STUDY ON CARGO FLOW PROJECTION IN TUMEN RIVER ECONOMIC DEVELOPMENT AREA

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ABSTRACT: The paper studies the methodologies of the cargo flow study and projections in Tumen River Economic Development Area(TREDA) that some governments and international scholars used. The authors consider that, in order to promote investment, facilitation of cross-border trade and infrastructure in the region, the basic methodology should be based on the regional economic growth of pertinent Northeast Asian countries and regions to make projections of the situations of regional cargo flows, and then analyzing the cargo flow trend. Based on the above, the authors utilize the routes comparison model and gravity model to forecast the cargo flows through the ports and related routes in TREDA (2000－2020). The authors also inquire into the main obstacles which affect the cargo flows of the region, analyze the influences on cargo flows if the obstacles change with sensitivity analyses and try to find the way to solve the obstacles.

KEY WORD: cargo flow projection, routes comparison model, gravity model, sensitivity analyses

1 DETERMINATION OF THE BASIC METHODOLOGY

Some governments and international scholars have made some projections of this region's cargo flows. In general, there are the following three projections:

The first one is Mr. Makoto Nobukuni's projection(Makoto, 1990), which is obtained on the basis of the relations between cargo transport volumes and the elasticity and its future changes. It proposed the assumption that "half of the incremental volumes of Northeast China will be transported through the TREDA ports". Its characteristic is that it raised the notions of the Chinese Government's grain security strategy and energy security strategy. They form the bases of his cargo projections. Based on that, he proposed the minimum-transport-cost mathematics model.

The second one is "Report on Executing Feasibility Study of the Reconstruction Plan of Port Zaru-

bino" by Economic Research Institute of Northeast Asia (ERINA)(ERINA, 1996). Its aim is to provide the basis for the expansion of Port Zarubino, and to base it on some relevant assumptions. One of the assumptions says that Northeast China is the port's hinterland. The varieties of cargoes generated by Northeast China's economic development will be bountiful and the cargo volumes will be always on the increase. China will follow the market economy and choose the most economical transport routes. The route share distributions are based on assumed proportions.

The third one is the projection made by Chinese local governments and scholars. The projection by the local Railway Bureau of Jilin Province is founded on their experience and judgements, holding that in the period of 2000－2005 the annual cargo flows of this area is no more than 900 000 tons. Professor Ding Sibao, member of the Northeast Asia Research Center (NARC) of Northeast Normal University, surveyed the production distribution and transport alloca

tion in both Jilin and Heilongjiang provinces during his study in 1991, determined the hinterlands of Port Dalian and the TREDA ports (Chinese Tumen River ports), and projected possible cargo flows in the hinterlands (mainly export cargo flows). However, this study fails to foresee the large idle capacities of Port Dalian, Northeast China's railways and roads, and it is also optimistic about the possibility of setting up a port on the Tumen River.

The above-mentioned studies and projections, due to their different emphases and targets, all have their own features and drawbacks. So, in order to further study the cargo flows through TREDA, to offer business opportunities to investors in a short-term projection, and to provide a scientific method (a tool) in a long-term projection, which may be used by different specialists together with their own assumptions. The basic methodology may be based on the regional economic growth of pertinent Northeast Asian countries and regions to make projections of the situations of regional cargo flows. And the cargo flows through the ports of TREDA and on the related routes can be analysed by using the route comparison model and gravity model.

2 GENERATION OF REGIONAL CARGO FLOWS AND THE PROJECTION

TREDA cargo flows mainly come from Northeast China, Siberia of Russia and Russian Far East, The Democratic People's Republic of Korea(DPRK) and Mongolia.

2.1 Projections of GDP Growth in the Studied Region

We analyze the average GDP increase rates of the concerned countries and regions in the three periods of 1980 – 1990, 1991 – 1996 and 1985 – 1996. Based on the average GDP increase rates of the two periods of 1991 – 1996 and 1985 – 1996, and referring to China's "The Ninth Five-Year Plan and the Long Term Prospect in 2010" and the World Bank report

(World Bank, 1997), we propose that the average GDP growth rate for China and northeast China will be 7.5% – 8.0% between 1997 and 2010, 6.5% – 7.0% between 2010 and 2020 (The average economic growth rates of northeast China is basically at the average level of China). The economy of Russia and the Far East started to pick up in 1997, and their GDP increased 0.4% over that of 1996. According to the projections made by the World Bank and the Organization of Economic Cooperation and Development (OECD), their GDP increase rate may reach 3.0% in 1998(OECD, 1997) (Russia plans to reach 2.0% – 4.0%), and 5.0% in 1999. Referring to the projection made by the International Monetary Fund (IMF), Russia's GDP growth rate is 1.1% in 1998 and 1.9% in 1999. So it is justified to think that along with the economic revival in Russia and its Far East, the GDP increase rate may reach 3.0% – 5.0% in 2000, and this trend is expected to last until 2020. As for Mongolia, its GDP average increase rate was – 2.6% from 1991 to 1996 compared with 3.9% in the period of 1980 – 1990. Mongolia's economy started to pick up from 1994, the growth rates in 1994 and 1995 were 2.3% and 6.3% respectively. So it is justified to think the growth rate will be 4.5% – 5.0% from 2000 to 2020. Due to the natural disasters in the recent years, which resulted in very poor agricultural yields, DPRK is suffering from enormous economic difficulty. Its average growth rate was – 4.4% from 1991 to 1996. We feel it extremely hard to make any projections of its average increase rate from 2000 to 2020 because of the uncertainty about its internal situations. The ideal results would be that its economy may recover or stop decreasing by 2000, and the increase rate will be 3.0% – 5.0% from 2000 to 2020.

2.2 GDP Elasticity and Its Variations

The trade data-the total import & export value, the import value and the export value, the composition of the import & export value, and their average growth and the average GDP growth rates of different

countries are analyzed in different periods of time (1980 – 1990, 1991 – 1996 and 1985 – 1996). Based on the above-mentioned two average growth rates, the trade elasticity of the relevant areas in the three different periods can be analyzed. These analyses reveal that the economic development of northeast China is closely related to their trade. We pick out the data from 1991 to 1996 and the data from 1985 to1996 as two groups of reference data, it shows that the trade elasticity value was smaller between 1991 and 1996 than the average value between 1985 and 1996. Then we can go on to analyze the upper and the lower values of these two groups of trade. As for Russian Far East, DPRK, and Mongolia, from 1980 to 1996, their economic development was very unstable. Sometimes the economic development was negative, but its trade growth was positive. Sometimes both the economic development and the trade were in negative. In this case, the elasticity does not work, and their trade value and their development rates have to be determined by our experience and our informed judgment based on the existing data, and the situation in the period of 1980 – 1990.

2.3   Projection of Regional Cargo Flows

The total trade value of northeast China and total trade values of the three provinces from 1990 to 1995, as well as the import & export volumes of the Northeast Asian countries, are analyzed. It is found that, generally speaking, the Russian shares as well as DPRK and Mongolia constitute about 15% of the imports and exports of northeast China, to be more exact, about 50% in Heilongjiang, 13% – 20% in Jilin, and about 6% in Liaoning. This analysis is very important, because in northeast China's trades with Northeast Asia and other parts of the world, the cargo flows to Russia and its Far East, DPRK and Mongolia do not go through ports, especially for TREDA. So their shares should not be considered when the foreign trade cargo flows of northeast China are analyzed. Owing to the Sino-Russian strategic partnership and both countries' desire for trade growth, the

trade cargo flows between northeast China and Russia and its Far East will increase a great deal. At least they will remain to be like now.

Main foreign trade partners of Russia are European countries, Byelo russia, and Independent States. Total foreign trade of Russian Far East, which only accounts for about 3% – 4% of Russian foreign trade, is the trade among Russia and countries & regions of Asia and Pacific Region (APR). So, in Russia's trades with Asia and Pacific Region, the cargo flows to and from Northeast China, DPRK and Mongolia do not go through ports of TREDA, so their shares should not be considered when the foreign trade cargo flows of Russia and Russian Far East are analyzed. The total foreign trade cargo flows of Russia, account for about 3% of total (2% of export and 3% – 5% of import) will go through the ports of TREDA.

All of the foreign trade of Northern Hamgyong of DPRK will go through the ports in TREDA, accounts for about 15% of DPRK. Mongolia want to participate in the economic cooperation of Northeast Asia and desire to look for a mouth of sea, a part of the cargo flows generated in the eastern part of Mongolia will go through the ports in TREDA. About 15% – 20% of total of Mongolia's foreign trade will go through the ports in TREDA according to the analyses of its eastern three provinces.

We classify the trade commodities into three main categories: bulk, general and container. As for value, from the current cargo flow situations, northeast China's container in total cargo is apparently 50%, bulk and general account for 1/4 of the total respectively; Russia's bulk, general and container account for 1/3 of the total respectively. But as for volume, bulk and general take big shares. The trade variety analyses deal with the regional variety structure of cargo flows in the period of 1990 – 1995, the corresponding value to a unit volume is 150 US $/t for bulk in northeast China (100 US $/t in Russia and other countries), 550US $/t for general and 20 000 US $/TEU for container (1 TEU = 18 tons).

3 CARGO FLOW COMPARISONS OF DIFFERENT TRANSPORT ROUTES

Cargo flows may have, from their origins to their destinations, many routes. In order to find out the possible routes from their origins to their destinations, the distances, transport costs and time (including traveling time and time spent on border crossings and transshipments, etc.) must be converted into unit currency value, to obtain the total financial costs for the cargo transports. However, because there are too many factors involved, sometimes the financial costs fail to reflect some potential diversion chances. For instance, China subsidizes heavily its railways. Border crossing charge is another consideration. So the actual costs may be much higher.

3.1 Choices of the Origins and Destinations

Based on the above ascertain of cargo product, we choose the following regions as the origins: Harbin and Mudanjiang of Heilongjiang Province. Changchun, Jilin, Baicheng and Yianji of Jilin Province, and Shenyang of Liaoning Province, Ulanbatar and Choybalsan of Mongolia, Taisiet of Siberia of Russia.

The destinations will be as follows: Kobe/Osaka of the eastern part of Japan and Niigata of the western part of Japan, Pusan of South Korea. As for the other parts of the World, we choose Singapore and San Francisco of the western part of America as another two destinations.

3.2 Port and Choices Among Different Routes

We classify the related ports of Northeast Asia into the following parts: (1) Port Vanino, a northern port of the Russian Far East; (2) Vladivostok Port Cluster, which include port Vladivostok, Nakhodka and Vostochny in the south of Russian Far East; (3) Zarubino Port Cluster, which include port Posjet and port Zarubino of Russian Far East; (4) Rajin Port Cluster, which include Rajin, Sanbon and Chongjin of DPRK; (5) Dalian Port Cluster, which include Dalian, Yingkou, Dandong and Jinzhou port of Northeast China.

For instance, there are 4 alternative routes for cargoes from Harbin to Kobe/Osaka (Harbin – Dalian – Kobe, Harbin – Vladivostok – Kobe, Harbin – Rajin – Kobe, Harbin – Zarubino – Kobe). Each of the routes passes different ports, so there are several routes from different origins to different destinations. Transport modes may be the rail or the road, and the ratio between the two modes will vary with the regional economic development, so we must make comparisons among the transport routes of the two modes. Each of the routes is composed of the distance, different transport modes, transshipment (not for the road transport between China and Russia), and loading & unloading. Then we can calculate the time needed and the total charges that occur all the way to the terminal. In addition, route analyses must be combined with cargo varieties transported.

3.3 Determination of the Route Cost and Comparison

Freight composition: Freight can be different kinds and items. In this area, because the loading and unloading charges have been counted into the transport costs, they are zero. Freights vary with different distances in different countries. Inter-country rail transports may have extra charges, such as the gauge transfer between China and Russia, and between China and Mongolia, and the Sino-DPRK border crossing charges. Border crossing charges include transshipment and inspections

Transport time: It can be calculated on the basis of distances and the speed. As for rail, the speed is 240 km/d in northeast China, Russia and its Far East, and Mongolia, and 120 km/d in DPRK. As for the road, the speed is 60 km/h in northeast China, Russia and its Far East, and Mongolia, and 30 km/h in DPRK. It is assumed that the vehicle runs nonstop 24 hours a day. The time taken to cross borders and clear away from ports is the current average. The

bigger and the more comprehensive the port is, the less time it needs to pass it. This has to do with the operation efficiency.

Time cost: It is based on the bank interest, and the cargo value is considered. The time cost is added to the financial cost of different routes. It needs to be pointed out here that the "interest" can not be replaced simply by bank loan interests, because time does not mean exactly the same thing to different cargoes and all the individual consignors. If the consignors are pressed by the bank loan deadline, or he needs his cargoes to reach their destination as soon as possible, the time cost here may be estimated higher. In another word, time efficiency must be raised.

After all the freight and charges calculated, we can get the total cost of one route, so we can analyze the total costs and determinate advantageous and disadvantageous of all the routes preliminary.

4   ROUTE SHARE DISTRIBUTION ON THE BASIS OF ROUTE COMPARISONS

4.1   Gravity Model

Gravity model is used to decide transport shares and allocate them to various routes on the basis of comparative attraction of different routes. The prerequisites of the model chosen here are that the attractiveness will increase when the capacities of the ports on these routes increase, and it will decrease when the transport costs (including time costs) decrease. At the same time, the transport modes (rail and road) and their shifts are taken into consideration. The gravity model can be expressed in the following formula:

$$A_i = S_i^a / C_i^b, \quad B_i = S_i^a / C_i^b, \quad (i = 1, 2, \ldots n)$$

A_i means the attractiveness of the rail; B_i refers to the attractiveness of the road, S refers to the size of the port, C refers to the transport cost, and a, b, are pending coefficients. So the relation between the route share and the total transport volume is:

$$F_i = F * (c * A_i / \sum A_i +$$

$$d * B_i / \sum B_i), \quad (i = 1, 2, \ldots n)$$

F_i refers to the total transport volumes in the region. $A_i / \sum A_i$ refers to railway share and $B_i / \sum B_i$ refers to road share. c and d are the turnover weights of rail and road respectively.

4.2   Port (cluster) and Its Capacity

1) Port Vanino. It will divert some cargoes from other ports in the Russian Far East. Its throughput capacity now is 12.5 million tons. According to the analyses of the current situations, it will remain to be like this by 2000, and reach 15.2 million tons in 2010 according to the planning. It will be about 22.8 million tons in 2020 in the same increasing rate of Dalian (50%).

2) Vladivostok Port Cluster. Their total throughput capacities are 42.4 million tons and the same capacity by 2000, and in 2010 will be 52.6 million tons (of this Vladivostok, Nakhodka and Vostochny Port will expand to 13.8 million tons, 18.5 million tons and 20.3 million tons respectively according to the planning). It will be 78.9 million tons in 2020.

3) Zarubino Port Cluster. The total throughput capacities of port Posyet and Zarubino are 2.1 million tons in 1996. According to Russian plans, by 2010, Port Zarubino will be 7.8 million tons of capacity, Posjet will be 2.6 million tons (total 10.4 million tons)

4) Rajin Port Cluster. The total throughput capacities are 14.6 million tons at present. According to DPRK's plans, the throughput capacities of the three DPRK ports will reach 130 million tons and 70% cargoes will come from northeast China. These have been analyzed in the description of the current situations and are held to be impossible. So the repeated multiple analyses are applied to these ports, speculating that their capacities will reach 22 million tons in 2010, and 33 million tons in 2020, which, to some extent, seems to be more reasonable.

5) Dalian Port Cluster. The total throughput ca-

pacities were 80.0 million tons in 1996. It diverts most of the cargoes of northeast China, and its capacity will reach 120 million tons by 2010 according to the planning and 180 million tons by 2020.

4.3 Value a and Value b

The value a and the value b are from experience, which is shown in the following formula:

$$G_i/G_1 = A_i/A_1 = (S_i^a/S_1^a)/(C_i^b/C_1^b), \quad (i = 1, 2, \ldots n)$$

Through analyzing the ratio of cargo share diversions from Changchun to Dalian, to Yingkou and to Qinhuangdao by the year and the proportion of the capacities of the three ports, it can be calculated that the value a is about 0.84 and value b is about 0.60. Obviously, these values reveal that the capacities of ports may be more influential than the freights in the route share distribution, and it conforms to the reality. The route to the southern ports of northeast China are kind of stable beaten tracks. As regional trade and port capacities develop, and as the operational efficiency rises, the influence of port capacities will be stable and the freight will play a more important role. Thus, in the projection of cargo share distribution,

the value b will be 0.8, 1.0 and 2.0 respectively in 2000, 2010 and 2020. In another word, by then the port capacities will be stabilized, and the freights will have more impacts.

4.4 Value c and Value d

These two parameters are weights of the rail and the road in the route share distribution. Based on the experience of other countries and the analyses on transport volumes and turnovers in the period of 1952 – 1996, the shares of road increased year by year, they are 95% and 5% in 1990 compared with 85% and 15% in 1996. So they will be 80% and 20% before 2000, 70% and 30% before 2010, and before 2020 60% and 40%, or maybe 50% and 50%.

5 RESULTS OF THE MODEL ANALYSES

On the basis of the methodology (routes comparison model and gravity model), we use the software Excel 97 under the operating system Windows 95. The projection results are shown in Table 1 and Table 2.

Table 1   Cargo flows through different port clusters

	1996		2000		2010		2020	
	Volume($\times 10^6$t)	Share(%)	Volume($\times 10^6$t)	Share(%)	Volume($\times 10^6$t)	Share(%)	Volume($\times 10^6$t)	Share(%)
Vladivostok	17.08	20.6	19.1 – 19.9	21.5	45.9 – 49.8	22.2 – 22.5	116 – 123	22.6
Zarubino	0.90	1.1	1.9 – 2.0	2.1 – 2.2	15.5 – 16.7	8.9	30.7 – 32.8	6.0
Rajin	5.00	6.0	5.4 – 5.8	6.1 – 6.2	25.3 – 27.2	12.3	50 – 53	9.7
Dalian	60.00	72.3	62.7 – 64.9	70.3 – 70.1	119.7 – 127.6	58 – 57.7	316 – 337	61.7
Total	82.98	100	89.1 – 92.6	100	206.4 – 221.4	100	512 – 547	100

Table 2   Cargo flows on alternative routes in the regions (($\times 10^6$t))

Alternative routes	2000			2010			2020		
	Railway	Road	Total	Railway	Road	Total	Railway	Road	Total
Suifenhe – Vladivostok	1.6 – 1.7	0.5 – 0.6	2.1 – 2.3	2.4 – 2.5	1.0 – 1.1	3.4 – 3.6	1.9 – 2.0	1.6 – 1.7	3.5 – 3.8
Tumen – Rajin	2.9 – 3.0	1.0	3.9 – 4.0	6.6 – 7.0	1.6 – 1.7	8.1 – 8.7	11.1 – 11.8	3.0 – 3.1	14 – 14.9
Tumen – Zarubino	0.4	0.1	0.5	1.7 – 1.8	0.6 – 0.7	2.4 – 2.6	1.8 – 1.9	1.1 – 1.2	2.9 – 3.1

6   SENSITIVITY ANALYSES

The practical value of the above route comparison model and gravity model lies with the sensitivity analyses, which has to do with some analyses of variants of some coefficients and results.

6.1   Changes of Throughput Capacity

The bigger the capacity, the stronger a port cluster attracts cargo flows. Through analyses, if the throughput capacity of Vladivostok increase, for instance, 10% that of 1996 in 2000, the share will increase 2% that of 1996 in 2000. If the throughput capacity is two times that of 1996 for Zarubino cluster, the cargo flows shares through the cluster will increase from 2.0% to 3.1%. If the capacity of Rajin cluster increase 50% that of 1996, the share of the cluster will increase from 6.2% to 7.5%.

6.2   Changes of Charge Criteria

At present, railway charge of China is very lower than that of Russia, about 1/9 that of Russia. As for the Chinese rail subsidy, the road's diversion function becomes stronger, the rail feels more pressure. Some Chinese local governments have already started to raise their rail freights to RMB 0.37 yuan/t·km. Russia's border crossing rates are much more higher than that of other countries (this will be a disadvantageous to use the ports of Russia). If China raise the rail freights, for instance, as the level of local railway, when China goes step by step toward the market economy, especially the renovation of large and middle-sized state enterprises. And the border crossing rates of Russia decrease to the half of the present, the cargo flows through ports of TREDA and on the related routes will increase obviously, refer to Table 3 and Table 4.

Table 3 Cargo flows through different port clusters

	1996		2000		2010		2020	
	Volume($\times 10^6$t)	Share(%)	Volume($\times 10^6$t)	Share(%)	Volume($\times 10^6$t)	Share(%)	Volume($\times 10^6$t)	Share(%)
Vladivostok	17.08	20.6	19.1 – 19.9	21.5	51.3 – 55.6	23.9 – 24.2	99.5 – 106	19.4
Zarubino	0.90	1.1	1.9 – 2.0	2.1 – 2.2	19.2 – 20.7	9.0	39.9 – 42.6	7.8
Rajin	5.00	6.0	5.4 – 5.8	6.1 – 6.2	26.4 – 28.4	12.3	56.8 – 60.6	11.1
Dalian	60.00	72.3	62.7 – 64.9	70.3 – 70.1	117.7 – 125.5	54.8 – 54.5	318 – 339	61.8
Total	82.98	100	89.1 – 92.6	100	214.6 – 230.3	100	514 – 548	100

Table 4   Cargo flows on alternative routes in the regions (($\times 10^6$t))

Alternative routes	2000			2010			2020		
	Railway	Road	Total	Railway	Road	Total	Railway	Road	Total
Suifenhe – Vladivostok	1.6 – 1.7	0.5 – 0.6	2.1 – 2.3	3.6 – 3.9	1.6 – 1.7	5.2 – 5.6	6.0 – 6.4	2.6 – 2.7	8.6 – 9.2
Tumen – Rajin	2.9 – 3.00	1.0	3.9 – 4.0	7.4 – 7.9	2.4 – 2.5	9.7 – 10.4	18.3 – 19.5	4.8 – 5.1	23.1 – 24.6
Tumen – Zarubino	0.4	0.1	0.5	2.7 – 2.9	1.0 – 1.1	3.8 – 4.0	5.5 – 5.9	1.9 – 2.0	7.4 – 7.9

6.3   Changes of Transport Efficiency

The rise of transport efficiency lies in the full utilization of all the routes' capacities (including port operations, border crossing). Dalian cluster has very high operation efficiency, but the operation efficiency of the routes and ports of TREDA is commonly low, and there are big discrepancies among the ports. Especially in TREDA, where the specialization, modernization and comprehensive capacity of the ports are

low. There are no scheduled liners, rail transship-ments between China and Russia, and between China and Mongolia. There still remain the problems of bor-der crossing charges. All this has a bad effect upon route choices of cargo owners. But the operation effi-ciency problem can not be solved over night, and it is held that the operational efficiency will not be raised dramatically by 2010. Once the problem solved, the cargo flow shares via ports of TREDA and on the re-lated routes will increase, so the construction and ren-ovation of the infrastructure is import to the regional cargo flow development.

6.4 The Opening of New Routes

The opening of new railway segments can affect route choice and new cargo flows from and to some re-gions attend route diversion. According to the plan-ning of China Railway Bureau, the construction of Eastern Side Railway of northeast China will be com-pleted and on operation in 2005. So after 2005, part of cargo flows from and to Liaoning Province, espe-cially its east, will go through ports in TREDA, cargo flows through Zarubino and Rajin cluster will in-crease. With the regional economic cooperation, Mon-golia desires to look for a sea mouth in order to con-nect with the other countries of Northeast Asia close-ly. By the land bridge railway between China and Mongolia, which transit northeast China will be the nearest way for Mongolia to the Sea of Japan. But it will be very difficult for both Mongolia and China to construct the railway because of large mount of funds,

neither Mongolia nor China can provide the funds. In addition, it will take long time to construct the rail-way in term of the construction of new segments in the east of Mongolia and the renovation of current railway in northeast China. The ideal results would be that the construction of the railway will be completed and on operation in 2020, then there will be some car-go flows through the new railway. Even soon, there will be only 15% – 20% of total Mongolia's cargoes (about 4 million tons) go through the three clusters in TREDA.

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