

Public Transportation System and Sustainable Development of Urban Transportation under Transit Oriented Development Mode: A Case Study of Jinan City

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Abstract. For more than 40 years since the reform and opening up, Chinese cities have faced tremendous pressure on transportation. In recent years, the Chinese government has recognized the importance of developing public transportation. From easing traffic congestion, improving air quality, and increasing the happiness index of residents, the government is making progressive efforts so as to upgrade sustainable urban development. The Transit Oriented Development (TOD) mode of public transportation is adopted to provide ideas for the sustainable development of urban transportation. This research analyses the theoretical mode of sustainable development of public transportation TOD, takes economy, environment and society as the entry points, and then analyzes the current situation of TOD mode development of public transportation in Jinan. After summarizing the shortcomings of its public transportation master plan and combining the excellent cases of Tokyo, Japan, and Hong Kong, China, this study analyzed the advantages of successful public transportation TOD mode for Jinan's reference. Secondly, based on the basic transportation situation of Jinan, the future sustainable development of TOD mode is elaborated. In terms of transportation supply, transportation demand, and transportation system, it puts forward suggestions for sustainable development, including "congestion tax", "rail + property" linked development, and rational planning of the urban layout. It also looks forward to the future development of Jinan in terms of economic, environmental and social aspects of sustainable development, in order to help Jinan improve the TOD mode to overcome the traffic congestion problem and promote the sustainable development of the city.

Keywords: Transit Oriented Development, traffic congestion, sustainable development, Jinan City.

1. Introduction

Public transportation is a basic service provided by governments and is also the artery of urban economic development. However, in the process of urban development centered on economic construction, little attention has been paid to the economic, social, and environmentally friendly functions of public transportation. As an important mode of transportation in the modern urban transportation system, public transportation, in the context of the current pursuit of sustainable development in Chinese cities, a correct understanding of the relationship between urban public transportation and sustainable development can effectively guide the development of public transportation and promote the health and sustainability of urban economic development.

According to the "China's Major Cities Traffic Analysis Report", Jinan has a domestic congestion ranking on the list of "traffic jam cities". In order to solve the problem of urban traffic congestion under the rapid development of this city, a typical representative theory of Transit Oriented Development (TOD), meaning "public transportation guided urban development", was adopted. It effectively guided urban construction planning, emphasized the role of public transportation in urban development, and focused on the development and construction around stations.

TOD in Jinan has just begun and only preliminary attempts have been made, which has not been well implemented. How to use TOD theory to effectively control traffic congestion was an urgent problem for Jinan. The development of the city and the improvement of the economic level of residents led to a sharp increase in the demand for transportation, air pollution caused by traffic congestion and tailpipe emissions and other problems also appeared as a result of the rapid increase in the number of car ownership. Traffic congestion led to a series of problems such as decreased

travel efficiency within the city, increased travel costs, energy consumption and environmental pollution, which affected the overall image of Jinan and the city's economic development.

2. Literature Review

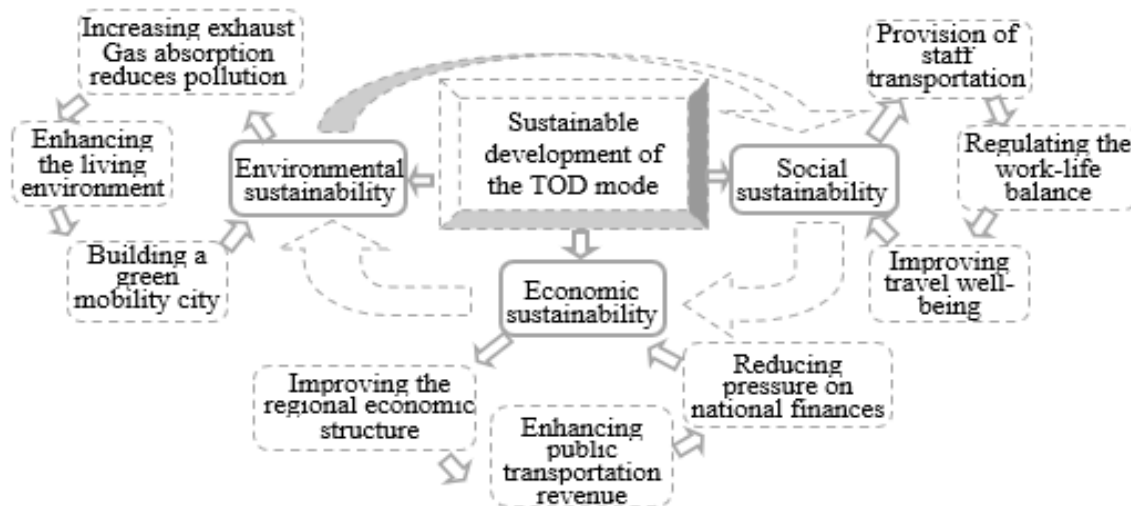


Fig. 1 Mechanism of TOD Sustainable Development Mode (Picture Credit: Original)

As shown in Figure 1, the mechanism of TOD is mainly reflected in three aspects: social, economic, and environmental.

2.1. International Scholars' Views on TOD

Peter Calthorpe, first put forward the concept of “transportation-oriented development” for the phenomenon that cities did not need to expand, a new urban construction mode dominated by public transportation, and systematically elaborated the concept and connotation of TOD [1]. Through surveys and case studies, Robert Cervero stated that TOD had made significant contributions to sustainable development patterns in cities such as improving air quality, preserving open space, creating walkable environments, increasing transit ridership and tax revenues, and redeveloping cities [2, 3]. Lucas and others promoted the TOD concept through regional planning and believed that the TOD construction was consistent with the future direction of sustainable urban development [4].

2.2. Domestic Scholars' Thoughts of TOD

Domestic research on TOD mode also had some development on the basis of foreign countries. In 1996, the Chinese government approved the National Environmental Protection “Ninth Five-Year Plan” and 2010 Visionary Goals, which proposed that urban development must take the road of sustainability [5]. Urban transportation was the premise and guarantee of urban development, moreover to ensure the sustainable development of the city, the first step was to address the issue of sustainable development of urban transportation. Jundong Wang believed that urban rail transit had brought great secondary environmental impacts to the economic, social and ecological environments of cities while improving travel conditions and regional accessibility [6].

In recent years, Junyun Cao and others optimized the crossing experience of pedestrians through the pedestrian-oriented design principles in TOD, returning people to a green and healthy walking life while attracting the crowd's use of and attention to public transportation [7]. Huapu Lu proposed that China needed to establish a comprehensive transportation system with urban public transportation as the main body, aiming to realize the sustainable development of urban transportation, which was exactly in line with the concept of TOD [8]. Jizhong Cheng believed that the rational use of TOD planning urban transportation could be the efficient use of urban land, to solve environmental pollution [9].

2.3. Current Research Gap

As for the research on TOD-oriented urban development, most of the relative studies were in first-tier cities in China, mainly focusing on theoretical and conceptual studies, moreover major of its role for sustainable development in the future stayed at a phenomenal level, and it lacked the ability to analyze problems of a certain region and give the targeted recommendations. They also lacked the integration of domestic and international research and targeted application of the proposal. Therefore, this paper took Jinan as an example, analyzing the three main aspects of the mechanism of TOD mode sustainable development mode, synthesizing the existing pieces of literature and combining with successful cases to illustrate the TOD mode's influence on the future sustainable development of transportation and the problems of the current mode in Jinan, then put forward the planning suggestions for the future development of TOD mode of public transportation in Jinan.

3. Successful Experiences of TOD Mode in Domestic and International Cities

3.1. Experience of Hong Kong

The public transportation-led traffic pattern, with rail transit as the backbone and public transportation as the main body of service. In Hong Kong, people can reach almost anywhere by rail transit. In addition to the wide coverage, rapid interchange is also possible through subway stations, and the connections of buses, cabs, and walking are extremely close [10].

According to the theory of TOD, Hong Kong carries out the planning and design of “rail + property”, emphasizing the integrated development and construction of living, employment and shopping around the rail. Except for rail transit, Hong Kong provides seamless integration of rail and ground transportation, optimizes the convenience of using public transportation for its citizens, and plans the city holistically. It also uses data analysis to rationalize station layouts (see Figure 2) [11].

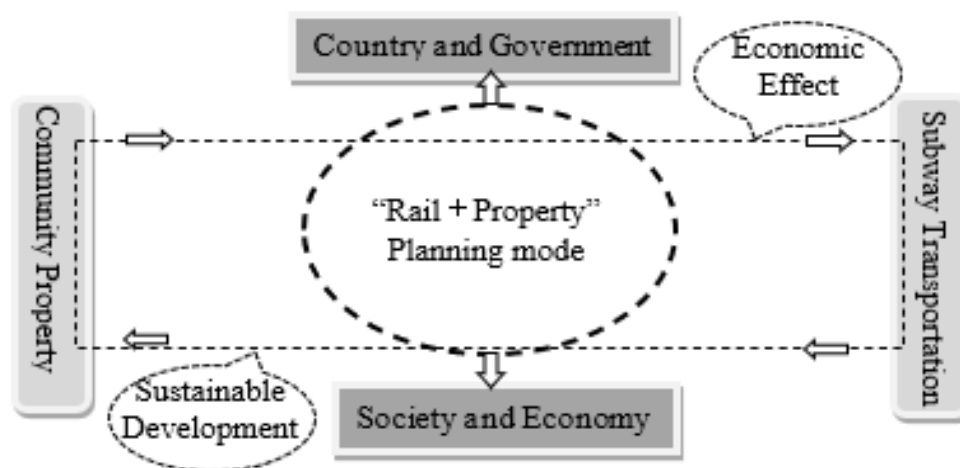


Fig. 2 “Rail + Property” Planning in Hong Kong (Picture Credit: Original)

3.2. Experience of Tokyo

Tokyo residents use public transportation for most of their daily trips. In Tokyo, there are many rail lines which connect closely and transfer conveniently. Travelling with in-situ transfers and on-time arrival enhances the comfort of taking the rail and reduces the possibility of choosing private cars [12].

The urban pattern of Tokyo is a representative polycentric type, with the main center being the political and economic center and international financial center, moreover, Shinjuku and Ikebukuro as the two sub-centers, which play a role in linking with Tokyo. Different districts such as Osaki, Asakusa and Shibuya represent different functions. These distribute traffic volume through planning help to manage traffic congestion.

Uncivilized use of cars accounts for a significant proportion of the causes of traffic congestion. In Tokyo, residents rarely use private cars because of the high price of parking and rental. Paid parking spaces are not only expensive, but also time-limited, with high fines for exceeding the time limit, which disguises incentives for residents to use public transportation.

4. Current Situation of TOD Mode in Jinan

4.1. TOD, Urban Layout, and Economic Development

The public transportation TOD mode in Jinan is not very complete at present, covering 21 projects such as Jinan Dongqiang, Zhongyou and Xixing. It is basically developed around the subway stations, and the land will be supplied to the market with priority, then the connection between subway stations and the surrounding space will be closer [13].

Table 1. Distribution of New TOD Complexes Under Planning [14]

Project	Quantity	Distribution
Dongqiang	14	New East Station, Zhangma, Huashan, Licheng High-speed Railway Station, Tangye, Xingcun, Xiuyuanhe and other areas
Zhongyou	4	Old commercial port, The Fifth People's Hospital of Jinan, Dongcang, Hongjialou and other districts
Xixing	3	Wangfujuang Station, Metro Line 1 and 2, Medical Silicon Valley, Line 4 and Line 6, Bitouri Vehicle Section, Line 6, Yujiashuang Station

From the data in Table 1, it can be seen that the distribution of TOD projects in the east, center and west varies greatly, with the number in the east far exceeding that in the center and west. This indicates that the population is heavily concentrated in the east, which is economically developed, with greater differences in economic development than the other two parts. The city center is too concentrated, resulting in excessive traffic pressure near the center and higher congestion during peak hours.

4.2. TOD and Environmental Pollution

Since the TOD mode began to be implemented in 2018, Jinan's Air Quality Index has been on a downward trend as a whole, with occasional rises; the air quality grade of excellent has been on a slow upward trend, and the air quality grade of severely polluted has been on a downward trend, which only occurs occasionally in 2019, 2021, and 2023, and the overall air environment has become a positive trend.

4.3. TOD and Social Life

From the survey including the proportion of people who switched modes of transportation due to lack of access to transportation showed that more than half of the respondents in the survey switch to private cars or online taxis occasionally due to the inconvenience [10]. In the course of daily travel, most people's choices of transportation are centered on buses, cabs, online taxis, shared bicycles and walking, with Bus Rapid Transit covering a lesser area than the above transportation modes. According to the survey of only 235 respondents, the urban congestion situation in Jinan is still not optimistic, with a low level of public satisfaction, and the overall situation needs to be greatly improved.

5. Problems of TOD Mode in Jinan

5.1. Individualized Travel Causing Environmental Pollution

The advantages of public transportation are not prominent, which is manifested in the lack of bus transfer facilities and the difficulty of exchanging passenger flows on bus routes, which not only give passengers a poor experience of interchange, but also lead to buses clustering on the road. Compared with cars and battery cars, there are shortcomings in terms of convenience and speed, resulting in the personalized travel sharing rate being higher than the bus sharing rate, moreover leading to traffic congestion while also aggravating tailpipe emissions and increasing environmental pollution.

For Jinan, overall planning of the city should be carried out, through the data analysis of the reasonable arrangement of stations, to achieve seamless ground public transportation and rail transit, further increasing the sense of experience of residents taking public transportation.

In addition, similar to increasing the cost of parking, Jinan can appropriately levy the “congestion tax” during peak commuting hours, to enter a specific road or part of the downtown area of the vehicle charged a certain fee or tax. This can be achieved by regulating travel behavior, increasing the use of public transportation facilities, dispersing or reducing traffic flow, easing road congestion, and improving the operational efficiency of the road network.

5.2. Complicated Underground Conditions Causing Poor Experience for Residents

Because of the many underground springs in Jinan, the situation is complex, and the underground public transportation facilities such as the subway in the route planning have certain limitations. This has led to the selection of some of the subway stations being unreasonable, so some of the stations lack public transportation facilities connected to them, resulting in residents choosing more convenient transportation.

For Jinan, although the public transportation network is dense, the underground routes are limited. Therefore, in order to improve the travel experience of residents, the government should carry out the design of “rail + property”. In the area where above and below the subway residential, employment, shopping and other integrated developments, can be more convenient for daily travel.

5.3. Unclear Delineation of Urban Functional Structure

Currently, the urban and transportation planning of Jinan lacks comprehensive and coordinated considerations, and the traffic congestion management process also lacks consideration of the functional structure. Moreover, urban planning lacks a holistic and systematic approach and the integrated planning of urban transportation and land use.

Jinan could learn from Tokyo's TOD mode to build a more reasonable urban spatial structure, taking into account the social and environmental aspects and meeting the human needs of citizens. Compared to Jinan, which lacks integrated land planning, Tokyo has changed from a single-center centralized city to a multi-center functionally decentralized city and also succeeded in reducing the pressure on urban population and traffic. Therefore, Tokyo's experience is an important reference for Jinan, which wants to create a multi-center pattern of “one main city, five sub-districts, twelve districts and two satellite cities”. This can disperse the functions of the city and reduce the pressure on the central area [15].

6. Conclusion

Traffic congestion is a problem that every city has to go through, as long as the administrators start from the perspective of traffic demand, formulate reasonable and effective integrated management measures, and firmly carry out the implementation in place, Jinan will become a livable city with convenient travel. The TOD solution for urban traffic congestion is not only in line with the trend of Jinan's traffic development, but also sets the right direction for the management of traffic congestion. This paper thereby provides ideas for the management of congestion and Jinan to solve the problem

of traffic congestion. It is also hoped that through this paper, more people will understand the TOD mode and use it as the core to solve the traffic congestion problem.

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