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Intercity Rail Transit and Integrated Development of the Pearl River Delta Urban Cluster: Based on the Perspective of Network Analysis

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Intercity rail transit is an important power promoting the integrated development of urban clusters. This paper adopts a social network analysis to analyze the impact of the intercity rail development on the integration of the Pearl River Delta urban cluster in 2010, 2012, and 2020, respectively. The results show that the development of intercity rail transit is generally conducive to enhancing the network development trend of the Pearl River Delta urban cluster, strengthening the inter links and promoting the division of labor within the urban cluster, reinforcing the status of the center cities, thus promoting the integrated development of the Pearl River Delta urban cluster. However, the development of intercity rail transit still cannot break the former core–periphery structure, which may aggravate the unbalanced development among cities. Therefore, on the one hand, accelerating the construction of intercity rail transit is an important path to promote the integrated development of the Pearl River Delta urban cluster; on the other hand, it is necessary to optimize the intercity rail network planning, so that the adverse impact could be mitigated.

Keywords: Urban cluster; integrated development; intercity rail transit; network analysis; the Pearl River Delta.

1. Introduction

Integrated development is a new trend that is on the rise in the development of urban clusters in China. The rapid development of intercity rail transit is one of the key driving forces for that. As Oskar Fröidh said, inter-regional transportation system is the material carrier of integrated regional development (Fröidh, 2005). Transportation integration is an important guarantee for the economic integration of urban cluster (Qin *et al.*, 2005; Batten, 1995). Currently, intercity rail transit is becoming a revolutionary factor in changing the transport relations system within Chinese urban cluster, which will have a long-term impact on the overall situation of the integrated development of urban cluster. It is of particular note that the network characteristics reflected in the rail transit development within urban cluster plays a special role in the process of the integrated development of urban cluster. According to Metcalfe's Law, variations in the number and quality of the

transport nodes may lead to exponential change of the network's value. Therefore, it is necessary to apply network analysis to the study of the role transportation networks play in the integrated development of urban cluster.

In this context, some researchers started to study the impact that the development of intercity rail transit made on urban cluster. Through studying the structural features of the transportation network in American urban cluster, Levinson found that there is a positive correlation between the scale and status of the transportation network in urban cluster, and that the construction of transportation networks has a significant influence on the connection and communication of the cities within the urban cluster (Levinson, 2012). Stanev adopted the method of GIS to research the influence that transportation network development posed on urban cluster in the Balkans during the period between 1987 and 2000. The results suggested that transportation networks promote the concentration and expansion of urban cluster, playing a crucial role in its development (Stanev, 2013). Liu *et al.* studied the network structure of the Beijing–Tianjin–Hebei urban cluster using the indicator of transportation accessibility to compare the location of each city within the cluster. The results showed that the improvement of the traffic condition brought closer economic relations between the cities and the transformation of the urban cluster's spatial structure from "polycentric" to "banded" (Liu *et al.*, 2013). Liu *et al.* studied the spatial relation and the network pattern of the Central Plains Economic Zone by analyzing the data of intercity passenger volume, and figured out the degree centrality and betweenness centrality of the cities based on the data of highway and railway, respectively. The results indicated that the city of Zhengzhou and Luoyang occupied the central location in the network of spatial relation, and had a close connection with cities around. Among them, Zhengzhou and Kaifeng presented the development features of "urban integration" (Liu *et al.*, 2014). Based on the researches mentioned above, the reasons why intercity transit development influences the integrated development of urban cluster could be summarized. On the one hand, intercity transportation development strengthens the economic relations between cities, which can further enhance mutual cooperation and reliance; on the other hand, intercity transportation development improves the mobility of labor force between cities, reflected as the increase of the intercity passenger volume, which has a positive effect on the urban integration of employment, commuting, and industrial layout within the urban cluster.

With the development of intercity rail transit, the transportation network in Pearl River Delta is improving gradually. In 2009, Guangdong Province introduced the "Pearl River Delta Infrastructure Integration Program (2009–2020)", making the construction of rail transit network a priority in the transportation infrastructure integration. A research in 2005 pointed out that the intercity rail transit, in terms of space, basically overlaps with the industrial corridor in Pearl River Delta, which can strengthen the effect of the primary traffic corridor, reinforce the radiation effect of the central city and promote spatial integration (Cao and Liu, 2005). However, their study did not conduct a comprehensive and systematic investigation on the influence of intercity rail transit made on the integrated development of urban cluster in the Pearl River Delta. Therefore, this paper believes that since the urban cluster in the Pearl River Delta is in the period of rapid and large-scale rail

transit construction, there is a need for a comprehensive analysis on the impact that the construction and planning of intercity rail transit may have on the integrated development of urban cluster in the Pearl River Delta, so as to provide a scientific basis to make the intercity rail transit work as an contributing factor for the integration of urban cluster and anticipate the potential problems. Meanwhile, it can also provide references for making and improving the intercity rail transit planning in other urban cluster to meet the requirements of the integrated development.

2. Methodologies and Concerned Explanations

2.1. *Methodologies*

Based on the modified gravity model, this paper firstly calculates the economic relations between cities within the urban cluster in the Pearl River Delta under the influence of intercity rail transit. Then, the method of social network analysis is adopted to figure out how the intercity rail transit affects the integrated development of urban cluster in Pearl River Delta.

2.1.1. *The modified gravity model*

The internal mechanism of the formation and development of urban cluster is the continuous strengthening of the spatial economic relations between cities (Wang *et al.*, 2012). Strong economic relation between cities is an important symbol of integrated development of urban cluster. Since the economic relations are the reflection of the mutual influence between cities and the spatiality that causes the economic relations which rely on transportation infrastructure. Therefore, the economic relation could be used to describe the integrated development of urban cluster in the Pearl River Delta under the influence of intercity rail transit. The gravity model is a common method in terms of analyzing urban economic relations (Meng and Zhao, 2011), and the formula is as follows:

$$R_{ij} = \frac{\sqrt{P_i G_i}\sqrt{P_j G_j}}{D_{ij}^2}. \tag{2.1}$$

In this formula, R_{ij} is the strength of economic relations between city i and city j, P_i and P_j are the size of the population in city i and city j, G_i and G_j stand for the economy scale respectively of city i and city j, and D_{ij} means the spatial distance between city i and city j.

In view of the research needs, the gravity model in this paper has been modified in the following three aspects.

The modification of k. Since the economic relations between cities are unidirectional, in the case of equal economic size, population and distance, the gravitational contribution between the two cities are different (Wang *et al.*, 2006); therefore, it is necessary to introduce some parameters to modify the gravity model in order to distinguish the difference. Considering that this difference is closely related to the economic structure of the urban cluster, this paper draws on the research by Hou to introduce the parameter k that represents economic structure and modify the gravity model (Hou *et al.*, 2009).

Table 1. The meaning of the variations in the gravity model.

Variation	Meaning
R_{ij}	The economic relation between city i and city j
k_{ij}	The contribution rate of city i to R_{ij}
P_i, P_j	The permanent population of city i and city j
G_i, G_j	The GDP of city i and city j
D_{ij}	The shortest travel time between city i and city j

Here, we have,

$$k_{ij} = \frac{G_i}{G_i + G_j}. \tag{2.2}$$

The modification of the variable of population P. Considering the population mobility among the cities in the Pearl River Delta, this paper uses the permanent population instead of registered population as the indicator of urban population.

The definition of the variable of distance D. As time is becoming increasingly important to the economic relations between cities, spatial distances can no longer reflect the gravitational relationship between the cities; meanwhile, since the main effect rail transit has on the economic relations of the urban cluster is the shortening of travel time, therefore, time distance instead of spatial distance is used in this paper.

After the modifications mentioned above, the formula of the gravity model used in this paper is:

$$R_{ij} = k_{ij} \frac{\sqrt{P_i G_i}\sqrt{P_j G_j}}{D_{ij}^2}. \tag{2.3}$$

The meaning of the variations in the models is shown in Table 1.

2.1.2. *Social network analysis*

Social network analysis is a new method in social science research, which mainly reveals the structure and properties of the relationship between different social units. In recent years, the method of social network analysis is gaining more and more attention in the research field of network structure and integrated development of urban cluster (Liu *et al.*, 2013, 2014; Hou *et al.*, 2009; Li, 2011). Social network analysis can clearly describe the complex relationships between various cities within the cluster, so as to further reveal the process of integrated development of urban cluster. In light of the intercity rail transit network, this paper adopts the method of social network analysis to come up with the structural features and its change of the economic relations between cities within the urban cluster in the Pearl River Delta, and finds out the trends, characteristics, and existing problems of the integrated development of urban cluster in the Pearl River Delta.

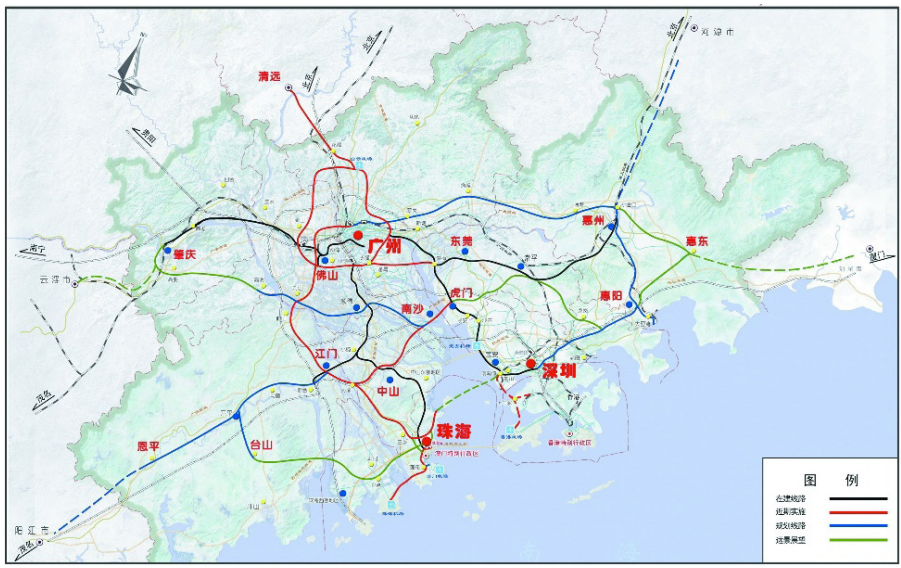
2.2. *Construction program of intercity rail transit of urban cluster in the Pearl River Delta*

"Pearl River Delta Infrastructure Integration Program (2009–2020)" put forward the construction scheme of intercity rail transit network as shown in Fig. 1. According to the scheme, the intercity rail transit network in the urban cluster in the Pearl River Delta will be "three rings and eight radical lines".

Overall, the intercity rail transit in the Pearl River Delta is centered on Guangzhou and regards Guangzhou–Shenzhen Line and Guangzhou–Zhuhai Line as the two principle axis and Xiaolan (in Zhongshan City)–Humen Connecting Lines as the framework, therefore forming the combined network with rings and radical lines. At present, the Guangzhou–Zhuhai intercity light rail, the Beijing–Guangzhou–Shenzhen high speed rail have already been built and running, Shenzhen–Xiamen high speed rail is in its trail running, Guangzhou–Guizhou, Guangzhou–Nanning high-speed railway will open next year, and Guangzhou–Foshan, Foshan–Zhaoqing, Guangzhou–Qingyuan intercity rail is still under construction. By 2020, the operating mileage of the intercity railway in the Pearl River Delta will be about 1,480 km, forming a "one-hour life circle" between the cities.

2.3. *Data source and processing*

Given that the Guangzhou–Zhuhai intercity rail transit (Jiangmen branch line not included) was officially opened on January 4, 2011, and the section between Guangzhou and Shenzhen North of the Guangzhou–Shenzhen–Hong Kong passenger dedicated line was opened on December 26, 2011, this paper selects the year 2010 and 2012 as a time point to



Source: According to the "Pearl River Delta Infrastructure Integration Program (2009–2020)".

Fig. 1. The layout diagram of the intercity rail transit in the Pearl River Delta.

compare the integrated development of urban cluster in the Pearl River Delta with and without intercity rail transit. Meanwhile, based on the "Pearl River Delta Infrastructure Integration Program (2009–2020)", this paper chooses the year 2020 as the third time point to study the integrated development of urban cluster in the Pearl River Delta after the completion of the whole intercity rail transit network.

When measuring and calculating the temporal distance in 2010, this paper first measures out the distance between the cities in Pearl River Delta according to *China Traffic Atlas*, then based on the designed speed for highway traffic in *Technical Standard of Highway Engineering in People's Republic of China* (*JTGB*01-2003) and the specific situation in Pearl River Delta, this paper selects speeds of 120 km/h for highways, 80 km/h for national road, 70 km/h for provincial road, and 50 km/h for county road to calculate the temporal distance between cities (Li *et al.*, 2012). The shortest temporal distance in 2012 between cities will be calculated according to the railway schedule. The temporal distance in 2020 is predicted in accordance with "Pearl River Delta Infrastructure Integration Program (2009–2020)" by the mileage of the transportation network and designed speed.

3. Results Analysis

First, the economic relations between nine of the cities in the urban cluster in the Pearl River Delta in year 2010, 2012, and 2020 are figured out.[1] Then, Ucinet 6.216 is used to recognize the network structure and changes of the urban cluster in the Pearl River Delta. On this basis, the network density, centrality, and central potential, cohesive subgroups, structural similarity, along with the core–periphery structure of the urban cluster in the Pearl River Delta is analyzed one by one, thus revealing the processes and characteristics of integrated development of urban cluster in the Pearl River Delta.

3.1. *Intercity rail transit enhances the networking development tendency of the urban cluster in the Pearl River Delta*

After importing the economic relation matrix of the urban cluster in the Pearl River Delta in year 2010, 2012, 2020 into Ucinet 6, the resulting network structure is respectively shown in Figs. 2–4. From these 3 figures, it is can be seen preliminarily that under the influence of intercity rail transit, the networking development tendency of the urban cluster in the Pearl River Delta is increasingly evident. With 2 running intercity rail lines, the economic relations network of urban cluster in the Pearl River Delta in 2012 was significantly more efficient than that in 2010 when there is no intercity rail transit. In 2020, the economic relations network of urban cluster in the Pearl River Delta will become more complex after the construction of the intercity rail transit network is completed. This suggests that the development of intercity rail transit is now and will in the future promote the process of the integrated development of urban cluster in the Pearl River Delta.

[1]See tables in Appendices A–C.

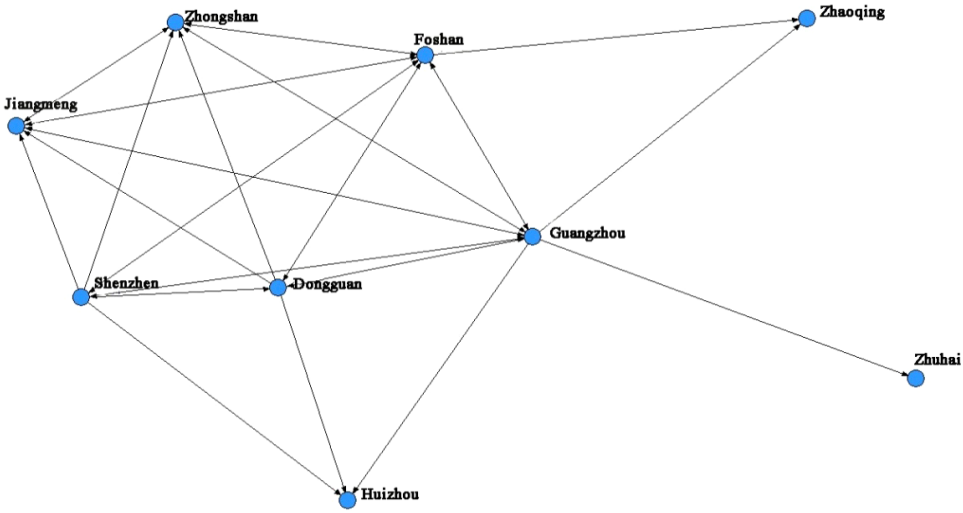


Fig. 2. The economic network of urban cluster in the Pearl River Delta in 2010.

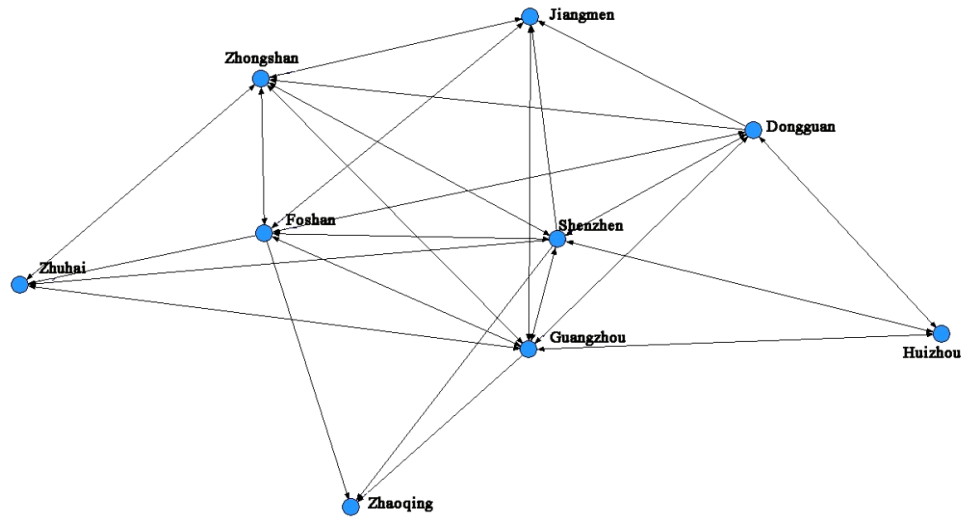


Fig. 3. The economic network of urban cluster in the Pearl River Delta in 2012.

3.2. *Intercity rail transit strengthens the internal relations within the urban cluster in the Pearl River Delta*

As for directed network with multiple values, the calculation of network density is more complicated. The arithmetic of network density is to use the number of links in theory to divide the actual number of links in the network. In this paper, the weighted total of the links that exist theoretically is defined as eight times of the maximum value of economic

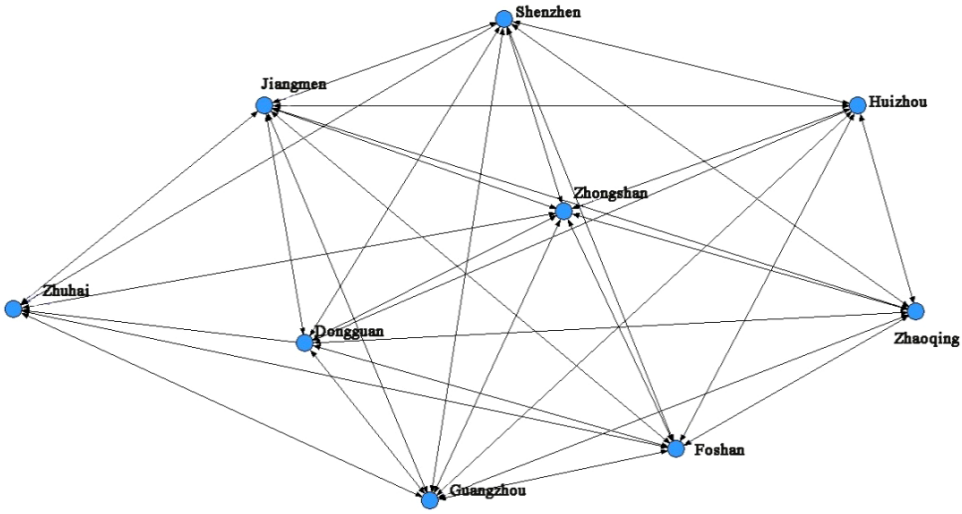


Fig. 4. The economic network of urban cluster in the Pearl River Delta in 2020.

Table 2. Density of the economic network of the urban cluster in the Pearl River Delta.

Time (year)	2010	2012	2020
Network density	0.4444	0.5833	0.9167

relation intensity, and the actual weight is the total of the weighted sum of all relations, whose results are shown in Table 2.

Network density suggests the degree of closeness between the nodes in a network (Liu, 2004). The closeness between cities within the urban cluster is proportional to the network density. After the opening of Beijing–Guangzhou–Shenzhen high-speed rail and Guangzhou–Zhuhai light rail, the network density of economic relation of the urban cluster in the Pearl River Delta increased from 0.4444 in 2010 to 0.5833 in 2012, with a growth rate of around 31.3%. In 2020, when the intercity rail network is completed, the network density of economic relations of the urban cluster in the Pearl River Delta will be 0.9167, which is raised by 106.3%. It can be seen that with the opening of intercity rail transit, the internal relations within Pearl River Delta will be enhanced significantly. In 2020 when the intercity rail transit network is completed, the internal relations of cities within the urban cluster in the Pearl River Delta will be extremely close.

3.3. *Intercity rail transit readjusts the internal relations pattern of the urban cluster in the Pearl River Delta*

Here, network centrality analysis is used to examine the influence intercity rail transit development has on the internal relations pattern of the urban cluster in the Pearl River

Delta. First, this paper analyzes the changes of pattern due to economic spread among cities in the Pearl River Delta according to the point centrality. Second, it also observes the change of the overall diffusion pattern of urban cluster in the Pearl River Delta according to the center potential.

In urban cluster, the status and influence of a city is proportional to its point centrality. The city with greater point centrality plays a central role in the urban cluster, therefore becomes the core city. Since the economic network of the urban cluster in the Pearl River Delta is directed, this paper separately analyzes the in-degree and out-degree of the various cities at different points of time. As for the meaning of the two types of point centrality (Luo, 2005), the former one refers to a city's influence on other cities, while the latter, the extent that a city is influenced by other cities.

It can be seen from Table 3 that under the influence of intercity rail transit, there has been a few changes in the economic relations between cities within the urban cluster in the Pearl River Delta. Firstly, the point centrality of the city is increasing, which indicates that the mutual impact between cities is stronger. Secondly, in terms of the out-degree, Guangzhou, Foshan, Shenzhen, and Dongguan rank the top 4, which suggests that they have a significant spread effect. In addition, from the perspective of in-degree, these four cities also rank the top 4, with differences in their respective precedence. By 2020, upon the completion of the intercity rail network, Guangzhou, Foshan, Shenzhen, and Dongguan will take the first to the fourth place in sequence in terms of the out-degree, while the Foshan is of the greatest in-degree, followed by Dongguan, Guangzhou, and Shenzhen in sequence. Among them, Shenzhen, Guangzhou, and Foshan present a greater out-degree than in-degree, which suggests that their spread effect to other cities is obvious. Dongguan, by contrast, shows that the impact it receives from other cities will be greater than its own spread effect. Meanwhile, it is also noted that the reason that Foshan and Dongguan are of a greater point centrality is that they have Guangzhou and Shenzhen as their immediate neighbors. Thirdly, Zhongshan, Jiangmen, Huizhou, Zhaoqing, and Zhuhai all possess less point centrality, especially the in-degree is greater than the out-degree, which illustrates that the spread effect of those cities to others is less than that of other cities. Lastly, Zhuhai has the minimum point centrality, showing that under the influence of intercity rail transit, Zhuhai is hardly becoming the core of the urban cluster in the Pearl River Delta.

As is shown in Table 4, the out-degree centralization in the Pearl River Delta is on the rise, indicating the expansion of the overall spatial extent of economic relations between the cities, which is good for the overlapping and crossing of the market area between cities, along with promoting interdependence. In addition, though there is rise in the in-degree centralization in the Pearl River Delta, the rise is significantly less than that of the out-degree. The gap between the two expanded from 5% in 2012 to about 13% in 2020. This suggests that the internal relation of the urban cluster in the Pearl River Delta is unbalanced. The distinction of point centrality in Table 3 also proves the point. Among the nine cities located in the urban cluster in the Pearl River Delta, there is an evident gap between Guangzhou, Foshan, Shenzhen, Dongguan, and the remaining five cities.

Table 3. The changes of point centrality of economic network of the urban cluster in the Pearl River Delta.

	In-degree						Out-degree					
Rank	2010		2012		2020		2010		2012		2020	
1	Guangzhou	150	Guangzhou	596	Guangzhou	1,637	Foshan	99	Guangzhou	465	Foshan	1,094
2	Foshan	69	Shenzhen	330	Foshan	1,127	Guangzhou	72	Foshan	336	Dongguan	938
3	Shenzhen	53	Foshan	189	Shenzhen	754	Dongguan	44	Zhongshan	129	Guangzhou	762
4	Dongguan	29	Dongguan	53	Dongguan	499	Shenzhen	33	Dongguan	115	Shenzhen	518
5	Zhongshan	9	Zhongshan	33	Zhongshan	221	Jiangmen	26	Jiangmen	72	Zhongshan	486
6	Jiangmen	7	Jiangmen	15	Jiangmen	84	Zhongshan	22	Shenzhen	48	Jiangmen	281
7	Zhuhai	0	Huizhou	8	Huizhou	70	Huizhou	14	Huizhou	28	Zhaoqing	179
8	Zhaoqing	0	Zhuhai	5	Zhaoqing	44	Zhaoqing	5	Zhuhai	22	Huizhou	146
9	Huizhou	0	Zhaoqing	0	Zhuhai	9	Zhuhai	2	Zhaoqing	14	Zhuhai	41

Table 4. The changes of the centralization of economic network of the urban cluster in the Pearl River Delta.

Time (year)	2010	2012	2020
Out-degree centralization (%)	18.77	21.05	26.97
In-degree centralization (%)	10.49	15.05	14.16

3.4. *The intercity rail transit is beneficial for promoting the division in the urban cluster in the Pearl River Delta*

The division of the cities is an important basis for interdependence. There is an interactive relationship between the division and integration. Division facilitates integrated development, and integrated development, in turn, inevitably brings about spatial shift of industries and making the regional structure differences more obvious (Fan, 2004), thus further promotes the division. Therefore, this paper analyzes the structural similarity of the economic network of cities within the urban cluster in the Pearl River Delta to assess the influence intercity rail transit has on the division. Using the method of exact matching in Ucinet 6, the structural similarity between the cities in the economic network can be calculated. As is shown in Table 5, in 2010 there were 13 pairs of cities that have the structural similarity between 50% and 60%, only one pair (Zhongshan–Jiangmen) fell into the 70–80% category, and two pairs (Zhuhai–Zhaoqing and Zhuhai–Huizhou) greater than 80%. Among them, the similarity of Zhuhai and Zhaoqing is even as high as 89%. In 2012, under the influence of the opening of two intercity railways, similarity between the cities had dropped significantly. Cities of structural similarity between 50% and 60% reduced to four pairs, Zhuhai and Zhaoqing are still of the highest structural similarity, however, only 72%. In 2020, after the intercity rail transit network is completed, the structural similarity

Table 5. The structural similarity of the economic network of cities within the urban cluster in the Pearl River Delta (Unit: %).

Time (year)	Structural similarity (x)			
	>80	$80 > x > 70$	$70 > x > 60$	$60 > x > 50$
2010	Zhuhai–Zhaoqing, Zhuhai–Huizhou	Zhongshan–Jiangmen	—	Shenzhen–Zhuhai, Shenzhen–Dongguan, Shenzhen–Zhaoqing, Zhuhai–Shenzhen, Zhuhai–Dongguan, Zhuhai–Jiangmen, Zhuhai–Zhongshan, Dongguan–Jiangmen, Zhaoqing–Jiangmen, Zhaoqing–Zhongshan, Jiangmen–Zhongshan, Jiangmen–Huizhou, Zhongshan–Huizhou
2012	—	Zhuhai–Zhaoqing	—	Zhuhai–Jiangmen, Zhuhai–Huizhou, Zhaoqing–Jiangmen, Zhaoqing–Huizhou
2020	—	—	—	—

Note: The cities that of similarity less than 50% are not of obvious similarity, therefore, are not included in the research.

Table 6. The core–periphery structure of the urban cluster in the Pearl River Delta.

Time (year)	Core	Semi-periphery	Periphery
2010	Guangzhou, Foshan, Shenzhen	Dongguan, Jiangmen, Zhongshan	Zhuhai, Huizhou, Zhaoqing
2012	Guangzhou, Foshan, Shenzhen	Dongguan, Jiangmen, Zhongshan	Zhuhai, Huizhou, Zhaoqing
2020	Guangzhou, Foshan, Shenzhen	Dongguan, Jiangmen, Zhongshan	Zhuhai, Huizhou, Zhaoqing

between the cities of the urban cluster in the Pearl River Delta will decline significantly, the structural similarity of the cities will be less than 34%. It is obvious that the intercity rail transit plays an important role in promoting the division of cities within the urban cluster in the Pearl River Delta. The upgraded level of division will definitely strengthen the integrated development of the urban cluster in the Pearl River Delta.

3.5. *Intercity rail transit development will not change the core–periphery structure of the urban cluster in the Pearl River Delta*

At present, the economic pattern of the urban cluster in the Pearl River Delta takes on a core–periphery structure. So, will the development of intercity rail transit change this structure? A fitting test of the core–periphery model is conducted on the data of the economic relations of cities within the urban cluster in the Pearl River Delta in 2010, 2012, and 2020. The results show that correlation coefficient of the data matrix and pattern matrix is large. The correlation coefficient is 0.968 in 2010, 0.997 in 2012, and 0.947 in 2020, the degree of fitting between the two appears to be high. This suggests that the development of intercity rail transit does not change the core–periphery structure of the urban cluster in the Pearl River Delta.

As is illustrated in Table 6, Guangzhou, Foshan, and Shenzhen have always been the core of the economic network in the Pearl River Delta, Dongguan, Jiangmen, and Zhongshan are in "intermediate" zone, while Zhuhai, Huizhou, and Zhaoqing belong to the peripheral zone. It can be seen that this structure tends to be a hindrance to the construction of the Guangzhou–Foshan–Zhaoqing economic circle, Shenzhen–Dongguan–Huizhou economic circle and the Zhuhai–Zhongshan–Jiangmen economic circle in Guangdong.

4. Conclusion and Enlightenment

To sum up, this paper comes to the following conclusions. First of all, the development of intercity rail transit network is beneficial to the networking development tendency of the urban cluster in the Pearl River Delta. Under the influence of the development of intercity rail transit, the complexity of the economic networks of the urban cluster in the Pearl River Delta is becoming increasingly evident. Second, intercity rail transit strengthens the internal relations of the urban cluster in the Pearl River Delta, and triggers changes of the relation pattern between different cities. While interaction and dependence among the cities

is growing stronger, the central position of Guangzhou, Foshan, Shenzhen, and Dongguan is enhanced, which leads to a greater gap between other cities. What is worth noticing is that the development of intercity rail transit strongly limits the potential of Zhuhai in becoming a core city. Third, the intercity rail transit plays a significant role in promoting the division of cities within the urban cluster in the Pearl River Delta, thus, the cities will be of low structural similarity. A higher level of the division will lead to the interdependence between cities. Lastly, the development of intercity rail transit does not change the core–periphery structure of the urban cluster in the Pearl River Delta. Generally speaking, Foshan, Guangzhou, and Shenzhen are the core of the urban cluster in the Pearl River Delta, with Dongguan, Jiangmen, and Zhongshan in the "intermediate" zone, while Zhuhai, Huizhou, and Zhaoqing belong to peripheral areas.

Based on the conclusions above, this paper believes that generally the development of intercity rail transit is conducive to the integrated development of the urban cluster in the Pearl River Delta and is gradually becoming an important force. Therefore, Guangdong needs to speed up the construction of intercity rail transit in the Pearl River Delta to promote the integrated development. It is to be noted that, this paper provides some valuable enlightenment that are different from the common awareness. First of all, when emphasizing on central cities like Guangzhou and Shenzhen, Dongguan and Foshan should also receive active support, and their potential and conditions of becoming central cities is to be effectively exploited. An appropriate approach is to continue promoting the urban integration of Guangzhou and Foshan, and the integrated development of Shenzhen, Guangzhou, and Dongguan. Second, under the influence of the existing intercity rail transit planning, it is very difficult for Zhuhai to become the core city. The Hong Kong–Zhuhai–Macao Bridge will help to alleviate this constraint. However, the design of the Hong Kong–Zhuhai–Macao Bridge does not take rail transit into account in the beginning, which is a massive regret. Third, the core–periphery structure of the urban cluster in the Pearl River Delta will not be impaired by the intercity rail transit, with Guangzhou, Foshan, and Shenzhen as the core, Dongguan, Jiangmen, and Zhongshan as the "intermediate" zone, and Zhuhai, Huizhou, and Zhaoqing as the peripheral area. This will hinder the construction of the Guangzhou–Foshan–Zhaoqing economic circle, Shenzhen–Dongguan–Huizhou economic circle and the Zhuhai–Zhongshan–Jiangmen economic circle in Guangdong province. Therefore, during the integrated development of urban cluster in the Pearl River Delta, whether the adoption of the policy that regards these three economic circles as priority appropriately needs further scientific proof.

In addition, in terms of method, this paper shows that using social network analysis to study the influence of intercity rail transit on the integrated development of urban cluster can obtain conclusions beyond the existing knowledge or experience.

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Appendix A. The Economic Relations between Cities within the Urban Cluster in the Pearl River Delta in 2010

	Guangzhou	Shenzhen	Zhuhai	Foshan	Dongguan	Zhaoqing	Jiangmen	Zhongshan	Huizhou
Guangzhou	0.00	19.37	1.56	85.87	17.69	2.63	9.56	9.21	2.64
Shenzhen	17.39	0.00	0.52	6.25	21.98	0.73	1.57	1.75	3.66
Zhuhai	0.18	0.07	0.00	0.20	0.08	0.05	0.30	0.64	0.04
Foshan	45.30	3.67	0.92	0.00	3.65	1.55	8.22	6.15	0.85
Dongguan	7.29	10.09	0.29	2.85	0.00	0.48	1.04	1.36	6.78
Zhaoqing	0.25	0.08	0.04	0.28	0.11	0.00	0.14	0.10	0.06
Jiangmen	1.40	0.26	0.39	2.29	0.37	0.21	0.00	3.99	0.07
Zhongshan	1.58	0.33	0.96	2.00	0.10	0.19	4.66	0.00	0.08
Huizhou	0.41	0.63	0.06	0.25	0.53	0.09	0.08	0.08	0.00

Appendix B. The Economic Relations between Cities within the Urban Cluster in the Pearl River Delta in 2012

	Guangzhou	Shenzhen	Zhuhai	Foshan	Dongguan	Zhaoqing	Jiangmen	Zhongshan	Huizhou
Guangzhou	0.00	269.24	15.11	307.10	74.26	8.57	45.92	105.94	11.89
Shenzhen	257.30	0.00	2.09	19.13	30.79	1.57	5.30	8.11	6.00
Zhuhai	1.68	0.24	0.00	0.29	0.20	0.08	0.71	2.61	0.08
Foshan	152.04	9.91	1.28	0.00	4.83	3.07	12.98	5.06	0.64
Dongguan	27.46	8.10	0.66	3.61	0.00	0.61	1.51	1.98	9.57
Zhaoqing	0.92	0.18	0.07	0.67	0.18	0.00	0.29	0.17	0.09
Jiangmen	6.47	0.78	0.90	3.69	0.58	0.38	0.00	4.55	0.22
Zhongshan	19.08	1.53	4.24	1.84	0.96	0.29	5.81	0.00	0.34
Huizhou	2.08	1.10	0.13	0.43	4.52	0.12	0.22	0.33	0.00

Appendix C. The Economic Relations between Cities within the Urban Cluster in the Pearl River Delta in 2020

	Guangzhou	Shenzhen	Zhuhai	Foshan	Dongguan	Zhaoqing	Jiangmen	Zhongshan	Huizhou
Guangzhou	0.00	411.72	13.20	596.16	331.05	63.43	72.24	106.64	43.09
Shenzhen	379.44	0.00	5.49	84.76	163.09	20.64	18.84	51.58	29.75
Zhuhai	1.13	0.51	0.00	1.26	1.00	0.57	1.67	5.47	0.42
Foshan	249.44	38.48	6.15	0.00	366.67	59.22	125.98	255.55	25.52
Dongguan	88.43	47.27	3.11	234.08	0.00	18.50	29.88	41.64	36.75
Zhaoqing	7.06	2.49	0.74	15.74	7.70	0.00	4.76	5.42	1.95
Jiangmen	8.54	2.42	2.30	35.60	13.23	5.06	0.00	13.69	2.74
Zhongshan	19.92	10.45	11.91	114.07	29.11	9.09	21.62	0.00	4.83
Huizhou	8.75	6.56	0.99	12.39	27.95	3.57	4.70	5.26	0.00

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