Evolution mode of urban correlation in Yangtze River Delta under "Grade-Network" *

—— Analysis based on the big data of population mobility

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[Abstract] with the aid of space and space behavior big data, with urban "population flow" between the path, with "level + network" multidimensional superposition analysis for the research idea, in the "level-network" under the cognitive method of urban association, urban correlation evaluation standard and its scope of application after analysis, determine and established from the perspective of "level-network" cognitive urban relevance of concern and measure the relevance of urban correlation index system. At the same time, on the basis of optimizing the existing analysis means, the Yangtze River Delta urban agglomeration is taken as a sample to quantitatively measure the change of urban correlation index between 2015 and 2020, and further refine the six evolution modes of urban correlation in the Yangtze River Delta through hierarchical analysis and cluster analysis. Discovery: The overall urban agglomeration in the Yangtze River Delta shows a development trend of "weakened hierarchical structure" and "network correlation and stability"; The Yangtze River Delta urban cluster has formed within a relatively balanced hierarchical structure, Meanwhile, in the national population mobility network, In the Yangtze River Delta urban agglomeration, the cities that play an obvious role in population transport and transport are still a few provincial capital cities; From the perspective of the "level- -network" two-dimensional superposition, Cities in the Yangtze River Delta can be classified as " the highest correlation and stable correlation, Grade- -Network two-dimensional

equilibrium " in Shanghai and Suzhou, "The association is high and stable, Network dimension dominated " in Hangzhou and Nanjing; "The correlation is high but clearly volatile, Network dimension dominated " in Hefei, Wuxi, Jinhua and Ningbo, a total of 6 types.

[Key words] urban association; population flow; Yangtze River Delta; urban network; urban level

After the rise of network society, "flow space (space of flows)" has quickly become the object of "place space (space of places)" and quite concerned by researchers in urban geography. Scholars have carried out a long-term research on the urban system and urban attributes in these two types of space, and have formed two distinct research dimensions: "grade" and "network". As far as "urban association" is concerned, its connotation is basically consistent with the "spatial interaction (spatial interaction)" proposed by Haggett, that is, "the constant exchange of material, energy, personnel and information between cities".

As stated in Castells, the realistic background of urban development at this stage is "the interdependence and long-term coexistence of place space and flow space". In this background, there are a large number of scholars from the "level" and "network" two dimensions to cognitive urban correlation law and characteristics, and has formed a certain consensus, namely: hierarchical dimension and network dimension city association although the expression form and effective range will be different, but both for attention and measure the different direction of the city association state provides an effective path, also are currently cognitive and explore "urban relevance" must both important perspective. At the same time, in recent years, the scale of the floating population in China and the application of spatial and temporal behavior big data based on mobile location services have ushered in explosive growth, making "population flow" quickly become an important path to recognize the urban correlation at the present stage.

But from the perspective of the existing urban association research, due to the lack of common consensus, accurate and detailed reflect the inter-city population activities and population flow data, scholars or more through the traditional economic industry, social culture, infrastructure path of urban correlation measurement and research, or although the "population

flow" the effective research perspective, but still failed to focus on "level-network" urban correlation under the dual dimension difference and contact, also failed to "grade-network" dual dimension evaluation of urban correlation value standard and measurement method for clear and effective definition.

In short, the existing urban association studies also have some problems, such as the neglect of the short-term floating population, the lack of rank-network coupling research and the lack of dynamic analysis results. This paper is with the help of space and time behavior of big data, with "population flow" between cities as the path, with the level of network dimension superposition analysis as the research idea, optimize the existing analysis of the 2015-2022 in Yangtze river delta urban agglomeration urban correlation evolution dynamic research, and further explore the evolution of urban correlation mode, in order to explore the population flow law, rich city association research path, promote the development of Yangtze river delta regional integration to provide certain academic reference.

1 The The analysis of urban correlation under the two dimensions of "grade-network"

1.1 The cognitive method of urban association under the two dimensions of "rank- -network"

The cognition of urban correlation from the hierarchical dimension is mainly based on the "central theory" proposed by Christaller: the city represents the heart by providing goods and services externally and becomes the center of a certain region; while the lower center is controlled by the higher center and becomes the "supplementary area" of the latter. Thus, under the level dimension is mainly through "cities between different elements agglomeration degree and geographical proximity difference and compete with each other, and form the rights distribution structure" to build "vertical to urban association", its from high to low one-directional, asymmetric direction and span, with the distance attenuation obvious space characteristics, mainly used to affect the size of the urban system grade structure, and determine the rank of urban status and power size.

From the network dimension to cognitive urban association can refer to Castells for "network society" and "flow space" concept definition and analysis: economic globalization makes the city by providing different economic functions and perform their reciprocal effect into

the international production network, and make the relationship between the city from a simple "control-attachment" relationship to "collaboration, feedback and complementary" relationship. Thus, under the network dimension is mainly through "different elements flow frequency and contact channel attribute differences and mutual cooperation, and form the interaction coordination structure" to build "level to the city association" (also some scholars think that the perspective of the city association is narrow city network), with the hub node as the center of the directional direction and larger span, with the distance attenuation is not obvious space characteristics, mainly used to affect the urban system network structure, and determine the hub of urban strength relationship.

1.2 Evaluation criteria of urban relevance under the two dimensions of "grade-network"

So based on the above "urban relevance cognition method", from what aspects should the "relevance" of different cities be evaluated under the double dimension of "hierarchy-network"? The answer to this question can be found in the following theories and empirical examples.

1.2.1 Evaluation criteria of urban relevance under the grade dimension

In the hierarchical dimension, based on the central theory of Christaller, the researchers further extend the connotation of the "center" of the city, and jointly measure the strength of the correlation with the "centrality" and "control force" of the city and the role of the city in maintaining the stability of the hierarchical structure.

"Centrality" actually represents the city's ability to pool resources in the urban system, Because the hierarchical correlation is mainly constructed through "hierarchical control", Therefore, a city's "ability to gather resources" also includes two aspects: First, The resource scale directly occupied by the city itself, —— From the perspective of population mobility, The scale of resources directly occupied by cities can be achieved through its direct occurrence / attraction of " total population mobility (quantity of population, Qi) " to measure; 10 Second course, Cities by taking control of the other cities, And then indirectly occupy the scale of resources, In the existing studies, Scholars are mainly based on Neal's " transformation centrality (alt-based centrality, ACi) " algorithm to carry out empirical analysis and measurement.

"Control force" represents the ability of cities to control the flow of resources in urban

systems, and the empirical study in this aspect began with the concept of "alter-based power (API)" proposed by Neal. Compared with centrality, control emphasizes the "dependence" of a city and the potential influence on the resources in the urban system. The control of a city is mainly determined by the position of the city in the hierarchical system.

In addition, Christaller and Zipf based on urban "sequence-scale" relationship to build the "city scale-number of power law distribution" "pyramid" type ideal urban architecture, in the urban system, any city with other cities "sequence gradient (rank gap, RGi)", the more likely to be close to the urban system "at the top of the pyramid", is more scarce, more indispensable object on structure, to "maintain the stability of the urban system of hierarchical structure" is also more important.

1.2.2 Evaluation criteria of urban relevance under the network dimension

In the network dimension, the researchers put forward the evaluation criteria of urban correlation, which are obviously different from the hierarchical dimension: judging the relevance of cities through the ability of urban communication flow elements, the influence of cities on factor flow, and the role of cities in maintaining the stability of network structure.

The ability of urban communication flow elements: Wasserman and other scholars point out that the ability of the transmission flow elements of a node in a network is mainly affected by two aspects: one is the " close centrality of the node in the network (closeness centrality, CCi)" big or small, That is, the more close a node is to the other nodes, The easier it is for it to convey information; The second is the " correlation equilibrium between the node and other nodes in the network (link balance, LBi) " level, That is, the more direct, balanced and diversified the association path of one node and other nodes is, The more likely the node is to play a greater role in the propagation process of the flow elements.

The impact of cities on factor flow: Burt first noticed this in his study of "structural holes", Freeman Given the " intermediate centrality (betweenness centrality, BCi)" metric, That is, by measuring the frequency of a node in the shortest path between pairs of other points to describe the influence of the node on the flow of elements in the network, Among them, the network nodes with high intermediate centrality are in many correlation paths, With information

advantages and control advantages, It is therefore more likely to have a significant impact on the flow of factors in the network.

The role of cities in maintaining the stability of network structure: From the perspective of the stability of network structure, scholars point out that the importance of nodes should be reflected in the role of nodes in maintaining the stability of network. For a node in the network, the more the number of associated paths with other nodes, and the higher the "node correlation degree (point connectivity, PCi)" in the network, the more obvious the role in maintaining the stability of the network structure.

1.2.3 Summary

In a word, under the hierarchical dimension / network dimension, "three research concerns" and "four correlation indicators" can be used as the criterion layer and the index layer respectively to construct the hierarchical hierarchical structure to measure the urban relevance.

1.3 Urban relevance under the two dimensions of "level- -network"

The scope of application is just as Christaller emphasizes that "the central area often only plays a central role in a certain area", the urban association in the hierarchical dimension is often relatively introverted and formed in the existing settlement; from Castells, " the network in the urban dimension is basically not restricted by the administrative / geographical boundary, showing a strong extraversion, which enables the city to connect with the vast space outside the settlement. Coincidentally, in recent years, many scholars at home and abroad also take "beyond geographical proximity" and "non-local connection" as the basic characteristics of urban association under the network dimension when discussing the urban association and urban system from the perspective of network.

Therefore, in the discussion of urban relevance under hierarchical dimension, the scope of research and analysis should focus on the internal space of an urban system; in the network dimension, the internal space of an urban system should be taken as the research scope, and the external space associated with the urban system should be included in the scope of research and data analysis.2 Study design

2.1 Study data

The data related to population mobility used in this paper is obtained from two platforms: "Tencent Location" and "Baidu Migration", The data records the same object (all are 337 prefecture-level administrative regions except Sansha City), The coverage time is different (due to the data interface shutdown, The data used in this paper are respectively: provided by Tencent platform, Population mobility data from 2015 to 2019; Provided by the Baidu platform, Population mobility data for 2019-2022), Therefore, this paper converted the two types of data through the intersection interval of the two platforms, And unified its granularity, Finally, the relevant records of the daily and successive flow direction (including inflow and outflow), and the top ten other cities with the heat of population flow are obtained.

2.2 Research methods and technical routes

Centering on the urban correlation in the Yangtze River Delta under the "hierarchical dimension" and "network dimension", the hierarchical hierarchical structure is constructed through "three research concerns" and "four correlation indicators" respectively. In the following, following the idea of "hierarchical analysis" to solve the problem of correlation size and change in the dimension of "level-network", further the "cluster analysis" method will be introduced to refine the correlation evolution mode of the cities in the Yangtze River Delta.

The technical route of this paper is specific as follows: First, Analyze the evolution of various correlation indicators in the Yangtze River Delta cities from 2015 to 2022; second, Weting and stacking the correlation indicators of each city through hierarchical analysis, The "rank / network dimension correlation" over the years; third, Based on the "rank / network dimension correlation" of each city over the years, Extract the evolution mode of urban relevance in the Yangtze River Delta under the grade dimension and network dimension through cluster analysis; fourth, Then the evolution mode of the Yangtze River Delta city correlation under the hierarchical dimension and network dimension, So as to summarize the evolution mode of urban correlation in the Yangtze River Delta from the perspective of "rank-network".

3. Analysis of the evolution characteristics of the urban correlation index in the Yangtze River Delta

Yangtze river delta urban agglomeration not only city number more, different cities correlation change pattern also have big differences, so the following in the analysis of index evolution, are respectively to the indicators of "change process analysis (i. e., identify the cities in '2015-2022' the continuous time sequence change pattern)" + "change results analysis (i. e., compare the cities in '2015' and '2022' two time node index size)", to more comprehensive detailed grasp the evolution of the Yangtze river delta city correlation index.

3.1 Evolution characteristics of urban correlation indicators in the Yangtze River Delta under the grade dimension

3.1.1 Urban correlation index system in the Yangtze River Delta under the grade dimension

According to the previous summary of "measuring the hierarchical hierarchical structure of urban correlation under the hierarchical dimension". The following index system is used to quantitatively measure the urban correlation in the Yangtze River Delta under the "grade dimension". It should be noted that the traditional algorithms of "transformation centrality" and "transformation control" in the table both default that the relationship between cities is "equal two-way correlation", which leads to the algorithm will inevitably trigger infinite loop operation. Therefore, this paper first judges the "control / attachment" relationship between any two cities, and then screens the "control object" of the measurement city to participate in the calculation of ③, so as to ensure that the calculation logic fits with the "hierarchical control relationship" under the hierarchical dimension.

3.1.2 Evolution characteristics of urban correlation indicators in the Yangtze River Delta under the grade dimension

In general, the "grade dimension correlation indicators" generally show the changing process characteristics of "large fluctuation and fierce competition among cities" and "the indicators of economic strong city are generally reduced, and the indicators in small and medium-sized cities are generally increased in term". This shows that from 2015 to 2022, the attraction of the stability of hierarchical structure in the functions and functions of small and medium-sized cities are growing, which also leads to the development trend of "equalization" in the Yangtze River Delta region.

Specifically, in addition to the "total population flow", which has maintained a "relatively stable hierarchical relationship" for a long time, the other three indicators all show a changing trend of "obvious gap between cities at different levels, fierce competition among cities within the same level, and the differences between cities narrowing over time".

In the index of "total population flow", "Shanghai, Hangzhou, Suzhou and other economically strong cities take the way, and small cities such as Zhoushan and Chizhou are relatively backward" has been maintained for a long time. This shows that different cities in the Yangtze River Delta have formed a clear and solid hierarchical relationship based on the difference in the scale of population flow.

In the index of "transformation centrality", the change trend of "the intensity of high school heart city decreases and the intensity of low central city increases" is very obvious. This shows that in terms of "the ability to connect other cities and gather resources", the economic strong cities in urban agglomerations are generally weakened, while most small and medium-sized cities have improved.

In terms of the index of "transformation control", "Shanghai, Suzhou, Hangzhou and other economically strong cities are the first tier, while other small and medium-sized cities are the second tier. The internal competition of each tier is fierce, and the gap between the two echelons is gradually narrowing" is quite significant. This shows that the cities with the improved ability to "control resource flow" in the Yangtze River Delta urban agglomeration are mainly small cities with weak economic strength and late development start. In addition, with the passage of time, the hierarchical relationship between different cities based on the difference in the intensity of transformation control is gradually weakening.

"Position order gradient" this index presents "Suzhou, Hangzhou, Nanjing and other economic strong city for the first tier, Jiaxing, Changzhou for the second tier, other small and medium-sized cities for the third tier, each echelon internal competition is fierce, different echelon overlap between few" change, and the similar to the indicators, "rank order gradient rise city not only less, and in 2015 the order gradient is generally low" this feature is also very obvious. This shows that the gap in the scale of population flow between different cities in the Yangtze

River Delta urban agglomeration is gradually narrowing, and the "role of maintaining the stability of hierarchical structure" in most cities is gradually declining, but the hierarchical relationship between different cities based on the order gradient is always "obvious differences between levels and fierce competition within the levels".

3.2 Evolution characteristics of urban correlation indicators in the Yangtze River Delta under the network dimension

3.2.1 Urban correlation index system of the Yangtze River Delta under the network dimension

According to the above summarized "hierarchical structure of urban correlation under the network dimension", the following index system quantitatively measures the "urban correlation in the Yangtze River Delta under the" network dimension ". It should be noted that because the intercity flow network constructed in this paper belongs to the "directed weighted network", the "accessibility" between any two cities can not be judged simply by the "unmanned flow connection between the two cities" when calculating the "node correlation degree" in Table 2. Considering the special features of cognitive urban association under the network dimension (emphasis on two-way connection, Reflect the collaboration between the cities), It can be stipulated that the "two accessible cities (take cities i and j for example)" in the intercity flow network constructed in this paper should meet the following two standards at the same time: First, There is a two-way population mobility association between the two cities, And the Rij> min R, Rji> min R, Min R is the mean value of the flow scale of people between all cities; 10 Second course, For the scale of population flow between two directions (Rij, Rji) between the two cities, If Rij> Rji, Rij <2 Rj should be met; in like manner, If Rji> Rij, Rji <2 Rij should be met.

3.2.2 Evolution characteristics of urban correlation indicators in the Yangtze River Delta under the network dimension

Overall, the "network dimension correlation index" generally presents the "small volatility" "tail difference" the change process characteristics and "the gap between different cities is always relatively stable" the change of the result characteristics, it shows that in 2015-2022, the Yangtze river delta cities in the national network for the spread of population flow, influence ability and maintain the stability of the network structure have not changed significantly.

Specifically, the two indexes of "intermediate centrality" and "node correlation degree" both show the characteristics of "large difference between different cities and significant grade differentiation", but the two indexes of "close centrality" and "correlation equilibrium" show the state of "the difference between different cities is not obvious".

"Close to the centrality" although present "high school heart city intensity reduction, low central city strength" difference of variation, but also long maintained "Shanghai, Hangzhou as the first tier, Nanjing, Suzhou for the second tier, Ningbo, Hefei, Wuxi, Jinhua for the third tier, other cities for the fourth tier, the echelon internal occasional competition, between different echelon completely not overlapping" classification characteristics. This shows that the difference between "distance and other cities in the network" among cities in the Yangtze River Delta is narrowing, but the hierarchical relationship between cities based on the difference of proximity centrality intensity is always relatively stable.

"Linkage equilibrium" shows a relatively distinct change state of "Nanjing, Hefei, Hangzhou and other economically strong cities take the lead for a long time, while small and medium-sized cities such as Xuancheng and Yancheng gradually catch up". Meanwhile, the change trend of "the intensity of high correlation equilibrium and the increase of low correlation equilibrium" is also obvious. This shows that with the increasing dependence of the strong economic cities in the Yangtze River Delta urban agglomeration on other cities in the network, and the decreasing dependence of small and medium-sized cities on other cities in the network, the advantages of the strong economic cities in the Yangtze River Delta urban agglomeration in the "balance of correlation path" are shrinking.

In terms of the index of "intermediate centrality", "Shanghai and Hangzhou are the first echelon, Nanjing and Suzhou are the second echelon, Ningbo and Hefei are the third echelon, and other cities are the fourth echelon. There is occasional competition within each echelon, and different echelons do not overlap at all" has been maintained for a long time. This shows that under the network dimension, the difference of the influence ability on the flow of elements among cities in the Yangtze River Delta is always very obvious, and the hierarchical relationship based on this is always clear and stable.

In the index of "node correlation degree", most cities have improved to a certain extent. At the same time, we can clearly observe the inter-city difference of "Shanghai is far ahead, Hangzhou, Nanjing and Suzhou follow and have fierce competition, while other cities maintain a significant gap with the above four cities for a long time". This shows that the number of correlation paths between cities in the Yangtze River Delta and other cities in the network is gradually increasing, but the cities that play an obvious role in maintaining the stability of network structure " are still a few economically strong cities in the urban agglomeration.

4. Refining the evolution mode of urban relevance in the Yangtze River Delta

4.1 The evolution mode of urban correlation in the Yangtze River Delta under the subdimension

As the basic link to refine the evolution mode of urban correlation in the Yangtze River Delta, hierarchical analysis (AHP) is needed to quantitatively evaluate the correlation strength of urban nodes in the Yangtze River Delta —— The judgment matrix is constructed according to the previous hierarchical model, and the weight of each level factor should be determined through the expert scoring method. On this basis, for any city i in the Yangtze River Delta urban agglomeration, its correlation indicators can be weighted and superimposed, thus obtaining "urban correlation in Yangtze River Delta (DCCPi) in grade dimension" and "urban correlation in Yangtze River Delta in network dimension (NCCPi)":

$$DCCPi = 0.356Qi + 0.258ACi + 0.268APi + 0.117RGi \quad (1)$$

$$NCCPi = 0.314CCi + 0.18LBi + 0.249BCi + 0.257PCi \quad (2)$$

Since "evolution" involves not only the magnitude of the association, Also are closely related to the changing state of the association itself, Therefore, for any city in the Yangtze River Delta, To further calculate the "association size (DCCPavgi / NCCPavgi)" in the rank / network dimension (i. e., the mean correlation of city i between 2015-2022) and the "change of association (DCCPdifi / NCCPdifi)" (i. e., the difference between the city i "2022 association" and its "2015 association"), After standardizing the above data separately, Systematic clustering analysis was performed by the SPSS analysis platform.

Based on system clustering pedigree diagram, compare the Yangtze river delta city "divided

into five categories" and "divided into four categories" of two "gap" (i. e., d1, d2), under the level dimension of Yangtze river delta city correlation evolution pattern refined into five types, the network dimension of the Yangtze river delta city correlation evolution pattern refined into four types.

4.2 Refining of the evolution mode of urban correlation in the Yangtze River Delta from the perspective of "Level-Network"

Will refine above points under the dimension of Yangtze river delta urban correlation evolution pattern, on the basis of the analysis of the city correlation size and its changes of further into and compare "level-network" the dominant relationship between ⑥, thus the different evolution pattern and its corresponding urban characteristics finally summarized as follows.

Associated and stable, level-network dual-dimensional equilibrium (corresponding to Shanghai, Suzhou): this part of the city under the "level-network" dual dimensional correlation are long-term ranks in the top, its not only as a long-term population distribution within the highest level of the center, is also guarantee the smooth flow of population across the country indispensable nodes.

High correlation and stable correlation, network dimension dominant (corresponding to Hangzhou, Nanjing): the part of the city correlation also remain at a high level, even under the network dimension and Shanghai, Suzhou belong to the first echelon, but under the level dimension and the two cities still has a certain gap, visible this part of the city is not only the population distribution of the second center, in the national population flow function is the most important one of several key nodes.

High correlation but obvious fluctuation, network dimension dominant (corresponding to Hefei, Wuxi, Jinhua, etc.): this part of the city correlation is relatively stable at a high level, especially under the network dimension and Hangzhou, Nanjing city, but there is still a big gap under the level dimension, this part of the city belongs to the population of the tertiary center, at the same time across the country is to ensure the smooth flow of secondary important nodes.

Correlation has a higher starting point but gradually lower, level dimension dominant

(corresponding to Changzhou, Yangzhou): this part of the city under the network dimension correlation is not high, and the level dimension of correlation was once ahead of Jinhua and Ningbo, but with the passage of time also gradually lower, this part of the city was population within the tertiary center, but its central level gradually decreased over time, at the same time with the Yangtze river delta urban agglomeration population exchange between long short board, in the status and role in the inter-city people network is not highlighted.

Low correlation but have obvious growth, grade dimension dominant (corresponding to Yancheng, Taizhou, Xuancheng, etc.): this part of the city correlation level although close to the end, but in 2015-2022 have substantial growth (especially the grade dimension more obvious), this shows that this part of the city in the center of the level is not high, but has shown obvious growth trend, have become the center of the third urban agglomeration, and its population exchange with the Yangtze river delta urban agglomeration has obvious defects, is the most common node in the national traffic network.

Lowest and stable correlation, level-network dual-dimensional equilibrium (corresponding to Jiaxing, Zhoushan, Anqing, etc.): this part of the city correlation is located at the end for a long time, not only change over time, and under the "level-network" any dimension of lack, visible this part of the city not only in the ability to absorb population is weak, and the Yangtze river delta urban agglomeration city population exchange is less active, in the hierarchical system of urban agglomeration and nationwide flow network are the most members of the "popular".

5 Conclusions and discussion

5.1 Conclusion

In this paper, "population flow" between cities as the cut path, with "grade-network" multidimensional superposition analysis as the research idea, on the basis of theoretical analysis on the established from the perspective of "level-network" under the focus of cognitive urban relevance and measure of urban correlation index system, and the Yangtze river delta urban agglomeration in 2015-2020 "grade-network" under the dual dimensions of urban correlation evolution after analysis, draw the following conclusions:

① In terms of the change characteristics of correlation indicators, under the grade

dimension, cities show the change characteristics of "the difference of correlation intensity of different cities narrowing over time"; in the network dimension, the correlation of cities in the Yangtze River Delta generally shows the change characteristics of "small fluctuation range" and "little difference" —— The development trend of "weakened hierarchical structure" and "stable maintenance of network association".

② In terms of the evolution pattern of correlation under different dimensions, Under the hierarchical dimension, The evolution mode of the correlation of cities in the Yangtze River Delta is not only many types, And the number of different types of cities is also relatively close, At the same time, cities with high correlation generally gather in the belt of "Nanjing- -Changzhou- -Wuxi- -Suzhou- -Shanghai" around ——, which not only shows that the Yangtze River Delta urban agglomeration has formed a relatively balanced hierarchical structure, It also proves that large cities with a relatively large population and concentrated capital and technology can indeed have a positive radiation effect, And then drive the development of the surrounding cities; Under the network dimension, The evolution pattern of correlation in the Yangtze River Delta is not only less types, And the number of different types of cities also varies significantly, At the same time, the highly correlated cities are generally provincial capitals, municipalities directly under the central government and other economic center cities, There is no obvious agglomeration trend in space, This means that in the national population mobility network, In the Yangtze River Delta urban agglomeration, the cities that play an obvious role in population transport and transport are still a few provincial capital cities.

③ From the perspective of "level + network" two-dimensional superposition, Yangtze river delta city in 2015-2022 correlation evolution pattern can be divided into six types, it is worth noting that on the level-network leading relationship "network dimension" city is generally large population, urbanization level higher economic city, considering the population flow actually represents the capital, information, technology and other elements of the flow and change, it is not hard to judge the current city if intention to solid or enhance the level of economic development, must actively integrated into the national and even a wider range of factor exchange and production network.

5.2 Discussion

If in this paper by the "model refining" six types of city as the basis, the follow-up research can further explore the "correlation size and change" and economic, social, environment, "external factors" between the correlation, and further induction "level-network" under the perspective of Yangtze river delta city correlation evolution mechanism.

In addition, this paper takes the urban population flow as the construction path of urban association, and discusses the change of urban correlation, the subsequent research can construct the urban correlation based on the traditional correlation elements such as infrastructure, economic industry, society and culture, and understand the evolution of urban correlation from the above perspective; in addition, due to the limitation of data sources, this paper cannot eliminate the influence of the rural floating population on the "urban correlation". The above contents can be further studied further, but it does not affect the reference significance of the conclusion of this paper.