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PROSPECT OF THE TRANSIT-ORIENTED DEVELOPMENT IN CHINA

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Abstract
Even though transit-oriented development (TOD) concept remains disputable in the United States (U.S.), it is almost universally accepted by the Chinese planning community. This is largely attributed to China's national policy on prioritizing the public transit development. It should be recognized that, due to the existence of substantial differences between the U.S. and China in population density, land use intensity, personal income level, urban spatial structure, and propensity to use public transit, it is inappropriate for China to directly utilize the U.S. TOD-related planning parameters without making a proper adjustment. China needs to develop its own TOD-related planning parameters based on its concrete circumstances. At present, China has achieved great strides in TOD research and practices, yet still lacking a nationwide TOD inventory data base. Additionally, this paper makes several improvement recommendations for the TOD implementation in China.

Keywords: transit-oriented development, China, public transit, land use.

1. INTRODUCTION

China is the most populous country in the world with more than 1.3 billion population. In 2009, the total number of Chinese cities has reached 655, of which 53 super-large cities have more than 1 million non-agricultural population.

In contemporary China, rail is playing an instrumental role in carrying a large number of passengers and relieving traffic congestion in urban areas. Compared to other transit modes, rail has obvious advantages in its large carrying capacity, fast speed, reliability, safety, and energy conservation. In the meantime, it is also characterized by its high construction cost, long construction period, and significant environmental impacts. At present, about 10 Chinese cities have subways or heavy rail transit systems either in operation or under construction. Several cities also have light-rail transit systems. In addition to rail, bus rapid transit (BRT) is becoming more and more important in China because of its large carrying capacity, low construction cost, short construction period, and less environmental impacts. Many Chinese cities have implemented BRT projects.

In view of the above situations, transit-oriented development (TOD) is bound to be a natural choice for China, because this is a relatively resource-poor country with per capita land and resource ownership rate much lower than the world average. In fact, prioritized development of public transit has become China's national

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transportation policy. Because of this reason, the TOD research has been rapidly surging in China during the past decade with many TOD-related books and journal articles published .

Nevertheless, TOD is a foreign-born concept initially invented in the U.S. In transferring and applying this American planning concept to China, we still need to be cautious and selective. This paper first reviews the TOD concept in the U.S. It then introduces the different schools of thoughts on TOD among American researchers. Thirdly, the paper compares and highlights the differences between the U.S. and China, which have important implications on the transferability and applicability of TOD concept to China. Finally, it makes a series of improvement recommendations. A concluding section summarizes research findings.

2. TOD CONCEPT AND 5D PRINCIPLES

2.1. TOD Concept

In 1993, Peter Calthorpe, the noted American urban designer and new urbanist, proposed the TOD concept. TOD refers to the high-density and mixed-use land development centering on a transit station, typically rail station. From 1993 to present, a myriad of studies and practices have been completed throughout the U.S., which are well documented and researched by the publications of the Transit Cooperative Research Program (TCRP) under the Transportation Research Board (TRB), National Research Council.

Throughout the U.S., the most important type of TOD is rail TOD (RTOD), followed by bus TOD (BTOD). In 2002, based on their nationwide survey of more than 100 TOD projects in the country, Cervero et al. (2004) found the following composition of TOD projects: Subway TOD (37.4%), Light Rail TOD (31.3%), Commuter Rail TOD (21.8%), bus TOD (7.8%), ferry TOD (1.7%). Therefore, more than 90% of the TODs in the U.S. are located in the vicinity of large-capacity rail stations. Since rail station has its strong image, permanency, and fixity, it appeals more to potential investors. In contrast, bus stop lacks a strong image, permanency, and fixity, thus attracting less investment and development activities. Because of these reasons, there are few BTOD projects.

2.25. Principles of TOD

The 5D principles of TOD generally recognized by the American planning community are: Density，Distance，Diversity, Design, and Destination Accessibility. Any TOD projects properly following these 5D principles are expected to be successful.

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2.2.1. Density

TOD intends to increase land use density at pivotal locations and curb urban sprawl. Higher residential and employment densities in the vicinity of transit station will make residents or workers more likely to use public transit, and support local economic activities. With the distance from transit station increases, development densities will be gradually tapering down and auto modal shares will be increasing accordingly. Higher-capacity transit facility requires higher land use density to support it.

For example, in Portland, Oregon, central city TOD had a transit modal share 4 times as high as that of outlying TOD in 1995 (Dill, 2007), reflecting the critical importance of development density in impacting transit ridership. Table 1 shows the minimum residential density requirements of different types of TODs.

TABLE 1 - RESIDENTIAL DENSITY THRESHOLDS FOR TOD PROJECTS

Source	TOD Type	Residential Densities (Dwelling Units/acre)
San Diego TOD Guidelines	Urban TOD (LRT served) Neighborhood TOD (Bus served)	25 (18) 18 (12)
Washington County, Oregon (LUTRAQ Study)	Urban TOD (LRT served) Neighborhood TOD (Bus served)	15 (7) 8 (7)
Portland Tri-Met, TOD Guidelines	LRT Served TOD Bus Served TOD	30 : 0 - 1/8 mile 24 :1/8 - ¼ mile 12 :1/4 - ½ mile 24 : 0 - 1/8 mile 12 :1/8 - ¼ mile

Source： Community Design + Architecture. (2001). *Model Transit-Oriented District Overlay Zoning Ordinance.* Oakland, CA: Community Design + Architecture. Note: LUTRAQ = Land Use, Transportation, and Air Quality.

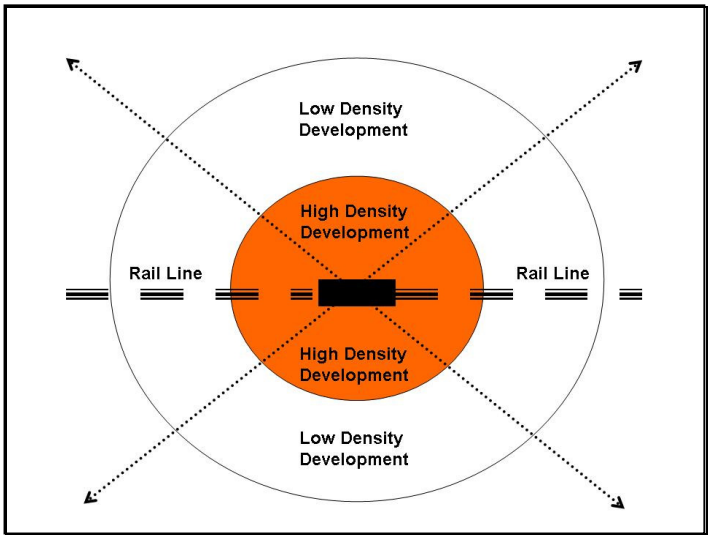

FIGURE 1 - LAND DEVELOPMENT DENSITIES IN THE VICINITY OF A RAIL STATION

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Table 1 indicates that minimum residential density requirement for RTOD is much higher than that for BTOD. Land use density increases towards the stations. Figure 1 illustrates the land development densities of a rail station.

2.2.2. Distance

This requires the walking distance from where residents live to station to be kept within 400 meters (¼ mile, or 5 minutes). The highest development densities should be concentrated within the ¼ mile radius of a transit station, so residents can walk to board transit instead of driving there. Take the Washington Metro Rail for example, with the distance increase of every 1,000 feet from the station, transit modal share will be reduced by 7%. For the commuting trips, the reduction will be 12% due to the higher time sensitivity of commuting trips.

In 2000, a survey on the 6 commuter rail stations in Chicago with the highest ridership revealed the results shown in Table 2.

TABLE 2 - DISTANCE FROM TRAIN STATION VERSUS PERCENTAGE OF WALKING TRIPS

Distance from Train Station	Percentage of Walking Trips
0-0.5 Mile	82%
0.5-1.0 Mile	41%
1.0-2.0 Miles	8%
> 2 Miles	1%

Source：Evans et al. (2007).

2.2.3. Diversity

Diversity requires a TOD to have mixed land uses, combining commercial, residential, office, and other land uses together. Mixed land uses allow for the presence of transit users and activities all the times, which will add more safety, security, and economic vitality to the TOD district. Mixed land uses tend to induce more walking trips, and internally capture vehicle trips. Table 3 gives some examples of mixed-use TOD projects.

TABLE 3 - EXAMPLES OF MIXED-USE TOD PROJECTS

Location	Development Mix	Situation	Travel Impact
Ballston Station Area, Arlington, VA, 1960-2002	5,914 residential units Office: 5,721,000 sf Retail: 840,000 sf Hotel: 430 rooms	The Ballston area has been transformed from an automobile-oriented close-in suburb into a full-fledged TOD since the Metro Rail station opened in 1979.	The walk mode share of access/egress for the station in 2002 was 67% of about 22,000 average daily entries plus exits.
Village Green Arlington Heights, IL, 2001	250 condominiums Office: 17,000 sf Retail: 53,000 sf	A big grocery store is within walking distance. One of several downtown redevelopment projects.	17% residents report commuter rail as their primary commute mode.
Mockingbird Station, Dallas, TX, 2000	211 apartments Office: 140,000 sf Retail: 180,000 sf	A full service grocery store is within 5 minutes on foot.	Parking requirement reduction of 27% was allowed for shared use parking. About 10% of patrons are reported to arrive by transit

Source：Evans et al. (2007).

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2.2.4. Design

The TODs and stations should be properly designed to increase amenities, encourage more pedestrian activities, and minimize conflicts between pedestrian and motor vehicular trips.

2.2.5. Destination Accessibility

This refers to the accessibility from a transit station to its surrounding activity centers. As shown in Figure 2, accessibility links transportation and land use together. The higher the accessibility of a transit station, the more likely the residents will use this station, and the vice versa.

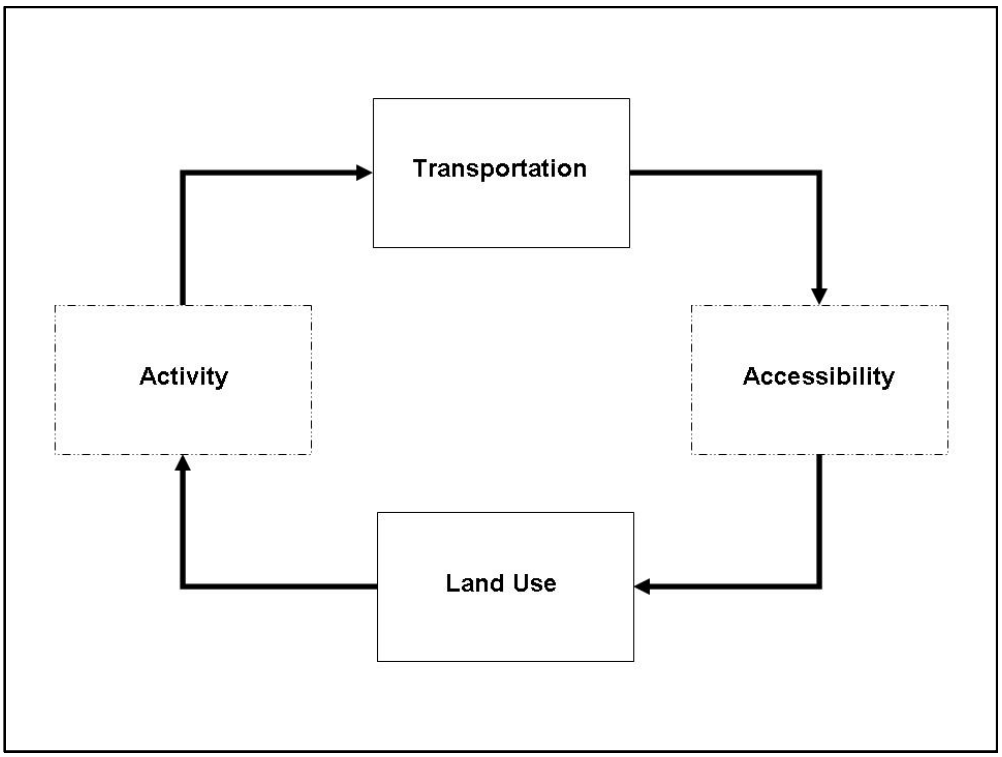

FIGURE 2 - INTERRELATIONSHIPS BETWEEN TRANSPORTATION AND LAND USE

Source: Giuliano (2004).

2.3. TOD Research in the U.S.

During the past decades, there have been voluminous studies on TOD topic. Roughly speaking, there are three schools of thoughts among researchers: proponents, skeptics, and opponents. A brief review is provided below.

2.3.1. TOD Proponents

Cervero et al. (2004) surveyed more than 100 transit agencies on their goals for TOD projects. The survey results are summarized in Table 4.

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TABLE 4 - RELATIVE FREQUENCY OF TRANSIT-AGENCY GOALS FOR TOD PROJECTS

TOD Goal	% of Transit Agencies Agreeing to This Goal
Increase Ridership	20.0%
Promote Economic Development	15.6%
Raise Revenues	13.3%
Enhance Livability	11.1%
Widen Housing Choices	8.9%
Private Development Opportunities	6.7%
Improve Safety	4.4%
Share Construction Costs	4.4%
Reduce Parking	4.4%
One-Stop Center/Fare Outlet	4.4%
Improve Intermodal Integration	2.2%
Enhance Pedestrian Access	2.2%
Improve Air Quality	2.2%
Put Property on Tax Rolls	2.2%

Source： Cervero et al. (2004).

Though TOD has many benefits, even its proponents admit that there are many barriers for TOD implementation, such as fiscal barriers, political barriers, institutional barriers, and technical barriers.

2.3.2. TOD Skeptics

Boarnet et al. (2001) argue that high-density and mixed-land uses may have indeterminate transportation impacts. It is impossible or ineffective to solve transportation problems through adjusting land use policies. Tolls or government interventions may be more direct and effective approaches.

In Giuliano's opinion (2004), it is unrealistic to expect public transit to solve urban transportation problems in the U.S. With the polycentric development and suburbanization of urban areas, central city relatively declines. Because of this land use change, the downtown-bound public transportation network is no longer able to meet people's travel needs. Due to its prohibitively high costs, subway construction is often unaffordable to many cities. It can not be justified by low population density in many cities, either. Land use change is a gradual and slow process. Therefore, the impacts of land use on transportation cannot be immediately effective.

2.3.3. TOD Opponents

According to Gordon and Richardson (2001), suburbanization, decentralization, and people's preferences of driving private automobiles and living in single-family houses is a natural phenomenon, fitting the market economic laws. It is impossible for TOD to solve urban transportation problems. Public transit only plays a secondary, supplemental role in urban transportation.

In summary, the TOD concept was initially proposed in the U.S. in order to address severe transportation issues created by suburbanization and urban sprawl. All in all, TOD has played a limited role in increasing

transit ridership, coordinating transportation and land uses, and realizing sustainable development goals in the U.S.

At present, there are quite a few obstacles to overcome before TOD projects can be successfully implemented in the U.S. This author also believes that TOD cannot reverse the overall trend of automobile-led suburbanization and urban sprawl. Since the U.S. is an auto-oriented country, it is unrealistic to expect TOD to fundamentally improve urban transportation and air quality.

3. THE DIFFERENCES BETWEEN THE U.S. AND CHINA

As shown in Table 5, there exist substantial differences between the U.S. and China. These differences directly affect the transferability and applicability of the TOD concept to China.

TABLE 5 - THE U.S. AND CHINA DIFFERENCES

Category	U.S.	China	Implications for China
Population Density	U.S. has a large land mass with a relatively low population density (32 persons/km^2). Private automobile is the principal transportation means. Therefore, the threshold for average TOD population density is moderate.	China has a much higher population density (139 persons/km^2). The population density of the Shanghai proper is 13,635 persons/km^2,much higher than the threshold proposed by Peter Calthorpe in 1993 for average TOD population density, 8,100 persons/km^2, and very close to what proposed by Dittmar and Ohland (2003) for urban neighborhood TOD, 15,000 persons/km^2.	China cannot directly use the population density threshold used in the U.S. TOD projects. Instead, it needs to develop its own threshold. For example, urban TOD density must be higher than suburban TOD; rail TOD has a higher density than bus TOD.
Land Uses	Most U.S. cities have practiced standard zoning, which separates different land uses.	China generally has the mixed land use pattern. Some buildings have a vertical integration of apartments (upper floors) and shops (first floor), or have commercial facilities located near the entry to residential area.	China's existing land use mix for a particular TOD district needs to be carefully examined to ensure its appropriateness. According to Calthorpe (1993), urban TOD has higher percentage of commercial and office land uses, and neighborhood TOD is required to have higher residential land ratio. The actual mix of different land uses varies from place to place.
Propensity to use public transit	In the U.S. public transit has a lower attractiveness due to decentralized land uses, suburbanization, higher automobile ownership, and better highway system.	China has a higher propensity to use public transit due to higher population density and lower auto ownership.	In China, TOD has a lower potential to further increase transit modal share beyond existing level.
Non-motorized modal share	The modal shares of walking and bicycling person trips in the U.S. are less than 1%.	China's modal shares of walking and bicycling person trips are about 30-40%.	In China, improving walking and cycling environment has a limited effect on increasing transit uses.
Walking distance	Up to 400 meters.	Up to 400 meters.	Same criteria.

Source: Zhang and Liu (2007).

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4. RECOMMENDATIONS FOR THE TOD DEVELOPMENT IN CHINA

This paper makes the following recommendations for the TOD development in China.

4.1. Apply the System's Point of View in TOD Planning

Planners need to apply the system's point of view in TOD planning. As shown in Figure 3, the most important planning elements are adaptive land use and adaptive transit. Each planning element is impacted by both internal and external factors, thus forming a very complex system. An adaptive land use for TOD requires refining 5D features of land uses to better fit public transit requirements. In the meantime, it is necessary to improve public transit's operating performance and convenience to make it more appealing to potential transit users.

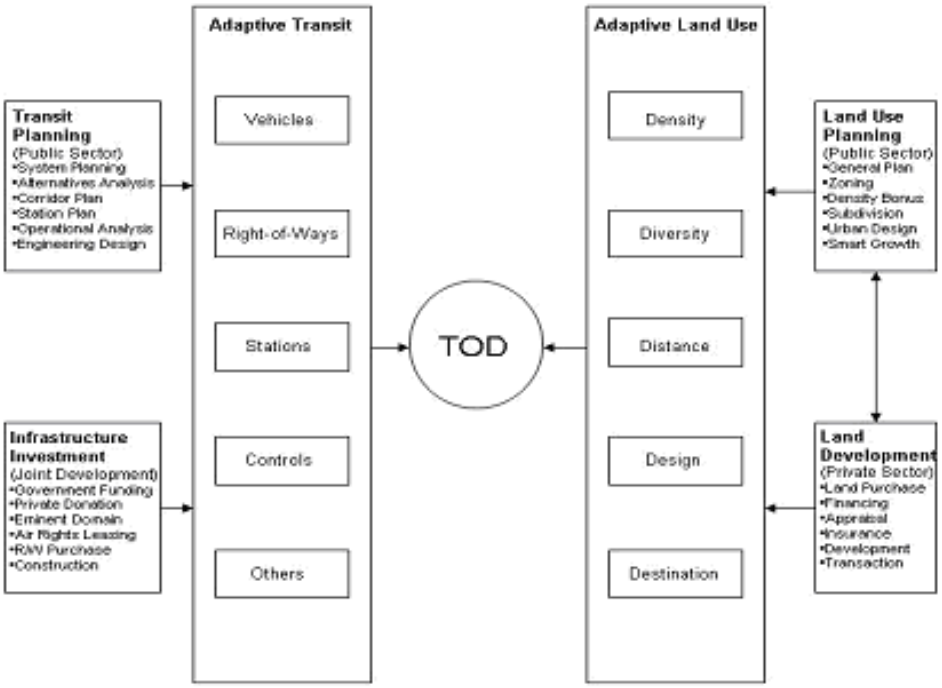

FIGURE 3 - TOD PLANNING ELEMENTS

4.2. Implement the RTOD-led and BTOD-supplemented TOD Development Strategy

In the super-large Chinese cities, it is necessary to implement the rail TOD or RTOD development strategy because these cities have sufficiently high population density to justify metro rail construction. However, for those medium-sized Chinese cities unlikely to build rail, TOD projects are recommended for the districts in the vicinity of bus rapid transit (BRT) stations. Like in the U.S., China is expected to have more RTOD projects than BTOD projects in the future.

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4.3. Make a Transition from TOD, to TOC, and ultimately to TOM

TOD represents the nodal land development around a transit station. A more advanced level of TOD development is the so-called Transit-Oriented Corridor (TOC), which is the "pearl necklace-like" linear land development chaining all nodal TODs together. See Figure 4 for an illustrative example of TOC in Nanjing, China. The ultimate level of TOD development is perhaps the Transit-Oriented Metropolis (TOM). A TOM consists of multiple interconnected TOCs throughout the metropolitan area.

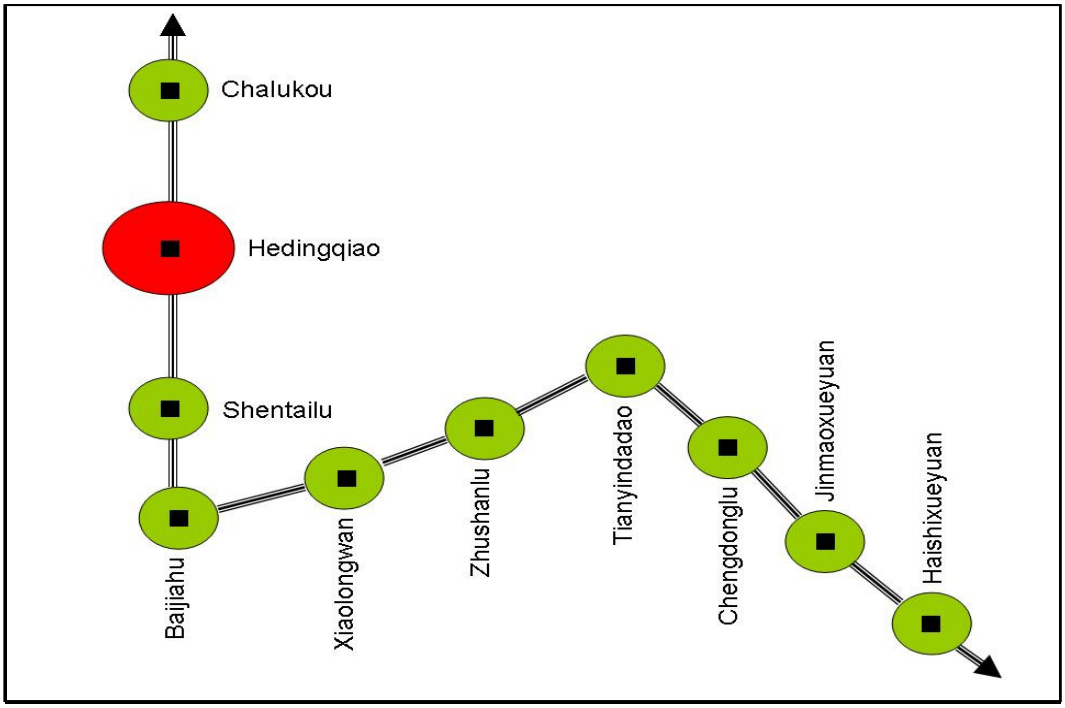

FIGURE 4 - ILLUSTRATIVE EXAMPLE OF TOC IN NANJING, CHINA

4.4. Build New Transit-Oriented Urban Spatial Model and Databases

The old monocentric urban spatial model is being replaced by the polycentric urban spatial model. Some important TOD districts may become new city subcenters to be modeled. The multitude of TOD districts constitutes the cornerstone of the new urban spatial structure.

Building this new transit-oriented urban spatial model requires huge amounts of data, which must be collected through different kinds of surveys on a large scale. At the national level, it becomes very urgent to build a nationwide TOD inventory database (geodatabases, ArcGIS shapefiles, and codebooks) including major TOD projects in the country. The most important TOD research products should be compiled into the TCRP-like publications. The Chinese central government needs to take the lead in this project. Local governments should also actively participate in this project.

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5. CONCLUSIONS AND RECOMMENDATIONS

The Chinese cities, especially the large and super-large cities, are growing at the unprecedentedly high speeds, which have resulted in severe traffic congestion, worsening air pollution, uncontrolled urban sprawl, and loss of farmland. To address these pressing issues, it makes sense for China to implement the transit-prioritized national transportation policy with the implementation of more TOD projects in its urban areas.

TOD is the planning concept originally proposed in the U.S. in the early 1990s. Even though TOD projects are mushrooming in the U.S., the concept itself remains disputable among planning scholars and researchers. There are still many obstacles to overcome in order to successfully implement TOD projects in the U.S. cities.

In contrast, TOD fares better in China which has a higher population density, a mixed land use pattern, and a lower automobile ownership. However, it is inappropriate to directly transfer and apply the U.S.-based TOD planning parameters to China without making a proper adjustment. China needs to develop its own TOD planning parameters and performance indicators. For some cities with high density already, the issue is perhaps not so much to further increase its density, instead, to better coordinate the relationship between land use and transportation, to make zoning amendments to get a better land use mix, and to improve urban/station design to minimize pedestrian/vehicular traffic conflicts.

This paper makes several recommendations on the TOD implementation in China. Since TOD project is very complex, it needs to be proceeded in a systematic and cautious way, with an emphasis on rail TOD in super-large cities. In the long run, TOD should be expanded to TOC, and ultimate to TOM so the entire urban development will be transit-oriented. On the technical side, it is essential to build new transit-oriented urban spatial model, and to construct the nationwide TOD inventory database. In a nutshell, TOD has a bright future in China even though there are still lots of work to be done.

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