Proceedings of Business and Economic Studies, 2025, Volume 8, Issue 4
http://ojs.bbwpublisher.com/index.php/PBES
Online ISSN: 2209-265X
Print ISSN: 2209-2641

Configurations for Xiamen-Zhangzhou-Quanzhou Regional Economic Integration--Based on Fuzzy Set Qualitative Comparative Analysis

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Abstract: Achieving mutual benefits in the process of city cluster integration is the core of sustainable regional economic development. This means the core city is driving and avoids the siphon effect. Therefore, it is crucial to analyse which factors affect the differences in integration outcomes. In this paper, for the 28 districts and counties of Xiamen-Zhangzhou-Quanzhou City Cluster, we use FsQCA to analyse the configuration of the impacts of five conditions, namely, urbanization, infrastructure development, level of public services, degree of government intervention, and industrial structure, on the intensity of the districts and counties' economic linkages. This paper obtains four group conditions of high economic linkage intensity and seven paths leading to low economic linkage intensity. And in this regard, it puts forward suggestions such as constructing a mechanism for coordinated development of regional industries and accelerating the convenient sharing of public services.

Keywords: Regional economy; Xiamen-Zhangzhou-Quanzhou metropolitan area; FSQCA

Online publication: September 8, 2025

1. Introduction

Regional economic integration is one of the essential strategies for China's current economic development (Liu, 2014)[1]. Through economic integration, it can break the administrative division and geographical restriction, strengthen the connection and cooperation between cities in the region, optimize the allocation of resources, and promote the coordinated development of the regional economy (Liu et al., 2011[2]; Zhang et al., 2021)[3]. Zhangzhou, Xiamen, and Quanzhou are located on the southeast coast, known as the "Golden Triangle of Southern Fujian", and share the commonality of Minnan culture, constituting an essential urban agglomeration in the Southern Fujian region. At a high level of planning, Xiamen-Zhangzhou-Quanzhou regional integration has been vigorously promoted by policy. Since 2011, economic ties between the three cities have been strengthened, with the realization of co-location of communications, inter-city high-speed rail links, bus card integration in infrastructure, common protection of watersheds, and collaboration on pollution control in the environmental field.

Over the past decade, the three cities have gradually formed an organic pattern of regional economic integration. Still, the current speed of integration falls short of the expected process. The three cities of Xiamen, Zhangzhou, and Quanzhou are economically complementary. If resource sharing and complementary advantages are realized, the sustainable development of the regional economy will be better promoted.

The essence of regional economic integration is the integration and development within a complex system. The complex system is not simply how the independent variables (such as industrial structure, fiscal expenditure, policy strength) affect the dependent variable (the degree of economic integration). Instead, the configuration conditions play a role here. The relationship between the independent variables may be the key to explaining regional economic integration. This may also explain why existing studies show that city clusters may lead to different results at different stages of development and for various reasons; for example, in some cases of city cluster integration and development, it is shown that the core cities siphon off more than they radiate to the peripheral cities. In contrast, in other cases, the later cities can leverage the first cities to develop more rapidly.

Qualitative comparative analysis is based on Boolean algebra and set theory. It is usually used for cross-case comparative analyses of medium-sized samples to study the logical relationship between multiple conditions and outcomes. Fuzzy set qualitative comparative analysis (FSQCA) extends the original method and helps to understand complex cause and effect in real society (Du et al., 2017) [4]. Previously, there are no articles using qualitative comparative analysis in the research on Xiamen-Zhangzhou-Quanzhou regional economic integration, and this paper focus on the combination of conditions affecting Xiamen-Zhangzhou-Quanzhou regional economic integration. On the academic level, this paper will try to use qualitative comparative analysis for integration path research, thus enriching the framework of analytical tools for the regional economy.

In summary, this paper uses Fuzzy Set Qualitative Comparative Analysis (FsQCA) to analyse the combination of conditions affecting the regional economic integration of Xiamen-Zhangzhou-Quanzhou from the level of districts and counties of the cities. This paper begins with a review of the literature on the influencing factors of regional economic integration in Part II, followed by a general analysis of the current status of regional integration in Xiamen-Zhangzhou-Quanzhou; describes the selected conditional variables and data processing in Part III; carries out a fuzzy-set qualitative comparative analysis in Part IV; and concludes and puts forward relevant recommendations in Part V.

2. Literature Review and Current Situation Analysis

2.1. Influencing Factors of Regional Economic Integration

From the existing studies, it is known that there are differences in the degree of economic integration of Chinese urban agglomerations (Zhou et al., 2010 [5]; Wang et al., 2021) [6], and many possible factors affect this integration (Chen, 2008 [7]; Cao et al., 2017) [8]. These factors can be classified into three aspects: policy, economy, and society.

In terms of policy, the higher-level government increases support for cross-regional cooperation, strengthens cooperation between city clusters, and promotes industrial transfer, which is conducive to the development of regional integration. However, the effect of policy implementation will affect the degree of integration (Peng,2009 [9]; Ma, 2019 [10]).

On the economic front, factors such as industrial structure, capital flows, technological innovation, and infrastructure development may all affect regional economic integration, but their relationship with integration varies across different city clusters (Guo et al. 2016 [11]; Liu et al., 2020 [12]; Ma et al., 2022) [13]. It is usually

believed that urban economic growth and urbanization can promote regional integration by creating more market opportunities and increasing the gravitational value between cities; infrastructure development can reduce intra-regional trade costs; and rationalisation of industrial structure can promote regional integration more than advanced development. For example, Liu and Hu (2011) [2]found that the construction of transport infrastructure promotes regional economic integration by increasing the volume of inter-regional trade. Wang and Li (2018) found that urbanization in the Yangtze River Delta has a direct positive impact on regional economic growth [14]. Xie et al. (2021) find that upgrading industrial structure inhibits market integration development [15].

On the social front, population mobility, cultural and educational exchanges, etc., also affect the sustainability of economic integration (Chen et al., 2009[16]; Cao et al., 2017[8]). Chen et al. (2009) empirically analyzed that the integration of entrepreneurial culture and the integration of risk-taking culture in the Yangtze River Delta region promotes economic integration. Liu and Yue (2020) found that the same language attribute in the integration process is a positive driving factor [12]. Moreover, the quality of basic public services affects the behavioral choices of enterprises and individuals, affecting the flow of talents and capital.

2.2. The current status of Xiamen-Zhangzhou-Quanzhou regional integration

This paper calculates the economic affiliation and gravitational force values for the years 2005, 2010, 2015, 2019, and 2022 using the gravitational force model to investigate the changes in mutual economic ties between the Xiamen-Zhangzhou-Quanzhou metropolitan area under policy impetus. The gravity model measures the strength of the interaction force between regions brought about by economic size and distance.

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

Where, R_{ij} is the strength of economic affiliation between two regions; P_i, P_j is the total population of the area; G_i, G_j is the GDP of the two cities; D_{ij} is the distance between the cities, and k is the correction coefficient, computed as the ratio of the GDP_i to the sum of the GDP of the two cities. Among them, the GDP and population data are from the Fujian Provincial Statistical Yearbook, and the inter-regional distance measure is from Gaode Map.

Tables 1-5 show that the gravitational value between Xiamen, Zhangzhou, and Quanzhou has increased. In contrast, the gap between Xiamen's gravitational value and Quanzhou's has widened from 2015 onwards, and Xiamen's core position in the Xia-Zhang-Quan metropolitan area has gradually been established. Furthermore, Zhangzhou is relatively weaker in terms of gravitational value. In terms of economic affiliation, relative to Quanzhou, Zhangzhou and Xiamen are getting closer to each other, exceeding 80% by 2022. However, the gravitational values of Xiamen and Zhangzhou are not symmetrical.

Table 1 2005 Xiamen-Zhangzhou-Quan Economic Affiliation and Gravity Value

	Zhangzhou	**Xiamen**	**Quanzhou**
Zhangzhou		68.59 %	45.26 %
Xiamen	72.54 %		54.74 %
Quanzhou	27.46%	31.41 %	
Gravitational value	38.08	64.48	59.78

Table 2 2010 Xiamen-Zhangzhou-Quanzhou Economic Affiliation and Gravity Value

	Zhangzhou	Xiamen	Quanzhou
Zhangzhou		68.57 %	40.44 %
Xiamen	76.26 %		59.56 %
Quanzhou	23.74 %	31.43 %	
Gravitational value	105.63	169.16	154.50

Table 3 2015 Xiamen, Zhangzhou-Quanzhou Economic Affiliation and Gravity Value

	Zhangzhou	Xiamen	Quanzhou
Zhangzhou		64.11 %	35.54 %
Xiamen	76.42 %		64.46%
Quanzhou	23.58 %	35.89 %	
Gravitational value	219.64	326.02	323.29

Table 4 2019 Xiamen-Zhangzhou-Quanzhou Economic Affiliation and Gravity Value

	Zhangzhou	Xiamen	Quanzhou
Zhangzhou		67.84 %	34.71 %
Xiamen	79.87 %		65.29 %
Quanzhou	20.13%	32.16 %	
Gravitational value	458.55	682.56	557.87

Table 5 2022 Xiamen-Zhangzhou-Quanzhou Economic Affiliation and Gravity Value

	Zhangzhou	Xiamen	Quanzhou
Zhangzhou		67.18 %	31.93 %
Xiamen	81.36 %		68.07 %
Quanzhou	18.64 %	32.82 %	
Gravitational value	594.05	983.67	735.51

Data source: The author's own calculation.

It is difficult to deeply analyze the degree of regional integration and influencing factors only from the city level of Xiamen-Zhangzhou-Quanzhou, therefore, combining the basic situation of Xiamen-Zhangzhou-Quanzhou districts and counties, this paper chooses the level of urbanization, infrastructure development, public service level, the degree of governmental intervention and industrial structure as the conditional variables, and conducts the configuration analysis using FsQCA. The interdependence of the cause conditions and the multiple concurrent causality constituted by different combinations are analyzed by QCA. Under the asymmetric assumption of QCA, the combinations of conditions that lead to high and low regional economic integration can be found separately.

3. Data, conditions and initial calibration

In this paper, we use 28 districts and counties of Xiamen, Zhangzhou, and Quanzhou[1] as the research objects. The relevant data are obtained through the statistical yearbooks of Fujian Province, Xiamen, Zhangzhou, and Quanzhou in 2022.

3.1. Outcome variables

The outcome variable is each district and county›s economic linkage intensity (YLZ). Using the above gravity model, this paper calculates the gravity value of each district and county under Zhangzhou, Xiamen, and Quanzhou in 2021 (as shown in Table 6).

Table 6 Economic linkage intensity of districts and counties in 2021

District	Gravitational Value	Ranking	Region	Gravity Value	Ranking
Siming	4881.869	1	Longwen	289.4323	15
Jinjiang	2433.863	2	Anxi	203.4722	16
Huli	2111.141	3	Luojiang	125.2894	17
Licheng	1404.353	4	Quangang	79.09763	18
Haicang	1209.668	5	Changtai	78.53895	19
Jimei	1013.2	6	Zhangpu	72.97904	20
Nan’an	668.8897	7	Yongchun	49.45518	21
Shishi	617.5331	8	Nanjing	37.30712	22
Xiangcheng	584.3566	9	Pinghe	29.55761	23
Longhai	579.6245	10	Dehua	17.77763	24
Fengze	564.3684	11	Yunxiao	16.95439	25
Hui’an	404.4446	12	Zhao’an	16.59603	26
Xiang’an	396.4438	13	Dongshan	9.319764	27
Tongan	337.5056	14	Hua’an	4.960915	28

Data source: Calculated by the author.

3.2. Conditional variables

Five conditions are selected in this paper to explore their impact on the intensity of economic linkages:

Urbanization level (CZH) is selected to measure the average value of the urbanization rate of the resident population at the end of the average year from 2011 to 2020.

Infrastructure development (GLLC) is selected to be measured by the share of road mileage in total land area.

Public service level (RJCW) is calculated by selecting the number of beds per capita from the health data of each district and county.

Degree of government intervention (CZZC): The proportion of fiscal expenditures to GDP is selected to measure the degree of local government intervention.

Industrial structure (GYJG): The advanced industrial structure is selected as the measurement variable; that is, the value added of the tertiary industry is used to subtract the value added of the secondary industry.

3.3.Calibration

This paper determines the fuzzy set affiliation score based on the existing literature and considering the specific situation of the county economy. In particular, the full affiliation score is 90%, the mediation score is 50%, and the full non-affiliation score is 10%. Table 7 summarizes the post-calibration descriptive statistics of the fuzzy sets for each condition and outcome.

Table 7 Post-calibration descriptive statistics

Variable	Mean	Standard Deviation	Mini	Max
Economic linkage intensity (YLZ)	0.4285714	0.3528326	0.04	1
Urbanization level (CZH)	0.5039286	0.3509613	0.01	0.95
Infrastructure development (GLLC)	0.4528571	0.3189252	0	0.99
Public service level (RJCW)	0.4939286	0.3064001	0.01	1
Degree of government intervention (CZZC)	0.4875	0.3538222	0.04	0.99
Industrial structure(GYJG)	0.4714286	0.3460875	0.02	1

4. Analysis of results

4.1.Analysis of necessary conditions

Consistent with previous QCA studies, a necessary conditions analysis is first required. The consistency level responds to the extent to which the cases of the same condition configuration state share the same outcome. This paper limits the threshold value of the necessary conditions to 0.9. Tables 8 and 9 show the results of the necessary conditions analysis for high and low economic linkage intensities, respectively. As seen from the tables, none of the conditions in the knot model has a consistency level greater than 0.9, i.e., none of the conditions are necessary for the outcome variable.

Table 8 Necessary condition analysis for high economic linkage intensity

	Consistency	Coverage
CZH	0.884167	0.751949
~CZH	0.382500	0.330454
GLLC	0.724167	0.685331
~GLLC	0.591667	0.463446
RJCW	0.623333	0.540853
~RJCW	0.635833	0.538462
CZZC	0.425833	0.374359
~CZZC	0.772500	0.645993
CYJG	0.659167	0.599243
~CYJG	0.560000	0.454054

Table 9 Necessary condition analysis for low economic linkage intensity

	Consistency	Coverage
CZH	0.418750	0.474841
~CZH	0.781250	0.899928
GLLC	0.486250	0.613565
~GLLC	0.750625	0.783943
RJCW	0.591250	0.684020
~RJCW	0.603125	0.681016
CZZC	0.682500	0.800000
~CZZC	0.466250	0.519860
CYJG	0.495000	0.600000
~CYJG	0.669375	0.723649

4.2. Sufficient conditions analysis

Sufficient conditions analysis can demonstrate the possible conditional configurations of multiple factors. Tables 10 and 11 show the results of the sufficient conditions analysis at high and low economic linkage intensities, respectively. According to Ragin (2008), the thresholds for the analysis were set at 0.8 for consistency, 0.5 for PRI, and 0.25 for coverage.

Table 10 Sufficient conditions configuration for high economic linkage intensity

Conditional variable	High			
	H1	H2	H3	H4
CZH	■	■	■	■
GLLC	■		▪	▪
RJCW	⊗	▪	×	
CZZC		⊗	⊗	⊗
CYGJ	⊗	▪		▪
Raw Coverage	0.3725	0.439167	0.3725	0.371667
Unique Coverage	0.0991668	0.144167	0	0.0158333
Consistency	0.862934	0.95471	0.876471	0.864341
Consistency of the overall solution	0.736667			
Coverage of the overall solution	0.865818			

Note: ■indicates that the core condition is present, ⊗⊗ indicates that the core condition is missing, ▪indicates that the edge condition is present, ×indicates that the edge condition is missing, and a space indicates that the condition is optional.

According to Table 10, the urbanization rate is central to the strength of economic linkages in all configurations. The degree of government intervention has a missing core condition in all three configurations. It shows an irrelevant condition in one configuration, representing that government intervention plays no or a negative role in regional integration. As shown in Table 10, there are four conditional configurations of states

explaining high economic linkage intensity:

(1) H1: CZH * GLLC ~ RJCW * ~ GYJG

In H1, the urbanization rate and infrastructure development play a central role; the level of public services and industrial structure is the core condition missing, and the level of government intervention is an irrelevant condition. This configuration represents a path of high economic linkage intensity dependent on the dual drive of economic development level and infrastructure development. At the same time, the industrial structure has not been transformed to an advanced level, and the level of public services is relatively low. Typical cases under this drive are Haicang District and Jinjiang, which are dominated by secondary industries.

(2) H2: CZH * RJCW ~ CZZC * GYJG

This configuration indicates that regions will have higher economic linkage intensities driven by the level of urbanization, the level of public services, and the advanced industrial structure. At the same time, the degree of government intervention has an adverse effect on the change of economic linkage intensities under this configuration. Typical cases under this drive are Siming District, Huli District, Xiangcheng District, Fengze District, and Leicheng District, which are all in the main urban areas of Xiamen, Zhangzhou, and Quanzhou, where the infrastructure is already better developed, and thus do not appear in the group state condition. In this configuration condition, the level of urbanization is the core driver of the strength of economic linkages, with the level of public services and industrial advancement as auxiliary drivers.

(3) H3: CZH * GLLC ~ RJCW * ~ CZZC

This configuration indicates that the level of urbanization and infrastructure development positively affects changes in the intensity of economic linkages. In contrast, the level of public services and the degree of government intervention have an adverse effect on changes in the intensity of economic linkages. The classic cases of this driver are Jinjiang and Shishi, two county-level cities that mainly focus on manufacturing, so the level of urbanization is the primary driver of the intensity of economic linkages, and the infrastructure is gradually improving, which is a secondary driver. The degree of government intervention is a core condition missing, and the level of public service is a marginal condition missing, which may be due to the more developed private economy in the region and weak policy intervention.

(4) H4: CZH* GLLC ~ CZZC * GYJG

This configuration indicates that the level of urbanization, infrastructure development, and industrial sophistication have a positive effect on the change of economic linkage intensity, while the degree of government intervention has a negative effect. This configuration is similar to H2, where less government intervention favours market-driven industrial upgrading. The cases of this group of states are Fengze District, Shishi, Longwen District, and Licheng District.

Table 11 Sufficient condition group states for low economic linkage intensity

Conditional variable	LOW						
	NH1	NH2	NH3	NH4	NH5	NH6	NH7
CZH		⊗	⊗	▪	⊗	⊗	⊗
GLLC	⊗	⊗	▪				⊗
RJCW				■	■	×	×
CZZC	▪	⊗	×	■	■	×	
CYGJ	⊗		×	⊗	▪	×	⊗
Raw Coverage	0.4175	0.52125	0.275	0.186875	0.288125	0.325625	0.389375
Unique Coverage	0.021875	0.0750001	0.01125	0.00749999	0.02375	0.02375	0.00312501
Consistency	0.915069	0.980023	0.862745	0.917178	0.962422	0.869783	0.956989
Consistency of the overall solution	0.744375						
Coverage of the overall solution	0.892135						

Note: ■indicates that the core condition is present, ⊗⊗ indicates that the core condition is missing, ▪indicates that the edge condition is present, ×indicates that the edge condition is missing, and a space indicates that the condition is optional.

In order to gain a deeper understanding of the drivers of regional integration, Table 11 demonstrates the group condition for low economic linkage intensity. It can be seen that “happy families are all similar and unfortunate families have their misfortunes”, resulting in more configurations of conditions that lead to weaker economic linkage strength in a particular region. Combining the individual configurations is broadly classified into the following driving paths: urbanization level inhibition (NH3, NH5, NH6), industrial structure inhibition (NH4), infrastructure development-industrial structure inhibition (NH1), urbanization rate-infrastructure development-inhibition of government intervention degree (NH2), urbanization rate-infrastructure development-industrial structure inhibitory (NH7).

Taken together, a low level of urbanization represents a relatively weak economic development of the place, which in turn affects the strength of the place›s economic linkage. In the case of the group state NH3 Hua›an, for example, its total GDP is ranked at the back of the pack and is relatively unattractive.

Among these regions, some have a single industrial structure and are dominated mainly by primary or secondary industries, which makes these regions less resistant to external economic shocks, less attractive, and less relevant to the outside world, and thus have a lower strength of economic ties. Typical case for the group NH4 Dehua County, Dehua industry is mainly based on the ceramic industry chain, in recent years, most of the small and medium-sized manufacturers in Dehua actively develop e-commerce, and in the local e-commerce one-stop service chain, but due to the region›s internal in the low-end market competition fierce, external competitors Jingdezhen in the high-end market occupies a larger share of the market, compression of the space for enterprise innovation.

From the various driving paths, it can be found that places with weaker infrastructure development have higher trade and people movement costs, and thus are less attractive to other regions. Take the group state NH1, NH2, NH7 all appeared Zhao›an as an example, the reason is that Zhao›an is located in the southernmost part of Zhangzhou, far away from the core area, the infrastructure construction is relatively weak in Xiamen, Zhangzhou

and Quanzhou area, at the same time, adjacent to Guangdong, facing the siphoning effect of the two sides, resulting in more challenging to attract investment and industrial development, and in the combined effect of several factors, the intensity of the economic ties to the surrounding areas is low, and the degree of integration is poor.

5. Conclusion

This paper chooses 28 districts and counties in Zhangzhou, Xiamen, and Quanzhou as the research object, uses the method of FsQCA to analyze the group path that leads to the differences in the strength of the economic ties of the districts and counties, and obtains the following conclusions:

First, economic development is the core source of economic linkage intensity, followed by infrastructure development. Higher levels of government intervention may have a negative impact.

Second, from the perspective of regional integration, the level of public services does not dominate, and lower levels do not necessarily lead to a region›s lack of attractiveness.

Third, there are regional differences in the choice of industrial structure. For urban core districts, higher quality of public services and industrial sophistication can boost the strength of economic ties. For non-core districts and counties, it is more important to prioritize their own strengths than to promote the transformation of the industrial structure into an advanced one, and the development of primary and secondary industries is instead conducive to enhancing the strength of economic ties.

This paper puts forward the following policy recommendations to promote the economic integration of Xiamen, Zhangzhou and Quanzhou taking into account the new trend and pattern of economic development:

First, the connectivity between non-core counties and core areas should be strengthened to reduce the cost of the flow of factors in the region.

Secondly, it accelerates the convenient sharing of public services to mobilise the construction of economic integration. Xiamen, Zhangzhou, Quanzhou can realise the integration and sharing of cross-city public service resources through the joint construction of intelligent demonstration projects such as intelligent transport and medical care.

Thirdly, it is to build a mechanism for the coordinated development of regional industries, and promote the coordinated development of the economy through the coordinated development of industries, which in turn will promote the development of economic integration. According to the comparative advantages of each district and county›s industrial base and factor endowment, a cross-regional communication and collaboration mechanism must be established to form a new rationalization pattern and industrial structure development. For example, Xiamen, Zhangzhou and Quanzhou can promote the integration of the digital economy and the real economy through the construction of digital economy industrial parks to strengthen the training of digital technology personnel, digital empowerment of the countryside, and other ways to promote the development of the digital economy and the integration of the real economy.

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