

# Study on the Measurement of Regional Economic Connection in the Pearl River Delta

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**Abstract**—The process of regional economic development is a process in which regional economic connections are continuously strengthened. This paper uses gravity model to measure the economic connection strength and total strength of cities in the Pearl River Delta from 2000 to 2017, and then calculates the economic connection strength within the region, and analyzes the historical trajectory of economic connections in the Pearl River Delta. The results show that the total strength of economic connections between the cities in the Pearl River Delta keeps going up, forming the Guangzhou-Foshan-Shenzhen area with the strongest total strength of connections, Dongguan-Zhongshan-Jiangmen area with strong total strength and Huizhou-Zhuhai-Zhaoqing area with weak total strength. The economic connection difference between the east and west sides of the Pearl River Estuary have been gradually widened, and the situation of strong east and weak west is constantly strengthened.

**Keywords:** *Pearl River Delta, economic connection strength, total strength of economic connection*

## I. INTRODUCTION

The Pearl River Delta includes the nine cities at the mouth of the Pearl River such as Guangzhou, Shenzhen, Zhuhai, Foshan, Dongguan, Zhongshan, Jiangmen, Huizhou, and Zhaoqing. It is one of the most powerful and active regions in Guangdong and even China. The GDP of the Pearl River Delta in 2017 was 7571.014 billion Yuan, accounting for 80.1% of that of Guangdong Province. However, the internal economic development of the Pearl River Delta region is extremely unbalanced. In 2017, the GDPs of Shenzhen and Guangzhou ranked top two in the Pearl River Delta and were respectively 2249.006 billion Yuan (29.7%) and 2150.315 billion Yuan (28.4%), and totally accounting for almost 60% of the GDP in Pearl River Delta. The GDP of Zhaoqing ranked last and was only 211.001 billion Yuan, accounting for only 2.7% of the GDP in Pearl River Delta. The process of regional economic development is a process of constant strengthening of regional economic connection. The higher the level of regional economic connection is, the more it can promote the rapid, stable, and sustainable development of the overall regional economy.

Economic connection refers to the mutual connection between regions, within regions, between cities and towns, between rural areas, and between urban and rural areas in exchange of raw materials, materials, industrial and

agricultural products, and in technology and economy. [1] The measures include accessibility, economic influence scope, economic connection strength, the degree of economic membership, and so on. The measurement models mainly include gravity model, central function intensity model, and potential model. Many scholars in academia have used various methods to measure and study the regional economic connections in the economic zone on the west side of the Straits, the Beijing-Tianjin-Hebei urban agglomeration, the Yangtze River Delta, and the Pearl River Delta [2] [3] [4] [5] [6] [7]. Regarding the study of regional economic connection in the Pearl River Delta, Zhu Lie believed that the cities in this region had strong economic connection and significant economic spillover effects [8]. Gao Qiaofeng believes that Guangzhou as the center city of the Pearl River Delta has not enough economic connection with other cities in the region and its economic radiation to other cities needs to be strengthened [9]. Li Guoping thinks that compared with Guangzhou, the economic connection strengths between Shenzhen and other cities in the region are weaker [10]. Cai Lili analyzed and found that the density of the regional economic connection network of the Pearl River Delta was increased year by year, and the regional economic development tended to be integrated. [11]

## II. RESEARCH METHOD AND DATA SOURCES

### A. Research method

The theory of gravity model is derived from the law of universal gravitation and is one of the three models for measuring the strength of regional economic connection. The calculation basis is that the strength of regional economic connection is directly proportional to the socioeconomic scale between the two regions and inversely proportional to the square of the distance.

Economic connection strength is used for measuring a city's economic radiation capacity and its ability to receive radiation. The calculation formula is:

$$C_{ij} = \frac{\sqrt{G_i P_i \times G_j P_j}}{D_{ij}^2} \quad (i, j=1, 2, \dots) \quad (1)$$

Wherein,  $C_{ij}$  is the strength of the economic connection between two cities;  $P_i$  and  $P_j$  represent the numbers of permanent residents in the two cities at the end of the year;  $G_i$  and  $G_j$  are the regional GDPs of the two cities;  $D_{ij}$  is the distance between the two cities.

The total strength of economic connection of a city is the sum of the economic connection strengths of the cities. It comprehensively reflects the role of the city's foreign economic connection. The calculation formula is:

$$C_j = \sum_{i=1}^n E_{ij} \quad (i,j=1,2,\dots) \quad (2)$$

This indicates that the greater the total strength is, the higher the degree of regional economic connection is.

**B. Data sources**

In this paper, 2000-2017 is taken as the period for research; the nine cities in the Pearl River Delta are taken as the research objects. The purpose is to measure the economic connection strength and total strength and reveal the evolutionary trends and characteristics of the regional economic connections in the Pearl River Delta. The data source of the resident population and regional GDP at the end of each year is from the "Guangdong Statistical Yearbook" (2001-2018), and the distance between cities is obtained from Baidu maps.

**III. EMPIRICAL ANALYSIS**

**A. Measurement of economic connections between cities in the Pearl River Delta**

According to formula 1, the author calculated and obtained the economic connection strength of each city from 2000 to 2017, and drew the economic connection strength measurement table for 2000, 2009, and 2017 ("Table I"). As can be seen from "Table I", the top three pairs of cities with mutual attraction among the nine cities in the Pearl River Delta in the three years are always Guangzhou-Foshan (7.11, 36.45, 91.24), Guangzhou-Dongguan (4.34, 21.73, 53.24), and Shenzhen-Dongguan (2.36, 13.19, 35.01), the last three pairs of cities are always Zhuhai-Huizhou (0.05, 0.20, 0.58), Zhuhai-Zhaoqing (0.03, 0.11, 0.31) and Huizhou-Zhaoqing (0.03, 0.11, 0.32). Benefiting from the close spatial distance and the core positioning on the two-city development, Guangzhou and Foshan have a high frequency of material, personnel, information and the like resources exchange, showing significant inward absorption and undertaking functions, and the economic gravity between the two places has always been at the top of the list. Guangzhou, Foshan, Shenzhen, and Dongguan are the major economic growth poles of the Pearl River Delta. They have strong economic interactions and large economic connections. However, the economic connections between Zhuhai, Huizhou and Zhaoqing are always lower than 1, and the exchange of materials, personnel, and information between the three cities is lacking.

TABLE I. MEASUREMENT OF ECONOMIC CONNECTIONS BETWEEN CITIES IN THE PEARL RIVER DELTA IN 2000, 2009, AND 2017

Region / Year	2000	2009	2017	Region / Year	2000	2009	2017	Region / Year	2000	2009	2017
Guangzhou-Shenzhen	1.79	8.85	27.25	Shenzhen-Zhongshan	0.76	4.25	11.98	Foshan-Jiangmen	1.37	5.74	12.21
Guangzhou-Zhuhai	0.31	1.31	3.78	Shenzhen-Jiangmen	0.55	2.21	5.84	Foshan-Zhaoqing	0.48	2.32	5.52
Guangzhou-Foshan	7.11	36.45	90.24	Shenzhen-Zhaoqing	0.12	0.56	1.66	Huizhou-Dongguan	0.58	2.89	7.22
Guangzhou-Huizhou	0.43	1.88	5.45	Zhuhai-Foshan	0.17	0.80	2.01	Huizhou-Zhongshan	0.07	0.35	0.93
Guangzhou-Dongguan	4.34	21.73	53.24	Zhuhai-Huizhou	0.05	0.20	0.58	Huizhou-Jiangmen	0.07	0.27	0.67
Guangzhou-Zhongshan	0.93	4.72	12.26	Zhuhai-Dongguan	0.20	0.96	2.37	Huizhou-Zhaoqing	0.03	0.11	0.32
Guangzhou-Jiangmen	1.71	6.17	15.06	Zhuhai-Zhongshan	0.52	2.49	6.55	Dongguan-Zhongshan	0.46	2.64	5.91
Guangzhou-Zhaoqing	0.68	2.83	7.70	Zhuhai-Jiangmen	0.24	0.82	2.02	Dongguan-Jiangmen	0.45	1.84	3.87
Shenzhen-Zhuhai	0.75	3.48	10.86	Zhuhai-Zhaoqing	0.03	0.11	0.31	Dongguan-Zhaoqing	0.12	0.58	1.35
Shenzhen-Foshan	0.77	4.41	11.83	Foshan-Huizhou	0.16	0.82	2.06	Zhongshan-Jiangmen	1.20	4.93	10.99
Shenzhen-Huizhou	0.87	4.28	13.43	Foshan-Dongguan	1.31	7.62	16.25	Zhongshan-Zhaoqing	0.07	0.32	0.79
Shenzhen-Dongguan	2.36	13.19	35.01	Foshan-Zhongshan	0.55	3.21	7.26	Jiangmen-Zhaoqing	0.19	0.66	1.54

**B. Analyzing the measurement of the total strength of economic connection between the cities of the Pearl River Delta**

According to formula 2, the total strength of economic connections between the cities in the Pearl River Delta is calculated ("Table II"). As can be seen from "Table II", since 2000, the total strength has kept going up. The top three cities are always Guangzhou, Foshan, and Shenzhen, followed by Dongguan, Zhongshan, and Jiangmen, and finally Huizhou, Zhuhai, and Zhaoqing; they respectively form the extremely strong, strong, and weak areas of the Pearl River Delta in terms of the total economic connection strength.

In extremely strong area, the absolute value of the total strength of economic connection is high and the growth rate is high. It is the core growth pole of the Pearl River Delta and has a significant driving effect on surrounding cities. The overall strength of Guangzhou's economic connection was increased from 17.31 in 2000 to 214.98 in 2017, with an absolute increase of 197.67 and a growth rate of 91.95%. The overall strength of Foshan's economic connection was increased from 11.78 in 2000 to 145.60 in 2017, with an absolute increase of 133.82 and a growth rate of 91.91%. The overall strength of Shenzhen's economic connection was increased from 7.97 in 2000 to 117.85 in 2017, with an absolute increase of 109.88 and a growth rate of 93.24%. However, Guangzhou is far ahead in terms of both the absolute value of the total strength and the growth rate. It can be seen that although Guangzhou, Foshan, and Shenzhen are the major economic growth poles of the Pearl River Delta, have large economic connection strength, and the growth rate of the total strength of Shenzhen's economic connection is slightly higher than that of Guangzhou's, the absolute difference in the strength of the economic connection between Guangzhou and other cities is constantly enlarged. In 2000, the absolute difference in the strength of the economic connection between Guangzhou and Foshan was

5.53, the absolute difference in 2009 was 23.27, and the absolute difference was increased to 69.38 in 2017. This indicates that Guangzhou has maintained its center position in regional politics, culture, basic research and higher education; Foshan and Shenzhen's foreign economic radiation capacities are still weaker than Guangzhou.

In strong area, the absolute value of total strength of economic connection is large and the growth rate is high. The overall strength of Dongguan's economic connection was increased from 7.85 in 2000 to 100.37 in 2017, with an absolute increase of 92.52 and a growth rate of 92.18%. The overall strength of Zhongshan's economic connection was increased from 4.63 in 2000 to 54.69 in 2017, with an absolute increase of 50.06 and a growth rate of 91.53%. The total strength of Jiangmen's economic connection was increased from 4.14 in 2000 to 35.32 in 2017, with an absolute increase of 31.18 and a growth rate of 88.28%. This shows that the three regions receive strong radiation from cities in extremely strong areas and have strong development motive.

In weak area, the absolute value of total strength of economic connection is small and the growth rate is relatively high. The total strength of Huizhou's economic connection was increased from 2.10 in 2000 to 28.50 in 2017, with an absolute increase of 26.4 and a growth rate of 92.63%. The total strength of Zhuhai's economic connection was increased from 2.27 in 2000 to 28.48 in 2017, with an absolute increase of 26.21 and a growth rate of 92.10%. The total strength of Zhaoqing's economic connection was increased from 1.03 in 2000 to 11.90 in 2017, with an absolute increase of only 10.87 and a growth rate of 91.95%. The three cities are far away from the core economic circle of Guangzhou, Foshan, and Shenzhen, affect the structure and deepening of economic connection with them, are thus located in the edge of the Pearl River Delta and have weak capacity to receive economic radiation from extremely strong and strong areas.

TABLE II. TOTAL STRENGTH OF ECONOMIC CONNECTIONS BETWEEN THE CITIES IN THE PEARL RIVER DELTA

Year/Region	Guangzhou	Shenzhen	Zhuhai	Foshan	Dongguan	Jiangmen	Zhongshan	Huizhou	Zhaoqing
2000	17.31	7.97	2.27	11.78	7.85	4.14	4.63	2.10	1.03
2001	20.00	9.33	2.62	13.60	9.31	4.36	5.36	2.43	1.16
2002	22.68	11.09	3.03	15.37	10.93	4.84	6.16	2.81	1.31
2003	26.77	13.55	3.64	18.24	13.19	5.55	7.33	3.31	1.52
2004	32.15	16.53	4.38	22.12	16.08	6.51	8.88	4.02	1.83
2005	38.29	19.99	5.26	27.11	19.20	7.68	10.77	4.81	2.10
2006	47.48	23.41	6.30	33.99	23.50	9.26	13.12	5.75	2.53
2007	59.64	30.63	7.91	42.89	29.83	11.34	16.52	7.33	3.15
2008	73.26	37.00	9.30	52.94	36.43	13.57	19.92	8.89	3.88
2009	83.93	41.22	10.16	60.66	40.42	15.01	22.37	9.96	4.44
2010	103.90	50.56	12.27	74.88	49.05	18.33	27.50	12.52	5.62
2011	119.32	59.30	14.39	84.97	56.29	21.49	32.52	14.95	6.72
2012	129.90	65.93	15.77	91.93	61.13	22.98	36.03	16.82	7.44
2013	145.63	74.03	17.58	101.25	68.38	25.15	39.72	19.08	8.52
2014	157.89	81.35	19.49	109.19	74.07	26.80	42.70	21.07	9.36
2015	173.92	90.89	21.51	119.70	80.76	29.17	46.30	22.83	10.22
2016	192.76	102.82	24.10	131.38	89.68	31.96	50.53	25.35	11.16
2017	214.98	117.85	28.48	145.60	100.37	35.32	54.69	28.50	11.90

C. Analyzing the regional economic connection strength of the Pearl River Delta

According to "Table II", the author calculated the total and average strengths of economic connection between the east and west sides of the Pearl River Estuary as well as the proportion of total strengths of economic connection between the two sides among the Pearl River Delta region ("Table III" "Fig. 1"). The results show that Guangzhou, Shenzhen, Huizhou, and Dongguan on the east side had a large total strength of economic connection, and their total proportion in the Pearl River Delta was always growing, from 59.63% in 2000 to 62.59% in 2017. Zhuhai, Foshan, Jiangmen, Zhaoqing, and Zhongshan on the west side

maintained a weak growth in the total strength of economic connection, but their total proportion in the total Pearl River Delta was constantly declining, from 40.37% in 2000 to 37.41% in 2017. From the perspective of the average connection in the region, the east side was increased from 8.81 in 2000 to 115.42 in 2017, with a growth rate of 92.37%, and the west side was increased from 4.77 in 2000 to 37.41 in 2017, with a growth rate of 87.25%. The growth extent of the east side is obviously larger than that of the west side. Hence it can be seen that the economic connection difference between the east and west sides was gradually widened, and the situation of strong east and weak west was constantly enhanced.

TABLE III. MEASUREMENT AND CALCULATION OF THE STRENGTH OF THE ECONOMIC CONNECTION BETWEEN THE EAST AND WEST SIDES OF THE PEARL RIVER DELTA

	The east side			The west side		
	Total strength of economic connection	Proportion in the Pearl River Delta	Average connection strength in the region	Total strength of economic connection	Proportion in the Pearl River Delta	Average connection strength in the region
2000	35.22	59.63	8.81	23.85	40.37	4.77
2001	41.07	60.24	10.27	27.11	39.76	5.42
2002	47.49	60.74	11.87	30.70	39.26	6.14
2003	56.82	61.03	14.20	36.28	38.97	7.26
2004	68.78	61.14	17.20	43.72	38.86	8.74
2005	82.29	60.86	20.57	52.92	39.14	10.58
2006	100.14	60.57	25.04	65.20	39.43	13.04
2007	127.43	60.90	31.86	81.81	39.10	16.36
2008	155.58	60.97	38.89	99.61	39.03	19.92
2009	175.54	60.91	43.88	112.64	39.09	22.53
2010	216.03	60.92	54.01	138.59	39.08	27.72
2011	249.86	60.95	62.46	160.09	39.05	32.02
2012	273.79	61.12	68.45	174.16	38.88	34.83
2013	307.12	61.50	76.78	192.23	38.50	38.45
2014	334.38	61.70	83.60	207.53	38.30	41.51
2015	368.40	61.89	92.10	226.89	38.11	45.38
2016	410.61	62.24	102.65	249.13	37.76	49.83
2017	461.69	62.59	115.42	275.99	37.41	55.20

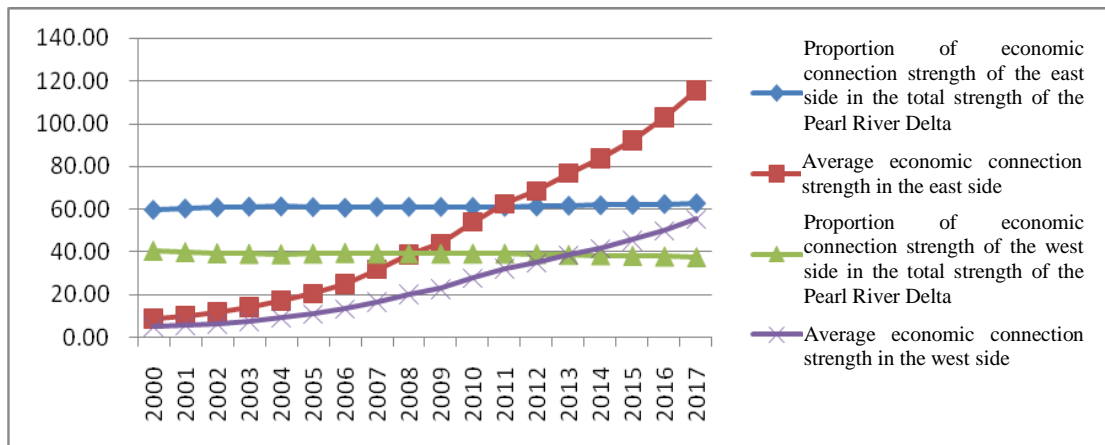


Fig. 1. Measurement of the strength of the economic connection between the east and west sides of the Pearl River Delta.

IV. CONCLUSION

From the perspective of the strength of economic connection between cities, Guangzhou-Foshan, Guangzhou-Dongguan, Dongguan-Shenzhen have high economic connections, and their foreign economic connection strengths

ranked top. The value of economic connections between Zhuhai, Huizhou and Zhaoqing are low, and the inter-region economic connections are weak.

From the perspective of the total strength of economic connection between cities, since 2000, the values of cities in

the Pearl River Delta kept going up, and form the Guangzhou-Foshan-Shenzhen area with the strongest total strength of connections, the Dongguan-Zhongshan-Jiangmen area with strong total strength and the Huizhou-Zhuhai-Zhaoqing area with weak total strength. In extremely strong area, the absolute value of the total strength of economic connection is high and the growth rate is high. Such area is the core growth pole of the Pearl River Delta and can significantly drive the economic connection of surrounding cities. In strong area, the absolute value of total strength of economic connection is large and the growth rate is relatively high. Such area receives strong radiation from cities in the extremely strong area and has strong development motive. In weak area, the absolute value of total strength of economic connection is small and the growth rate is relatively high. Such area is located in the edge of the Pearl River Delta and has weak capacity to receive economic radiation from the extremely strong area and the strong area. Guangzhou goes far ahead in terms of both the absolute value of the total strength and the growth rate. In the Pearl River Delta, there is still a single-center pattern, and a balanced multi-center pattern has not yet been formed.

From the internal perspective of the Pearl River Delta region, the economic connection between the cities on the east side of the Pearl River Estuary is close. The total economic connection strength, total strength growth rate, and average economic connection strength are much higher than those on the west side. The economic connection difference between the east side and the west side is gradually enlarged, and the situation of strong east and weak west is continuously enhanced. Therefore, in order to realize a coordinated development of regional economies in the Pearl River Delta and give full play to the radiating and driving role of the Pearl River Delta to Guangdong's economic development, it is necessary to formulate different countermeasures for regions with different economic connection strengths. The functions of extremely strong area and strong area to absorb, digest and radiate the weak area should be brought into full play. Further, it is needed to enhance road traffic network construction, reduce the time required for transportation connection, and increase accessibility between cities in the region. Moreover, it is possible to integrate and optimize the economic resources on both sides of the Pearl River, and strengthen the industrial division and cooperation between the two sides.

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