Population migration and environment reconstruction of Bay Area Urban Agglomeration——Evidence from the Beibu Gulf Megalopolis

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Abstract. Bay area construction is an important part of regional energy and environment construction and high-quality economic development, and people-oriented is the core of high-quality development, so it is of great significance to re-examine the development of Bay Area Urban Agglomeration and energy and environment structure from the perspective of population migration. Based on the gravity data of Beibu Gulf Urban Agglomerations, this paper uses the social network analysis method to deconstruct the population migration and spatial network structure of urban agglomerations. The results show that the network strength of the Beibu Gulf Urban Agglomeration is gradually increasing, and the network integrity is significantly enhanced; the external radiation effect of the central city is enhanced, showing the spatial characteristics of "gathering and diffusion in one". The conclusion of this paper is of great significance to the formulation of energy and environmental policies and the promotion of high-quality development of bay area integration.

1. Introduction
With the continuous acceleration of urban development in China, population migration has become the new normal of urban social development [1]. As the focus of demography, urban geography, regional economics and other disciplines, population migration is also an important way to study the interaction between cities and the relationship between energy and environment [2]. Since Zipf put forward the gravity model of population migration in 1940s, great progress has been made in the systematic research of population migration [3]. Many scholars have made targeted research in this field from the space-time effect of population migration, the relationship between population migration and urbanization, the relationship between economic growth and population migration, and the income gap caused by population migration There are differences in the social and cultural environment of a city, but there are universality in the migration mode, which mainly shows that the migration probability is inversely proportional to the urban order.

Population migration leads to the continuous evolution of urban spatial structure, embodies the spatial difference of regional energy environment, and becomes the key factor affecting urban development, regional economy and even national economic development [4]. Some scholars focus on the in-depth study of the relationship between population migration and the development of urban agglomerations, mainly from the following four aspects: first, from the spatial model of population migration to explore its role in promoting urban agglomerations; second, from the population
migration to analyze the stability of urban agglomerations; third, to measure the effect of population migration on the industrial upgrading of urban agglomerations; fourth, to measure the population migration and urban agglomeration. The coupling relationship between the influence of city size distribution and its causes is explored. It can be seen that most of the existing studies focus on the analysis of the temporal characteristics or spatial status of population, and lack of discussion on the migration network model of the bay area. Population means the consumption of energy and the pollution of environment, the demand of population migration for energy and the reconstruction of environmental structure should be the focus of current research, so new research methods and perspectives need to be introduced.

Based on the connotation, representation and existing research of population migration network, this paper makes a comparative static analysis of population migration flow in three time nodes of Beibu Gulf Urban Agglomeration by using the data of population migration relationship reconstructed by gravity model, and focuses on exploring the network characteristics and spatial structure attributes of population migration in this area, including migration intensity and coordination, migration shape. On this basis, the paper discusses the internal mechanism of the formation of population migration network of urban agglomerations, and provides a new perspective for the future development of Beibu Gulf urban agglomerations.

2. Model Construction and Data Sources

The population gravitation model is used to build the data system needed for network analysis. Because of the complexity of population migration itself and the difficulty of obtaining specific population migration data accurately, it is necessary to effectively estimate the population migration phenomenon according to the objective reality of urban agglomeration development. Gravity model is the first model used to measure population migration. With the impact of economic factors on population migration increasing, the population gravity model needs to consider the impact of economic factors. The specific formula is as follows:

\[ T_{ij} = K \frac{P_i \times G_i \times P_j \times G_j}{D_{ij}^b}, \quad (K = \frac{G_i}{G_i + G_j}, \quad i \neq j, i = 1, 2, 3 \cdots n, j = 1, 2, 3 \cdots n) \]  

(1)

Where \( T_{ij} \) represents the population attraction of city \( i \) to city \( j \), \( P_i \) and \( P_j \) represent the population scale of city \( i \) and city \( j \), \( G_i \) and \( G_j \) are the per capita GDP level of the corresponding city, \( D_{ij} \) is the shortest traffic distance between the two cities, \( b \) is the distance attenuation index. Taking into account the direction and difference of population gravity between cities, the city gravity parameter \( K \) is introduced to represent the unidirectionality of population gravity. By using this formula, the gravity matrixes of 12 cities in Beibu Gulf in 2004, 2010 and 2016, and the gravity magnitude between any two cities at three time points are calculated, and three \( 12 \times 12 \) matrixes \( Y_{ij} \) are obtained as the initial matrixes. According to the value of the initial matrixes, 100 is selected as the cut-off value point, and then the binary matrix \( Y'_{ij} \) is obtained, indicating whether there is population between each city node Migration status, so as to build the Beibu Gulf Urban Agglomeration population migration network data model.
3. Characteristics of Population Migration Network in Beibu Gulf Urban Agglomeration

3.1. Analysis on the integrity of population migration network

| Year | Network density | Correlation degree |
|------|-----------------|--------------------|
| 2004 | 0.0606          | 0.1515             |
| 2010 | 0.1667          | 0.8333             |
| 2016 | 0.3333          | 0.8333             |

From 2004 to 2016, the growth rates of network density and relevance are 0.2727 and 0.6818, respectively, which shows that the overall development of population migration network in Beibu Gulf Urban Agglomeration is rapid, the strength and connectivity of population migration network are significantly enhanced, and the corresponding energy demand and environmental structure efficiency have changed significantly. In terms of network density, although there is an increasing trend, the density value is still less than 0.5, indicating that some cities in the Beibu Gulf are in a weak migration state, and the energy and environment allocation efficiency is not high. From the perspective of relevance degree, the network relevance degree has reached 0.8333 by 2010. The overall correlation between cities is relatively high, which indicates that population migration exists in most cities, which is conducive to the coordinated development of the overall network, as well as the improvement of energy utilization efficiency and environmental pollution control in the future.

Use Netdraw drawing tool in UCINET to draw the network relationship intensity map between any two cities in Beibu Gulf Urban Agglomeration in 2004-2016, as shown in Figure 1:

![Network relationship intensity map](image)

**Figure 1.** 2004, 2010, 2016.

It can be seen from Figure 1 that since 2004, the lines in the population migration network have become increasingly dense, and the network density has gradually increased, indicating that the population migration intensity among the Beibu Gulf urban agglomeration has gradually increased, and the migration channels and directions have diversified. At the same time, the core node and the edge node are well-organized, and the migration flow of large-scale population is only formed among a few core nodes. Maoming, Fangchenggang, Zhanjiang, Nanning and Qinzhou are the main migration...
cities of Beibu Gulf city group, while the population of Dongfang, Yulin, Danzhou, Chongzuo and other cities is in a weak migration state, and there is a risk of marginalization. The change of node size of Fangchenggang is the most obvious, which shows that the population migration intensity between Fangchenggang and other cities is gradually increasing, its comprehensive energy utilization capacity is constantly improving, and the status of environmental governance is increasingly important. From the point of view of the connection strength, the population connection between Maoming and Zhanjiang, Fangchenggang and Qinzhou is the most close, which constitutes the two main lines in the migration network. Haikou and Zhanjiang, Yulin and Nanning, Yulin and Zhanjiang, Maoming and Yangjiang, Qinzhou and Beihai are closely related to each other, forming multiple sub main lines in the network. On the whole, the spatial distribution of population migration in Beibu Gulf Urban Agglomeration is not balanced, the migration network is increasingly prominent and tends to be stable, and the energy and environment pattern is constantly emerging.

3.2. Analysis on the centrality of population migration network
Considering the orientation and difference of population migration between cities, the direction of population migration in urban agglomerations is more detailed in terms of point in degree and point out degree. Point in degree indicates the degree of influence of node city by other cities in the urban agglomeration; point out degree indicates the intensity of node city’s influence on other cities in the urban agglomeration. As shown in Figure 2 and Figure 3:

Figure 2. Point out centrality
Figure 3. Point penetration centrality

In the vertical time contrast, the degree of point out and the degree of point in center of each urban node increased significantly, indicating that the degree of influence and affected, connection and connected among cities in Beibu Gulf Urban Agglomeration is deepening. In the horizontal comparison of cities, from the point of view of the degree of center, Zhanjiang, Maoming, Qinzhou, Nanning and other cities show significant characteristics of population inflow, which are the core cities of population inflow; Maoming, Zhanjiang, Fangchenggang, Nanning and other cities have a greater impact on other cities, which are the core cities of population outflow within the urban agglomeration, with a distinct level of population flow.

There is a strong positive correlation between the centrality of population migration network and the scale of urban economic development. Nanning and Zhanjiang are the most important growth poles in the Beibu Gulf region, with a good foundation for economic development, so there are the main city of population inflow and energy consumption. It is worth noting that there is a strong similarity between the point out centrality and the point in centrality. That is to say, the core city attracting population aggregation is also the main city of population diffusion. The diffusion effect and polarization effect are the same, forming the phenomenon of “aggregation and diffusion in one” in the Beibu Gulf Urban Agglomeration. This shows that the expansion of economic scale of each city has attracted a large number of population agglomeration, but also accompanied by the development of coastal economy. This makes the population continue to spread, which is related to the rapid economic development stage of the Beibu Gulf region in the strategic transformation. At the same time, Haikou
is located in Hainan Island, which is far away from other cities in the Beibu Gulf, so the center degree of point entry is relatively low, and it has not become the core city of population migration; the center degree of entry and exit of cities such as Dongfang, Chongzuo, Danzhou and Yangjiang are all in a low state. In order to prevent the risk of internal isolation and marginalization of urban agglomerations, it is necessary to focus on promoting the development of these areas and other cities within the urban agglomerations To strengthen the ability of environmental governance.

4. Concluding Remarks and Policy Implications
Firstly, the overall characteristics of the migration network of Beibu Gulf urban agglomeration are obtained from the network density and correlation degree. Since 2004, the network density and correlation degree of Beibu Gulf Urban Agglomeration have increased in varying degrees, which indicates that the population migration intensity among cities has increased year by year, and the energy consumption intensity has increased significantly. However, compared with the correlation degree, the network density is still in a low density state, indicating that although the economic contact channels and cooperation between cities are increasing day by day, the population migration network is not mature, and the environmental governance system has not yet formed. At the same time, the degree of network connection is unbalanced, which shows that the population migration between the core cities of Beibu Gulf Urban Agglomeration and the surrounding cities is relatively strong, but the connection between other cities is relatively weak, and the energy utilization shows a gathering trend. Secondly, according to the results of network centrality analysis, the population migration of Beibu Gulf urban agglomeration has distinct hierarchical characteristics. Zhanjiang, Maoming, Qinzhou and Nanning are the main cities of population inflow, and Maoming, Zhanjiang, Fangchenggang and Nanning are the core cities of population outflow, which shows that the spatial structure of Beibu Gulf Urban Agglomeration presents the phenomenon of "gathering and diffusing in one"; meanwhile, the trend of point out center decreases year by year and that of point in center increases year by year, which shows that the trend of population concentration is strong However, the trend of population divergence is weak, that is to say, there is a phenomenon of unbalanced spatial distribution of population in urban agglomerations. On this basis, this paper puts forward the following suggestions:

First, because economic factors are the main reason for population migration, the cities in the Beibu Gulf Urban Agglomeration that are lagging behind in development should pay attention to the economic connection with the core cities, explore the potential of economic growth, make full use of the diffusion effect of energy advantages and environmental governance advantages, and promote the integrated development of urban agglomeration. Second, we should pay attention to the construction of infrastructure such as transportation and communication among cities, reduce the relative distance between cities, and reduce various natural factors that hinder population migration and environmental governance.

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