The impact of transportation infrastructure on regional economic development-----based on the circumstance of Yangtze river delta area.

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Abstract

The purpose of this article is to analyze the impact of transportation infrastructure investment on regional economic development in Yangtze River Delta Area, including three provinces and one city. To study the interrelationship between transport infrastructure and economic growth, we collected time series data for four regions from 2000 to 2019. Although there are some existing studies have explored the same topic, this paper has its own contribution because: ①it used different data and indicators for transportation and economy, ②it used different empirical approaches which are Granger Causality model, including panel unit root test and cointegration test. The result indicates that the transportation infrastructure has a causal relationship with economic growth only in Shanghai and Jiangsu province, the correlations between the four regions are positive which means increasing in the investment of transportation infrastructure leads to an increase in economy. Since the Yangtze River Delta Area has an excellent freight transportation system, this paper also gives an analysis of the freight transportation.

1. Introduction

Over the past few decades, infrastructure has been a hot topic both government and publics focused on. In the early 1960s, people gradually paid more attention to the environment, healthcare and insufficient housing, meaning that “quality of life” emerged as a focus of public policy. (Aschauer, 1990). As a key factor of infrastructure (Boarnet,1996), transportation infrastructure is always mentioned as a critical factor promoting economic growth. For example, a large volume of research on macroeconomic development analysis has been done by Aschauer (1989a,1989b,1989c), indicating that transportation infrastructure has the positive impact on economic development. In addition, Fogel (1962) argued that the investment in transportation infrastructure was little effective for economic growth. Nowadays, many scholars argue that an increase in the investment of transportation infrastructure have a positive relationship only in rich countries. For most of developing countries, their citizens tend to give more concern on basic necessities of life, such as food, dress and shelter, transportation seems to be less important factors, comparing with other basic necessities of life. Transportation is the basic industry to promote economic development, it occupies an important position in the national economy. Economic development needs transportation to provide channels to

complete the circulation and exchange of goods; Transportation cannot be separated from the support of economy and needs to rely on the favorable conditions created by economic development. Transportation and economy complement each other and are inseparable. In 2002, the World Bank's report elaborated the relationship between transportation and economy, emphasizing that transportation is the key to economic progress. If the national or regional transportation program policy design is unreasonable and uncoordinated with the economy, it will not only fail to achieve the expected goal, but also bring a lot of negative effects. The principle of system theory emphasizes that the progress and development of transportation must be coordinated with the development of national economy. It can be seen that the harmony between transportation and economy is vital to the national economy, and it is an important foundation to ensure the steady and rapid development of economy.

On the one hand, urban construction is conducive to the development of the whole country and is an important strategy to realize national rejuvenation. In the history of the United States, as a vast country, investment in transportation infrastructure will lead to more cities, which will be more closely connected to each other, and thus promote the overall economic growth of the country. On the other hand, the investment in transportation infrastructure can effectively shorten the distance between urban and rural areas and make the convenient connection between urban and rural areas. As we all know, with the passage of time, the rural population will gradually shift to the city, is the construction of the city of laborers. But those who remain in rural areas do not benefit from the growth of urbanization and are even poorer. Some argue that the expansion of the U.S. highway network has contributed to massive suburbanization, leaving many cities without a viable economic model.

1.1 Research question:

The main purpose of this article is to investigate whether there is a linkage between transportation infrastructure and economic growth?

If yes, what is the relationship, positive or negative?

Since the reform and opening up, China's economy has experienced a state of rapid development for nearly 30 years. All regions of the country have grasped the development opportunity and actively developed the economy at the appropriate time. Especially, the period from 2003 to 2007 was the heyday of China's economic development. Around 2011, China's economic development has undergone fundamental changes and entered a new stage -- the new normal of economy. The

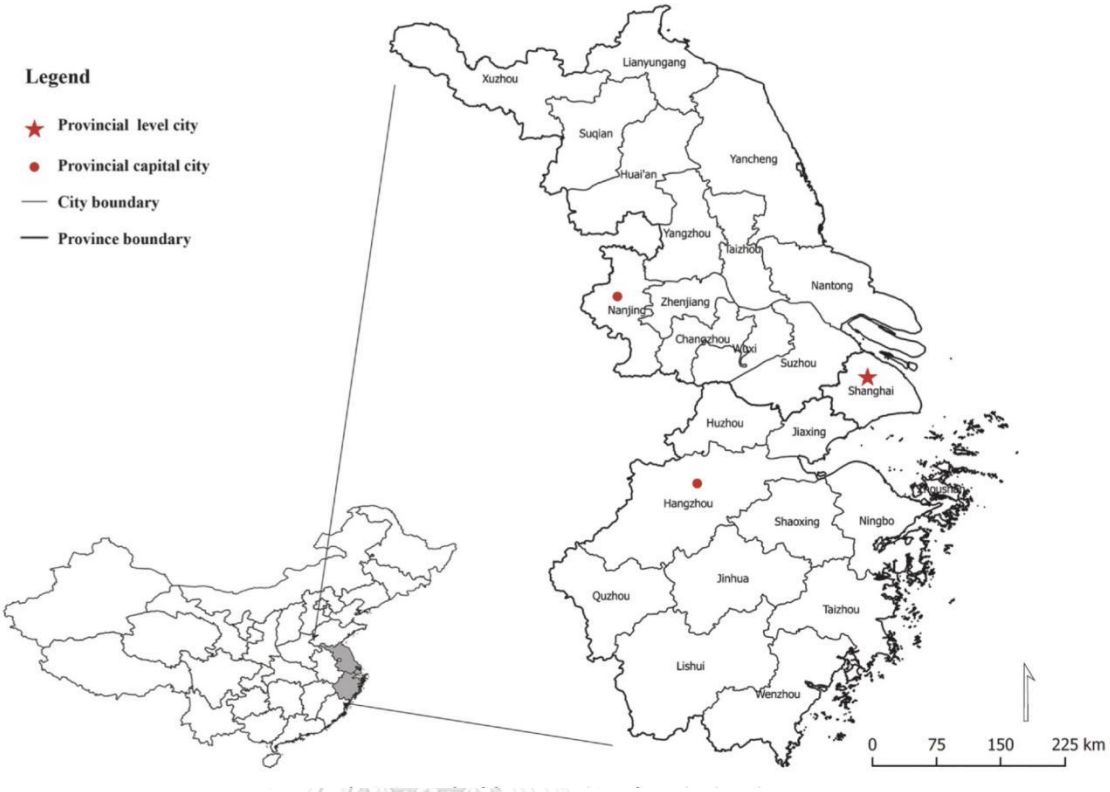
original model of economic development driven by the input of economic factors has been difficult to adapt to social changes and cannot bring good benefits to the country, so it is imperative to change the previous development model. Under the circumstance of strongly recommending the new normal model that China's economy is growing at a slower pace than in the past, and the economic structure has gradually been optimized. As several industries that promote economic development, the reform process of transportation has stages, and transportation is the main feature accompanying economic development. In the initial period of transportation, in order to meet the increasing demand for transportation, the large-scale construction of transportation infrastructure is the primary and key task of the transportation industry. In the mid to late 1990s, the government actively issued various policies and measures to promote the completion of many large-scale infrastructure projects. Especially after 2000, domestic transportation industry stride into a new period of supernormal development. The best evidence of the sound development of China's transport sector is the publication of the White Paper on the Development of China's Transport in 2016. During the rapid progress in the past two or three years, the comprehensive transportation network has begun to take shape. The transportation network is characterized by multi-node, gridded and full coverage. The "five vertical and five horizontal" comprehensive transportation channels have been basically unblocked. By the end of 2015, the state's key multi-level railway network had begun to show its true appearance. The total length of railway operation ranked second in the world, with more than 120,000 roads. The length of high-speed rail has occupied the world's first; The mileage of expressways in operation also ranks first in the world, exceeding 130,000 kilometers. The length of inland river channels in operation is 127,000 kilometers, ranking first in the world. The number of civil aviation airports in China has broken through 210, and the safety standard of civil aviation operation is generally high. It can be seen that the transportation mileage of various domestic transportation modes has reached the forefront of the world, and the transportation industry has taken a leading position in the world. In 2010, China's transportation industry is undergoing a phased transformation from the original infrastructure construction to multimodal transportation, hub connection, comprehensive transportation management, thinking of a higher quality of transportation development.

Many previous studies present that transportation infrastructure plays an important role in the optimization of the spatial structure of urban agglomeration. After 1978, China’s transportation infrastructure system has developed rapidly due to the Reform and Openness policy. However, China, a country with significant economic disparities, was facing unequivocal challenges in terms of the economic and political stability. In order to address the spatial disparities, GOC (the government of China)

has figured a lot of measurements, such as East-west cooperation and Western development strategic (Tian,2002; Wen,2005). According to the National statistical Bureau (1998, 2004), The eastern region accounts for about 34 percent of China's population and land area, yet it accounts for more than 50 percent of the country's gross domestic product. The Yangtze river delta is located at Eastern, China. Most of the major transportation hubs like Beijing-Shanghai line quickly become overloaded. Capacity utilisation on the Beijing-Shanghai line has exceeded 90 per cent since the 1970s, a figure that is far higher than for key parts of the railway. All official information indicates that the Chinese government has begun to increase its spending on global transportation infrastructure construction (Wu, 2009). Due to the support of government policies, the investment in road construction in western China accounts for a large part of this fund, but the level of use has not been significantly improved (Liu, Zhang, & Peng, 2009).

1.2 The circumstance of Yangtze river delta area

The Yangtze River Delta, including Shanghai, Jiangsu province, Zhejiang province and Anhui province, is located at the Eastern China (Figure 1). This area not only has the most developed economy and the most intensive population, industries, wealth in our country, but also is the first area to start regional integration and has the fastest development as well as strongest foundation in the process of the integration. As an important part of national economic modernization, the Yangtze River Delta should first try to build economic modernization, actively explore the developing model and experience of economic modernization, and strive to set a good demonstration and lay a good foundati0on for our country’s economic modernization and overall development (National Development and Reform Commission, 2016).



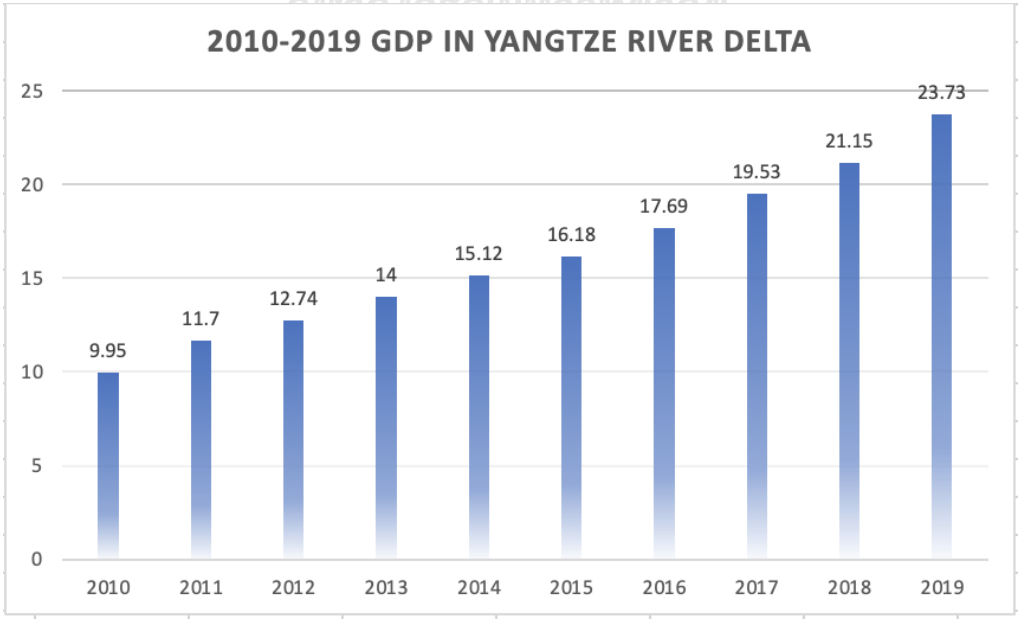
(Figure 1) Source: National Development and Reform Commission, 2016

Since the policy of reform and open was brought up, the Yangtze River Delta has developed into a region with the strongest comprehensive economic strength and the fastest development speed in China. In 2019, the GDP of the Yangtze River Delta reached 23.7 trillion yuan, accounting for 23.9% of the national GDP, with a year-on-year growth rate of 6.4%, 0.3 percentage points higher than the national growth rate (Figure 2). The history proves that the Yangtze River Delta has experienced a process of evolution from decentralization to agglomeration, from single center in Shanghai to multiple centers in Nanjing, Hangzhou, Suzhou and so on. The specific structure is shown in Table 1 below:

	Time	Transportation	Industry Feature	Spatial structure
The age of highway	1990s to 2020	A dense network of highway leads to every village	Online shop delivery, logistics transportation	Intensive network
The age of high-	2010 to 2020	An intricate network of high-speed railways, with two	Convenient, comfortable and fast, mainly responsible	

speed railway		main arteries, runs from Shanghai to Nanjing and Hangzhou, connecting the provincial capitals of two neighboring provinces	for passenger transport	
The age of railway	1978 to1980s	An intricate network of highways, with two main arteries, runs from Shanghai to Nanjing and Hangzhou, connecting the provincial capitals of two neighboring provinces	Construction is early, undertake bulk commodity cargo transport, the speed is slower	Intensive network

(Table 1) Source: http://www.stats.gov.cn



(Figure2) Note: the unit of GDP is trillion yuan. Source: http://www.stats.gov.cn

The discussion on the relationship between infrastructure and economic development not only has a great significance to the development of the whole country, but also is the actual demand of infrastructure development in the Yangtze River Delta region. There are a lot of analysis on the coordination relationship between infrastructure and economy， for instance, Aschauer (1988, 1989a, 1989b, 1989c) came out with three fundamental results: (1) In a private-sector neoclassical production technology , infrastructure capital carries a positive marginal product; (2) The investment of infrastructure has a positive stimulating effect on private investment in plant and equipment; (3) That infrastructure capital is complementary to private capital. Hulten and Schwab (1993) engaged in a heated debate on infrastructure. Although many previous researches related to infrastructure have been completed, there are few studies focus on the circumstance of Yangtze river delta area and the correlation between transportation infrastructure and economic development. In an attempt to construct a deeper understanding on this topic, this paper uses the Granger causality model to analysis the relationship between regional transportation infrastructure and economic growth. Take three provinces: Jiangsu, Zhejiang, Anhui and one city: Shanghai in the Yangtze River Delta region as the research objective.

1.3 The cargo delivery industry in Yangtze River Delta Area

In recent years, China's Internet industry has developed rapidly, among which the online shopping industry is the most rapid. This article takes freight turnover values as the index of transportation infrastructure to measure the causal relationship with economic development, because the Yangtze River Delta has not only made remarkable achievements in economy, but also has the most developed cargo transportation network. The Yangtze River Delta has superior traffic location advantages and unique spatial advantages. The mainland coastline of the region is nearly one thousand kilometers long, and the fine coastline of the Yangtze River is more than 600 kilometers. By the end of 2002, Jiangsu, Zhejiang and Shanghai had a total of 3,249 kilometers of expressways, accounting for 13% of the country. In 2003, six expressways were built in Jiangsu province, and the total mileage of expressways opened to traffic in Jiangsu province exceeded 2,000 kilometers, ranking the third and the highest density in China. With the intensification of the construction of "Three Main Supports and One Supports" in the Yangtze River Delta, the highway backbone and highway hub of the two provinces and one city have been developed rapidly in recent years, and the planning and research of the regional highway backbone and trunk highway network are also being carried out in an orderly way. In addition, the gradual improvement of vehicle technology, information transmission and processing

technology and management level in the Yangtze River Delta region have laid a good material foundation for further adapting to the development of economic integration in the Yangtze River Delta region and constructing an integrated highway fast freight transport system in the Yangtze River Delta region.

In more detail, highway transport has already become the important force of cargo transport of many countries and regions. There is a common characteristic in the development of domestic transportation in developed countries, that is, the development of inland river and railway transportation takes precedence, and that of highway transportation comes from behind. Since the 1960s, the development of road transportation has far exceeded the railway, leaping into the first place of all kinds of transportation modes, and becoming the main force of goods transportation in these countries. In terms of freight transport, the proportion of road freight traffic in Europe, the United States and Japan has reached more than 80% at present. In the world urban belt regions, due to the high density of cities and the frequent flow of people, money and goods, but also due to the short space transport distance, road transport plays a more important role. It is inevitable for the development of road transport industry to establish highway express freight transport system. For a long time, China's road freight transport is basically a kind of self-transport extensive situation, cannot meet the social and economic development of fast, high quality, efficient transport needs. Build highway rapid freight system is to through the scientific organization and management and operation mechanism, guided by the theory of modern logistics, the organic combination of highway transportation all factors of production, rapid highway freight system as a new growth point of highway transportation and breakthrough for the development of modernization, highway transportation mode of production from extensive to intensive direction, Realize the modernization of highway transportation and meet the requirements of social and economic development.

From the development of the transportation industry in the Yangtze River Delta, the railway transportation market mainly concentrates on the middle to long distance intercity passenger transport and the middle to long distance freight transport. And highway transportation has the advantage that the door to door, flexible, and the fast pace of modern production and life style are interlinked, especially for medium and short cargo transport, by rail and water transportation, although the Yangtze river delta region has natural advantages for the development of water transport, and water transport less investment, low transport costs, but its agility, speed slow, also restricted by season, It is only suitable for the transportation of bulky cargo. From the point of the Yangtze river delta region's own logistics constitute, also suitable for development of highway transportation, because of its geographical range is relatively

narrow, transport of goods belong to medium and short distance transportation, the demand for road transportation is bigger: relatively poor resources in the region at the same time, the regional logistics is given priority to with light quality high quantity of light industrial products, suitable for small road transport. Since the transportation connection between cities is inversely proportional to the distance between cities, the Yangtze River Delta region, which has the largest number of cities, the largest scale and the highest density, has a higher incidence of internal goods exchange than other regions in China. In such a dense urban area, for the medium and short distance goods transport within the region, road freight occupies the appropriate proportion, and has an absolute advantage, can give full play to the point of many, wide, mobile, flexible and door to door advantage. With the further globalization of economy, under the background of China to further expand the opening to the outside world policy, in the sea for the development of pudong new area, the Yangtze river delta region of city export-oriented economy to flourish, the city asked further strengthen cooperation and resource advantage complementary, along with the improvement of the regional highway network and the development, More and more goods will be transported by road between cities.

In order to meet the higher requirements of economic development on the road transport system, the government departments in the Yangtze River Delta not only invested a lot of manpower and material resources on the infrastructure such as roads and stations, but also paid great attention to how to adjust the development direction of road transport enterprises to strive for the rapid freight transport and broad market. The transportation administration departments of Jiangsu, Zhejiang and Shanghai signed the Protocol on the Integrated Development of Road Transportation in the Yangtze River Delta, marking the further development of the cooperation and interaction mechanism of transportation administration in East China, especially in the Yangtze River Delta region. At the same time, Zhejiang Provincial Department of Communications focuses on giving play to the unique advantages of road transportation, in order to realize the leapfrog development of Zhejiang road transportation industry, It has organized and compiled four sub-plans, namely, 2003-2020 Zhejiang Road Passenger and Freight Transportation Development Plan, Zhejiang Road Transportation Station Development Plan, Zhejiang Intelligent Road Transportation System Plan and Zhejiang Road Transportation Administration Development Plan. After more than a year of planning research, planning evaluation, subject identification, and widely seek the opinions of the relevant parties, has been formally issued on August 12, so as to achieve rapid road transportation in Zhejiang Province to make a detailed planning, for the road transportation in Zhejiang Province to achieve leapfrog development and describing a blueprint.

At present, there are 6 expressways and 9 national highways in the Yangtze River Delta, which constitute the main framework of regional highway traffic. Four-lane expressways in Jiangsu and Zhejiang have each exceeded 1,000 kilometers, connecting provincial cities and cities under the jurisdiction of the provincial government. By the end of 2002, the density of highway networks in Jiangsu, Zhejiang and Shanghai had reached 58.6 km / 100 square km, 44.17 km / 100 square km and 99.1 km / 100 square km respectively. In a few years, the expressways in the two provinces will exceed 2,000 km respectively, which will be relatively saturated.

In order to meet the needs of regional economic development in the new century, the national roads with large traffic capacity and many towns along the route will be gradually built into expressways. The construction of the expressway network will strengthen the economic connection between the central cities in the Yangtze River Delta and form a development pattern of the central city network radiation. According to the long-term plan, the highway network density in the Yangtze River Delta will reach 95km/lOOkm2 in 2010, and the driving time between any two prefecture-level cities in the delta region will be less than 4 hours, and the driving time between Shanghai and prefecture-level cities will be less than 3 hours. The construction of the expressway network connecting the cities of the Yangtze River Delta will certainly attract the increase of goods circulation between cities, improve the speed of goods transportation and save the time of goods on the way.

2. Literature review

Apart from the above, a large number of researches examined the impact of transportation infrastructure on economic growth in China with data at the national level or regional level. The results of these cases showed a strongly positive correlation between transportation infrastructure and economic development. Bin and Bo (2020) indicated that the strengthening of transportation construction can effectively promote economic development, and the coordination degree of the two variables should be further enhanced. As one of the most common modes of transportation, highway plays an indispensable role in promoting the development of regional economy. It also points out that highway transportation plays an important role in regional economic development and can make regional economy develop actively (Yan, 2020). Qiujun (2015) found that the overall coordination degree between the transportation system and the economic system in Guangxi is relatively high, which can basically meet the development needs of each other. Qi (2001)

concluded when the regional economy develops slowly and weakly, its demand for transportation and input capacity shrinks, which is manifested as the restriction and hindrance of the regional economy to the development of transportation. When the regional economy is booming, it has an urgent need for the development of transportation and the enthusiasm of investment is exuberant. However, because of the technical and economic characteristics of the development of transportation, it is impossible to show the effect quickly, which is the restriction of the development of regional economy by the lag of the development of transportation. This relationship was also present in Fujian province. Song and Van Geenhuizen (2014) applied the production function to investigate the output elasticity of port infrastructure in four port regions and found the clear positive effects of port infrastructure investment in all regions. Ma and Li (2001) investigated the effect on private sector of transportation infrastructure capital stocks as well as the production elasticity by using an econometric model. Korea (2000) through the further analysis of the traffic development, put forward the "alternate push-pull theory", the theory of relationship between transportation and economic development to do a deep, it was assumed that the gradient and upheaval is the process of the development of transportation industry, two distinctive period of the two phases alternating play a major role in the development process, the pulse mode. When a new subversive mode of transportation appears, the transportation industry will enter a new "period of upheaval", and there will be a period of "gradual change" between the two "periods of upheaval".

Munnell (1992) gives a comprehensive discussion on these econometric issues. Most of this literature focuses on using single-equation, static production function methods to measure the impact of transportation infrastructure on the national economy. According to this regulation, private output has many advantages, not only to increase employment and GDP, but also to allow the government to use tax revenue to invest in public capital. This approach is not trusted because the level estimates are based on non-stationary variables, and therefore OLS estimates without co-integration are false. In addition, OLS estimates are subject to simultaneity biases, and even when these biases are corrected, they still fail to draw conclusions about causality. In the past, the government formulated various policies for the development of China's transportation infrastructure, hoping that the transportation infrastructure could meet the needs of its booming economy. However, the results were not very ideal, that is to say, the construction of transportation infrastructure could not keep up with the development of China's economy (Zhang, 2009). Scholar Rong (1993) creatively put forward the transportation theory, and described the interaction between the transportation system and the economic system from the point of view of the constantly changing relationship between the two systems, especially the change of the total cargo volume as the core variable. He believes that the continuous progress of transportation

industry is inseparable from the process of industrialization, and that transportation and industrialization complement each other and cannot be dispensable. It can be said that there is no industrialization without transportation. Process stages of transportation, according to the sequence division, before the main transport stage, transportation and transportation after phase, in 2016, rong for the original transportation theory about transport stages division was described, further pointed out that as the scale of transportation infrastructure gradually perfect, our country's transportation style manager periodically change.

In foreign studies, Yasir, Aihu and Abubakr(2017) pointed out that in Pakistan, only economically developed provinces can see the mutual relationship between transportation and economy, while in economically underdeveloped areas, there is no necessary connection between transportation and economy. Ford and Poret(1991) further studied the relationship between economic development and transportation construction and pointed out that differences in the level of infrastructure investment could partially explain the differences in national productivity growth. Achauer (1989a) showed that before the 20th century, the infrastructure development of many countries was relatively backward, which led to the shift of the focus of national policies and strategies. Moreover, the investment in transportation infrastructure is a large expenditure of national finance. If a large investment in transportation infrastructure is made, it is bound to increase the financial burden of the country and affect the expenditure in other aspects. Therefore, in the early stage of economic development, the mode of investment is very different now, and the country must consider the overall balanced development.
In contrast to the above, some other studies have reported that infrastructure investment showed a negative relationship with economic development. Canning and Pedroni (2008) mentioned that infrastructure leads to long-term economic growth, but it varies widely from country to country. In countries with oversupply of infrastructure, there is no causal relationship between these two variables. Devarajan, Swaroop & Zou figured out that governments in developing countries have been misallocating public spending in favor of capital spending at the expense of current spending, causing a negative relationship between infrastructure investment and economic development.

The quantification and measurement of coordinated development is a hot issue among the analysis of relationship between transportation and economy. The widely used analysis are: IndicationSystem-IS, Elastic Analysis, Data Envelopment Analysis (DEA), Subordinate Function Analysis, Correlation analysis, Coefficient of Variation Analysis and Degree of Order Analysis. Bin and Bo (2020) applied multi-dimensional grey dynamic coordination model, used the quantitative evaluation method to analyze

the coordination degree between transportation and economic development. Qiujun(2015) applied Subordinate Function Analysis and Static coordination model and used the data of transportation and economy in Guangxi province to research the coordination between them. Qi (2001) made an in-depth discussion on the coordination relationship between transportation and economic development in Fujian Province, made a comparison of relevant indicators, evaluated the course of the relationship between them, found out the existing problems and correlation.

3. Data & Methodology

3.1 Data

This paper uses the values of GDP as an indicator of economic growth and freight turnover values (FTV) as the indicators of transportation infrastructure investment, focusing on historical data from 2000 to 2019 in the Yangtze River Delta region. Data in this study are collected from Regional Statistic Offices of Shanghai, Jiangsu, Zhejiang, Anhui and the statistical yearbook of these four regions. The data are manually collected from Shanghai yearbook, Jiangsu yearbook, Zhejiang yearbook and Anhui yearbook among 2000 to 2019.

The focus on the freight turnover values (FTV) in transportation infrastructure and not on a more comprehensive measure of the government investment, is dictated by data availability. In addition, the Yangtze River Delta has a developed freight network system. People living in this area do not need to pay for express delivery when they shop online, because online merchants have a special benefit called Jiang Zhe Hu Free Delivery Fee for their customers who live in Shanghai, Jiangsu, Zhejiang and Anhui province. As a result of it, this paper also explores the further development of the freight network system in the Yangtze River Delta area.

However, it is important to note here that the focus of our study on transportation infrastructure does not detract from the relevance of the analysis. The first reason is that we really looked at a lot about the relationship between the traffic infrastructure and the economic development of other similar paper, overview the relationship between the two variables, so this article to the results to compare with past research. The second reason is the inconsistency of time and region selected, the results will have important significance.

3.2 Methodology

To investigate the relationship between transportation infrastructure and economic development, this paper applies GC model as the empirical approach, using the time serials data in Yangtze River Delta. The main goal of this study is to find whether a high level of transportation will cause the development of economy if the data of transportation contains the information that helps predict economic growth (Granger, 1988). Hence, the empirical model is constructed as the following:

$$\ln GDP_{it} = \alpha_{0i} + \alpha_{1i} \ln FTV_{it} + \varepsilon_{it} \quad (1)$$

$$\ln FTV_{it} = \beta_{0i} + \beta_{1i} \ln GDP_{it} + \varepsilon_{it} \quad (2)$$

In this case, GDP indicates the real GDP, which is the index of economic. FTV is freight turnover values, and ε means the error. We apply ln series in order to look for elasticity and to keep the variable series stable, and the subscripts i and t indicate three province and one city (which is Shanghai, Jiangsu province, Zhejiang province and Anhui province) and the year （from 2000 to 2019）, respectively.

3.2.1 Descriptive statistic & Correlation analysis

	GDP.SH	GDP.JS	GDP.ZJ	GDP.AH	FTV.SH	FTV.JS	FTV.ZJ	FTV.AH
Mean	1734.77	44014.88	28360.37	14107.58	16388.4	6497.071	5966.303	6430.457
Std.Dev	9875.836	29774.13	17547.62	10208.44	6689.484	3446.305	3651.72	4557.443
Observation	20	20	20	20	20	20	20	20

(Table2)

From the values of mean in Table 2, we can see that Jiangsu has the largest value of GDP but the value of FTV is not the biggest. Although the Yangtze River Delta is the most developed region in China, Jiangsu contributes far more GDP than Anhui and Zhejiang in the provincial level.

Correlation	LN_gdp.sh	LN_gdp.js	LN_gdpzj	LN_gdp.ah	LN_ftv.sh	LN_ftv.js	LN_ftv.zj	LN_ftv.ah
LN_gdp.sh	1.000000							
LN_gdp.js	0.998224	1.000000						
LN_gdpzj	0.998962	0.999038	1.000000					
LN_gdp.ah	0.993481	0.995712	0.993157	1.000000				
LN_ftv.sh	0.977045	0.969439	0.97496	0.956377	1.000000			
LN_ftv.js	0.976154	0.980472	0.980292	0.971207	0.955151	1.000000		
LN_ftv.zj	0.983223	0.983094	0.987184	0.965602	0.977036	0.984582	1.000000	
LN_ftv.ah	0.946119	0.958763	0.952792	0.956563	0.891081	0.960916	0.940878	1.000000

(Table 3)

According to the result of covariance analysis, the correlations between GDP ang FTV in the four regions are 0.977045，0.980472，0.987184，0.956563 (Ranking as Shanghai, Jiangsu, Zhejiang, Anhui). The correlations are above 0.90, meaning that GDP ang FTV has significant and positive relationship.

3.2.2 Panel unit root

This paper selects a time series model, but most of the time series are not table. In order to make sure that all the series are stable, we need to run the panel unit root test and check the stationary for all variables (Granger, 1969). In this paper, we use Augmented Dickey-Fuller (ADF) test to check the stat›ionary of series and all process will be done in Eviews10.0. In ADF test, we mainly observe three values and select the best outcome according to the minimum values of AIC, SC and HQ. The results of ADF test showed as following (Table 4):

	(C, T, K)	ADF	5% Level	P-Value	Stationary
LN_gdp.sh	(C, T, 4)	-4.781408	-3.7332	0.0082	YES*
LN_gdp.js	(C, T, 4)	-2.914500	-3.0299	0.0622	YES***
LN_gdp.zj	(C, T, 4)	-3.498303	-3.0299	0.0198	YES**
LN_gdp.ah	(C, T, 4)	-3.372455	-3.7332	0.0906	YES***
LN_ftv.sh	(C, T, 4)	-2.526327	-3.6908	0.3131	NO
LN_ftv.js	(C, T, 4)	-1.268800	-3.0299	0.6215	NO
LN_ftv.zj	(C, T, 4)	-3.607088	-3.0299	0.0159	YES**
LN_ftv.ah	(C, T, 4)	-0.868552	-3.6736	0.9391	NO
Noted: *, **, *** indicates the significant level at 1%, 5%, 10%, respectively					

(Table 4)

For the variables in log-levels and all t-statistics, LN_gdp.ah and LN_gdp.js are significant at 10% level, LN_gdp.zj and LN_ftv.zj are significant at 5% level and LN_gdp.sh is significant at 1% level which means these series are stationary at specific level. As for the three variables: LN_ftv.sh, LN_ftv.js and LN_ftv.ah, the critical values are bigger than the 10% critical value which indicates these three series are not stationary. Therefore, a 1^{st} difference test is needed to get the stationary series for these three variables, the results are showed below:

	(C, T, K)	ADF	5% Level	P-Value	Stationary
DLN_ftv.sh	(C, T ,4)	-3.7156	-3.0521	0.0140	YES**
DLN_ftv.js	(C, T ,4)	-3.3345	-3.7597	0.0985	YES***
DLN_ftv.ah	(C, T ,4)	-3.3246	-1.9614	0.0028	YES*
Noted: *, **, *** indicates the significant level at 1%, 5%, 10%, respectively					

(Table 5)

Now the critical values of LN_ftv.sh, LN_ftv.js and LN_ftv.ah are lower than 10% critical value which indicates that LN_ftv.sh, LN_ftv.js and LN_ftv.ah are stationary series after finishing the 1^{st} difference test. In order to investigate the relationship of cointegration between these series, a cointegration test is needed.

3.2.3 Cointegration test

The co-integration theory and its method proposed by Engle and Granger in 1987 provide another approach for modeling nonstationary sequences. Although some economic variables are themselves non-stationary, linear combinations of them may be stationary. Such a stable linear combination is called a cointegration equation and can be interpreted as a long-term stable equilibrium relationship between variables. Since the VAR model was not selected in this paper, EG two-step method was used to conduct co-integration test on the residual sequence by using the equation (1) and (2). If the residuals or ε_{it} were stationary, it stands both the variables are cointegrated. The results are collected in Table 6.

Region	Method	ε_{it} for Equation (1)	ε_{it} for Equation (2)
Shanghai	ADF	-2.168 (0.03) **	-3.069 (0.00) *
Jiangsu	ADF	-1.943 (0.05) ***	-2.020 (0.04) **
Zhejiang	ADF	-1.266 (0.18)	-1.536 (0.113)
Anhui	ADF	-1.1127(0.23)	-1.393(0.146)

Noted: *, **, *** indicates the significant level at 1%, 5%, 10%, respectively

(Table 6)

The results of cointegration test are various in different regions. The table provides evidence of integration between these variables in Shanghai and Jiangsu as all the statistic significantly reject the null hypotheses of no cointegration. However, the results of Zhejiang and Anhui indicate that we fail to reject the null hypotheses of cointegration. Thus, it can be pointed out that GDP and FTV has a long-run

equilibrium relationship in Shanghai and Jiangsu, which means the transportation infrastructure can facilitate these two regions' economic development.

3.2.4 Error correction model, ECM

Given that both prerequisite to the GC tests have confirmed of a causal relationship between transportation infrastructure and economic growth in Shanghai and Jiangsu province. GDP and FTV are cointegrated which means a causal relationship between both variables exists in the long-run equilibrium in the specific regions. The last step is to find whether there exists a short-run equilibrium relationship between two variables. In order to identify and quantify the direction of short-run and long-run causality, a dynamic error correction model (ECM) should be applied as the following equation:

$$\Delta lnGDP = \alpha 1i + \sum_{k=1}^{m} \beta 1\text{ik}\, \Delta lnGDPi, t-k + \sum_{k=1}^{m} \gamma\, 1ik \Delta lnFTVi, t-k + \delta 1i EMCi, t-1 + \varepsilon 1it \quad (3)$$

$$\Delta lnFTV = \alpha 2i + \sum_{k=1}^{m} \beta 2\text{ik}\, \Delta lnGDPi, t-k + \sum_{k=1}^{m} \gamma\, 2ik \Delta lnFTVi, t-k + \delta 2i EMCi, t-1 + \varepsilon 2it \quad (4)$$

Where GDP and FTV are the same as previously mentioned but i only stands Shanghai and Jiangsu. m is the lag length, Δ indicates 1st difference of the variables, $EMC_{i,\,t-1}$ denotes the error correction term. If the coefficients of the ΔGDP and ΔFTV are significant, it means that transportation infrastructure and economic development has a causal relationship in short run, if the coefficients of ECMs are significant, it implies that transportation infrastructure and economic development has a causal relationship in long run. The results from equation (3) and (4) are collected in Table 7.

Regions	Dependent variable	dlnGDP	dlnFTV	ECM
Shanghai	dlnGDP	-	0.77 (0.48)	-0.12 (0.02) **
	dlnFTV	2.05 (0.17)	-	-0.50 (0.01) *
Jiangsu	dlnGDP	-	0.82 (0.46)	-0.08 (0.17)
	dlnFTV	2.45 (0.12)	-	-0.37 (0.06) ***

(Table 7)

Based on the results above, in the short run, the coefficients of the ΔGDP and ΔFTV are not significant, which means that there is no causality. Increasing the investment of transportation infrastructure does not lead to a remarkable increase in economic growth in these two regions. In the long run, the coefficient of the error correction

model is significant for transportation infrastructure to economic growth but insignificant for economic growth to transportation infrastructure in Jiangsu province. There only exists a unidirectional causal relationship in Jiangsu. Appling the same logic, a bidirectional causality exits between the variables in Shanghai.

4. Conclusions

The Yangtze River Delta area, including Shanghai, Jiangsu province, Zhejiang province and Anhui province shows different outcomes on the causality test between transportation infrastructure and economic development in different regions. The outcome is somewhat surprising because the Yangtze River Delta has superior traffic location advantage, unique space advantage. Its information transmission, processing technology level and management level lay a good material foundation for further adapting to the development of economic integration in the Yangtze River Delta region and constructing an integrated highway fast freight transport system in the Yangtze River Delta region.

As the central city of the Yangtze River Delta, Shanghai is the most developed city with a very convenient transportation network. According to the above results, the coefficient of the error correction term is negative and significant to both GDP and FTV. Obviously, there is a two-way causality between the two variables, and the government's investment in transportation infrastructure can promote economic growth. Conversely, economic growth is also conducive to the development of transportation infrastructure. The results of Shanghai show that changes in economic growth rate do lead to significant increases in transport investment, which is in the same logic as changes in transport investment do lead to significant increases in economic growth rate. In the case of Jiangsu, its contribution to GDP ranks second at the provincial level in China. The coefficient of the error term is negative and significant when the population is taken as the dependent variable, which indicates that there is a one-way GC from economic growth to transportation infrastructure, changes in economic growth rate will lead to a significant change in transportation infrastructure investment, but transportation investment does not lead to economic growth.

As for Zhejiang province and Anhui Province, the results of them are not significant which means the transportation infrastructure investment and economic development in there two provinces do not has the long-run equilibrium relationship. Neither economic growth has any impact on transportation infrastructure investment nor transportation infrastructure investment is the cause of economic growth.

On the other hand, the above results do not provide evidence that transportation investment can promote economic growth. The above results were different among the three provinces and one city, among which there was a two-way causality between the variables in Shanghai and a one-way causality among the variables in Jiangsu. Although improvements in infrastructure can bring about some beneficial changes, the investment in transport infrastructure alone will not be enough to bring about significant changes in Zhejiang and Anhui provinces. Therefore, for areas with poor economic development, we should not only consider improving transportation infrastructure, but also pay attention to the educational, social and technological levels of relatively underdeveloped areas. Our results do not contradict Fogelian's (Fogel, 1992, 1964) explanation, nor Huang's (2008) view that in this period of rapid growth, the Chinese government should not only focus on the construction of transportation infrastructure. But they also fit an alternative interpretation, namely that infrastructure can provide substantial benefits to the overall economy, but lack of factor mobility limits the localization (and overall level of benefits) of the benefits. The lack of significant differences between connected and poorly connected regions does not rule out the possibility that infrastructure could benefit all these regions, but the lack of factor mobility prevents gains from being concentrated in relatively connected regions.

These results should not deter those who believe that investing in transport infrastructure can boost economic development. Instead, they emphasize the importance of other factors when considering the impact of infrastructure on economic growth. Moreover, as we point out in the introduction to this paper, the importance of the freight express system for the development of the long delta cannot be said to justify the investment in transport infrastructure. Finding reliable ways to estimate and even constrain social returns remains a very important next step in this research agenda.

We should remember that our experimental results do not deter those who argue that investing in transport infrastructure can boost economic development. Instead, our findings suggest that other factors are also important when considering the impact of infrastructure on economic development. Despite the economic growth and the positive correlation between the traffic infrastructure investment is the basic logic behind straightforward - economic development leads to the high demand for adequate transport infrastructure, government investment in infrastructure projects to meet this demand, this view is supported by many researchers, they prove that improve and efficient infrastructure can promote the economic growth of a country. However, we emphasize that investment in transportation infrastructure is not the only determinant of economic growth in the Yangtze River Delta. The policy implication

here, of course, is that given the impact of future growth, there is now a stronger reason to consider other causes of economic growth, such as education, geography, technological development, sociopolitical conditions, human capital and resource endowments. The results suggest a shift in policy towards poorer provinces. There is an urgent need for the government to make efforts to overcome other obstacles to regional economic growth and combine transport infrastructure investment as a comprehensive investment plan for the economic integration of the Yangtze River Delta.

5. Further development of this paper

This paper has made some achievements in the study of the relationship between transportation and economic development in the Yangtze River Delta. However, due to the limitation of my economic theory, there are still many defects and deficiencies in the research, and many problems need to be further discussed:

(1) The collection and collation of data related to transportation and economy are not perfect, and the selection of indicators has certain limitations, and the research on the coordination relationship between transportation and economy based on Granger Model focuses more on the long-term relationship. In the empirical study, the relevant data of the Yangtze River Delta from 2000 to 2019 are selected for analysis. The data volume is relatively small, and the results obtained have certain limitations. If the data can be further improved and more indicators selected for the study of comprehensive economic development and transportation infrastructure, the research foundation of this paper will be more solid.

(2) From the perspective of time, the change rule of coordination degree between transportation and economy and the relationship between coordination degree and economic development are empirically studied. In the future research work, the coordination between transportation and economy in different regions of China can be further compared and analyzed from the spatial dimension.

Apendix

1, Result for descriptive statistic:

	GDP.SH	GDP.JS	GDP.ZJ	GDP.AH	FTV.SH	FTV.JS	FTV.ZJ	FTV.AH
Mean	1734.77	44014.88	28360.37	14107.58	16388.4	6497.071	5966.303	6430.457
Std.Dev	9875.836	29774.13	17547.62	10208.44	6689.484	3446.305	3651.72	4557.443
Observation	20	20	20	20	20	20	20	20

2, Result for correlation analysis

Correlation	LN_gdp.sh	LN_gdp.js	LN_gdpzj	LN_gdp.ah	LN_ftv.sh	LN_ftv.js	LN_ftv.zj	LN_ftv.ah
LN_gdp.sh	1.000000							
LN_gdp.js	0.998224	1.000000						
LN_gdpzj	0.998962	0.999038	1.000000					
LN_gdp.ah	0.993481	0.995712	0.993157	1.000000				
LN_ftv.sh	0.977045	0.969439	0.97496	0.956377	1.000000			
LN_ftv.js	0.976154	0.980472	0.980292	0.971207	0.955151	1.000000		
LN_ftv.zj	0.983223	0.983094	0.987184	0.965602	0.977036	0.984582	1.000000	
LN_ftv.ah	0.946119	0.958763	0.952792	0.956563	0.891081	0.960916	0.940878	1.000000

3, Result for panel unit root test

	(C, T, K)	ADF	5% Level	P-Value	Stationary
LN_gdp.sh	(C, T, 4)	-4.781408	-3.7332	0.0082	YES*
LN_gdp.js	(C, T, 4)	-2.914500	-3.0299	0.0622	YES***
LN_gdp.zj	(C, T, 4)	-3.498303	-3.0299	0.0198	YES**
LN_gdp.ah	(C, T, 4)	-3.372455	-3.7332	0.0906	YES***
LN_ftv.sh	(C, T, 4)	-2.526327	-3.6908	0.3131	NO
LN_ftv.js	(C, T, 4)	-1.268800	-3.0299	0.6215	NO
LN_ftv.zj	(C, T, 4)	-3.607088	-3.0299	0.0159	YES**
LN_ftv.ah	(C, T, 4)	-0.868552	-3.6736	0.9391	NO
Noted: *, **, *** indicates the significant level at 1%, 5%, 10%, respectively					

4, Result for first difference test

	(C, T, K)	ADF	5% Level	P-Value	Stationary
DLN_ftv.sh	(C, T ,4)	-3.7156	-3.0521	0.0140	YES**
DLN_ftv.js	(C, T ,4)	-3.3345	-3.7597	0.0985	YES***
DLN_ftv.ah	(C, T ,4)	-3.3246	-1.9614	0.0028	YES*
Noted: *, **, *** indicates the significant level at 1%, 5%, 10%, respectively					

5, Result for co-integration test

Region	Method	ε_{it} for Equation (1)	ε_{it} for Equation (2)
Shanghai	ADF	-2.168 (0.03) **	-3.069 (0.00) *
Jiangsu	ADF	-1.943 (0.05) ***	-2.020 (0.04) **
Zhejiang	ADF	-1.266 (0.18)	-1.536 (0.113)
Anhui	ADF	-1.1127(0.23)	-1.393(0.146)

Noted: *, **, *** indicates the significant level at 1%, 5%, 10%, respectively

6, Result for EMC

Regions	Dependent variable	dlnGDP	dlnFTV	ECM
Shanghai	dlnGDP	-	0.77 (0.48)	-0.12 (0.02) **
	dlnFTV	2.05 (0.17)	-	-0.50 (0.01) *
Jiangsu	dlnGDP	-	0.82 (0.46)	-0.08 (0.17)
	dlnFTV	2.45 (0.12)	-	-0.37 (0.06) ***

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