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Study on the Coupling Mechanism of Urban Spatial Structure and Urban Traffic Organization

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Abstract

From the angle of the high relationship between the traffic organization and urban spatial structure, the geographic concept, coupling, was proposed in the article, and the coupling mechanism of urban spatial structure and traffic organization was studied primarily based on the analysis of the connotation of the coupling, and the coupling function of main associated factors between the urban spatial structure and traffic organization was analyzed.

Keywords: Urban spatial structure, Urban traffic organization, Coupling mechanism, Factor coupling

There were many relative researches about the urban spatial structure and traffic organization in the world, and the general opinion was that the close relationship existed between the urban traffic system and the urban land utilization, and selective analysis was made for the relative factors (Cervero, 2003, p145-163), or the development mode was proposed (Filion, 2007, p501-524). Some scholars further proposed that the cycle function of mutual association and restriction should exist between two parties, and both feedback loop and the empirical research result were proposed (Yan, 2004, P.643-652 & Mao, 2004, P.76-80 & Yan, 2006). These opinions all reflected the close relationship between the urban space and the traffic organization. From the research angle of long term, the coupling between the urban spatial structure and the traffic organization will be analyzed based on above research direction.

1. Definition and connotation of the coupling of urban spatial structure and traffic organization

1.1 Definition of the coupling of urban spatial structure and traffic organization

The coupling of urban spatial structure and traffic organization is defined by the phenomena that the urban traffic organization (including traffic structure and traffic space organization) and the urban structure join up because of high association (Han, 2007). The result of coupling can not only generate the material entity, but reflect the characters of immaterial flow. Based on that, the coupling development mode of urban spatial structure and urban traffic organization means the development mode which uses the coupling relationship between urban spatial structure and traffic organization for references, takes the mutual supported harmonious status of traffic organization and urban spatial structure as the target, improves the mutual cooperation of urban spatial structure and traffic organization, and accordingly realize the orderly development of urban space.

1.2 Connotation of the coupling of urban spatial structure and traffic organization

The coupling has the meanings in time and space. For the space, the fully combining and closely allocating of urban centers and main traffic nodes in the space distraction are the spatial premise to realize both coupling efficiency. The road organizations formed by different traffic vehicles make the framework of urban spatial structure. The change of traffic vehicles also makes the quick development of the suburb impossible, and the underground, overhead high speed roads and ground overpasses make the town space develop from the plane to the solid.

For the time, the coupling state of leading traffic mode and urban spatial structure through traffic infrastructures (including stations and road networks) needs longer time, i.e. the close allocation of traffic infrastructures and urban

nodes makes the leading traffic mode and urban spatial structure gradually form mutual supported state. In addition, the transformation from one kind of coupling state to another kind of coupling state is not transilient (Pan, 2002, P.17-40), so facing many obstacles from economy, society, technologies and politics, the transformation of coupling needs a quit long term to be gradually realized.

2. The coupling mechanism of urban spatial structure and traffic organization

2.1 Urbanization is the essential reason of the traffic mode change

When the urbanization process develops to certain degree and the extension of urban scale achieves certain extent that the urban economic living can only be ensured by the traffic vehicles, the interior urban traffic system can be generated, and corresponding traffic vehicles will occur and gradually develop (Liu, 1998, P.78-83). One important aspect of continual urbanization is that the population centralizes to the city continually, and the high population density will occur gradually, which will certainly increase the traffic demand to large extents. When the demand and supply of traffic achieve certain degree, original traffic mode will not adopt the sustainable develop of the city, and the advancement of the traffic technology will be extended extensively, and new traffic mode will replace the old traffic mode and reduce the pressure of the traffic demand.

2.2 Urban spatial structure decides the spatial distribution of the vested traffic mode and traffic network to large extents

The urban spatial structure is formed under the principle that the sites with different urban functions are distributed in certain space, and human traffic flow is the transfer in different functional sites. Therefore, the urban spatial structure decides the flux, flow and mode selection of human trip, and further decides the mode composing of urban traffic and the organization base of traffic space. The general urban traffic organization mode is to adopt the mass public traffic mode in the main direction of human trip, design the urban trunk road and bus routes, set up bus stations and the transport hubs of various vehicles transfer in the centralized functional sites, and perfect the urban traffic network. Once the urban functional space changes, the spatial allocation of various functional cites will change, and the happening cites, attracting cites, happening intension and attracting intension of original residents' trips will change, so the flow, flux and mode selection of trip will change, which will break original traffic balance and form new traffic balance. Therefore, the urban functional allocation mode is the base to form the urban traffic organization mode, and it can provide the development space and the objective necessity of the urban traffic organization. The change of urban functional allocation mode objectively requires the use of advanced traffic mode and the development and perfection of traffic spatial organization (such as the extension of bus lines, the increase of road net density and the perfection of infrastructure), and drives the change of the urban traffic organization mode.

Different traffic modes require different spatial organizations. The car traffic mode requires that the road construction is the first factor, so this mode can be utilized in any cities, but the distribution of the trunk roads should be consistent with the main passenger flow. MRT needs high requirement of infrastructure construction, and large construction costs, and sufficient passenger flow to support the management costs, so this mode can only be adopted in the cities with large passenger flow and good economic development level. So the spatial allocation of MRT stations will be largely influenced by the allocation of the nodes with large passenger flow in the urban spatial structure, and accordingly influence the line allocation of MRT.

2.3 Urban traffic organization will largely influence the urban spatial structure

First, when the traffic mode is confirmed, the extension of the urban space is limited and perfect traffic spatial organization will make the space flow more free, so the traffic accessibility of the geographical shift will be changed. Because of different geographical requirements of different urban functions, the change of traffic accessibility can decide the advantage and disadvantage of the urban micro geography, and decide the geographical shift selection of the functional sites on the micro layer, and further instruct the spatial distribution of urban functions, and strengthen or adjust original urban spatial structure. Second, the advancement of traffic mode provides technical premise for the spatial extension of urban function, and makes people arrive to farther places in the same time, which equals to reduce the spatial distance between two places. Under the situation that the traffic mode changes, perfect traffic spatial organization works in traffic mode, which can influence the geographical shift selection of functional sites through changing the geographical traffic accessibility in the larger spatial range, and redistribute and recombine urban economy, culture and business, and lead the spatial centralization and diffusion of different urban functions, and finally improve the formation of new urban spatial structure.

Of course, different traffic mode will generate completely different influences to the urban spatial structure. For example, comparing the car traffic and the MRT, the "door to door" advantage of the car traffic makes its regional accessibility far higher than MRT, and MRT is completely restrained by the spatial distribution of infrastructure. Therefore, the car traffic mode can make the urban nodes to be distributed in broader space. The classic geographical shift theory can better explain the relationship among different land utilization functions and intensions and different traffic geographical shift grads. In the function of land utilization economic cost, it is a necessary tendency to develop

the far low-density land with low land utilization cost.

Comparing with the "freedom" brought by the car traffic, MRT can follow people's mentality including convenient trip and few transfer, and successfully restrict more people around the station, and make the urban space to be extended with high density when it bring people accessibility. Taking the development of business center and track traffic as the example, based on the influence of traffic accessibility, the urban space has the self-organizational space character and relative effect around the station (the optimal site of traffic accessibility), and as the traffic geographical advantageous region, the urban center node is also the region with high-intention development centralizing many non-habitation functions such as business and office. MRT cam mainly fulfill the mass transport demands which can not be fulfilled by the general traffic because the urban center node is developed by the high-intention, and it can provide effective infrastructure support of the urban center, especially improve the development of the retail function of the urban center. On the one hand, the passenger flow in the stations of MRT is abundant, which can bring sufficient business passenger flow for the business center and improve the development of business. On the other hand, the stations of MRT couple with various urban nodes, which can provide passenger flow for MRT and ensure the normal operation of MRT. For example, the stations of MRT combine with various urban centers, and the traffic network can fully integrate with the urban public center network system, and the coupling region of each station will be the important node in the whole spatial structure system, and each node can be the comprehensive platform to offer high accessibility, and the advanced public service establishments with different classes (including business and office) will be allocated in this region at the same time.

From above analysis, the urban spatial structure and the urban traffic have the relationship of interactive feedback (seen in Figure 1), and in the long development process of the city, both parties harmonize continually and finally form different development modes with different characters by coupling. The usual mode is the mixed mode integrating the "low-density development-car traffic" mode with the "high-density development-public traffic" mode, and at present, many Chinese cities are trying to turn from the mixed mode to the "high-density development-public traffic" mode.

3. The coupling functions of main associated factors between urban spatial structure and traffic organization

The association of urban spatial structure and urban traffic organization roots in the spatial difference of traffic demand and supply, which also decides some factors in the urban spatial structure directly associates with some factors in the urban traffic organization.

3.1 Point-point coupling: the coupling of the urban functional sites distribution and the traffic infrastructure distribution in the center city zones

People flow in various functional sites and perform different activities in different functional sites, such as home, work site or school. The spatial distribution difference of functional sites decides the spatial difference of traffic demand, so in the process that the supply fulfills the demand, the spatial difference of the high traffic demand in the center urban region and the traffic demand distribution will certainly make the traffic infrastructure to be allocated in the geographical shift with large passenger flow, which will largely influence the public traffic station and junction with large passenger flow. The geographical shift of traffic infrastructure usually is the distributing center of passenger flow, so the spatial distribution of traffic infrastructure will strengthen or adjust the spatial distribution of functional sites in reverse.

3.2 Line-line coupling: the coupling of the urban spatial extension direction and the traffic infrastructure oriented function

High-density population in the quick urbanization term makes the urban centers can not bear the heavy load, and generate the demand to extend to the exterior. The urban extension possesses reasonable direction, but its function and population redistribution must depend on the directional function of traffic infrastructure, and only convenient traffic can attract large numerous of population diffuses along the ideal layout direction of the city. Therefore, the extension direction of urban space decides the extension direction of traffic infrastructure, and the leading function of traffic infrastructure is also the necessary measure for the effective extension of the city.

3.3 Face-face coupling

First, it is represented by the coupling of the urban spatial extension scale and the accessibility of traffic technology. The innovation of traffic technology offers the feasibility for the urban spatial extension, and the physical accessibility of traffic technology objectively decides the reasonable space of the urban extension on the technical layer, i.e. the urban spatial scale. And the extension degree of the urban space decides the actual accessibility of traffic technology. In the process that the urban space is continually extending under the support of traffic technology, the physical accessibility is gradually turning to the actual accessibility.

Second, it is represented by the coupling of the urban land development density and the traffic infrastructure network. Different land development densities decide the spatial differences of traffic infrastructure networks. In the process of

urban spatial extending and structure recombining, the different demands of the leading traffic mode to the passenger flow will decide the spatial distribution of traffic infrastructure network, and influence the land development density.

Third, it is represented by the coupling of the urban functional allocation and the urban traffic organization. In a long development process, the urban functional sites will form the urban functional allocation which is the base to form the urban traffic organization mode. At the same time, the urban traffic organization mode will restrict and lead the urban functional allocation (Han, 2007, P.106-110).

4. Conclusions

In a word, the urban spatial structure respectively associates with relative factors of urban traffic organization (the distribution of center traffic infrastructure, the leading function of traffic infrastructure, the accessibility of traffic technology and the traffic infrastructure network) from four aspects including the distribution of urban functional sites, the direction of urban spatial extension, the scale of the urban spatial extension and the development density of urban land (seen in Figure 2). The interactive feedbacks of these factors in a long term are performed simultaneously, and in the mutual coupling process of these factors, the coupling of urban spatial structure and urban traffic organization can be formed and perfected.

China is in the period of economic transformation, and the urban development mode and the traffic mode are in the transformation correspondingly. To reasonably and orderly develop Chinese city and traffic, it needs to study the coupling mechanism of urban spatial structure and traffic organization, and grasp the coupling function of associated factors, which will certainly improve the coupling development of Chinese urban development and traffic construction.

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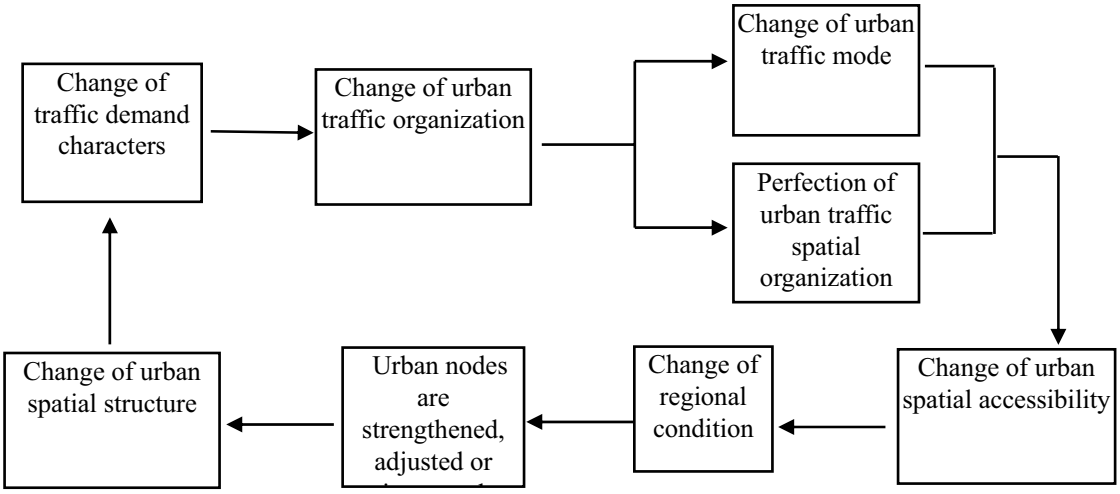

Figure 1. The Coupling Mechanism of Urban Spatial Structure and Urban Traffic Organization

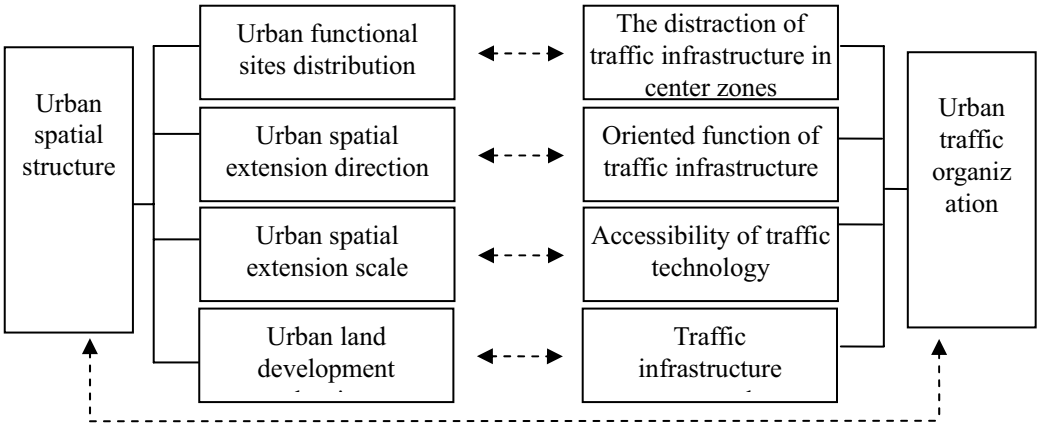

Figure 2. The Coupling of Main Factors between Urban Spatial Structure and Urban Traffic Organization