China's Ganyue Canal Construction: Forecast and Analysis of Its Transport Demand Based on Large Data

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Abstract. The Ganyue Canal directly connects the water systems of the Yangtze River and the Pearl River. This important link immediately benefits the economy and industrial development of the Jiangxi and Guangdong provinces and has a direct and significant impact on the waterway cargo transportation. This paper will consider the specific case of the comprehensive transportation system in the river valley of the Guanyue Canal. It will include economic and industrial factors affecting the regions concerned and will analyse the trends and demands of traffic development. It will establish a quantitative model based on the large data method measuring the coal, mineral building materials, cement, ore, cereals and steel-related products. Based on the forecast of its transport demand and economic analysis, this paper will highlight the necessity to construct the Ganyue Canal and will put forward several proposals to overcome the challenges of the building process.

Keywords: Ganyue Canal · Types of goods · Modes of transportation · Demand forecast

1 Introduction

As one of our country's main river system communication project, the Ganyue Canal is a major channel to open up the Yangtze River and the Pearl River river systems. To a certain extent, it plays an important role in complementing the use of water resources and comprehensive transportation. Thus, we can say that the Ganyue Canal project will make people prosper by integrating economic, social and ecological benefits. The Canal's hinterland service can extend to the middle reaches of the Yangtze River such as the Hubei and Anhui provinces, getting as far as the entire Yangtze River Basin and the middle and upper reaches of the Pearl River. It involves many national strategic economic zones such as the Yangtze River Economic Belt and the Yangtze River Delta, inevitably bringing a large number of waterway cargo transportation needs. During the preliminary planning and research phase, it is of great importance to carry out research on the main cargo transportation needs and an all round study of its economic nature so as to bring into play as fully as possible the value of the canal construction.

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Freight demand forecasting is the foundation of the entire planning of the canal's cargo transportation system and an important basis for the effective allocation of freight equipment and resources and the construction of an efficient freight system. It is necessary to forecast the demand for bulk cargo transportation on the canal channel. This paper predicts and analyses the main cargo transportation demand of the Ganyue Canal by sorting out the cargo transportation situation of the main navigable river sections of the Ganyue Canal and the freight exchanges of various modes of transportation based on the large data method.

2 The Construction of the Ganyue Canal: Analysis of the Current Situation

The Ganyue Canal and two connected rivers, namely, the Ganjiang River and the Beijiang River, together stretch over more than 1200 km, with more than 700 km in the Jiangxi province and over 500 km in the Guangdong province. Later, the two following waterways: the Ganjiang river in the Jiangxi Province and the Beijiang river in the Guangdong Province were directly connected, mainly because a segment of the Ganjiang river was passing through a cross-ridge section in the city of Shaoguan into the Sanshui District in Guangdong.

Among the three main components of the current canal, apart from the cross-ridge section that has not yet been opened to navigation, the other two sections are in operation. The main channel of the Ganjiang River has a total length of 606 km. The entire route can reach the Class III channel standard and can be used to navigate 1,000-ton ships all year round. The main affected areas include the Jiujiang Harbour (Hukou Port Area), the Nanchang Harbour, the Ganzhou Harbour and other ports. In recent years, due to the improvement of navigation conditions, the annual handling capacity of the Nanchang Harbour has drastically increased from less than 1,000 TEUs to over 200,000 TEUs. Amongst the goods transported, the quantity of cereals, non-metallic ores and coal has increased fairly rapidly whereas construction materials such as sand and gravel account for a large proportion of the cargo. At present, the Jiangxi Province is vigorously pushing forward the realisation of multimodal transport in Jiujiang Port, Nanchang Port, Ganzhou Port, etc., and is exploring and practicing ways of promoting the transportation of bulk cargoes from "railway to water".

3 Economic and Social Development of the Hinterland

Amongst the hinterlands served by the Ganyue Canal, the Jiangxi and the Guangdong provinces are core areas of the canal service. The hinterlands served by the canal can be extended to the middle reaches of the Yangtze River such as the Hubei and Anhui provinces and can further include the entire Yangtze River basin and the middle and upper reaches of the Pearl River. With the continuous improvement of the level of regional economic and social development, the adjustment of regional industrial structure will continue to accelerate, and the demand for water transportation will continue to increase, providing a good supply guarantee for the construction and development of the Ganyue

Canal. When it comes to economy and distance, transportation on the Ganyue Canal and its water communication system will reinforce the exchange of goods between the Yangtze River Economic Belt, the Pearl River Delta and the coastal areas in Southern China. Part of the Jianghai transport route and goods is heading for a shift in water transportation passageway, foreign trade cargo transportation will also be a more efficient tool occupying an increasingly dominant position.

The Jiangxi province is located on the south bank of the middle and lower reaches of the Yangtze River in central China. It is the hinterland of various regions: the Yangtze River Delta, the Pearl River Delta and Minnan which is Southern Fujian. In the light of cargo transportation needs, currently they mainly include minerals, building materials, agriculture, forestry, fishery, livestock products. Mineral resources in the province of Jiangxi are abundant. The reserves of more than 10 kinds of natural resources such as tungsten and tantalum occupy the first place in the whole country. Mineral transportation has also become a major activity in the province of Jiangxi's economic development. In the field of construction materials, the province of Jiangxi's market supply and demand has kept going from strength to strength. In 2020, the income from the construction materials industry was 336.3 billion RMB, a 5.5% increase from the previous year, thus accomplishing a net profit of 36.1 billion RMB, which represents a 10.1% increase. The fast and steady pace at which our country's agriculture, forestry, animal husbandry and fishery keep developing is of far-reaching significance for our national economy. In 2020, the province of Jiangxi achieved an output value close to 400 billion RMB, which represents a 142.14 billion RMB increase from 2012. In future, the transportation of resource-based mineral primary products in the province of Jiangxi will be significantly reduced. On the other hand, the demand for deep-processed products, composite products, auxiliary materials and ingredients will greatly increase.

The province of Guangdong is located in the southernmost part of our country. The total retail sales of consumer goods has been steadily increasing, foreign trade and foreign investment are stable too. Guangdong is also number one in the country when it comes to the volume of transported goods all year long. Yuebei, that is Guangdong north, is the main production base of industrial raw materials in the province. It occupies a dominant position in the Pearl River Delta transfer industry. As to the demand in cargo transportation, it is currently mainly in minerals, coal and textile related products. According to related statistics, gold mines in the province of Guangdong are widely spread out. The level of use and distribution of major ores is going up. In the early stage of development, the enormous initial consumption rate of coal in the province of Guangdong changed into optimised consumption patterns of energy sources. Presently the total coal consumption is subjected to strict control and the total coal consumption in 2020 will be about 165 million tons. The province of Guangdong is our country's major exporter of textiles and clothing. The modern light industry and textile industry clusters are mainly spread out within the Pearl River Delta nucleus area. However, due to the impact of the Covid-19 pandemic, the textile and clothing export volume in the province of Guangdong has to some extent declined.

4 Transport Demand Forecasting for the Ganyue Canal

4.1 Forecasting Ideas and Methods

In this paper, combined with the economic and social development of the regional hinterland and the related influence of water system connectivity on the adjustment of transportation structure of the whole society, the traffic four-stage method commonly used in road planning is introduced, the relationship between hinterland economic output value and waterway freight volume is established according to historical data and the elasticity coefficient is obtained. The growth rate of waterway freight volume is obtained from the economic growth rate in the target year and the future traffic distribution of each province is calculated by using the Follett method, which is allocated to the regional waterway network after the canal is connected in the target year, so as to get the transportation volume of the proposed canal and its key reaches. Because the Ganyue Canal spans Jiangxi and Guangdong provinces and has a long transportation distance, it is not suitable to forecast the transportation volume of the whole route. Therefore, according to the order of project development, it is forecast separately for the Hukou-Ganzhou reach of the Jiangxi Province, the Yueling reach at provincial boundary and the Shaoguan-Sanshui estuary reach of the Beijiang River in the Guangdong Province.

The transportation volume of each OD community is based on annual statistics. Taking 2020 as the current year, we start off the initial cargo distribution matrix (abbreviated as the PA matrix) according to the Jiangxi province currently available shipping route. Then we take the cargo volume from the point of origin (originating harbour) to the point of attraction (harbour of destination) for each existing route as the distribution flow basic/raw data. Using the growth rate method, according to the current PA matrix and the future channel network structure, a matrix of the current year is obtained through multiple iterations of forecast OD quantity, the transfer amount and induced volume.

In view of the current PA matrix, the Flat method is used to forecast the distribution of water transportation volume. The calculation formula is as follows:

$$T_{ij}^{f} = T_{ij}^{0} \times G1i \times G2j \times \frac{Li + Lj}{2} \tag{1}$$

$$Li = \frac{P_i^0}{\sum_j T_{ij}^0 G2_j}, Lj = \frac{A_j^0}{\sum_i T_{ij}^0 G1_i} \tag{2}$$

Formula split down:

- T_{ij}^{f}: Water transport volume between plots i and j in target year;
- T_{ij}^{0}: Water transport volume between plots i and j in base year;
- $G1i$: Increase rate of water transport occurrence in plot i, i.e. $G1i = \frac{P_i^f}{P_i^0}$;
- $G2_j$: Increase rate of water transport attraction in plot j, i.e. $G2_j = \frac{A_j^f}{A_j^0}$;
- L: Impedance factors of occurrence or attraction of waterway transport;
- P_i^0,A_j^0: The amount of water transport in plot i and the amount of water transport attraction in plot j in base year;

- P_i^f,A_j^f: The amount of water transport in plot i and the amount of water transport attraction in plot j in target year.

Replace T_{ij}^f with T_{ij}^0, replace $\sum_j T_{ij}^f$ with P_i^0, replace $\sum_i T_{ij}^f$ with A_j^0, repeatedly calculate and correct, until G_i, G_j converge to the error range of within 5% (confidence interval is 95%), so as to ensure that the goods generated and attracted in the same target year are consistent. Thus, the tendency P-A matrix in the target year is obtained, and it is gradually concluded that in 2035 and 2050, under the condition that the existed waterway network is open and accessible, the freight volume is 307 million tons and 334 million tons, respectively, and the error with the OD freight volume before distribution is less than 1%.

Based on the tendency P-A matrix, the gravity model is used to calculate the freight volume increase between the neighbouring hinterlands linked by the canal and the port and hinterland provinces with greatly shortened freight distance. The freight volume between two plots is in direct proportion to the occurrence power of the place of origin, in direct proportion to the attraction power of the place of arrival, and in inverse proportion to the water transport impedance (generalised cost) between two plots. The formula is expressed as follows:

$$Q_{ij} = K \cdot P_i^{\alpha} A_j^{\beta} / D_{ij}^{\gamma} \tag{3}$$

In which, K, α, β and γ are the parameters of gravity model, and D_{ij} is the matrix table of water transport impedance (generalised cost).

If the freight volume in the base year between OD point pairs with the change of water transport impedance is not zero, the formula for calculating the induced freight volume Qij' in the current interval is as follows:

$$Qij' = ((\frac{Dij}{Dij'})^{\gamma} - 1) \times Qij \tag{4}$$

If the freight volume in the base year between OD point pairs with the change of water transport impedance is zero, the formula for calculating the induced freight volume in the current interval is as follows:

$$Q'_{ij}{=}K \times P_i^{\alpha} A_j^{\beta} / (\frac{1}{D_{ij}^{\prime\gamma}} - \frac{1}{D_{ij}^{\gamma}}) \tag{5}$$

In the distribution forecast of freight volume, the multi-path probability distribution method is adopted. The canal freight traffic is forecasted by the alternative route characteristics of the ship. The main criteria are: the shorter the generalised voyage time including navigation time, unit freight, number of lockages between any two plots, the greater the probability of choosing this route for transportation.

$$P(k) = \frac{exp(-\theta \cdot t_i)}{\sum_{i=1}^{m} exp(-\theta \cdot t_i)} \tag{6}$$

$$T_{\mathrm{ij}(k)} = T_{ij(k)} \times P(k) \tag{7}$$

Formula split down:

- Tij(k): Freight volume allocated by T_{ij} to route K;
- T_{ij}: Freight volume from Plot i to Plot j;
- θ: Distribution parameters of goods flow;
- m-The number of effective freight routes;
- P(k): The use probability of the kth freight route;
- t_k: the generalised voyage time of the kth freight route.

According to the freight growth coefficient of the gravity model, considering the existing road network connectivity and channel capacity, the distribution of freight flow among the hinterland is obtained.

For inland river OD routes, there are differences between different modes of transportation only in terms of costs, time, degrees of freedom (number of gates passing through) etc. Therefore, generalised costs are introduced to adjust the weights, so as to obtain the original coastal and riverside after the canal is repaired. The amount of diversion and inducement of the route.

4.2 Forecast of Main Cargo Transportation Volume

Experience analysis shows that various factors influence the way the main cargo transportation volume is forecast. The position of the industry and the planning objectives of the cargo in the hinterland -industrial products and raw materials, are important. Yearly statistics about import/exports and information received from industrial and economic departments are other key components to take into account.

As part of a comprehensive transport system, water freight traffic is not only related to the regional economic, industrial and social development, it is also affected by the overall transportation needs and the size of the relevant goods that are transported during the target year.

4.2.1 Coal

Based on each province in 2020, various aspects of cargo transportation were sorted out such as: the historical data of the total economic volume, industrial structure, coal freight volume of various transportation modes and the waterway coal freight volume in the hinterland. The increase and decrease trend of coal transportation volume in the canal was analysed and forecast (Table 1).

At the moment, with regards to the coal coming from the Jianxi province, the domestic supply mainly depends on the "North-South coal transportation" in North China, whereas foreign trade is transferred from one ship to another at coastal ports. Since the beginning of the 13th Five Year Plan in China, the total freight volume of coal and railway coke fuel in Jiangxi has risen from 12.16 to over 18 million tons. Heavily hauled railways such as the one in Haoji, have become progressively saturated. With the change in the

Table 1. Coal handling capacity of ports in various provinces in 2020 Statistical unit: 10,000 tons

Year	Jiangxi Province			Guangdong Province		
	Total	Outbound	Inbound	Total	Outbound	Inbound
Total handling capacity	4622.2	468.5	4153.7	3003.9	16	2987.8
Nanchang	1204.1	3.6	1200.5			
Jiujiang	2462.3	144.2	2318.1			
Jiangxi others	955.9	320.6	635.2			
Shaoguan				191.5	0.2	191.3
Qingyuan				382.2	0.4	381.8
Guangdong other				2430.2	15.4	2414.7

channel conditions, the standardisation of waterway ships, the optimisation of transport organisation, the coal cargo volume in the GanJiang River and in the Beijiang River will substantially grow.

The main consumers of coal are thermal power plants, cement plants, non-ferrous metal smelters, which are industrial companies with large scale industry expansion and are responsible for the increase in demand for coal consumption. In addition, since the year 2016, the province of Jiangxi has been focusing on getting rid of outdated methods in order to prioritise coal production capacity reduction. Up to June 2019, the whole province managed to shut down a grand total of 393 coal mines and withdraw 23.72 million tons of coal production. Consequently, in recent years, the price of the coal from the province of Jiangxi has kept going up and the coal shortage in the whole province has also increased from 6,183.99 tons in 2016 to more than 80 million tons in 2018.

The main consumers of coal in Guangdong are thermal power plants, smelters, ceramic businesses and non-ferrous metal companies. Industrial companies in Qingyuan and in Shaoguan, along the Beijiang River, transport the coal to them from three directions: first, from the hinterland coal production in North and Central China. This is mainly done by railway transportation. Second, from Guizhou along the Hongshui River - Xijiang waterway transportation. After the construction of the new railway in Shao (guan), He (Zhou) and Liu (Zhou), Shaoguan will increase its rail-water combined mode of transportation. Third, from the Pearl River Delta harbour, where domestic coal and imported coal from China are brought in. Currently, coal to Shaoguan is mainly transported by rail and by road, whereas coal to Qingyuan is mainly transported by rail, road and inland waterway. Both cities need 20 million tons of coal altogether. After the synchronised completion of the Beijiang River level III channel with the canal, coal from major ports in the Pearl River Delta can be transported northward to Shaogan and Qingyuan, while a small quantity of "North Coal" from the north of China can be transported southward via water-rail transportation to Jiangxi, which will also supplement the coal demand in Shaoguan. In future, the existing level of demand will briefly increase. The Beijiang River will assume 40–50% of the transportation demand. The coal demand in both cities will be about 12 million tons.

Table 2. Forecast of coal freight flow in the target year Unit: 10,000 tons

	Flow direction	2035	2050
Hukou-Ganzhou	Up stream	750	1000
	Down stream	3550	3500
Cross section with provincial border	Up stream	750	1000
	Down stream	0	0
Shaoguan-Sanshui estuary	Up stream	2000	2350
	Down stream	0	0

The next step consists in forecasting the freight volume between OD points in the province of Jiangxi and what is currently happening in the ports of Shaoguan and Qingyuan in the province of Guangdong. The upward flow of the current is from south to north, whereas the downward flow is from north to south. According to model calculations, it is possible to satisfy the coal water transportation demand for the Hukou-Ganzhou section in Jiangxi, for the Jieyueling section in Guandong, in the province of Jiangxi and for the Shaoguan-Foshan Sanshuihekou section in Guangdong (Table 2).

In future, the demand for coal in the province of Jiangxi will keep on increasing steadily until it reaches saturation. After the Ganyue canal is open to navigation, imported coal can be transported in central and southern Jiangxi. For instance, coal in Jian and in Ganzhou can be transported from the Pearl River estuary to the north by inland waterways. It is estimated that that should result in a 33–40% diversion of the coal transportation from the Yangtze River Delta ports into the hinterland. After the synchronised completion of the Beijiang River level III channel with the canal, coal will be able to be transported from major harbours in the Pearl River Delta northward to Shaoguan and to Qingyuan, and a small quantity of "North Coal" in the north of China will be transported southward by rail-water transportation in Jiangxi, which will also top up the coal demand in Shaogan. In future, the existing level of demand will briefly increase. The Beijiang River will assume 40–50% of the transportation demand. The coal demand in both cities will be about 12 million tons.

4.2.2 Mining Construction Materials

In the light of our country's multipurpose use of fly ash, its in-depth and varied utilisation, water sediment, fly ash can progressively achieve top quality cement as raw material. The power plant in the hinterland canal, through the production of iron and steel, provide an adequate supply of fly ash and water sediment. Presently, the sand capacity in the province of Guangdong amounts to 80 to 100 million cubic metres, including 70% of sea sand, whilst the annual demand for sea sand is 70 million cubic meters. The northern part of the canal, in the province of Jiangxi, is very rich in natural mineral resources, Besides, building materials, fly ash and water sediments are low value commodities. In order to reduce transport costs and to maximise the shipping utilisation ratio, it is possible to use inland waterways upstream to transport coal and iron ores (Table 3).

Table 3. Handling capacity of port in various provinces in 2020 Statistical Unit: 10,000 tons

Year	Jiangxi Province			Guangdong Province		
	Total	Outbound	Inbound	Total	Outbound	Inbound
Total handling capacity	5323.4	3945.7	1377.7	7407.2	3348.2	4059.1
Nanchang	1584.2	744.6	839.7			
Jiujiang	3412.9	3096.7	316.2			
Jiangxi others	326.2	104.5	221.9			
Shaoguan				17.4	17.4	-
Qingyuan				339.8	335	4.8
Guangdong others				7050	2995.8	4054.3

Table 4. Forecast of the freight flow of mining and construction materials in the target year Unit: 10,000 tons

	Flow direction	2035	2050
Hukou-Ganzhou	Up stream	3190	3420
	Down stream	610	680
Provincial border cross section	Up stream	0	0
	Down stream	610	680
Shaoguan-Sanshui estuary	Up stream	0	0
	Down stream	2100	2050

The next step consists in forecasting the freight volume between OD points in the province of Jiangxi and what is currently happening in the ports of Shaoguan and Qingyuan in the province of Guangdong (Table 4).

In line with the "Jiangxi province machine-processed Sand Industry Development Plan (2020–2025), the annual production of sand will reach 80 million tons by 2025, including 45% of the total production capacity in Yichun, Jian and Ganzhou combined. According to estimates, the yearly demand for construction sand in the province of Jiangxi is superior to 200 million tons. The total supply of river sand in the province is around 130–140 million tons per year. The sand and gravel transportation along the Gan Jiang river can amount to about 40 million tons. In the next 5 to 10 years, the annual demand for machine-processed sand in the province of Jiangxi will be around 60–70 million tons. The external transportation of machine-processed sand will be about 10–20 million tons. According to the production capacity of the power plant in the province of Jiangxi, it is estimated that by 2035, the province will produce 15 million tons of fly ash and 5 million tons of water sediment, representing 40–50% of the canal's inter-provincial shipping volume.

4.2.3 Metal Ores

The iron and steel factories in Jiangxi require over 33 million tons of iron ore. Yichun and other places within the province supply about 6 million tons. The remainder comes from outside the province. Nanchang harbour's handling capacity of iron ore will have reached 12 million tons by 2035. With the development of intensive metal processing, it should be possible to maintain a key position in the iron ore demand. With the improvement of navigation conditions, the majority of imported ore formerly transported overland will now be transferred to waterways, through Shanghai, Ningbo-Zhoushan and Guangzhou using the Jiujiang harbour, via the Yangtze River or using the Ganzhou harbour via the Beijiang river. In future, the direction given to the iron and steel industry in the whole province will be to limit production, adjust existing structures and keep the scale of operations under control. There won't be any major variation in the overall demand. However because of the decline in self-sufficiency rate, the amount of imported metal ores will increase and the demand for them will reach 28–31 million tons (Table 5).

According to the model calculation, the cargo flow of metal ores can be obtained in the Hukou-Ganzhou section in Jiangxi, the Jieyueling section in the Jiangxi province, Guangdong and in the Shaogan-Foshan Sanshuihekou section in Guangdong (Table 6).

Table 5. Port handling capacity per province in 2020 Statistical unit: 10,000 tons

Year	Jiangxi Province			Guangdong Province		
	Total	Outbound	Inbound	Total	Outbound	Inbound
Total handling capacity	1428.6	63.3	1365.3	230.3	16.3	214
Nanchang	597.5	5.1	592.4			
JiuJiang	804.5	47.4	757.1			
Jiangxi other	26.6	10.8	15.8			
Shaoguan				56.4	-	56.4
Qingyuan				97.4	-	97.4
Guangdong other				76.5	16.3	60.2

Table 6. Metal ore cargo flow forecast for the target year Unit: 10,000 tons

	Flow direction	2035	2050
Hukou-Ganzhou	Up stream	330	490
	Down stream	1370	1410
Provincial border cross section	Up stream	330	490
	Down stream	0	0
Shaoguan-Sanshui estuary	Up stream	760	830
	Down stream	0	0

Basing our calculation on the current production capacity of iron and steel in Shaoguan, it is estimated that in 2035 and in 2050, Shaoguan will need to import from abroad 10–11 million tons of iron ore, while 7–8 million tons will be shipped to Shaoguan harbour from other parts of the country via the Beijiang river. The water transport volume of various metal ores such as antimony, tungsten, lead and zinc will reach 400,00–600,000 tons. Additionally, import supply via foreign trade will be complemented by metal ore transportation from Guangxi which has plenty of various metal ores. The route will be from Guangxi to Shaoguan port and to Jiangxi inland river port through Xijiang, the Beijiang river and the Gangjiang river. The sum total of non-metal minerals transported from Guangxi to Jiangxi is estimated at 1–2 million tons.

4.2.4 Cement

Currently the Ganyue canal in the Jiangxi section along the hinterland region altogether has over 10 cement manufacturers, mainly spread over Nanchang (9 locations, 14 million tons), Ganzhou (production capacity limited to 15 million tons) and other places with an annual cement production of 20–22 million tons. Cement is also one of the main water cargo on the Beijiang River. Shaoguan and Qingyuan are located in the mountainous area of northern Guangdong where limestone mines are widely spread out. They are also the main cement producing areas in Guangdong. At the moment, in Shaoguan, the cement industry group which produces annually more than 20 million tons of new dry processed cement continues to expand further and exports have reached 60% of the production (Table 7).

The next step consists in forecasting the freight volume between OD points in the province of Jiangxi and what is currently happening in the ports of Shaoguan and Qingyuan in the province of Guangdong (Table 8).

Table 7. Harbour cement handling capacity by province in 2020 Statistical unit: 10,000 tons

Year	Jiangxi Province			Guangdong Province		
	Total	Outbound	Inbound	Total	Outbound	Inbound
Total handling capacity	1687.2	1188.6	498.6	2646.1	2355.5	290.5
Nanchang	498.9	2.4	496.5			
Jiujiang	1076.8	1074.7	2.1			
Jiangxi others	111.5	111.5	-			
Shaoguan				-	-	-
Qingyuan				297.1	297.1	-
Guangdong others				2349	2058.4	290.5

Table 8. Forecast of cement cargo flow by target year Unit: 10,000 tons

	Flow direction	2035	2050
Hukou-Ganzhou	Up stream	1580	1640
	Down stream	320	360
Provincial border cross section	Up stream	0	0
	Down stream	320	360
Shaoguan-Sanshui estuary	Up stream	0	0
	Down stream	2850	2900

According to an estimate, the production capacity will reach 24 million tons by 2030, the number of exports being 12–14 million tons. Moreover, the annual production of cement and clinker in the Wujiang River Basin in Lechang is 4 million tons (400,000 tons of coal consumption). Considering the homogeneity of the surrounding industries as well as the local consumption amount, cement exports are given priority in the south of the Pearl River Delta. Also, cement production in Qingyuan, Yingde Shi reaches more than 30 million tons per year. The export cargo transported through the Beijiang river accounted for more than half.

4.2.5 Food

The Southern Jiangxi area in the middle section of the Ganyue canal is a major base for the whole country's marketable grains. Having communication opportunities at both ends, the middle reaches of the Yantzte River and of the Pearl River Delta, the canal is essential to the enormous consumer market. According to a research report on agricultural demand, as the population increases, the structure and the urbanisation develop, so by 2030 our country will reach the peak of its demand for cereals, reaching 718.29 million tons. Soybean demand will be 112.87 million tons and forage demand will be 519.714 million tons. The total amount of food consumption will be stable at 185–200 million tons (Table 9).

The PA matrix was calculated and the cargo method was used to forecast the distribution of water transportation. The demand for grain cargo in the Hulou-Ganzhou section, in the Yueling section and in the Shaoguan-Foshan Sanshuihekou section in the target years was thus obtained effectively (Table 10).

According to the province of Jiangxi's population and standards of living per capita, it is estimated that cereal consumption will peak to reach 23.68 million tons. With the initial formation of the external "south from the north" grain transportation pattern, it transpires that it is necessary to transfer cereals from Northeast China and flour from east China, a total of 6–8 million tons of food. Simultaneously, every year, about 7 million tons of rice and other cereals are transported southward to Jiujiang, Nanchang, Ganzhou and other harbours. This represents an increase by more than 31% during the past three years. In 2019, the three major cereal harbours imported 4.5 million tons of food. In recent years, imports to the province of Guangdong and domestic and international food

Table 9. Grain handling capacity of ports in various provinces Statistical unit: 10,000 tons

Year	Jiangxi Province			Guangdong Province		
	Total	Outbound	Inbound	Total	Outbound	Inbound
Total handling capacity	242.1	3.8	238.3	768.1	74.1	694
Nanchang	188.1	0.6	187.5			
Jiujiang	51.6	3	48.5			
Jiangxi others	2.4	0.2	2.3			
Shaoguan				3.1	-	3.1
Qingyuan				19.2	-	19.2
Guangdong others				745.8	74.1	671.7

Table 10. Grain cargo flow forecast of the target year Unit: 10,000 tons

	Flow direction	2035	2050
Hukou-Ganzhou	Up stream	200	280
	Down stream	650	720
Provincial border cross section	Up stream	200	280
	Down stream	180	200
Shaoguan-Sanshui estuary	Up stream	270	280
	Down stream	180	280

purchase reached about 30 million tons. As the cost of land and labour increases, the quality and the price of agricultural imports are given more prominence and the number of imported agricultural products to Jiangxi and Guangdong will grow quickly. It is estimated that the Jiangxi province's cereal import demand will reach 7 and 10 million tons in 2035 and 2050 respectively, whereas the cereals shipped to the Pearl River Delta will remain around 3 million tons.

4.2.6 Steel

Steel products are currently the fourth largest commodity's handling capacity in the Jiangxi province. Jiujiang and Nanchang harbours are the two main ports with inbound and outbound steel shipping. The Jiangxi province's steel handling capacity reached a peak of 9.33 tons in 2016. After that date, the production capacity was adjusted in the hinterland and as a result, within the last two years, the steel handling capacity has declined. With the long term development of machinery and equipment in the Jiangxi province, along with the increase investment in infrastructure in the hinterland, the demand for steel consumption will grow steadily. The iron and steel produced in the hinterland of Jiujiang and Nanchang ports are consumed locally. According to relevant

Table 11. Steel handling capacity of ports in various provinces in 2020 Statistical unit: 10,000 tons

Year	Jiangxi Province			Guangdong Province		
	Total	Outbound	Inbound	Total	Outbound	Inbound
Total handling capacity	884.2	546.4	337.8	2442.7	273.7	2169
Nanchang	298.4	3.9	294.5			
Jiujiang	577.1	540.9	36.3			
Jiangxi others	8.7	1.6	7.1			
Shaoguan				23.1	23.1	-
Qingyuan				-	-	-
Guangdong others				2419.6	250.6	2169

Table 12. Steel cargo forecast in the target year Unit: 10,000 tons

	Flow direction	2035	2050
Hukou-Ganzhou	Up stream	600	500
	Down stream	400	800
Provincial border cross section	Up stream	0	0
	Down stream	100	200
Shaoguan-Sanshui estuary	Up stream	95	115
	Down stream	55	85

sources, the production capacity of Jiangling car manufacturing bases in Nanchang and Fuzhou will increase by 300,000 and 100,000 units by the end of the 13th Five-Year Plan, thus reaching a total of 1 million units. Car manufacturers will increase their production capacity by 1.18 million units in total during the 14th Five-Year Pan (Table 11).

The next step consists in forecasting the freight volume between OD points in the province of Jiangxi and what is currently happening in the ports of Shaoguan and Qingyuan in the province of Guangdong (Table 12).

Based on the above forecast results, the transportation volume of major cargo types in the target year is summarised and the detailed data is shown in Table 13.

Table 13. Cargo flow direction and flow forecast results by river section Unit: 10,000 tons

	2035						2050					
	Hukou-Ganzhou		Cross ridge		Shaoguan-Sanshui		Hukou-Ganzhou		Cross ridge		Shaoguan-Sanshui	
	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream
Coal	750	3550	750	0	2000	0	1000	3500	1000	0	2350	0
Mining materials	3190	610	0	610	0	2100	3420	680	0	680	0	2050
Cement	1580	320	0	320	0	2850	1640	360	0	360	0	2900
Metal ore	330	1370	330	0	760	0	490	1410	490	0	830	0
Food	200	650	200	180	270	180	280	720	280	200	280	280
Steel	600	400	0	100	95	55	500	800	0	200	115	85
Other	1700	1800	540	430	785	765	2000	1600	700	490	985	865
Total	10510	10620	2216	2084	4654	6766	11640	11160	2965	2535	5495	7225

5 Conclusion and Analysis

This paper established a 4-phase method in relation to the Ganyue Canal major cargo transportation volume. It carried out calculations, forecasts and analyses of the main Jiangxi-Guangdong Canal. The results can be seen in Table 14. According to the forecast results, in 2035, the total cargo volume up and down the Huzhou-Ganzhou section of the Ganyue Canal, will exceed 100 million tons, the cross ridge section will be around 2,000 tons and the Shaoguan Sanshui section will exceed 4000 and 6,000 tons respectively.

Among them, the Ganzhou to Hukou coal cargo volume is comparatively large as it almost accounts for 30% of the total transportation volume. Next come metal ores, whose cargo is expected to reach 1370 tons. Hukou till Ganzhou section, the mining and building material cargo volume from Hukou to Ganzhou will reach 3190 tons. Without exception, by 2050, the cargo volume on the three sections of the canal will all have increased and the proportion of each freight volume will basically remain the same. In the Ganzhou to Hukou section, the freight volume for steel products has been cut down compared to that 2015 figures. In the Yueling section, every type of commodity transportation has increased.

The construction of the Ganyue Canal enables efficient transportation of a large number of goods as well as long distance freight transport and water transport transfers. After the Ganyue Canal is completed, the Yangtze River, the Pearl River waterways will have an extra connection and the shipping route will be shortened. In Guangdong, Guangxi and in surrounding provinces, bulk cargo transport includes coal, minerals, building materials, cement etc. It highlights the superiority of a low cost and increased cargo volume thus shifting from road and railway transportation to waterway transportation. Consequently, the road and rail transport options will decrease as the water transportation option will increase, making the use of inland water transport a more obvious choice in order to optimise transportation.

When the Ganyue Canal opens up to navigation, it will reinforce the high efficiency of domestic circulation of goods, coal, iron and steel, minerals, agricultural products, cereal storage and logistics, industries that will clearly benefit from it. Related industries linked upstream and downstream and with horizontal connections will also indirectly benefit from the canal. Simultaneously, it will further promote connection between the mainland and the Pearl River Delta region, increase exportation and importation efficiency, and bring about a new two-fold cycle pattern in which domestic and international water circulation are promoting each other. Under the background of pushing forward high-quality development of the Yangtze River Economic Belt, the canal will further the leverage of the Yangtze River Economic Belt to cover a large area, with integrated strength for the industry. The canal will connect the Yangtze River Economic Belt with the Pearl River river system and with the YueGangAoDawanQu (Guangdong-HongKong-Macao Greater Bay Area). Those links will extend the scope of the Yangtze River Economic Belt and the industries will benefit. Southern Jiangxi and northern Guangdong will be able to efficiently accept industrial transfer from coastal areas, bringing into play their own resource advantages. Continuously improving the level of natural resource use, the employment and industrialisation level, thereby promoting the region and the development of an export-oriented economy.

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