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2025 Volume 3, Issue 5
Lecture Notes in Education, Arts, Management and Social Science
ISSN(Online): 2705-053X

Symbiosis Theory and Regional Economic Integration: Evidence from Zhangzhou

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Abstracts: Under the logic of symbiosis Theory, urban development needs to consider integrating internal and external development to allocate scarce resources effectively. Therefore, this paper quantitatively analyses the districts and counties in Zhangzhou from the perspective of symbiosis theory, using the "gravity model" and social network analysis. We find that the economic network within Zhangzhou's districts and counties remains weak. The central district acts as the sole dominant node, attracting resources from surrounding areas while offering limited outward spillovers, and symbiotic linkages among peripheral units are still low. On the one hand, Zhangzhou needs to play the role of the core area of the city as a link to build a platform for inter-district and county collaboration and to strengthen internal integration and development; on the other hand, Zhangzhou is in a relatively secondary position in the Xiamen, Zhangzhou and Quanzhou metropolitan area, and needs to give full play to its industrial strengths in the process of integration and development, and to avoid the problem of the central city attracting too much of all kinds of resources.

Keywords: Urban Development; Gravity Model; Symbiosis Theory; Social Network Analysis; Regional Economic Integration

Online publication: June 26, 2025

1. Introduction

Under the influence of the intensification of political and economic conflicts in various countries, countries face an unstable and uncertain world. Facing the uncertainty of the global economic development trend, China is accelerating the formation of a new "double cycle" development pattern. For Zhangzhou, how to better become a hub in the "double cycle", to release more economic growth momentum, is the urgent need to explore the issue.

Zhangzhou is located in the southeastern part of Fujian Province, and now has four districts, seven counties, and five development zones. From the existing economic data, the development of the districts and counties within Zhangzhou is more uneven, without deeper cooperation and complementary differences, which makes the development of the counties and districts in Zhangzhou City uneven. In contrast, the concept of Xiamen-Zhangzhou-Quanzhou metropolitan area has been put forward for more than ten years since 2010, and the economic relationship is mainly expressed in the following ways: advantageous cooperation, differentiated division of labor, and gradual fading of spatial location boundaries [1]. However, there are some problems in which, for Zhangzhou, the imbalance of development between regions in the process of results in more resources flowing out of Zhangzhou [2].

When Zhangzhou explores the integration of internal and external development, it is necessary to first understand

the current symbiosis model of Zhangzhou city districts and counties. Can such a symbiosis model meet the inherent requirements of integrated development? What is the path of integration? This paper explores precisely these questions.

In the second part of this paper, we review the relevant literature and analyse the current situation of symbiosis in Zhangzhou; in the third part, we analyse the gravity model, urban flow model, and social network; in the fourth part, we summarise and put forward relevant suggestions.

2. Literature Review and Current Situation Analysis

2.1. Symbiosis Theory Related Research

The study of integration and development within a region is the scope of new geographic economics and regional economics, and this paper starts from the symbiosis theory and adopts the idea of mixed research to explore this topic.

The introduction of symbiosis theory from biology to social science research has been framed in the past [3-5]. In urban and regional development research, the three elements of symbiosis theory (symbiotic unit, symbiotic environment, and symbiotic mode) are usually chosen as the analytical framework [6-7]. This type of research is characterised by its logical simplicity and predominantly qualitative research. Among them, symbiotic patterns are usually classified according to "behavioural style" and "degree of organisation". Recently, under the framework of symbiosis theory, scholars have focused on one perspective of regional development and added other theories for nesting [8-9]. For example, [10] provide a process perspective on industrial symbiosis, developing a methodology known as event sequence analysis to explore the dynamics of symbiotic relationships. Research on the symbiotic relationship between the knowledge-intensive service industry and high-tech manufacturing industry under the framework of symbiosis theory [11], a comparative study of the cross-border integration of regions adjacent to Beijing and Shanghai [12], and research on synergistic development of tourism in Guangxi's regional cities [13]. While relatively few articles apply symbiosis theory to the study of overall regional economic integration, some scholars have used symbiosis theory to explore the integrated development of the county economy [14-15]. Reviewing the research on regional development based on symbiosis theory, two shortcomings are visible: one, if other disciplinary theories are introduced under the framework of symbiosis theory for nesting, it is easy to blur the inner logic of symbiosis theory and make the research out of focus; two, the research method of qualitative research only has the advantage of the discussion on the policy side, and the credibility is weaker when it enters into the discussion on the economic side.

In the symbiosis system, the symbiosis unit is the node regions; the symbiosis environment, which will be divided into dimensions according to the specific characteristics of the region, will be observed by multiple dimensions, i.e., economy, policy, infrastructure dimension, and socio-culture. Symbiotic patterns are key in studying urban agglomerations, which respond to how symbiotic units interact with each other in the existing symbiotic environment [16]. Symbiotic modes are usually classified in terms of "mode of behaviour" and "degree of organisation": firstly, depending on the mode of behaviour, they can be classified as parasitic, biased symbiosis, asymmetric mutualistic symbiosis, and symmetric mutualistic symbiosis; secondly, depending on the degree of organisation, they can be classified as point symbiosis. It can be divided into point symbiosis, intermittent symbiosis, integrated symbiosis, and continuous symbiosis.

2.2. Symbiotic system analysis of Zhangzhou City districts and counties

Regarding symbiotic environments, Xiamen, Zhangzhou, and Quanzhou form the 'Minnan Golden Triangle,' sharing commonalities in Minnan culture. At a higher planning level, the regional integration of the Xiamen-Zhangzhou-Quanzhou area is strongly promoted by policy. Zhangzhou and Xiamen exhibit continuous symbiosis in organisational structure and asymmetric symbiosis in behavioural patterns. On one hand, due to geographical location and transportation convenience, the main urban areas of Zhangzhou and the various districts of Xiamen are easily accessible, with some residents living in Area A and working in Area B. In contrast, Xiamen has a stronger magnetic force on population flows from surrounding areas, as the relatively higher urban public services and recreational environment

within Xiamen Island result in a more noticeable influx of people from Zhangzhou to Xiamen on weekends. On the other hand, Xiamen has long been committed to developing a headquarters economy, attracting many private enterprise headquarters from Quanzhou to settle in Xiamen.

Additionally, due to its higher urban status compared to Zhangzhou and Quanzhou, Xiamen holds a relative advantage in attracting talent and capital. However, due to its economic structural issues, Xiamen's economic spillover effects on surrounding cities are limited. This has led to asynchronous development between Xiamen and Zhangzhou in their interactive relationship. In this process, Zhangzhou can only seek to absorb external industrial chain transfers rather than gain greater support through regional integration and development.

Zhangzhou and Quanzhou exhibit intermittent symbiosis in terms of organisational structure and asymmetric mutual benefit symbiosis in behavioural patterns. Quanzhou holds a clear first-mover advantage in economic development, with a robust private economy and manufacturing sector, and each district and county possesses distinctive industrial chains. Its total economic output exceeds that of Xiamen and Zhangzhou, but its industrial structure lacks a strong complementarity with that of Zhangzhou. There is some economic interaction between the two symbiotic units, but it is not particularly close. In the future, the petrochemical industrial chain linking the Gulong Development Zone with the Quanzhou Port and QuanHui Petrochemical Industrial Zones will deepen the industrial symbiosis between Zhangzhou and Quanzhou.

The districts and counties are culturally similar in terms of the symbiotic environment within Zhangzhou. However, the economic policies are biased towards promoting the development of the central urban area and the four major development zones, superimposed on the differences in geographic factors. This leads to a significant difference in the economic development status of the districts and counties and a significant difference in their accessibility to each other.

In order to analyse the symbiosis pattern of the districts and counties in Zhangzhou City, the districts and counties are divided into four regions according to the 14th Five-Year Plan of Zhangzhou City: the core area of the central city (Longwen, Xiangcheng, Longhai, and Changtai), the northern green industry development piece (Hua'an), the city cluster around Dongshan Bay (Zhangpu, Yunxiao, Dongshan, and Zhao'an), and the western mountainous area of ecological protection piece (Nanjing and Pinghe).

Among them, the core area of the central city is the key urbanisation area of Zhangzhou City. It is at the forefront of co-location with Xiamen, which has a relatively high degree of economic development. The significant economic development zones in the region are geographically close to each other and have close interaction, with a relatively high degree of symbiosis. The other counties and districts have their speciality industries, with fewer inter-industry linkages, except for integrating related resources constructed in culture and tourism. Thus, this paper argues that except for the core area of the central city, which belongs to asymmetric reciprocal symbiosis and continuous symbiosis, the other regions within the region belong to asymmetric reciprocal symbiosis and intermittent symbiosis. At the same time, the inter-region has not yet reached the organisational degree of intermittent symbiosis.

3. Empirical analyses

In this part, we will quantitatively investigate the economic linkages of the districts and counties within Zhangzhou City through the Gravity Model and social network analysis. Social network analysis is an analytical method that has been introduced from sociology into regional economic development research in recent years [17-18]. In this method, symbiotic units are regarded as nodes in a social network, and the relevant measures of the social network can be calculated to understand the positioning and nature of each symbiotic unit in the symbiotic system.

3.1. Gravity Model

The concept of the Gravity comes from physics, and the Gravity model measures the strength of the interaction force between economies due to economic scale and distance [19].

$$R_{ij} = k_{ij} \frac{(\sqrt{p_i \cdot G_i} \times \sqrt{p_j \cdot G_j})}{D_{ij}^2} \quad (1)$$

In the formula, R_{ij} is the intensity of economic ties between the two cities; P_i and P_j are the total population of the urban areas of the two cities; G_i and G_j are the GDPs of the two cities; D_{ij} is the distance between the cities, and k is the correction coefficient, which is computed as the ratio of GDP_i to the sum of the GDPs of the two cities. Population and GDP data are from China Urban Statistical Yearbook 2020, Fujian Statistical Yearbook, and Zhangzhou Bureau of Statistics. The distance measure between districts and counties is from Gaode Map. Among them, the economic affiliation is the ratio of the strength of economic ties between cities to the sum of regional economic ties.

In this section, Longwen District and Xiangcheng District of Zhangzhou City are combined into an urban area to calculate the economic affiliation and Gravity strength values of the districts and counties in Zhangzhou in 2019. As shown in **Table 1**, the high and low Gravity strength values of the districts and counties vary widely within Zhangzhou City. After merging the two districts, the Gravity value of the urban area is the highest at 202.91, followed by Longhai's Gravity value of 161.08, and Zhangpu's Gravity value of 36.52. at the same time, Hua'an has the smallest gravity value, only one percent of the urban area's gravity value. Moreover, it can be seen from the economic affiliation degree that the link between the urban area and Longhai is the strongest, the economic affiliation degree of the urban area to Longhai reaches 50 %, followed by Changtai at 23 %, which is similar to the study of qualitative analysis, which has formed a higher degree of symbiotic relationship between the four symbiotic units within the core area of the central city.

Table 1. 2019 Economic affiliation and Gravity value of Zhangzhou districts and counties

	Downtown	Longhai	Yunxiao	Zhangpu	Zhao'an	Changtai	Dongshan	Nanjing	Pinghe	Hua'an
Downtown		61.86%	4.26%	18.13%	3.50%	50.73%	2.62%	21.66%	11.62%	22.96%
Longhai	50.55%		4.63%	18.64%	8.07%	27.51%	3.25%	9.48%	6.34%	12.42%
Yunxiao	1.38%	1.84%		22.69%	29.53%	1.51%	37.51%	3.48%	5.50%	3.60%
Zhangpu	7.10%	8.94%	27.39%		11.18%	5.16%	10.08%	5.04%	10.96%	8.46%
Zhaoan	0.83%	1.28%	21.59%	6.77%		0.81%	38.65%	1.78%	2.65%	3.07%
Changtai	23.10%	15.33%	2.12%	5.99%	1.55%		1.13%	6.74%	4.19%	19.16%
Dongshan	0.58%	0.88%	25.64%	5.70%	36.13%	0.55%		1.18%	1.65%	1.79%
Nanjing	8.42%	4.51%	4.17%	5.01%	2.92%	5.76%	2.07%		55.44%	12.18%
Pinghe	6.49%	4.33%	9.46%	15.62%	6.24%	5.14%	4.16%	48.84%		16.36%
Hua'an	1.54%	1.02%	0.75%	1.45%	0.87%	2.83%	0.54%	1.80%	1.64%	
Gravity Value	202.91	161.08	15.16	36.52	12.11	29.17	10.24	26.12	27.67	2.12

Data sour**ce:** calculated by the author through raw data

3.2. Social network analysis

In order to deeply analyse the economic links between the districts and counties within Zhangzhou City. This paper further analyses the city's economic linkage matrix data through Ucient6.56. Firstly, the economic linkage matrix is binarised, and the software is used to generate the economic linkage network map of Zhangzhou districts and counties in 2019. In the linkage network, the more connecting lines represent the closer the links between the nodes, and it can be seen that three core points are formed in Zhangzhou city: downtown, Longhai, and Zhangpu. These three core points are an important presence in the formation of the regional economic network, and the remaining districts and counties have increased their connectivity with other regions while establishing links with the core regions.

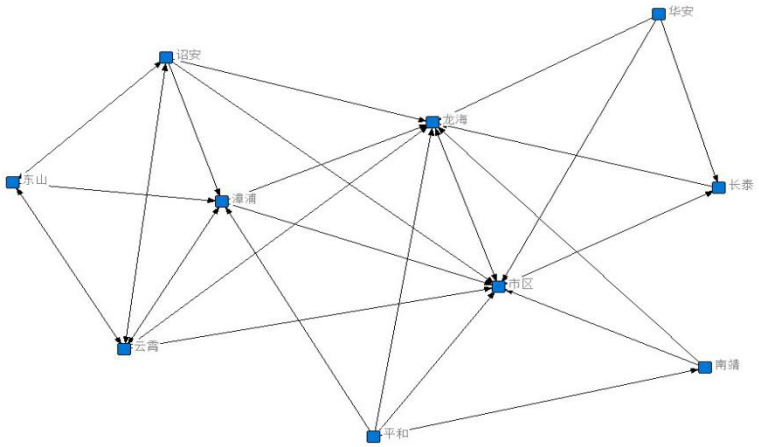

Figure 1. Network of economic linkages among districts and counties in Zhangzhou 2019

Secondly, this paper calculated the centrality degree and structural holes of the districts and counties in Zhangzhou City in 2019 using Ucient 6.56. As shown in **Table 2**, from the standard in-degree and standard out-degree of centrality of point degree, it can be seen that in the standard in-degree urban area and Longhai are far ahead, which means that these two nodes receive the inflow of capital, information, and labour from other regions. However, in the standard out-degree, downtown and Longhai are lower, implying that these nodes are weaker in external output and influence. Despite their better development, this also reflects that downtown and Longhai have a limited role in driving other neighbouring districts and counties. In the intermediary centrality degree, several counties and districts are 0, implying that these counties and districts do not have an intermediary centrality role. A high degree of intermediary centrality means it can play the role of a bridge to communicate with other nodes, where the urban areas, Yunxiao and Zhangpu, play the role of a bridge.

Moreover, according to the structural hole theory, the meaning of structural hole is due to the lack of direct connection between two nodes; at this time, a third node is needed in the middle to form a connection. This third node occupies a structural hole in the whole network. At the same time, it also means that the node area occupying the position of a structural hole has more information and resources in the city cluster network. As can be seen from **Table 3**, in which the larger the adequate size of the network and the higher the efficiency, the greater the node's influence, it can be seen that the urban area and Longhai are the most important nodes in the network. Moreover, the limitation represents that the node can use structural holes in the self-network; the smaller the limitation, the better. It can be seen that the urban area and Longhai have the least limitation, followed by Zhangpu. Hua'an has a low adequate network size, low efficiency, high limitations, low hierarchy, and is at the periphery of the entire intra-city economic linkage network, implying that it is not well connected to other nodes.

Table 2. Degree of centrality data for Zhangzhou districts and counties in 2019

	DegreeCentrality		BetweennessCentrality
	Standardout-degree	CriterionInDegree	NBetweenness
downtown	22.2	88.9	9.722
Longhai	11.1	88.9	0
Yunxiao	55.6	33.3	9.722
Zhangpu	33.3	44.4	9.722
Zhao'an	55.6	22.2	1.389
Changtai	22.2	22.2	0

Table 2 (Continued)

	DegreeCentrality		BetweennessCentrality
	Standardout-degree	**CriterionInDegree**	**NBetweenness**
Dongshan	33.3	22.2	0
Nanjing	33.3	11.1	0
Pinghe	44.4	11.1	5.556
Hua'an	33.3	0	0

Data source: calculated by the author using Ucient

Table 3. Network structure hole related indicators

	Effsize	**efficienc**	**Constrain**	**hierarchy**
downtown	5.750	0.719	0.409	0.099
Longhai	5.500	0.688	0.445	0.123
Yunxiao	3.000	0.600	0.603	0.057
Zhangpu	3.429	0.571	0.562	0.064
Zhao'an	2.786	0.557	0.643	0.083
Changtai	1.250	0.417	0.956	0.084
Dongshan	1.300	0.433	0.947	0.059
Nanjing	1.750	0.583	0.891	0.022
Pinghe	2.400	0.600	0.708	0.046
Hua'an	1.333	0.444	1.049	0.016

Data source: calculated by the author using Ucient

Through the gravity model and social network analysis, we found that the economic linkage network formed within the districts and counties of Zhangzhou City needs to be further strengthened. The existing economic linkage network mainly relies on the core area as a node. In contrast, the core area cannot radiate to the outside world but attracts the inflow of resources from the surrounding districts and counties. Except for the central core urban area, the degree of symbiosis between units is low, similar to the findings of the qualitative study.

4. Conclusion and Policy Recommendations

This paper argues that regional integrated development is important for regions to achieve sustainable development. As for cities, integrated development implies the twofold integration of counties and districts within the city and the external urban agglomeration in which they are located. Thus, this paper applies the research framework of symbiosis theory and argues that in a symbiotic environment, when symbiotic units reach a degree of organisation of integrated symbiosis and a symmetric integrated symbiosis of behaviour, this is called integrated development. Using the quantitative analysis model, the Gravity Model was used to measure the Gravity value and economic affiliation between counties in Zhangzhou in 2019, and the social network analysis was used to explore the economic network constructed by counties within Zhangzhou City.

The above analyses show that the overall linkages between counties and districts in Zhangzhou are weak, relying mainly on the network effect brought about by the linkages between core symbiotic units. Among them, the symbiosis

patterns between the central core city districts consisting of Longwen District, Xiangcheng District, Longhai, and Changtai are asymmetric and continuous symbiosis. In contrast, the symbiosis relationships between other symbiotic units are weak. The symbiosis pattern affects the division of labour, complementary advantages, and economic integration of industries within the city, thus Zhangzhou needs to strengthen the economic linkage network among the districts and counties.

Based on the above analyses, this paper argues that Zhangzhou should actively seek to interact with the industrial chain between Xiamen and Quanzhou. On the other hand, it can focus on the integration and development within the city. In the city counties, to explore the new mode of intra-regional specialised division of labour, the construction of communication and consultation mechanisms between district and county governments is necessary to avoid duplication of construction and intra-regional competition. For example, to build a cross-regional exchange and cooperation platform mechanism for each key planning industry in Zhangzhou City, create a region-wide complementary industrial chain, and reduce duplicated investment and financial competition. At the same time, to promote intra-regional factor flows, we should accelerate the construction of relevant infrastructure between counties and cities, eliminate barriers to various flows, and reduce the cost of factor flows in the region. Infrastructure construction in the era of digital economy is not only about traditional infrastructure, but also building an intelligent city network, digital city planning with new technology, so that the technology already available in the first development region can be better empowered for the relatively weak development of the county. It can also strengthen the construction of the mechanism of cultural exchanges within the region of southern Fujian, forming a closer link between cultural performances and tourism resources, and strengthening the social consensus in the region. On the one hand, it is to integrate Minnan culture-related resources as well as special agricultural and sideline products in Zhangzhou City, to promote the integration of cultural and creative industries and food processing industries, and to create special IP series products with the Zhangzhou logo; on the other hand, it is to build a mechanism for Minnan whole-area tours with relevant cultural and tourism places in Xiamen and Quanzhou, in order to reduce the transaction costs for consumers.

Disclosure statement

The author declares no conflict of interest.

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