Analysis on Regional Freight Transport in a Regional Integrated Transportation System

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Abstract: The current researches on regional integrated transportation system mostly focus on passenger traffic and the related investment, but the concern of the freight transport is low. In order to clarify the position of regional freight in the regional integrated transport system, this paper will study in three aspects: 1) The relationship between freight and regional economy, 2) comparison between passenger and freight transport in a region, 3) the role of different transport modes in regional transport system. In addition, we use the Granger causality analysis and correlation analysis to get quantitative results in Beijing-Tianjin-Hebei region, according to statistical yearbook. The interaction between freight and economy is discussed and data shows that freight transport is not the direct cause of economy development.

Keywords: Region, Integrated Transport System, Freight, Granger Causality Test

1. INTRODUCTION

With the rapid development of economy and strengthening of economic ties around the world, urban size expands and united region composed of several cities appears. The concept of Metropolitan Area proposed at 1950s by Jean Gottmann, a famous French geographer, attracts more and more attention. Therefore regional integrated transport system becomes a popular issue as it provides foundation serving for regional development. Integrated transport system is defined as rational traffic division among different modes of transport, including rail, road, water, air and pipeline transport, and comprehensive development and utilization of these transport modes. As a developing country, China is investing a large amount of money to improve the transportation infrastructure, and it is important to understand the relationship between regional freight transport and regional integrated transport system. An analysis of China's transport system by Mao *et al.* (2010) considers that there is intensified conflict between transport supply and demand, which means massive growth of China's integrated transport system in the next few years.

Fan (2006) considered that the investment in transportation infrastructure by government can improve the economy. Many studies have found economic benefit from investment in transport infrastructure by establishing economic models (Mera, 1973; Aschauer, 1989). Banister and Berechman (2001) developed an approach to study whether

there are additional development benefits from transport infrastructure investment, which is based on defining the set of conditions, containing investment conditions and the political and institutional conditions. This research argued that only when all the three necessary conditions are operating at the same time, measurable and additional economic development will be found. There are also opposite views. Hulten and Schwab (1991) even point out that public infrastructure has little contribution to the economy. The investment in transportation facilities itself will produce GDP (Gross Domestic Product), but what is more important is to stimulate additional economic growth by reasonable investment. One benefit of the investment on transport is travel time saving, which is conducive to exchange of goods and may lead to economic activity rising. But there are also many investments on transportation infrastructure which don't show obvious effect on freight transport. For example, China has invested much money to the construction of the freeway, but some of the freeway has little traffic and income from the tolls is not enough to pay the loan interest. It is necessary to emphasize that the goal of investment on transport is not only about economy, but also improving the travel convenience of people, which is not analyzed in this research. The traffic infrastructure promotes economy by increasing freight and passenger transport, and the key issue is how transport growth and economy development affect each other.

In recent years, many researchers consider the range of region rather than city itself for the reason that regional development has an advantage of combining cities which benefit all the cities in the region. In order to clarify the effect of freight in regional integrated transport system, firstly the connection between freight and regional development should be figured out, because regional integrated transport system serves the developing of region. Vooren (2003) presented a dynamic, interregional model, which included economy, transport, infrastructure and other features, composed of a total of 37 endogenous variables. This model was applied to 40 regions of Netherlands, and it is found that either the economy influences transport or transport influences the economy. Anusha and Kazuya (2003) studied the freight policy in a region composed of six countries and emphasized the importance of planning. Brander *et al*. (2001) collected data from rail, truck, air and marine centers and analyzed the connection of different transportation modes in a region. Research about developed countries has got some progress, but developing countries like China needs more attention.

Wen and Shen (2008) studied the relationship between transportation infrastructure construction and economy growth in China and pointed out that they have positive influence on each other. According to a research on China's western region (Liu, *et al*., 2009), it indicates that the growth of economy and freight transport leads to the investment of transportation infrastructure and the growth of freight transport promotes the developing of economy. A study of railroad freight transportation (Chen, *et al*., 2007) indicates that regional economy and local railroad freight transportation has bidirectional relation, namely mutual cause and effect relations. These studies show that the construction of transportation system may cause the increase of economy, which promote the development of freight. But it is not sure that whether the freight transport or passenger transport caused by investment in infrastructure is the main factor that leads to economy growth, especially in a region of China.

Figure 1. Map of Beijing-Tianjin-Hebei region

There are three most developed regions in China, including Beijing-Tianjin-Hebei region, Yangtze River Delta region and Pearl River Delta region. Among them, the Beijing-Tianjin-Hebei region has become a tightly connected economy area. The integrated transport system in the region is being improved, especially with the operation of Beijing-Tianjin high-speed rail, which takes only 33 minutes from Beijing to Tianjin. The range of the Beijing-Tianjin-Hebei region is showed in figure 1, covering the city of Beijing, the city of Tianjin and Hebei province. The city of Shijiazhuang, which is marked with the spot in map, is the provincial capital of Hebei. And the high-speed rail between Beijing and Shijiazhuang takes only 79 minutes.

Table 1. Passenger and freight transport of Beijing-Tianjin-Hebei Region in 2009

Area	freight/10^4t	passenger/10^4	Turnover of freight transport/10^8t·km	Turnover of passenger transport/10^8km
China	2825222	2976898	122133.3	24834.9
Beijing	20470	129534	731.6	361.3
Tianjin	42324	23337	9606.6	250.2
Hebei	123065	77773	6405.2	1043.3
The Region	185859	230644	16743	1655
Region percentage	6.58%	7.75%	13.71%	6.66%

Data: China Statistical Yearbook

As shown in Table 1, the Beijing-Tianjin-Hebei region has an area of only 2.2% of China, but concentrates 7.5% of the population and shares about 7% of the passenger and freight transport volume in China, which proves the developing superiority of the region. In addition, the Beijing-Tianjin-Hebei region accounts for 10.8% of the total GDP of the country,

indicating the economy advantages of the region. This study will discuss this case to make the influence of freight on the Beijing-Tianjin-Hebei development clear.

2. DATA

The regional integrated transport system serves for both passenger transport and freight transport at the same time. To dig out the impact of freight, it is necessary to compare passenger transport with freight. According to the Statistics Bulletin issued by the City of Beijing, Tianjin and the Provinve of Hebei over the years and data processing, the passenger transport volume, freight volume and GDP of Beijing-Tianjin-Hebei region are calculated and used for analyzing.

3. METHODOLOGY

Granger causality analysis was presented to study the causal relationship between two variables in 1969. Its basic theory is that if variables *X* is the cause of variable *Y*, the past value of variable *X* can be used for predicting the future value of variable *Y*, and vice versa (Granger, 1988). In the analysis process, if the predicted value of variable *Y* with adding the past value of *X* is more accurate than the predicted value of *Y* just with the past value of *Y*, variable X is called the Granger cause of variable Y.

$$\sigma^2(Y_t/Y_{t-k};k>0) > \sigma^2(Y_t/Y_{t-k},X_{t-k};k>0) \quad (1)$$

where,

X_t, Y_t : stationary time series,

t : time,

k : lag years.

Equation (1) shows that if the produced error (minimum mean square error) of Y_t is smaller when both X_{t-k} and Y_{t-k} are used for forecasting, X_t is Granger cause of Y_t. Besides, X_t and Y_t are two stationary time series as a premise condition and k is the lag years, which means the length of effecting time.

Granger causality analysis can obtain the causal relationship between these variables and is a suitable method for the study. The mutual influences between transport volume and GDP need time to appear. Granger causality analysis takes the sequence of time into account and can get the result of impact along the time. So this method is applied to this research. In order to do the Granger causality analysis, it is necessary to ensure that the time series

variables are stationary to avoid spurious regression. If this condition is not satisfied, the Granger causality analysis is still credible only when the two variables have the co-integration relationship. The unit root test is conducted with both regional freight transport and GDP, and the result shows that the second order difference sequences are both stationary. The method of Augmented Dickey-Fuller test (ADF test) is used for unit root test and the calculation value is shown in Table 2 and Table 3.

Table 2. Unit root test of regional freight data

		t-Statistic	Prob.*
ADF test	statistic	-6.3484139	0.0002
Test critical values:	1% level	-4.4678946	
	5% level	-3.6449627	
	10% level	-3.2614522	

* Significant at 5% level.

The *t* value of regional freight transport data is -6.35($p<0.01$) while the *t* value of regional GDP data is -4.52 ($p<0.01$). After passing the unit root test, the co-integration analysis is carried out to figure out whether there is a long-term equilibrium relationship. The regression model is established between regional freight transport and regional GDP, and the ADF test is conducted with the estimated residual sequence, as shown in Table 4.

Table 3. Unit root test of regional GDP data

		t-Statistic	Prob.*
ADF test	statistic	-4.5164523	0.0090
Test critical values:	1% level	-4.4678946	
	5% level	-3.6449627	
	10% level	-3.2614522	

* Significant at 5% level.

Table 4. Unit root test of residual series data

		t-Statistic	Prob.*
ADF test	statistic	-5.1016907	0.00002
Test critical values:	1% level	-2.6693588	
	5% level	-1.9564059	
	10% level	-1.6084953	

* Significant at 5% level.

The results of the co-integration analysis indicates that there exists long-term correlation between regional freight transport and regional GDP ($t=-5.10$, $p<0.01$). So the Granger causality analysis is enabled to be done.

For more detailed analysis of distinction among different transportation modes in the regional integrated transportation system, their freight transport volume and average haul distance are calculated in the last few years in Beijing-Tianjin-Hebei region. In order to facilitate observation, the percentage of transportation mode and average haul distance are shown in Figure 2 and Figure 3.

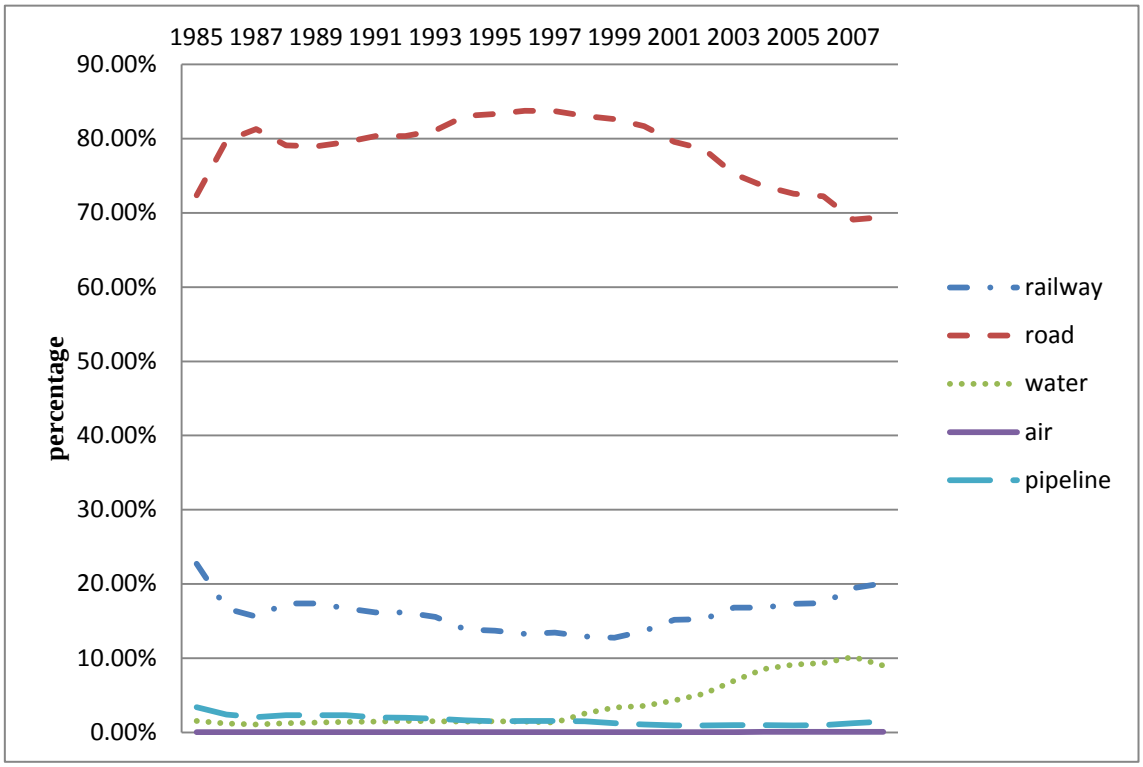

Figure 2. The percentage of all transportation modes in Beijing-Tianjin-Hebei region

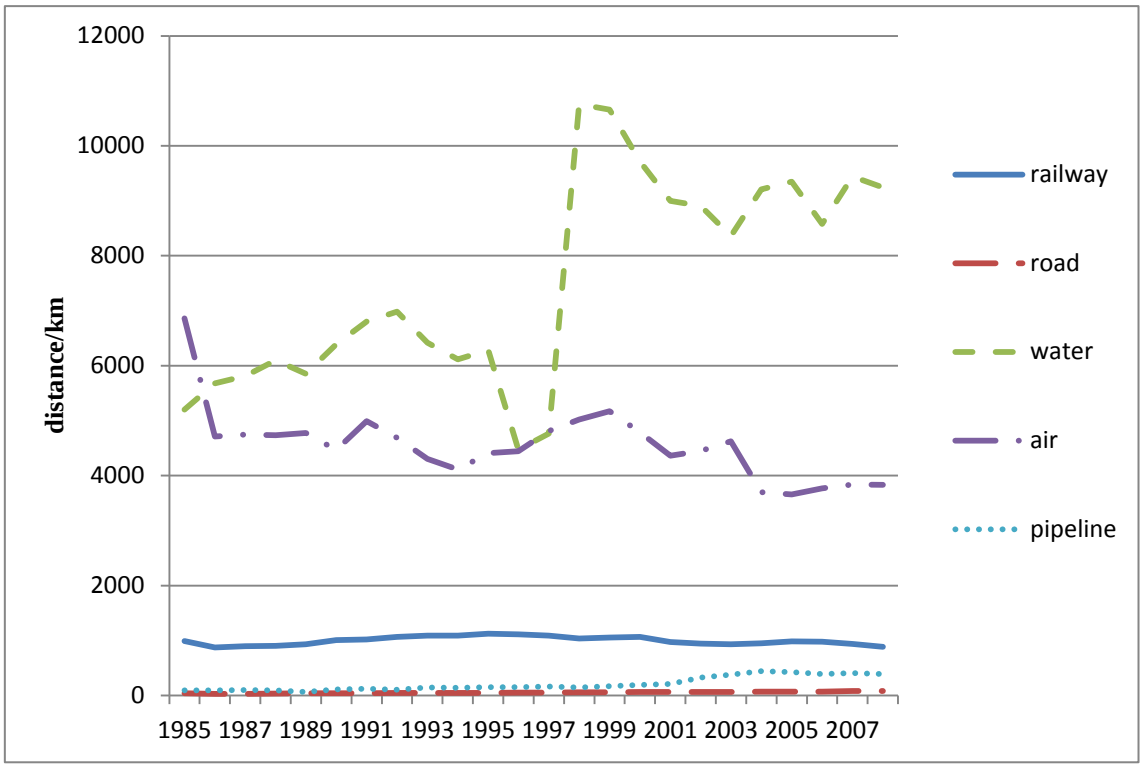

Figure 3. The average haul distance of all modes (km)

4. RESULTS

Based on the results of data calculating, the correlation between passenger transport and GDP is 0.925 (p=0.01) while the correlation between freight and GDP is slightly higher, which is 0.940 (p=0.01) by Pearson correlation analysis. It shows that passenger transport and freight both are closely related with GDP but the specific causal relation is unclear. The Granger causality analysis is carried out to do further analysis. The EVIEWS software is used for Granger causality analysis.

The data in Table 5 are respectively outcome indices of the Granger causality test for different lag year (1-5 years).

At 5% of significance level, the index shows that regional GDP is the Granger cause of regional freight transport volume when the lag year is 1, 2 and 4. But when the lag year is 3 and 5 years, the original hypothesis is not acceptable, which means regional GDP is not the Granger cause of regional freight transport volume. The different result under different lag year may be caused by data error and accidents. Still at 5% of the significance level, the hypothesis that regional freight transport volume is not the Granger cause of regional GDP is accepted, namely that data displays regional freight transport volume cannot cause the increase of the regional GDP whatever how long is the lag years.

Table 5. Freight and GDP Granger causality analysis

Null Hypothesis:	Lags	Obs	*F*-Statistic	Prob.
GDP is not the Granger Cause of FREIGHT	1	23	23.9394	9.00E-05*

FREIGHT is not the Granger Cause of GDP			0.05042	0.8246
GDP is not the Granger Cause of FREIGHT	2	22	4.51788	0.0267*
FREIGHT is not the Granger Cause of GDP			0.49968	0.6154
GDP is not the Granger Cause of FREIGHT	3	21	2.74574	0.0823
FREIGHT is not the Granger Cause of GDP			1.15838	0.3604
GDP is not the Granger Cause of FREIGHT	4	20	3.58294	0.0418*
FREIGHT is not the Granger Cause of GDP			2.24514	0.1303
GDP is not the Granger Cause of FREIGHT	5	19	2.73218	0.0996
FREIGHT is not the Granger Cause of GDP			1.173	0.3995

* Significant at 5% level.

In order to further understand the relationship between the freight transport volume and GDP, the regional passenger transport volume and regional GDP is conducted with Granger causality analysis as freight and passenger transport are the two types of transportation. Making it more obvious, the results after statistical analysis are list in Table 6, which is judged at 5% of significance level.

Table 6. Granger causality relationship between passenger transport, freight and GDP

Lag year	1	2	3	4	5
Freight is Granger cause of GDP	N	N	N	N	N
Passenger is Granger cause of GDP	Y	Y	Y	Y	Y
GDP is Granger cause of freight	Y	Y	Y	Y	Y
GDP is Granger cause of passenger	Y	Y	Y	Y	Y

N: not Granger cause; Y: is Granger cause.

Analyzing above results, it shows that GDP is Granger cause of passenger and freight transport volume when the lag year is 1 to 5 in Beijing-Tianjin-Hebei region. The development of regional economy produces a large amount of transportation demand, needing to improve regional comprehensive transportation system to satisfy the development of shipping requirements, not to restrict regional economic growth. On the other hand, passenger transport growth is the Granger cause of GDP, while data shows that freight transport volume is not. Passenger transport growth contributes to the regional economy and human resource exchanges, especially when the Beijing-Tianjin-Hebei region is primarily high technology industries and tourism. The increase of passenger transport will drive the development of regional economy. Nevertheless, the Beijing-Tianjin-Hebei regional freight transport mainly increases by economic development impetus, which is the result of economic development.

Knowing the distinction between freight and passenger transport in regional development, the effect of different transportation modes on regional integrated transportation system needs to be studied. Considering different transportation modes have different importance in integrated transportation system in range of region, the relationship between them should be explicit to direct the construction of integrated transportation system. Since various transportation modes have their respective characteristics, namely some are suitable for passenger transport while others for freight, all means of transportation need to be analyzed for further comparative study. The common modes of freight transport are railway transport, road transport, water transport, air transport and pipeline transport. It is worth

mentioning that pipeline transport services only used for the freight transport while the other four kinds of transportation mode serve for both freight and passenger transport. Any mode of transport has different characteristics, such as transportation speed, distance, cost, traffic volume, geographical environment and so on, so they have certain range of application.

According to Figure 2 and Figure 3, the relationships among different modes of transport are discussed. From 1985 to 2008, the proportion of different modes basically remains unchanged, which means that road transport accounts for about 70%, railway transport for 20%, water transport for 9%, pipeline transport for 1% and air transport for less than 0.1%.The percentage of water transport gradually increases as the port at Tianjin becomes importance, which is only 1.53% in 1985. In general, the most important transportation mode in regional freight is road transport for its fastness, convenience and flexibility.

The average haul distance of road transport is shortest, which is mainly applied to urban transport. The average distance along these years is 56 km for road transport, 210 km for pipeline, 999 km for railway, 4553 km for air and 7504 km for water. The data includes both transport inside the region and transport through the region, which may lead to error in long distance transport, for some transport through the region having no contribution to local economy will be calculated. The average haul distance of pipeline is relatively short because its major responsibility is transportation between the near cities. Railway transportation distance is long, including some transport between the internal cities in the region and some crossing Beijing-Tianjin-Hebei region. Air and water transport bears a lot of long international transport between China and other countries, especially water transport.

Average haul distance of road and pipeline transport is within 300 km and the farthest distance in Beijing-Tianjin-Hebei region is about 300 kilometers, so it is reasonable to consider road and pipeline as the mainly transportation modes burdening regional freight transport. The average haul distance of railway reaches 1000 kilometers, undertaking freight transportation crossing the Beijing-Tianjin-Hebei region. Water and air transport bear even longer distance transportation. According to the above analysis, in the regional integrated transportation system, road transport is still the most important mode to take on regional internal transportation task. The second is railway, especially the regional railway, taking on middle distance transportation task between the cities in the region.

5. CONCLUSIONS

This paper mainly studied on the freight transport in regional integrated transportation system and carried on the thorough analysis with the importance and traffic condition of freight in Beijing-Tianjin-Hebei region. Research shows that the regional economic has played a very important role in driving the promotion of regional freight transport development and traffic infrastructure construction. The regional economic development produces a large number of goods transport demand, and then generates larger requirements of regional integrated traffic infrastructure. In addition, rising of the level of comprehensive development will promote the increase of freight. However, in this study it is found that the freight transport and traffic infrastructure are not the directly cause of economy development, which is opposite to other

research. The investment of traffic infrastructure will produce GDP itself, but just meets the transport demand which is generated by regional developing. In the Beijing-Tianjin-Hebei region, road transport accounts for the most part. In the development of regional integrated transportation system, road transport should be given priority to for freight transport. Improving the regional highway network is an important precondition of the development of freight.

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