Delta regions mainly refer to Guangdong Province. Guangdong Province is the main export destination of Beijing、Jilin、Shanghai, Zhejiang, Guangxi, Sichuan and Yunnan, and is also the largest importer of Beijing, Jiangsu, Zhejiang, Hubei, Hunan, Chongqin, Sichuan, Guizhou, Yunnan and Gansu.

Because of far away from three centers mentioned above, it seems that the rest districts of the nation, especially Central regions and Western Regions, should have more trade flows with the surrounding areas. But in reality, expect that the trade relationship of Liaoning, Jilin and Heilongjiang is strong, the main trade partners of the rest districts are all the three centers.

5. Conclusions and policy implications

This paper used the method of Cross-Entropy and gravity model to estimate the inter-regional trade for 42 sectors. The data are from different sources, including regional Input-Output Tables of the year 2002 and the data of inter-regional trade through railway.

By comparing the volume of estimated inter-regional trade to that of the international trade, we find that the volume of inter-regional trade is nearly two times as much as that of international trade for the whole nation. Trade of many regions displays the same pattern as the whole nation, especially for the inland regions, such as the Central and Western of Mainland of China. However, the volume of International trade in districts of Shanghai, Jiangsu, Fujian and Guagndong are larger than that of inter-regional trade.

We also find that there are three mainly economic centers in China, namely, Jing-Jin-Ji regions、Yangtza River Delta and Pearl River Delta regions. No matter how far away form these economic centers are they, most inland provinces often trade more with these three centers than with the surrounding areas.

According to these findings, there are several policy implications. Firstly, since the inter-region trade is the main factor influencing economic growth for inner regions, most of which are less developed, the liberations of inter-regional market is an effective way to promote more balanced development for China.

Secondly, Although far away from coastal economic centers, many inner regions such as Xingjiang, Gansu and Sichuan still trade most with them, which is the result of long time unbalanced development, The coastal regions developed much faster because of geography advantage and effective measures promoting export. However, the long distance, which will cause large amount of transport expenses, means that this trade pattern of inter-regional is not optimal. In view of this, it had better to simulate the development of some inner regions and form another economic center, then the inland region can trade more with this economic inner center thus to cut down the overall transportation cost and enhance the economy efficiency.