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# Interaction Mechanism Study between Urban Transportation and Land Use on Multi-dimension

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***Abstract:*** *The research on the interaction between Urban Transportation and Land Use has always been a research hotspot, but we ignore the factors other than Urban Transportation and Land Use factors to a certain extent. The interaction between Urban Transportation and Land Use is a complex giant system. The whole system moves, develops and changes under unbalanced conditions. Due to the continuous changes of population, economy and environment, the correlation between various elements becomes more and more vague and complex. Practice shows that the interaction between the two is affected by external factors. These elements include urban entity elements and non entity elements of the city. This paper combs the factors affecting the interactive relationship between Urban Transportation and Land Use, and summarizes the main influencing factors. Analyze the impact of other factors on Urban Transportation and Land Use from different dimensions, and find the law of interaction. Through this study, it provides reference for the quantitative interaction between Urban Transportation and Land Use.*

***Keywords:*** *Land Use; Urban Transportation; Interaction Mechanism; Multi-dimension*

## 1. Introduction

The research on the interaction between Urban Transportation and Land Use has always been a research hotspot in this field. Among them, the model research based on Urban Spatial Form can be traced back to 1964, and Lowry Model is very representative [1]. In the following 20 years, some scholars further improved and developed the Lowry Model and integrated some elements of other dimensions. Among them, the representative comprehensive models include: the Land Use and Transportation Integration software package ITLUP [2] [3] [4] proposed by Putman et al. (1984-1996), the LILT Model developed by Mackett (1990, 1991) [5] [6], and the MARS Model proposed by Pfaffenbichler et al. (2010) [7].

For the impact research of economic and demographic dimensions, the Competitive Rent Network Balance Model established by Justin and Roger (2006) is used to adjust the competitive rent network balance of the relationship between transportation and residential location [8]. Zhang Fanghua (2018) suggested that in the process of coordinated optimization of Transportation Planning and Land Use, urban land and transportation development planning strategies should be formulated in combination with the characteristics of the city, taking into account the overall urban spatial layout and reasonable guidance [9]. Li Xiangmei (2019) proposed to formulate transportation and land development strategies and implement urban traffic zoning management in combination with the city's own characteristics, and believed that strengthening the mixed use of land can promote the positive feedback relationship between the two[10]. Many of the above studies pay more attention to the quantitative research of urban transportation and land use, and ignore the factors other than urban transportation and land use factors to a certain extent. Individual scholars have conducted multi-dimensional comprehensive research. For example, Dong Jun (2016) creatively built a Multi-dimensional Structure Model System covering the city with space as the core through semantic network modeling, and incorporated many deduction and analysis tools into the planning work of many aspects of the city[11], including Urban Transportation, Land Use, Landscape Architecture[12], Social Culture[13] , Cultural and other comprehensive element systems[14].

For a long time, Urban Transportation, as a key factor determining the form of Urban Land Use, often plays a supporting role. But in fact, Urban Transportation is not only the most direct "explicit"

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influencing factor of Land Use, but also an important "implicit" influencing factor. In addition to the direct interaction between Urban Transportation and Land Use, there are also factors such as culture, nature, planning, management, science and technology. And the interactive relationship between the two must be carried out under the blessing of some factors, or the two realize the interactive relationship under the connection of multiple systems. For example, natural factors affect Urban Transportation and Land Use at the same time, and their interaction is carried out under the influence of natural factors. At this time, the interactive system composed of Urban Transportation and Land Use is not parallel to the natural elements. At this time, the natural elements participate in the interaction in the form of some parameters. Therefore, before specific research, it is necessary to conduct multi-dimensional and multi-level interactive analysis of urban transportation and land use.

## 2. Interactive Analysis of Cultural Dimensions

### *2.1 Analysis of Interaction under the Influence of Asian Culture*

In history, every evolution of transportation technology and transportation mode has changed the Land Use Mode to varying degrees. In the early stage, human settlements reached their destinations by walking and using livestock as vehicles. At that time, the Land Use was not affected by any means of transportation, but showed a random state in terms of form. Then, due to the reasons of culture and etiquette, the Land Use Mode appeared geometric form.

As early as the Warring States period in China, ancestors vividly explained the close relationship between ancient transportation and urban construction mode of land use in the book of Zhou Li ·Kao Gong Ji. The book says: "The craftsman runs the country with nine miles and three gates. The country has nine longitudes and nine latitudes, and the nine tracks are painted. The left ancestor and the right society face the back market and the city faces one husband". The roads in the city referred to in the book adopt the longitude and latitude coating system. According to the system of "Three carriages can run on one avenue", there is also an "Outer road" around the city. There is a "Wild road" outside the city, which is connected with the road network in Guinea. It is a typical traffic mode affected by the cultural etiquette system. The specific details include strict road grades such as "Longitude and latitude road width nine tracks, outer road width seven tracks and wild road width five tracks". These factors combined with the land use management modes such as Lvli system, Lifang system and Street and lane system led to the more and more geometric urban structure of Xianyang, Han Chang'an and Tang Chang'an. This is the climax of highly interactive cultural system between ancient urban land use mode and transportation mode. As shown in Figure 1.

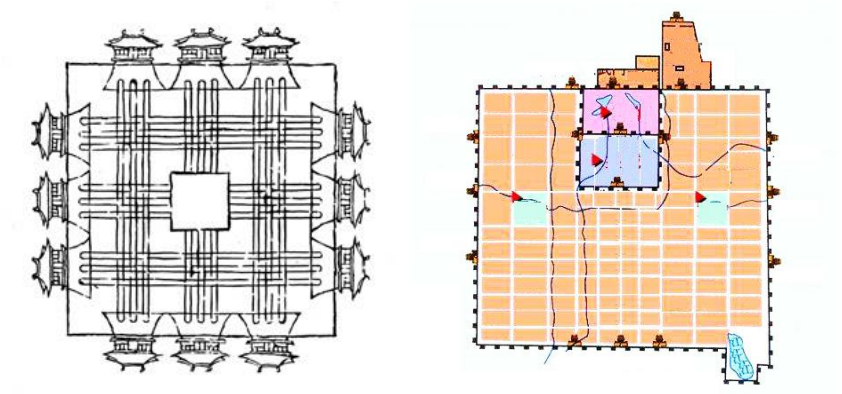

*Figure 1: Interaction pattern of land use and transportation in Chang 'an under the influence of Kaogongji*

In fact, the cultural factors here include aesthetics and traditional feng shui theory. We can see that Tang Chang'an has the aesthetic characteristics of central axis symmetry and left-right balance. This aesthetic characteristic is reflected in the traffic elements such as primary and secondary road networks and four city gates. It can be said that the road grid Bureau determines the land use form and scale. In addition, many cities in China have also been influenced by the theory of Feng Shui pattern in history, such as the common "front rosefinch, rear basaltic, left Qinglong and right white tiger", which generally refers to the natural landscape elements of feng shui culture of "rosefinch and basaltic", while "green dragon and white tiger" often refer to traffic elements such as roads and rivers. Here, traffic elements are intertwined in the pattern of urban land use. In terms of system and hierarchical culture,

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there are also the central axis series of cities such as Beijing and Xi'an. These central axis patterns are formed in the interaction between land use and road traffic. Therefore, although the development of modern cities is less and less affected by traditional culture, it is undeniable that for typical cities such as Xi'an and Beijing, culture comprehensively affects the interaction between modern urban land and transportation in the form of "soft" elements from the historical dimension.

### *2.2 Analysis of Interaction under the Influence of European Culture*

The urban Land Use Mode and Transportation Mode under the influence of cultural factors are reflected all over the world in the long history. We can usually see that cultural factors affect the form of Urban Land Use, but in western historical cities, street squares are the decisive factor of many urban structures. Especially in the Church Square and Star Square in medieval Europe, this paper takes the star square as an example to illustrate how culture and art participate in the interactive relationship between Urban Transportation and Land Use.

In Europe, the prototype of Vitruvius' ideal city has influenced the form of many European cities in the way of aesthetics, religion and culture. In his Ten Books on Architecture, Vitruvius suggested that the city was created by "the architect played by God". In addition to the terrain, orientation, environment and other factors, the road is the decisive factor to determine the urban morphological structure, and an urban plane form of centripetal polygonal geometric pattern is proposed. In this ideal place plane, all road traffic and land layout form a beautiful central symmetrical layout in different combinations.

Here, religion and aesthetics combined with culture have complicated the interactive form of Urban Transportation and Land Use, and finally formed a central symmetrical radioactive form. As shown in Figure 2.

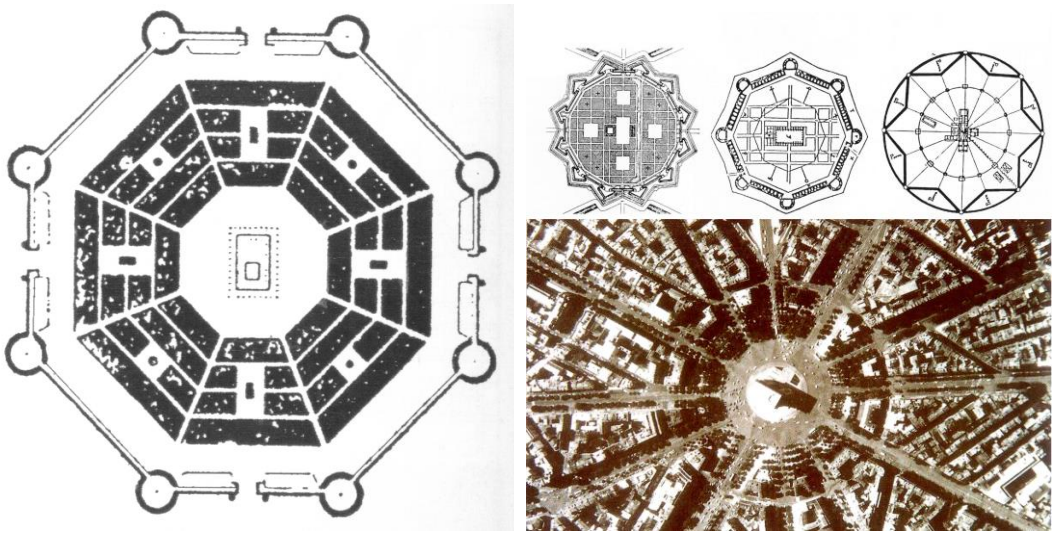

*Figure 2: Interaction patterns of land use and transportation in European cities influenced by Vitruvius "Ideal City"*

In the figure, the Vitruvius ideal city model is childish and even full of problems in today's scientific community. However, in the long course of human history, we cannot determine how human beings will look at us a hundred years later. Science and technology have metabolism and will continue to iterate, but cultural genes are indeed rooted in human society. Of course, they also affect the city genes that embody the crystallization of human social civilization. The role of culture in cities is obvious in many European cities. In the radial square of Paris and its surrounding streets, we can clearly see the decisive role of geometry and aesthetics in traffic organization, which is mainly reflected in the image axis formed by the road system. On this point, there are some similarities between the East and the West.

It should be noted here that the so-called culture in this section is a concept of broad integration, including broad culture in religion, system, feng shui, aesthetics, and tradition and so on. In our scientific measurement and quantitative analysis and decision-making, culture exists as a soft constant. Although in practice, cultural elements are sometimes not seen in data and variables, it is also that our so-called smart scientific and technological means can not reasonably take these factors into account.

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Objectively speaking, it is not that culture is not important, but that we have not reached the ideal height of science.

## 3. Interactive Analysis of Natural Dimensions

### *3.1 Interaction Analysis under the Influence of Topographic Elements*

Mountain city Chongqing is an important municipality directly under the central government in China. Chongqing has complex terrain and numerous mountains, forming a unique urban form. Under the influence of natural factors, the traffic structure of Chongqing also shows complex and diverse forms, specifically manifested in twists and turns, sharp turns, uphill and downhill and roundabout roads. Its land use mode is also different. There are often land with large elevation difference, and the form is complex, the size is different, and the optional means of transportation is limited. Among them, Beibei group, which is limited by Jialing River and its Longfeng River, Ma'an River, Mingjia River, chepan River and other water systems, is a typical case. There are many Northeast southwest natural mountains in Beibei cluster, most of which belong to the forbidden area of urban green space protection designated by Beibei District. The main ones are ma'ershigang, Huoyanshan, Longgang and the pig back in Chengnan New Area. These hills and green spaces intermittently extend into the area from the suburbs. Although Beibei has a good natural landscape, the contradiction between acceleration and land tension is very prominent. The phenomenon of mountains being occupied by buildings and artificially changing the natural form of mountains in the city occurs from time to time, forming the Land Use phenomenon of "Houses surrounded the mountains". As shown in Figure 3.

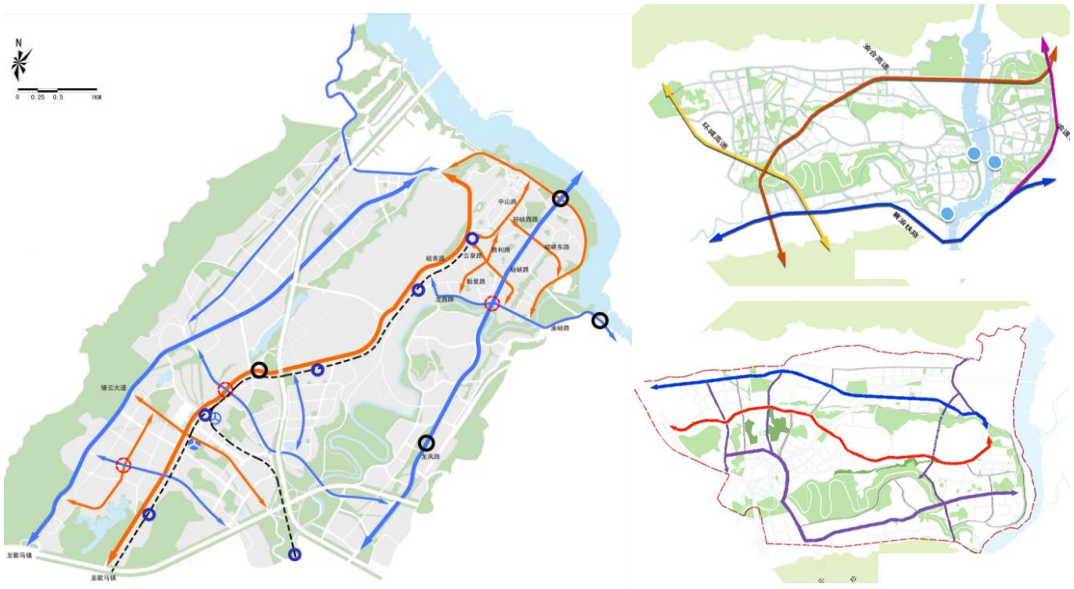

*Figure 3: Chongqing Beibei group traffic and land form*

The traffic connections of various areas within Beibei cluster mainly rely on the completed Jinyun Avenue (connecting Chengnan New Area, Chengbei new area and the old urban area), Beiqing Road (connecting Chengnan New Area, University area and the old urban area), Longfeng Road (connecting Chengnan New Area, longfengqiao town and the old urban area, which is not open to traffic at present), Dongyang bridge, The original national highway 212 (connecting Shili hot spring city, Chengbei new area and the old urban area). It can be seen from these roads that, affected by the terrain, the internal roads in Beibei are mostly "vertical" links in the north-south direction, while "horizontal" links are less, which hinders the traffic links between various areas of the city to a certain extent. This also makes the land use in this area have the characteristics of independent groups, and the land use forms vary with the mountain. There are traffic structures formed by complex terrain, which affect the scale and form of land use, as well as tortuous road traffic caused by various land use forms.

In addition to mountains and water bodies, other natural factors also have varying degrees of impact on urban transportation and land use, such as wind and rain climate, geological conditions, sunshine and wind direction, etc. It can be said that natural conditions are one of the most dominant influencing factors in the interaction between the two.

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### *3.2 Interaction Analysis under the Influence of Water Elements*

Specific traffic patterns in history sometimes decisively affect the land use pattern of a city. For example, historical cities dominated by water transportation often affect the land use pattern of the whole city because of the water network structure. Such typical Chinese and foreign urban cases include Pingjiangfu (Suzhou City) in ancient China and Venice in Italy, as shown in Figure 4.

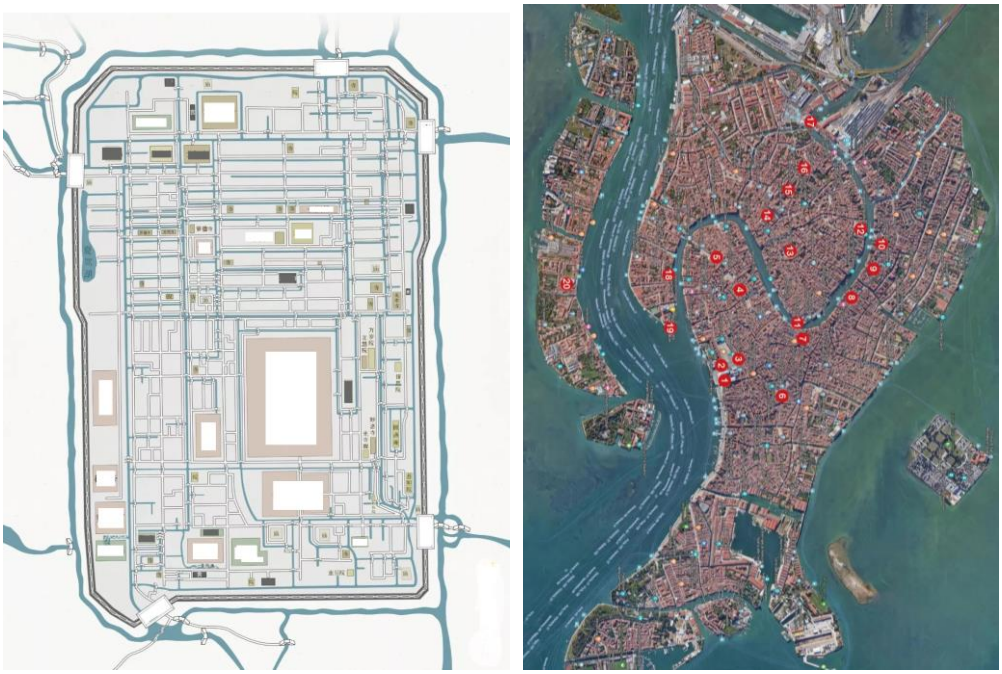

*Figure 4: Urban traffic and land use patterns in Suzhou and Venice*

Venice is a famous water city at home and abroad. The shape of the whole city is absolutely affected by the coastline. In addition to the overall land use form, the streets and roads in the city also grow in accordance with the tortuous outline. The rivers inside Venice are not only important traffic channels, but also shape influence. Speaking of this, Suzhou has a more unique waterway integrated transportation system.

Suzhou is located in the lower reaches of the Yangtze River, with dense water systems and a "double chessboard" pattern of parallel rivers and roads. Before the Song Dynasty, the urban residential area did not form a Fangli system, but irregular streets and alleys. It has a unique form of urban texture. Historically, the handicraft industry, free trade and various businesses in Suzhou City were very developed, which affected the land use mode to a certain extent. However, the largest impact on the characteristics of the land use mode of Suzhou city is the large and small water networks vertically and horizontally distributed in the city, which can be fully shown in the *Picture of Pingjiang River*. The ancient city of Suzhou has experienced several military disasters, but the river course as the skeleton of the ancient city of Suzhou can be used after renovation, and can play the role of transportation and supply. The excavation of the river course did not take place overnight, which made the urban land use pattern very stable and has influenced the present day, forming the scene in today's *Picture of Pingjiang River* of Suzhou.

The Picture of *Pingjiang River* vividly reflects the vertical and horizontal characteristics of rivers inside and outside Suzhou. The picture clearly shows that there is a wide moat outside the city wall, which is connected with the river channel in the city through the water gate; there are three main rivers in the east-west direction and four in the north-south direction, together with many tributaries, forming a vertical and horizontal water network. It can be said that it is these water networks that constitute the unique pattern of "seven rivers and eight gates and sixty squares" and " three hundred and ninety red railing bridges" (Bai Juyi) in Suzhou city. If the 65 "squares" are regarded as the land use mode, and the 359 bridges and water network are regarded as the main traffic elements, we can see that they show a situation of mutual restriction and interdependence. In addition, the streets, alleys, squares and bridges, as traffic elements, have promoted the formation of commercial land to a certain extent that is, fixed fairs, such as the square bridges named by Xishi, Lishi and grain city. In short, the urban land use of Suzhou is deeply affected by the traffic factors dominated by water. In addition to water, mountain

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and terrain elements are also one of the dominant factors affecting the interaction between urban transportation and land use.

## 4. Interactive Analysis of Economic Population Dimension

### *4.1 Interactive Analysis of Economic Dimensions*

The advantages and disadvantages of urban transportation can promote economic development. Perfect urban public transport is convenient for travel and can drive the rise of housing industry and commercial office along the line. These factors will stimulate employment and consumption, which is conducive to urban economic growth. The GDP growth rate and growth volume of a city are important indicators to measure the urban economy. They are usually positively correlated with the comprehensive land prices of commercial land, residential land, and industrial land and so on. And more capital investment can ensure the development of public transport with the improvement of economy, improve public transport facilities, improve traffic service level and optimize traffic mode.

From the perspective of Urban Transportation System, Urban Transportation affects Land Use in the form of transportation supply, and the economic foundation is the cornerstone of transportation supply. Some of these economic bases come from the transfer of land price income. In turn, transportation supply affects the "value" of land use. For example, in many "Airport economic circles", the land use mode of large hub airports integrated through industrial clusters, that is, the economic zone formed around the airport, determines the "price" of the region. In addition, the land price near the subway station will also show a positive correlation with distance.

Similar practices include SOD mode (Service-Oriented Development), that is, the development mode guided by the construction of social service facilities. For example, many years ago, Harbin carried out spatial migration of administrative and other urban functions through planning, that is, the government took the lead in entering the new area, namely Songbei district. SOD mode has achieved multiple goals, such as urban function transfer, spatial relief and optimization, and the improvement of government financial situation. This transfer enabled the simultaneous formation of municipal and social facilities in Songbei, resulting in a huge "raw and cooked" land price difference, completed the functional adjustment of land use factors and obtained the required funds. In the SOD mode, land and transportation play the role of making up lessons or missing lessons.

Another typical phenomenon is the development of subway cover. The specific form is to build subway supporting facilities in the upper space of subway, and carry out multi-level development and construction of Commerce, office, residence and so on. This mode is essentially a spatial economic mode, that is, rail transit is the guide and supporting services are provided for the city around the subway. In fact, this is a three-dimensional development of land. In addition to promoting local urban development, this development model will have many economic benefits, including realizing land price and realizing land price income; Create development income; Obtain value-added income from property and land; conserve passenger flow and increase operating income. This case shows that economy, land and transportation promote each other under certain conditions, that is, the Trinity interaction. Therefore, economic factors are the "constant" of urban transportation and land use, and almost all land and transportation factors are inseparable from economic factors.

### *4.2 Interactive Analysis of Population Dimension*

The urban population includes the total number of people engaged in various professional activities and supported in the city. There is a certain relationship between urban population and urban traffic conditions. Good traffic conditions can save manpower, time and money costs, shorten travel distance and travel time, and directly and indirectly stimulate employment. To a certain extent, they are the basic conditions for increasing the number of people. For example, some mega cities in China attract employed population through traffic conditions and produce population siphon phenomenon, which is a typical case.

The land scale and population scale of a city are the decisive factors of traffic demand and supply. Population is the direct source of urban land demand, and more population will also produce more traffic demand. And the larger the area of the city, the longer the distance of rail transit will be required, and even intercity transportation will appear between cities, which is difficult to meet the needs of

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general public transport. A large population will directly lead to traffic congestion, and large-capacity public transport supply will effectively alleviate this traffic pressure.

Land increment and Land utilization rate are also one of the necessary conditions to improve population carrying capacity, especially the labor demand generated by industrial centralized land is the main condition for population increase. The larger the production scale carried by industrial land, the more labor force will be gathered. The increase of population leads to the increase of demand for residential land, commercial land and public service land, which is generally positively correlated with traffic factors.

Generally speaking, urban population, urban land, urban transportation and urban economy are interactive combinations in the process of urban development. Generally, they belong to positive correlation and promote and influence each other, as shown in Figure 5.

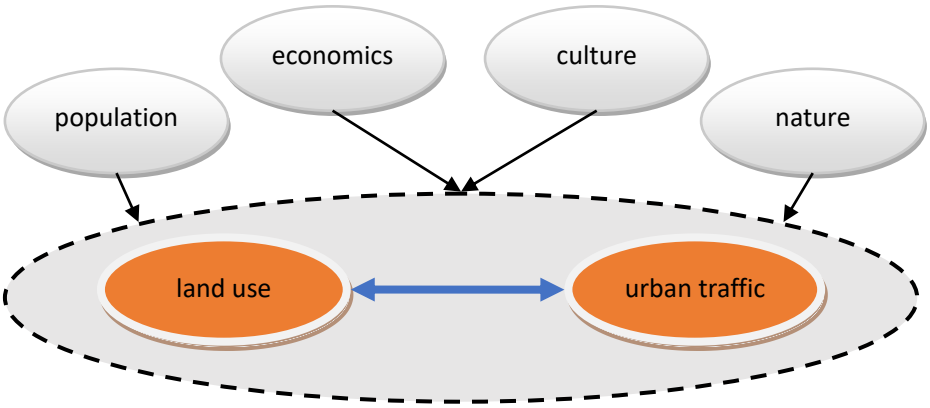


*Figure 5: The Multi-dimensional Comprehensive Interaction Diagram*

## 5. Conclusion

It is found that the interaction between Urban Traffic and Land Use at all levels and dimensions is realized under the clamping of some factors. Some of these factors have a relatively direct impact on the interactive relationship between urban transportation and land use, while others are more indirect; Some factors have always existed in the interactive relationship between urban transportation and land use, such as terrain, river, etc.; In addition, some factors exist randomly, such as ancient cities with historical factors, or cities with some special cultural characteristics, and so on.

Although humanities, society, nature, art and other factors are not directly influencing factors in many cases, their potential role cannot be denied. It should be said that these factors play different roles in different cities, and in many cases they are imperceptibly influenced. In the research, we can take Urban Transportation and Land Use as a relatively independent interactive system and comprehensively consider the factors outside the system. On the one hand, the elements outside the system participate in the interactive system of Urban Transportation and Land Use in the form of participants. On the other hand, the elements outside the system participate in the interactive system of Urban Transportation and Land Use in the form of "parameters" and "constants". In a word, Urban Transportation and Land Use interact under the comprehensive action of multi-dimensional factors.

## Data Availability Statement

The data used to support the findings of this study are included within the article.

## Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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