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CHINA SUSTAINABLE CITIES
INTEGRATED APPROACH PILOT PROJECT

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GEF-6 CHINA SUSTAINABLE CITIES INTEGRATED APPROACH PILOT PROJECT

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BEIJING

Preface

The Sustainable Cities Integrated Approach Pilot was a worldwide program established by the multinational Global Environment Facility in its sixth funding round (GEF-6). As implemented in China, it was aimed at helping Chinese cities use the principles of transit-oriented development (TOD) to achieve sustainable land-use policies and transit plans at the levels of city, transit corridor, and transit station. The five-year China project (GEF-6 China TOD) ran from December 2017 to March 2023. It was managed by the World Bank and implemented by China's Ministry of Housing and Urban-Rural Development (MoHURD) and seven representative large cities: Beijing, Tianjin, Shijiazhuang, Ningbo, Nanchang, Guiyang, and Shenzhen. The three special discussions in this report are based on the technical outputs of the project and provide a summary and elaboration of their respective TOD themes: urban regeneration, public participation, and urban rail financing. This report is prepared by the team from Beijing Jiaotong University.

NANCHANG

Special Topic 1:
URBAN REGENERATION

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Abstract

Urban regeneration in China seeks to enhance the accessibility and convenience of older or dysfunctional urban spaces through transit-oriented development (TOD). In the face of rising automobile ownership, congestion, a worsening of climate change, and social division, the TOD model promotes green transportation while bringing together new job opportunities closer to housing, lessening congestion, and increasing prosperity.

The GEF-6 China TOD project was aimed at helping seven pilot cities— Beijing, Tianjin, Shijiazhuang, Ningbo, Nanchang, Guiyang, and Shenzhen—incorporate the principles of TOD into their land-use policies and transit plans.

Noted here are TOD-related urban regeneration projects discussed in some of the pilot city reports. Some of the cities with a neighborhood regeneration project did not include it in their summary report. Such was the case of Kaiming Street in Ningbo. We summarize that project here as illustrative of the issues in urban regeneration through TOD.

Ningbo demonstrated regeneration by integrating underground spaces with the three rail transit stations along Kaiming Street. The strategy was crucial for restoring vitality for the following reasons: (1) The transportation infrastructure stitches together the entire area, improving both above-ground and underground pedestrian accessibility and alleviating traffic congestion. (2) The strategy provides high-quality commercial and public spaces—an "urban living room"—for residents in the vicinity of the rail transit station projects and throughout the city. (3) The strategy injects vitality into urban development by attracting young people for jobs and residences.

For reasons such as these, TOD will help regenerate older urban areas and enhance the quality of urban life in the process.

SHENZHEN

1. Introduction

The renovation of deteriorated communities in urban areas in China was an initiative that originated in the 1980s. Promoted by the Ministry of Housing and Urban-Rural Development (MoHURD), it was a significant effort to improve the quality of life for urban residents. The renovations helped improve the living environment and infrastructure of cities during the early stages of the nationwide era of reform and opening up.

Since the 1990s, urban regeneration in Chinese cities has received even more attention. It transitioned from local pilot projects to more extensive urban areas. In the urban regeneration activities of the 1990s, projects focused on the transformation of older city areas suffering from deteriorated housing, environmental pollution, and chaotic layouts. Receiving less attention were the issues of transportation and commercial prosperity.

After 2000, urban regeneration began to accelerate, and more diversified and comprehensive urban regeneration concepts emerged. During this period, various cities in China produced numerous cases of urban regeneration with different approaches and functions. Examples include Xintiandi in Shanghai, Juerhutong in Beijing, and Sanfang Qixiang in Fuzhou. They all have in common the goals of renovating and transforming urban communities while improving the material space.

However, in the 2010s, urban regeneration encountered problems and challenges. For example, the rapid growth of automobile ownership produced severe congestion in the narrow streets of old urban areas. Urban regeneration had to become more involved in the more difficult and costly transformation of transportation infrastructure. Likewise, urban functions and service facilities urgently needed to be enhanced in this new round of urban regeneration. Yet, the increasing costs of demolition and resettlement proved greater than the availability of project financing.

In recent years, transit-oriented development (TOD) has emerged as a new model for urban regeneration in the older urban areas of Chinese cities. Since the 2010s, TOD has shifted the focus of urban regeneration from the renewal of the material space to establishing complete "living circles": creating high-quality community environments and service facilities.

2. The Evolution of Policy

At the national level, the 2013 *Opinions of the State Council on Strengthening Urban Infrastructure Construction* led MoHURD to release, in 2015, *Guidelines for Planning and Design of Urban Rail Transit Areas*. MoHURD's 2015 guidelines set the framework for urban regeneration in terms of planning urban rail transit corridors—a TOD strategy. Developing the corridors included the development of underground spaces and improvements above ground to enhance urban vitality.

At the local level, various cities introduced policies to promote TOD via rail transit under the 2015 MoHURD guidelines. The original intention of these policies mostly concerned the development of rail transit stations rather than urban regeneration, but the practical effect was that the two overlapped: China's old urban areas are mostly located in the city center, so planning rail transit networks there also promoted sustainable urban regeneration. The local policies clarified the special ownership categories of land along transit corridors, providing a basis for comprehensive development, functional transfer, and underground space development combined with urban regeneration.

Several of the seven pilot cities in the GEF-6 China TOD project can serve as examples:

- In 2011, Shenzhen introduced the *Interim Measures for Pricing and Capital Contribution of State-owned Land Use Rights in Shenzhen*, which covered pricing and transfer for properties above rail transit. It provided the policy basis for Shenzhen's Rail + Property model.

- Also in 2011, Ningbo introduced the *Special Land Reserve System for Rail Transit*. It clarified the linkage between rail transit construction and the development of land along the rail transit line to ensure the availability of funds for rail transit construction.
- In 2014, Guiyang introduced the *Interim Measures for Pricing and Capital Contribution of State-owned Land Use Rights in Guiyang City Urban Rail Transit (2014)*, proposing the innovative model of a Rail + Property virtuous cycle to solve the problem of initial funding shortages for rail transit.
- In 2021, the Beijing municipal government issued the Beijing *14th Five-Year Plan for Economic and Social Development and the Outline of Vision 2035 (2021–2025)*, which proposed to "strengthen land use around rail transit stations and integrate above- and below-ground spaces." The Beijing Municipal Commission of Housing and Urban-Rural Development issued the *Guiding Opinions on the Management and Use of Vacated Underground Spaces in 2022*, emphasizing the "comprehensive consideration of vacated underground spaces in the region as public service and convenience facilities projects."

TOD projects in large cities typically integrate the construction of rail transit lines and stations with a revamping of land use and the urban form under market mechanisms. This integration helps urban renovation projects break free from the constraints of spatial form and housing renovation and take a more holistic path.

In the seven pilot cities supported by the GEF-6 China TOD project, China's national government has introduced the "micro center" policy. The approach combines the construction of new urban rail transit lines and stations with the application of land indicators to the radius area of rail transit services, optimizing the density and quality of construction within the service area.

Tianjin proposed a "5V" classification system for station types, improving the vitality of residential communities around traditional industrial areas through enhanced walkable accessibility.[1] Shenzhen concurrently undertook the redevelopment of urban villages while constructing its metro lines, creating a unique set of exemplary revitalization projects.

Guiyang, Shijiazhuang, and Nanchang have focused on the integration of above-ground and underground spaces for commercial complexes in conjunction with the construction of rail transit stations in the city center. This has enriched the options for the formation of new businesses around the stations. Noteworthy areas include the fountain square at the intersection of Guiyang Metro Lines 1 and 2, Beiguo Shopping Mall at the intersection of Shijiazhuang Metro Lines 1 and 2, and Bayi Pavilion at the intersection of Nanchang Metro Lines 1 and 4.

Combining urban planning policies with market forces to drive higher-quality and sustainable urban regeneration is crucial for the continued success of TOD in Chinese cities. This report, through the case study of urban regeneration in the traditional commercial area along Kaiming Street in the old city center of Ningbo, demonstrates how the integration of new urban rail transit with old city regeneration can promote revitalization through the TOD model.

3. Integration of Urban Regeneration and TOD

TOD in Chinese cities has been widely practiced since the rapid construction of urban rail transit began in the 2010s. However, the GEF-6 China TOD project involved a more systematic and comprehensive TOD model that also brought new research to bear on unique challenges posed by some of China's large cities. Urban regeneration driven by the GEF-6 China TOD project not only improved the accessibility of the old city and solved congestion problems, but also promoted the optimization of urban functions within walking range.

1 The Tianjin city-level research team modified the TOD 3V model proposed by the World Bank (Node Value, Place Value, Market Value) by introducing two additional factors: Environmental Value and Social Value, thus forming the 5V (or 3+2V) methodology.

Promoting Efficient Land Use and Mixed Functions

In the old central areas of Chinese cities, land often features complex ownership and a single function, which pose difficulties for urban regeneration. As subways, rail transit lines can penetrate deep into the inner city, providing new opportunities for land development. Urban regeneration driven by TOD improves the functional layout of land along the corridor by forming a more compact and mixed-use pattern. By complementing commercial functions and perfecting the "living circle," in which homes, jobs, and services are often within walking distance, TOD enhances the quality of life for residents in the inner city.

Promoting Industrial and Commercial Updates and Upgrades

Integrated TOD above and below ground can attract commercial complexes to declining areas and revitalize neighborhoods. To fully capture land value, rail transit development companies generate stable income beyond ticketing and monetize property capital by offering varied and flexible leasing arrangements in station spaces. Developing underground spaces in combination with rail transit in the city center fosters new commercial activities, driving the regeneration of the entire area by feeding back into investment in construction and operation.

Enhancing Convenience and Accessibility for Residents' Travel

Combining urban regeneration with TOD provides convenient and efficient public transportation options for older urban areas, reducing car travel and alleviating congestion with minimal environmental impact. As a low-carbon mode of transportation, rail TOD greatly upgrades the quality of travel in the city center and improves regional transportation.

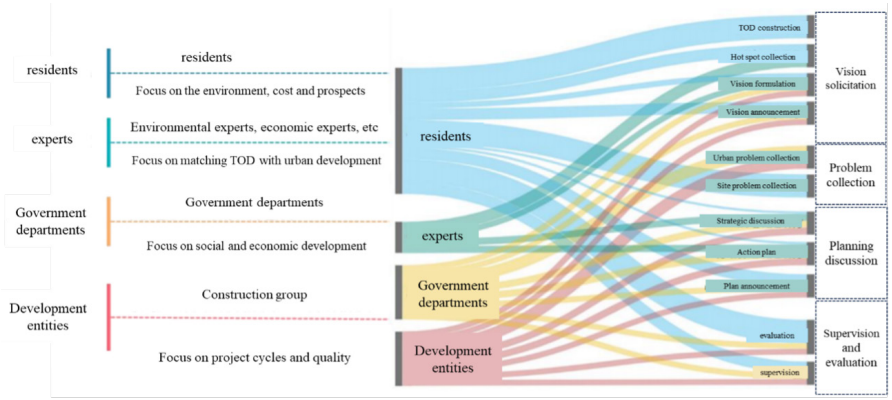
4. Urban Regeneration within Overall TOD Analysis and Planning

The seven GEF-6 pilot cities have pursued TOD at the city, corridor, and station scales, all of which can be represented as different levels of urban renewal (figure 1). At the city scale, the increase in density of rail transit networks and stations within a certain range is usually an organizing force in reshaping the city core and guiding its growth to near and far suburbs in a more compact, transit-oriented, and sustainable fashion. Regeneration of older areas of a city typically become part of the city-scale plan. But city-wide efforts are by definition large in scale and long in duration, requiring policies and overall planning support that are more systematic and comprehensive than those involved in efforts focused on the regeneration of specific older areas or on specific features of transportation infrastructure.

At the corridor scale, the focus is on the adjustment of land use and the improvement of transportation services along linear transportation infrastructure. Systematic and integrated functional adjustment studies are conducted by selecting representative sections of the corridor according to land use status and development potential. In the pilot cities, projects included the development of the Beijing suburban (suburb) railway line and, in Nanchang, the creative regeneration of old industrial areas at the end of metro Line 2.

At the station scale, the more controllable scope of projects allows the renovation of existing housing to accompany infrastructure construction. Among the pilot cities, Beijing, Tianjin, and Shenzhen have initiated urban regeneration projects in suburban and exurban areas at both corridor and station scales. Beijing, Tianjin, Shijiazhuang, Ningbo, Nanchang, Guiyang, and Shenzhen have selected areas around existing urban rail transit hubs or newly constructed rail transit stations for urban regeneration research (table 1).

Figure 1: Framework of Urban Regeneration Driven by TOD



Source: Beijing Jiaotong University.

Table 1: Representative Cases of Urban Regeneration in Seven Pilot Cities

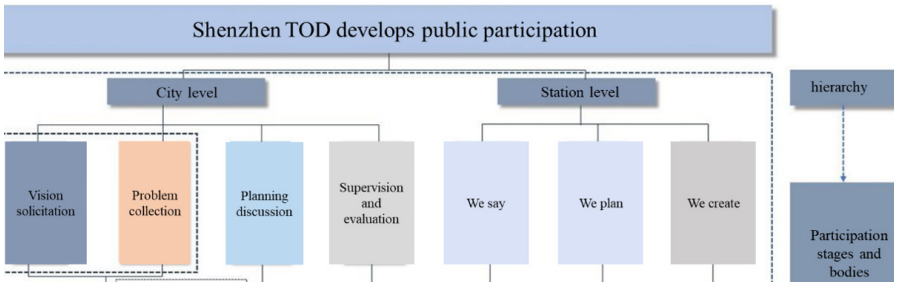
City	Corridor/Station	Location	Main Land Use Type	Scale
Beijing	Tongmi Line	Far suburbs	Industrial Park	Corridor
Tianjin	Jianchang Road Area	Suburban area	Residential	Station
Shijiazhuang	Shijiazhuang Line 4	Old city	——	Corridor
Ningbo	Kaiming Street	City center	Commercial	Station
Nanchang	Nanchang Line 2 (East Extension)	Suburbs	——	Corridor
Shenzhen	Bainikeng	Suburban area	Logistics, residential	Station
Guiyang	Zhongxi Road-Penshui Pool Station	City center	Commercial	Station

Source: Beijing Jiaotong University.

Beijing's Tongmi Line: Urban Regeneration under the "Micro Center" Policy

The construction of micro centers around transit stations is based on desired functions and hierarchical classifications. A micro center starts with core functions around the station and spreads out to surrounding areas to encompass a variety of other functions (figure 2). The scheme transforms the station area into a regional center with prominent advantages, distinctive features, and mixed functions.

Figure 2: TOD Corridor and Station Regeneration: New Urban Functional Strategies



Source: Beijing World Union Junhui Real Estate Consulting, *Research on Rail Transit Lines and Land Optimization Based on the TOD Concept.*

Working with Beijing's policy on micro centers for urban rail transit, the city's technical team initiated a study of land regeneration along the suburban railway lines in the city.[2] It chose to focus on the transformation of existing stations and their surroundings along sections of the Tongmi Line, areas that were older and had a lower level of development: Huairou Station and Huairou North Station in the Huairou section, and Niulanshan Station in the Shunyi section of the Tongmi Line. These stations represented a core that would drive urban regeneration in the surrounding areas.

The technical team researched systems such as "slow traffic" (pedestrian, bicycle, and e-bike) networks, bus connections, and parking management around the stations. The results formed the basis for planning schemes to optimize the stations' connection capabilities and enhance their efficiency.

Those activities in turn supported development in the surrounding areas:

- Upgrading and improving supporting facilities and infrastructure around the stations
- Enhancing the urban environment
- Improving living quality
- Increasing land value
- Reserving land that would allow flexibility in future construction and development

The Beijing work demonstrated that, at the corridor level, TOD-driven urban regeneration achieves the goals of green transportation and organic decongestion, optimizes the urban spatial structure, and promotes high-quality urban development.

Regenerating Residential Areas in the Suburbs of Tianjin

Tianjin has been facing the excessive concentration of urban functions in the central area and increasing pressure from rising population, traffic, and environmental degradation. The construction of rail transit presented the project technical team in Tianjin with the dual TOD opportunity of pursuing regeneration of the old city while strengthening the development and construction of undeveloped land along the transit corridors.

In the suburban areas, the team focused on the Jianchang Road area, which is traversed by metro Line 5. They aimed to encourage the migration of population from the central area to the older suburbs such as Jianchang Road by improving the accessibility of public transportation and the living environment in those outlying areas. Three rail transit stations were identified as TOD units—Jianchang Road, Siyuan Road, and Jinzhonghe Street. Development goals and approaches were based on the current land use conditions and development potential. Improvements were made in transportation, environment, and public services within the area.

Inner-City Regeneration along Shijiazhuang Line 4

In the case of Shijiazhuang, the technical team focused on plans for a new metro corridor, Line 4, which would traverse the older, inner city and newer areas. Their research on the corridor aimed to promote urban regeneration in the inner city by addressing issues such as inefficient land use, imbalance between work and residence spaces, and the lack of high-quality public service facilities. Their aim was to enhance the quality of life and public service functions along the line there through a "subtraction and multiplication" strategy. That is, the inefficient use of industrial and warehouse land and job-residence imbalance would be addressed by relocating functions away from the inner city and "multiplying" those functions in the outer areas.

2 Beijing Sino-Ocean Junhui Real Estate Consulting (2021). *Rail Transit Line and Land Optimization Study Based on TOD Concept (Beijing).* Beijing.

Planning included several strategies:

- Assessing the land use efficiency within 500 meters of the stations. Land uses such as industry, logistics, warehousing, agriculture, and forestry that did not match the functions of the inner city were identified as sites for redevelopment.
- Conducting assessments of public service facilities for the line's two regional centers and 14 of the line's community-level centers. The station surroundings were separated into a core area, a direct impact area, and a secondary impact area. The team made recommendations for optimizing the functions and structures of public service facilities based on population density and station requirements. Existing sites with development potential were used for new layouts of public service facilities.
- Improving the overall job-residence spatial relationship. Relocate and generate job opportunities to the outer areas to achieve a more balanced relationship of work and residences.

Shenzhen: Bainikeng Urban Village Regeneration

In the case of Shenzhen, the technical team focused on the suburban Bainikeng area, exploring the mechanisms of urban village redevelopment around the rail transit hub station. The Bainikeng area is in Longgang District, on the edge of the core area of Shenzhen, and its development potential is relatively limited due to regional transportation and industrial constraints.

The area suffers from a significant mix of passenger and cargo traffic and a poor spatial environment. Dominated by agricultural product trading and logistics functions, Bainikeng has a severe shortage of basic life service facilities.

Bainikeng Station will become one of the stations on the under-construction Shenzhen-Dayawan Intercity Railway and a transfer station for the planned Shenzhen Metro Lines 18 and 21. To make Bainikeng Station a TOD hub for future three-line transfers, the technical team conducted a review of the area's roads and added bus transfer stations to relieve the traffic pressure around the rail transit station and improve the travel experience.

High-intensity development was planned to replace low-efficiency land around the Bainikeng hub. Efforts were made to encourage the convergence of diverse populations, creating a 24-hour, dynamic community.

In the hub station area, the emphasis was on mixed-use development, combining hub, office, and leisure functions to strengthen the hub's gateway nature and improve the area's overall appearance.

The technical team revamped the current distribution of public service facilities, constructing a community life-circle system based on residents' typical walking time. The team proposed a similar model for the configuration of public service facilities to better meet the residents' demands for daily life services (figure 3).

Figure 3: Optimized Living Facilities in the Renovated Bainikeng Area

Source: Beijing Jiaotong University.

5. Urban Regeneration of Ningbo's Old Town Center as Guided by TOD

The Kaiming Street area of Ningbo is in the Sanjiangkou area of the city center. The planning and construction of the Gulou, Chenghuang Temple, and Dongmenkou stations on metro Lines 1 and 2 have driven the economic growth of the entire old town center area.

The Kaiming Street area of the old town is one of Ningbo's landmark districts, hosting commercial and business activity, tourism, and public services. It is also a center of the city's traditional culture. The preservation of that cultural and historical heritage while updating the area with innovations to meet current needs would be the criterion of success for the TOD regeneration of the neighborhood.

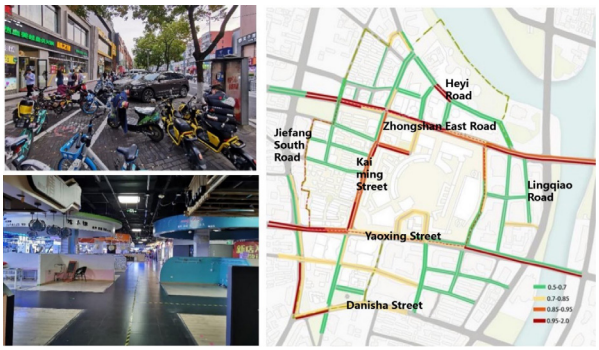
Historically, Kaiming Street was the location of the county office of Yinxian (Ningbo City). The area's rise was due to its location as a water and land transportation hub for the old city. It has always had a bustling and diverse atmosphere, with shops, entertainment, temples, and academies. Kaiming Street runs through the historical and cultural districts of Junci Temple and Lianqiao, which feature some of the city's most important cultural assets, including Tianfeng Pagoda, Chenghuang Temple, Yaohuang Temple, and Guanzong Temple. Kaiming Street's Tianyi Square is the most historically and commercially atmospheric zone in the old town center. Although Tianyi Square's leasing and operating company has adjusted formats in recent years and strengthened investments, the commercial vitality and quality have not improved.

The wider Kaiming Street area has experienced several rounds of urban regeneration focusing on improving its appearance and alleviating traffic congestion. The most recent round of updates, in 2021, aimed to enhance and transform aspects such as format, function, order, image, and management (figure 4). The results included an increase in pedestrian flow.

Figure 4: Renovating Facades on Kaiming Street

Source: People's Government of Haishu District, Ningbo.

Figure 5: Commercial Decline and Traffic Congestion in Kaiming Street



Source: China Metro Engineering Consulting, *GENB-3 Study on Improvement of Existing Rail Transit Stations based on TOD—Task 4: TOD Improvement Scheme Study.*

However, with the increase in pedestrian flow came an increase in traffic congestion, creating the most significant challenge to the urban regeneration of the area. Space for pedestrians was crowded out by vehicles (figure 5), creating difficulties that favored low-end over high-end commercial operations. The contemporary challenge lay in restraining the ever-increasing vehicular traffic that chokes the area's narrow streets, especially Kaiming Street, Zhongshan East Road, and Yaowang Street.

To address these long-standing issues, Ningbo City's GEF-6 China TOD technical team proposed the following policies and spatial planning methods guided by TOD.

Traffic Optimization as the Starting Point for Preserving Historical Context

The technical team proposed leveraging the potential of TOD through comprehensive transportation updates and renovations. Modernization and a reduction in traffic was pursued by connecting underground commercial spaces using rail transit stations.

The strategy required, first, systematically reviewing historical and cultural resources (figure 6). The principle was to make good use of historically protected buildings, support traditional businesses, and promote cultural and creative industries.

Next, historical and cultural elements were incorporated into the design of subway entrances and exits. Historical and cultural connotations of Ningbo were also incorporated in the design of surface-level pedestrian routes in the commercial districts, for example through features like ground pavement and landscape installations.

In these ways, the initiative aimed to preserve and use Ningbo's historical and cultural heritage to enhance the quality of the area as a unique cultural and commercial experiential district.

Delimiting the Urban Redevelopment Area through Coordination with Public Transportation

The team leveraged the core rail transit stations of Gulou Station, Dongmenkou Station, and Chenghuang Temple Station in the Sanjiangkou central district to improve connections between the redevelopment area and public transportation. To enhance the connectivity services of rail transit stations with the surrounding areas, Kaiming Street was made to connect to the existing underground pedestrian crossings in the north and to the existing underground passageways and the commercial area above Line K2 in the south. These connections facilitated the creation of a connected underground pedestrian space and optimized the organization of pedestrian flows.

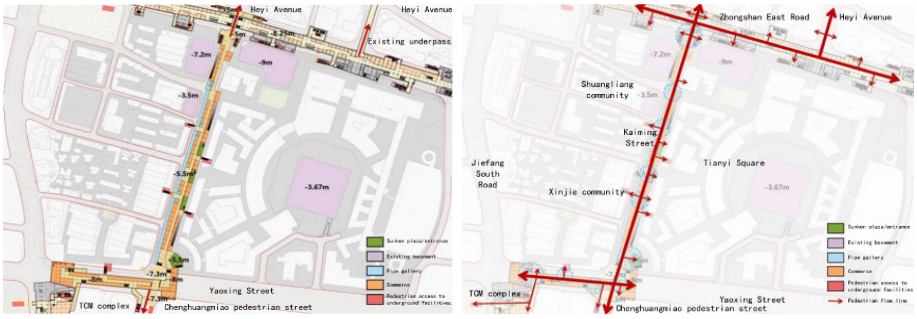
Figure 6: Analysis of Main Landmarks and Historical Resources along Kaiming Street Corridor

Source: China Railway Engineering Consulting Group, *GENB-3 Study on Improvement of Existing Rail Transit Stations Based on TOD, Task 4: TOD Improvement Scheme for Key Stations.*

Figure 7: Plan of Kaiming Street Under Ground

a. First floor

b. Pedestrian flow under ground



Source: Beijing Urban Construction Design & Development Group, *GENB-2 Implementation Decision Report of Ningbo TOD Improvement Pilot Project.*

Around the rail transit stations such as Gulou Station, Dongmenkou Station, and Chenghuang Temple Station, the underground spaces are interlinked. Connecting multiple above-ground public spaces to the underground space improves the pedestrian's underground experience. Signage, other markers, and moving walkways were added to help pedestrians navigate the underground corridors. The connected underground space forms a fishbone framework structure, with pedestrian walkways connected to the surrounding above-ground and underground spaces through dispersal staircases, escalators, and subterranean courtyards (figure 7).

The plan included improvements for transferring between rail and bus. The experience of cycling and walking was also enhanced. The demand for shared bicycles and e-bikes was accommodated with additional areas in which to park them to help shift the predominant mode of travel away from cars.

The rational delimiting of the TOD urban regeneration project area played a crucial role in the Kaiming Street project. The major issues and challenges in this area meant that research could not be confined to rail transit stations but rather would have to consider the comprehensive coordination and improvement of all public transportation infrastructure. Including elements such as multiple stations, established underground passageways, and surface-level connecting spaces in the research scope allowed the full range of travel modes to be reconfigured around the goals of urban renovation.

Revitalizing Above- and Below-Ground Commerce

Among the deficits of the Kaiming Street area were underutilized street-level, underground, and second-floor spaces and a poor realization of potential commercial value. The technical team treated these as a single problem and proposed a comprehensive integration of available above- and below-ground resources to increase commercial values.

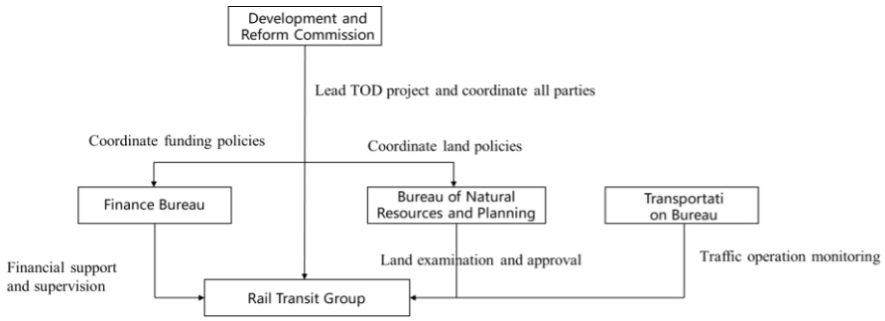
Integrating underground commercial space with the rail transit stations generates a significant influx of foot traffic into the underground pedestrian walkway and shops. The underground first floor contains commercial spaces, underground passages, utility corridors, and courtyards. The underground second floor includes the garage, utility corridors, ramps, and garage entrances and exits. Access from the underground station areas and commercial spaces created a unified, multilevel, transit-oriented commercial and public space. The renovation provides an expanded pedestrian realm offering year-round protection from the elements while offering an expanded showcase for the city's cultural history and achievements.

Multilateral Collaboration

The technical team also proposed a multilateral collaboration framework for the city's TOD-guided urban regeneration that could help assure sustainable funding. For the development of the Kaiming Street areas, it recommended that mechanisms be available to allow adjustments to the plan for special business needs. For example, under one such mechanism, market entities could receive exemptions from certain plan elements in exchange for investments in municipal construction, and policies such as floor-area ratio bonuses were implemented.

The government departments involved in the development cooperation framework included the city's Development and Reform Commission, Natural Resources and Planning Bureau, Finance Bureau, Transportation Bureau, and Rail Transit Group along with multiple key industries and other stakeholders (figure 8).

Figure 8: Ningbo TOD Joint Development Framework



Source: Shenzhen Urban Transportation Planning and Design Institute, *GENB-1 Ningbo TOD Strategic Study: Task 1-3 Results Report.*

The multilateral collaboration framework is intended to give full consideration to the opinions of stakeholders, including social groups, landowners, developers, and operators. The TOD project emphasized public participation throughout the entire process, in forms that included resident surveys, public meetings, and interviews with workers and shoppers to gain deeper insights into the transportation needs and behavioral characteristics of different groups.

The technical team also drew lessons from TOD promotion models, institutional mechanisms, and supporting policies in other cities, including Chengdu, Guangzhou, Qingdao, Chongqing, and Tianjin (one of the seven GEF-6 China TOD pilot cities). Drawing on those lessons and Ningbo's actual situation, the team proposed policies to optimize the institutional mechanisms of Ningbo's TOD urban regeneration projects. Three of these policies are as follows.

1. *A "Rail + Property" layered property rights mechanism*: Typically, underground spaces beyond the scope of planning do not belong to commercial properties, leading to operational and revenue challenges. In the case of Kaiming Street, the experience of the above cities suggested the creation of an intermediate layer between commercial office buildings and the underground second-floor rail station halls. This intermediate layer connected two stations with high commercial potential, forming an "underground commercial street" that could generate revenue to support the rail system. This policy represented an innovation in property rights ownership guided by TOD.

2. *Mechanisms for increasing the variety of businesses in underground space*: Fire safety and evacuation requirements in most Chinese cities reduce the potential for dining and shopping in underground spaces. The Kaiming Street project avoided these difficulties by including additional intermediate floors and plazas directly connected to outdoor spaces, enhancing ventilation and lighting in the underground space. By adopting measures to ensure compliance with fire safety regulations, including a prohibition of open flames, the proportion of restaurants, cafes, bars, and food vendors was increased, enhancing the commercial vitality of the underground space and providing richer and more convenient services for shoppers and nearby workers.

3. *Dual leadership of government and rail company*: To define the boundary of the comprehensive development unit, the Ningbo Rail Company worked with the city planning departments and also referred to other cities' technical guidelines, such as the *Chengdu Rail Transit Station Integrated Urban Design Guidelines and the Dongguan Rail Transit Station TOD and TID Planning Research Technical Guidelines*. As a result, in redeveloping Kaiming Street, the entire area was defined as a comprehensive development unit even though it was larger than what was strictly required for the construction of transportation infrastructure like rail lines and entrances and exits. Defined in this way, along with a buffer space, the development unit provided greater scope for integrating public transportation resources with revitalized underground spaces, allowing the rail company to connect as many surrounding businesses as possible. This not only increased the commercial operating space of the newly expanded intermediate floor but also realized a cost-benefit feedback mechanism for urban regeneration.

Summary and Reflections on the Regeneration of Kaiming Street

Urban regeneration in Ningbo under TOD guidance has enhanced the commercial vitality of Kaiming Street and optimized public transportation in the area. The integration of rail transit TOD with above- and below-ground pedestrian pathways has highlighted the characteristics of historical and cultural resources while revitalizing commercial spaces, providing more dining, leisure, and community services for surrounding office facilities. Increasing the proportion of connections between rail transit and buses, shared bicycles, electric bikes, and walkways created a well-designed pedestrian space.

However, certain city-specific conditions were prerequisites for the urban regeneration of the Kaiming Street area:

1. Ningbo's commercial development started early and progressed rapidly, accelerating the transition of the city's commercial form from shopping centers to high-quality urban leisure and commercial districts. The historical and cultural resources in the vicinity also contributed to the creation of themed commercial districts.

2. Property prices in the center of Ningbo were around CNY 40,000 per square meter, which is high among major Chinese cities. A high value makes it easier to achieve financial balance in urban development guided by TOD.

3. Some preferential policies were granted according to local policies regarding the development of underground spaces and property rights. Above ground, the land type was a mix of commercial and residential, while below ground, construction was based on the original underground passages and the Donggu Road commercial street, creating favorable conditions for regeneration.

Attention should be paid to what the corresponding prerequisites may be when undertaking urban center regeneration in other cities. Only then can TOD-driven urban regeneration be tailored to local characteristics and advantages.

6. Summary of Experiences and Outlook

In summary, TOD has become a significant force in promoting higher-quality urban regeneration in China. Relying on urban regeneration guided by rail transit, TOD optimizes the transportation infrastructure in old urban areas. It integrates rail transit stations with the above- and below-ground urban environment, thereby improving the accessibility and pedestrian-friendliness of the old city. It also brings about the intangible benefits of enhancing the quality of urban built spaces and the ambience of its commercial areas. Successful TOD regeneration projects strike a balance between the preservation of historical and cultural resources in the older city center and the development of new commercial spaces.

TOD regeneration projects can also have positive social impacts by reorganizing the "living circle" of public service facilities around rail transit lines and stations. In doing so, it enhances the accessibility of low-income groups to public service resources, promoting social equity based on the new public transportation infrastructure.

Outlook on Future Policies and Research

The experiences and innovations generated in the seven pilot cities of the GEF-6 China TOD project offer valuable lessons for other cities in China. A key insight for the regeneration of older urban areas is that the formulation of supporting policies is essential to high-quality TOD-guided projects.

Using pilot cities as examples, China has introduced some effective policies for TOD-guided urban regeneration at both the national and local levels. The activities covered by these policies include rail transit planning and design, above- and below-ground space development, confirmation of rail property rights, and management. At both the national and local levels, TOD-oriented policies will need to be continuously introduced and updated if they are to effectively serve high-quality and sustainable development.

Looking ahead, Chinese cities face some problems with TOD-guided urban regeneration that require further in-depth research. For example,

- As time passes, rail transit infrastructure itself will face aging and obsolescence. How will it be updated, and what impact will it have on the urban areas along the line?
- With the popularity of new transportation systems such as e-bikes and lower-capacity modes of rail transit, how can conventional bus operations avoid becoming a financial burden for the city?
- How can TOD be fashioned to meet the challenges of the latest travel modes?
- How can TOD projects meet the increasing demand of the aging population for barrier-free travel?

Solving these challenges awaits further research based on existing TOD-guided urban regeneration experiences.

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SHENZHEN

Special Topic 2:
PUBLIC PARTICIPATION

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Abstract

Transit-oriented development (TOD) is more than an engineering initiative. It encompasses broad environmental, social, and economic goals that affect a wide range of stakeholders within the general public as well as among development enterprises and local businesses. Each stakeholder varies in their level of involvement, degree of participation, focus of attention, and core demands. Therefore, understanding and coordinating stakeholder interests as much as possible is essential to garner the support needed to advance complex TOD goals. Unlike previous urban development plans in China, the GEF-6 China TOD project, involving seven pilot cities (Beijing, Tianjin, Shijiazhuang, Ningbo, Nanchang, Guiyang, and Shenzhen), explicitly recognized that "public participation" was a "mandatory action" for each contract. The project focused on two fundamental aspects of participation: (1) identifying types of stakeholders to allow customizing of participation to meet particular needs and interests and (2) designing formats for such customized interactions. This report summarizes experiences across the pilot cities and selects three—Beijing, Guiyang, and Shenzhen—to examine their particular approaches to the task: "open door" planning in Beijing, the "inclusive" concept in Guiyang, and the "full cycle" strategy in Shenzhen. The distinctive experiences of these pilot cities provide important practical lessons for other cities conducting public participation activities in their development projects.


NINGBO

Introduction

Transit-oriented development (TOD) aims to produce economic, environmental, and social benefits that advance the sustainable development of cities. The implementation of TOD projects takes place over many years with profound effects on residents' lives and community aspirations. Unless the projects are created with an understanding of the communities they affect and with the collaboration of residents, they are not likely to meet their goals. Hence, the success of TOD projects depends on coordinating the complex interests of multiple stakeholders, integrating their needs and visions into the formative stages of TOD projects, and using their feedback as the projects progress.

The GEF-6 China TOD project, involving seven pilot cities (Beijing, Tianjin, Shijiazhuang, Ningbo, Nanchang, Guiyang, and Shenzhen), incorporated public participation from the outset, making it an integral part of the planning and implementation in each city. Given that earlier phases of urban development in China have placed more emphasis on engineering and construction issues than on community input, the pilot cities' focus on public participation was highly innovative.

The GEF-6 China TOD projects emphasized public participation by taking account of public opinion in the initial planning. Project leaders surveyed specific and varied stakeholder groups to guide implementation; and they sought feedback to aid in improving the process in other parts of the city and for other elements of the overall TOD plan. By identifying disparate stakeholder groups involved in the projects, evaluating their influence and importance, and formulating customized participation plans for them, the project created effective ways for various groups to participate in the planning and design of the TOD initiatives and to evaluate their execution. In short, through public participation, the public at large and stakeholder groups learned about TOD strategies and in turn influenced them.

This report discusses the methods by which public participation was implemented and its results used in the GEF-6 China TOD project. It also examines activities in three of the seven pilot cities—Beijing, Guiyang, and Shenzhen—to illustrate the ways that participation was adapted to the particular conditions of each city's TOD projects. This report can serve as a reference for cities in developing countries around the world on how to orient their projects to community needs through public participation in the development process.

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Part 1: Public Participation as an Innovation

Before the GEF-6 China TOD project launched in late 2017, the typical approach to most construction and development projects in China focused on engineering issues. In planning, little consideration was given to broader social and environmental concerns or public opinion, nor were the effects of the projects on those concerns given much attention. In contrast, TOD aims to improve the livability of cities by bringing homes and workplaces and commercial activity closer together through urban redesign built around mass transit and nonmotorized transportation. Without carefully designed public participation, TOD would not receive the insights or learn of the aims of the many stakeholders involved. It would be unable to properly assess safety impacts, environmental effects, or the likely changes in residents' employment and travel, all core considerations for TOD.

In 2016, the Central Committee of the Communist Party of China and the State Council gave a strong boost to broadening the scope of development planning when they issued *Opinions on Further Strengthening Urban Planning and Construction Management*. That document explicitly required public participation to be established as a statutory procedure for major administrative decisions in urban planning.[1]

But even then, the mechanisms for public participation had still not been refined enough to identify the motivations and characteristics of various stakeholders and hence could not effectively match particular types of engagement activities to particular groups. Without an array of outreach efforts, each crafted to reach specific constituencies, most stakeholders would have only a limited understanding and awareness of such engagement opportunities and therefore of the project as a whole.

Therefore, the GEF-6 China TOD project needed a program for public participation that was both comprehensive and targeted. It wanted each of the seven pilot cities to encourage stakeholders' awareness of participation, identify stakeholder groups according to their interests and readiness to participate. The disaggregation of stakeholders helped the project to, in turn, shape formats for public engagement with TOD planning and execution in a manner most relevant to the expressed needs of the stakeholders.

1 In 2019, that requirement was embedded in Article 26 of China's Urban and Rural Planning Law. It stipulated that, before their plans could be approved, development agencies had to solicit opinions on their projects from experts and the public through meetings, public hearings, or other methods.

BEIJING

Part 2: Stakeholder Identification and Analysis

Public participation under the TOD framework involves both the general public and numerous stakeholder groups. These groups must be identified, and their importance for particular projects and development phases must be analyzed. Taken together, identification and analysis helps ensure that the specific needs of stakeholders in a particular TOD project will be addressed in a targeted manner and helps optimize the implementation of TOD projects.

Guiyang and Shenzhen made particularly extensive efforts to identify relevant stakeholders and to assess their importance for varying stages of the TOD process. Their criteria included socioeconomic and demographic characteristics as well as which stages of rail transit development were under consideration.

1. Guiyang

In Guiyang, the identification and evaluation of stakeholders had a unique emphasis: vulnerable groups, such as displaced migrants, low-income workers, women, ethnic minorities, the elderly, children, and people with disabilities. Guiyang considered the level of impact of TOD development on the surrounding environment during the project site selection phase, seeking to minimize the project's damage to the ecological and social environments.

The scope of social assessment was determined to be the urban development corridors of Phase I of Line S1, Phase I of Line 3, and the Circular Urban Rapid Rail project. Stakeholders engaged for participation for these corridors included the following groups:

- Government departments—district governments and related functional departments with a focus on municipal and district-level housing and urban-rural development, traffic management, natural resources and planning, ecological environment, civil affairs, and women's entities
- Relevant enterprises—municipal bus; municipal rail; and existing industrial, real estate development, and merchant enterprises
- Experts—in urban planning, transportation engineering, environmental protection, and other industries
- Individuals—all residents within the planning radiation range, with a focus on relocation and resettlement of those affected by land acquisition, employed workers, and women and children

2. Shenzhen

In Shenzhen, the identification and evaluation of stakeholders had a unique emphasis as well, in that it addressed the diverse interests and demands of various parties at four stages of TOD planning and construction: (1) soliciting social vision designs, (2) collecting TOD development issues, (3) deliberating on TOD strategies and action plans, and (4) constructing an indicator system.

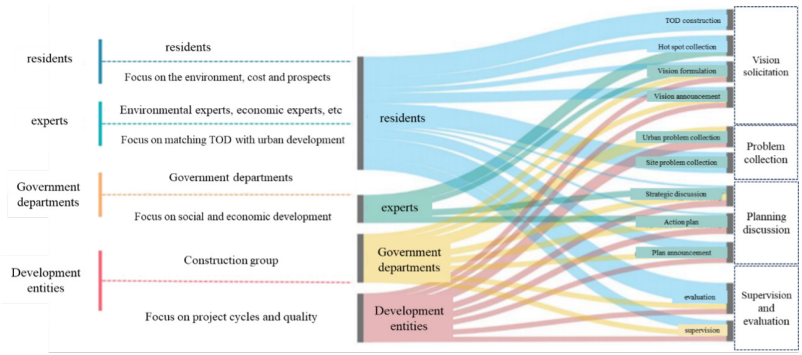
First, key stakeholders were identified among the following groups:

- Government departments that undertake the overall management of TOD: the commissions for Development and Reform, Urban and Rural Planning and Natural Resources, Housing and Urban-Rural Development, and Transportation; the Rail Transit Office, and district governments
- Entities that implement TOD project development and construction: commercial real estate developers, affordable housing development groups, subway groups, and local enterprises
- Experts who are responsible for overseeing the impacts of TOD development on the city at different stages: those in the fields of urban planning, transportation planning, investment and financing, and social security
- Residents, targeted both citywide and in the project's impact area

Second, these stakeholders were assigned varying degrees of involvement in the four selected stages of TOD planning and construction (figure 1).

1. Soliciting social vision designs: Attention was paid to the needs of all stakeholders. Different consultation methods were used for different consultation groups, allowing various stakeholders to deeply participate in the vision design of TOD.
2. Collecting TOD development issues: The process targeted government departments and development enterprises as well as residents both citywide and in specific communities. Government departments were primarily consulted on city-level development issues through discussions; development enterprises were consulted on city and station-level issues through meetings and interviews; and to identify gaps between vision and execution on station-level issues, residents were consulted through online and offline questionnaires.
3. Deliberating on TOD strategies and action plans: This stage primarily invited government departments, development enterprises, and technical experts to jointly formulate TOD strategies and action plans in various ways, including symposiums.
4. Constructing an indicator system: The focus was mainly on receiving feedback from the resident population through surveys and interviews to guide development of the criteria for evaluating the projects.

Figure 1: Participants in the Four Stages of Shenzhen Public Consultations



Source: Shenzhen Urban Transport Planning and Design Institute (2021b).

Part 3: Designing Formats for Public Participation

Only with the aid of feedback through public participation can the TOD process improve urban functions in a way that meets residents' needs and desires. In past development processes, information appeared in the public eye mostly in the form of results announcements. In contrast, the pilot cities of the GEF-6 China TOD project created a variety of public participation formats to optimize the formulation of TOD strategies and guide the implementation of TOD projects. These formats were variously designed for engagement by the general public as well as by specific categories of stakeholders at the city level and neighborhood or station level.

All seven pilot cities of the GEF-6 China TOD project conducted public participation research at the city level, fully integrating public participation and the social effects it reflected into the development strategy of urban TOD. At the station level, various cities conducted distinctive public participation activities based on specific stakeholders and the characteristics of each station (or neighborhood with several stations) to promote the implementation of TOD.

1. Beijing

Beijing organized city-level public participation through activities such as collecting questionnaires on citizens' visions, consulting station issues, surveying public travel demands, and constructing a supervision and evaluation system. They organized surveys through the WeChat public platform, published articles introducing topics, and guided up to 11 types of stakeholders to participate in the surveys.

To enhance the surrounding spatial environment of TOD rail transit stations, the Beijing team chose the Dongsi and Beiyuan stations for extensive public participation. The main content included forming a crowd portrait through station surveys, questionnaires, in-depth interviews, and site filming. The team used the results as guidelines in formulating environmental designs public service facilities around the stations. The participation process also helped in creating a toolkit to replicate the process at other stations.

2. Guiyang

Guiyang established mechanisms for addressing various stakeholders, including residents, experts, government departments, and development entities. These mechanisms included information disclosures, consultations, and the distribution of questionnaires. The results aided them in designing customized formats to obtain further public input and to provide feedback to the public as the project developed, both at the city and station levels of planning.

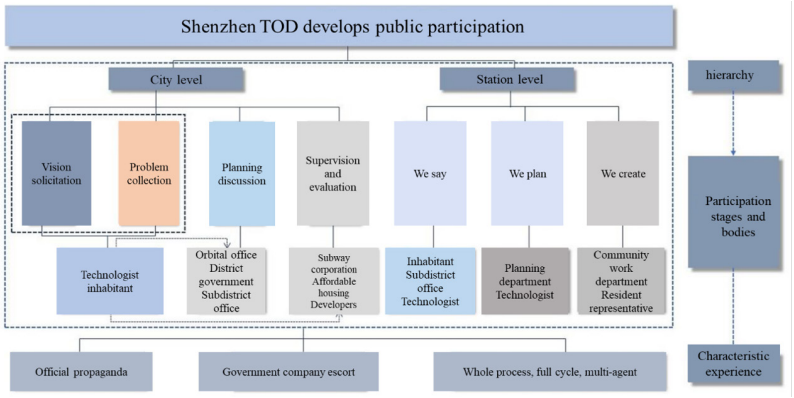
3. Shenzhen

Shenzhen conducted public participation activities throughout the course of the project. At all stages of participation, the participation of stakeholders was consistently encouraged , providing a solid community foundation for the implementation of TOD strategies.

At the city level (figure 2), public engagement was established for four distinct stages: soliciting social vision designs, collecting TOD development issues, deliberating on TOD strategies and action plans, and constructing a system of indicators (the criteria by which TOD activities are evaluated).

Shenzhen selected the neighborhood of Bainikeng as a representative unit for applying TOD planning strategies at the station level. Three stages of public participation were organized for the renewal of Bainikeng (figure 2): the "We Say" stage to collectively discuss the vision for Bainikeng, the "We Plan" stage for planning specifics, and the "We Create" stage for feedback and implementation. Using these formats within the TOD process, Bainikeng stakeholders helped improve the traffic situation in the neighborhood, optimize land development methods, and improve supporting facilities.

Figure 2: Shenzhen's Framework for Public Participation



Source: Beijing Jiaotong University.

Part 4: Specialized Participation Practices

The GEF-6 China TOD project operated under a strong mandate across all seven pilot cities to employ a thorough process of public engagement with the project's aims and implementation. Against that backdrop, the variations across the cities of Beijing, Guiyang, and Shenzhen in their practices and methods of public engagement were a function of their special concerns regarding the TOD process. Beijing emphasized the broadest possible engagement with all details of TOD at the station level. Guiyang focused on assessing and addressing impacts on vulnerable groups of residents. Shenzhen took special care to fine-tune its identification and involvement of stakeholder groups in its specially targeted neighborhood of Bainikeng.

1. Beijing's "Open Door" Planning Approach

In considering the design of rail transit stations in the TOD process, Beijing adhered to the principle and characteristics of "open door" public participation. Open-door planning aims to guide the design of surrounding environments through the results of public participation and promote the implementation of spatial transformation. The city used an iterative process by which relevant participation methods and results around a proposed station were summarized in a toolkit that was extended for use with other stations. This became an important method of strengthening public participation for TOD.

To realize open-door planning, Beijing gathered public opinion through various channels, including the WeChat platform and a visioning survey. Data on residents' preferences for service facilities, public transport, urban roads, and so on helped form the basis for the design of stations and their surroundings.

Planning for the Dongsi Station provides an example of the process (figure 3). Field research and interviews showed that during workdays, the age of most rail transit commuters ranged between the young and the middle-aged, whereas on weekend mornings the predominant group was the elderly. The main demands of respondents were focused on spatial zoning, increased greenery and shading facilities, attention to the details of designing seating and other resting facilities, organized parking, inclusion of elements of old Beijing culture, addition of information guides for surrounding places, and promotion of synergy between surrounding shops and spaces. In the planning phase, suggestions included constructing age-friendly public spaces and cultural display windows relevant to Dongsi.

Figure 3: Onsite Interviews for Beijing's Dongsi Subway Station

Source: Beijing Urban Construction Design and Development Group (2021).

2. Guiyang's "Inclusiveness"

Guiyang employed an inclusive approach to public participation that gave special attention to the needs of vulnerable groups. Their concerns and demands were fully considered in the planning process, taking into account their customs and living environments, and efforts were made to minimize the impact that TOD planning would have on them.

First, in the early stage of TOD planning, Guiyang conducted a wide-ranging survey of residents' travel habits and concerns. The surveys included the main modes of transportation, facilities surrounding the stations, and major issues. About 12,300 residents participated, including women (36 percent), the elderly (2 percent), and individuals with an annual family income below CNY 30,000 (21 percent). The feedback on residents' responses was integrated into the planning process. Areas with a concentration of low-income and ethnic minority populations received consideration in TOD route planning. Additionally, facilities free of mobility barriers were included in designs, along with accommodations such as women's and infant sanitary facilities and public safety facilities. Efforts were also mandated to provide employment opportunities for ethnic minorities and women.

Second, during the environmental and social impact assessment stage, formats such as questionnaires, visits, and discussions were used for further consultation with regional government departments and vulnerable groups. This process included feedback from groups affected by land acquisition, regional employed workers, women, children, the elderly, ethnic minorities, people with disabilities, and mobile populations.

3. Shenzhen's "Full Cycle" Action

At the station level, Shenzhen's Bainikeng community TOD plan conducted participation activities involving multiple stakeholders over the full cycle of the community renewal project—that is, from visioning to the critique of the plans (figure 4). The engagement addressed issues such as residents' difficulty in traveling, the absence of essential life service facilities, and the mixing of incompatible land uses.

During the "We Say" stage, TOD models were first promoted through a combination of online and offline methods. Before promotion, 80 percent of residents were unaware of TOD, a share that decreased to 3 percent after promotion. Subsequently, voices from diverse stakeholders were collected through formats such as interviews, questionnaires, wish cards, and video interviews.

During the "We Plan" stage, the planning team organized stakeholder workshops and project consultation meetings using a collaborative and interactive approach allowing stakeholders to efficiently and flexibly participate in the project preparation process.

During the "We Create" stage, public participation was conducted on the basis of fully informed residents. Two focus group discussions gathered the perspectives of industry associations and community residents to assess plans in terms of the core concerns and demands collected during the visioning stage.

Figure 4: Stages of Public Participation in Bainikeng

Source: China Academy of Urban Planning and Design (2021a).


SHIJIAZHUANG

Part 5: Conclusion

The engagement of key stakeholders in diverse public participation activities forms the basis for planning and implementing TOD projects. By identifying and analyzing stakeholder groups, creating formats for their engagement, and using their input to guide implementation, the GEF-6 China TOD project established major innovations in the conduct of urban development in China. Such public engagement put the TOD project in the seven pilot cities on a solid foundation of community partnership. Among the pilot cities, Beijing employed its "open-door" planning which helped optimize urban TOD policies through bottom-up public participation. Guiyang's "inclusive" concept focused on the needs of vulnerable groups, fully incorporating research results into strategic and planning designs. Shenzhen's "full cycle" action ensured the implementation of the common vision for the Bainikeng area TOD through a model of stakeholder participation covering the entire process.

These characteristic experiences of public engagement and influence provide an important example for the formulation and implementation of TOD projects. Three broad lessons are applicable to other cities in China and to cities in other developing countries around the world:

- Governments should provide guidance through relevant laws and regulations to ensure the implementation of a public participation system.
- Developers and planning teams should incorporate public participation into the early stages of TOD projects to help identify relevant stakeholder groups and design appropriate engagement formats.
- Ordinary citizens and other stakeholders should proactively raise awareness of their basic rights of engagement and participation.

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Special Topic 3:
URBAN RAIL FINANCING

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BEIJING

Abstract

Rapid development of urban rail transit in China has played a crucial role in optimizing urban spatial structures, alleviating urban traffic congestion, and promoting socioeconomic development. However, the large investment requirements and long payback periods of rail transit construction make it difficult for government finances to independently support the continuous development of urban rail. Broadening financing channels and exploring suitable financing models are key to relieving the funding bottleneck. This report reviews the development history and financing models of urban rail transit in China. It shows that comprehensive land development under transit-oriented development (TOD) can increase the value of land and generate development income along the rail transit line, thus supporting rail construction and operations. It proposes an analytical framework and financial tools, including a cost-benefit estimation model, for funding urban rail projects in the context of TOD. From the work of the GEF-6 China TOD project, it uses the experiences of Tianjin's Metro Line 4 as a case study to explore the issues in rail funding under the TOD model at both the corridor and station levels.


SHIJIAZHUANG

Introduction

Urban rail transit, characterized by its high capacity, speed, low energy consumption, and comfort, has played a significant role in promoting urban modernization, guiding the optimization of urban spatial layouts, alleviating urban traffic congestion, and driving urban economic and social development. Beginning with the start of construction of Beijing's Subway Line 1 in 1965, China's urban rail transit systems have undergone nearly 60 years of remarkably successful development. As of the end of 2022, mainland China—that is, China excluding the Hong Kong Special Administrative Region (Hong Kong SAR) and Taiwan—had 55 cities with 308 urban rail transit lines in operation with a total length of about 10,290 kilometers. Currently, China leads the world in terms of the scale of its rail transit operational lines, under-construction lines, and passenger volumes.

However, urban rail transit requires substantial investment with a long payback period, and traditional financing models heavily reliant on government finances cannot support its sustainable development. From 2014 to 2020, China approved a total investment of CNY 5 trillion for urban rail transit. During China's 14th Five-Year Plan period (2021–25), there will be a significant increase in operational mileage, about 3,000 kilometers, resulting in a massive funding gap. Financing is becoming a bottleneck for the development of rail transit.

To address this issue, this report employs the concept of transit-oriented development (TOD) to explore the financing of urban rail transit. The TOD model in part involves comprehensive land development to raise both the value of land along the rail transit route and development income and the reinvestment of some of the profits into rail construction and operation.

This report focuses on the development history of urban rail transit in China, existing financing models and representative cases, financing analysis frameworks and technical calculations, and the financing case of Metro Line 4 in Tianjin, one of the seven pilot cities supported by the GEF-6 China TOD project. Tianjin proposed "PPP + TOD" financing, which combines public-private partnerships (PPP) within the TOD model. The report calculates the financing costs and benefits of this approach for corridor and station TOD and provides financing strategy recommendations. The goal is to promote the resolution of funding issues in Chinese rail transit construction and operation, encourage sustainable urban development, and provide guidance for the financing of urban rail transit in China and other developing countries.


SHENZHEN

Part 1: Background on the History and Financing of Urban Rail Transit in China

The rapid growth of urban rail transit in China since the 1960s has been accompanied by the twin trends of greater government oversight meant to limit the resulting indebtedness incurred by cities and by new methods of financing the projects and the associated real estate development.

1. Regulation of Urban Rail Transit in China

The history of urban rail transit in China can be divided into three significant stages: City-Based Initiatives (until 2003), Standardized Development (2003–18), and Optimized Development (after 2018). Although urban rail transit development had generally proceeded in an orderly manner from the 1960s to roughly 2000, planning in some cities was overly ambitious in terms of their funding capabilities, which contributed to rising local debt burdens. In 2003, the State Council's General Office issued State Council Document No. 81, *Notice on Strengthening the Management of Urban Rapid Rail Transit Construction* (Document 81), which tightened approval requirements for urban rail transit.

As city plans to build urban rail nonetheless accelerated in the years after 2003, creating a return to the strains that had led to Document 81, the National Development and Reform Commission (NDRC) responded with a further tightening, significantly raising the thresholds that cities must meet before their future urban rail transit projects could be approved. In 2018, the State Council embodied NDRC procedures in State Council Document No. 52, *Opinions on Further Strengthening the Planning and Construction Management of Urban Rail Transit* (Document 52) (table 1).

Document 52 required that cities proposing to build subways have a general public finance budget revenue greater than CNY 30 billion and a regional GDP of more than CNY 300 billion. It enforced strict control of local government debt. Projects that triggered warnings of local government debt risk were not approved or were temporarily delayed.

Moreover, the Document 52 approval and review procedures for construction planning were more strictly enforced. Provincial development and reform departments collaborated with planning authorities and housing and urban-rural development departments; they conducted initial reviews of urban rail transit plans and submitted them to the NDRC. First-round construction plans for urban rail transit were reviewed by the NDRC in conjunction with China's Ministry of Housing and Urban-Rural Development (MoHURD) and were submitted to the State Council for approval, and the same process was followed for a project's subsequent construction plans. For approved plans, a thorough review of the construction scale and project funding arrangements was conducted to ensure that the construction scale matched the financial capacity of the local government.

Table 1: Rail Transit Operations in Major Cities in China, Ranked by Passenger Traffic, 2022

Criterion	2003 (Document 81)	2018 (Document 52)
Local budgeted public revenue	10 billion	30 billion
Regional GDP	100 billion	300 billion
Urban resident population	3 million	3 million
Recent flow intensity, passengers per hour	No minimum	Not less than 7,000
One-way flow intensity in rush hour, passengers per hour	30,000	30,000

Note: For full names of documents 81 and 52, see text.
Source: Beijing Jiaotong University.

2. Financing Models of Urban Rail Transit in China

The construction of urban rail transit faces a significant funding constraint created by high capital requirements and a lengthy payback period. Traditional funding relying solely on government finances are unsustainable. As a result, several alternative financing models have emerged, each with its advantages and disadvantages, as follows (and summarized in table 2).

Public-Private Partnership (PPP)

The PPP model involves cooperation between the government and private capital to achieve the maximization of overall benefits. The government can provide support in policy, financial funding, and administration, while private capital provides funds and expertise in construction and management. Compared with traditional models, PPP has the advantages of relieving fiscal pressures, enhancing market vitality, and promoting infrastructure development in fiscally weaker regions. It has rapidly gained popularity in the fields of infrastructure development and engineering construction. The model does not, however, necessarily prevent the project from adding to government debt.

Build-Operate-Transfer (BOT)

The BOT is a concession arrangement in which government authorities sign time-limited agreements with private enterprise for an infrastructure project. The enterprise is responsible for financing, construction, operation, and maintenance during the contract period and receives project earnings. The government retains supervisory and regulatory rights over the infrastructure, and at the end of the concession period, the enterprise transfers the infrastructure to the government without charge. The financing costs of this arrangement may be relatively high, and the income may be uncertain.

Rail + Property

The Rail + Property model emerged with the use of the TOD concept for urban rail development. TOD focuses on intensively developing transit station areas that combine culture, commerce, education, entertainment, and habitation within about a 10-minute walk from the station. It maximizes the use of land, harmonizes the conflict between land scarcity and traffic congestion, and maximizes the use of public transit and slow modes of transportations. The higher land values created under the TOD concept can be captured in part by government to help finance the infrastructure. A disadvantage is that land development cycles, and therefore return on capital, can be slow.

Real Estate Investment Trust (REIT)

In 2020, China introduced the REIT model to revitalize existing infrastructure assets. REITs offer advantages in financing, investment, and operations. They provide financing via equity stakes reduce local government debt risks. REITs are standardized financial products with stable (but not guaranteed) dividends, low liquidity, low investment thresholds, and transparency. They are well received by private sector capital. REITs can solve the problem of exiting from traditionally financed infrastructure projects by facilitating re-financing. The REIT thereby creates a virtuous funding cycle and enhances project operations by entrusting existing assets to professional teams. The REIT nonetheless carries various forms of economic risk for investors.

Table 2: Comparison of Alternative Funding Models for Urban Rail

Model	Advantage	Disadvantage
PPP (public-private partnership)	Government and investors work together to maximize the overall benefits	Potentially adds to the government's debt burden
BOT (buy-operate-transfer)	Investors operate independently; project property rights are transferred to the government free of charge, which greatly reduces government financial risks	The cost of financing is high and the income is uncertain
Rail + Property	Intensive and economical use of land around rail stations; development of transportation and the surrounding property connected; project funding captured from higher land values	Long land development cycle, slow return of capital
REIT (real estate investment trust)	Guards against local debt risks; high acceptance by private sector capital; solves the exit path problem of project capital	Not a fixed-income product; low market liquidity

Source: Beijing Jiaotong University.

3. Examples of Rail Transit Financing

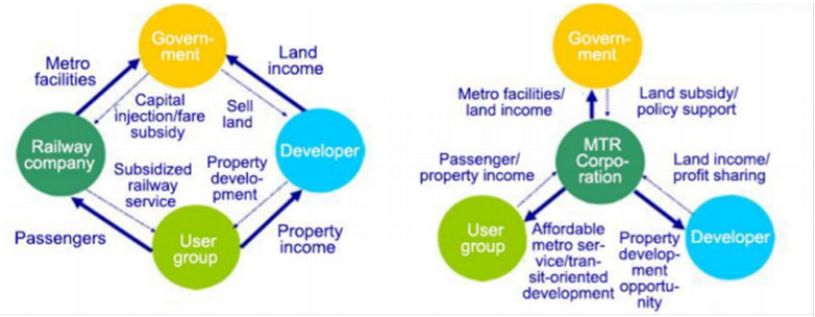
Xuzhou (PPP Model)

The first urban rail transit project in China to be tendered and implemented under PPP procedures was the construction of Xuzhou's Metro Line 2 (with a total length of about 24 kilometers). The total investment for the first phase of the project was CNY 6.7 billion, with government capital investment of CNY 1.5 billion supplied by the Xuzhou municipality and the remainder from the China Development Bank. Private sector capital investment was CNY 5.2 billion, with the China Railway Construction Corporation (CRCC), a large central enterprise, being introduced as a strategic investor and general contractor. The project company was jointly established by CRCC and the municipal rail transit company. After it won the bid, CRCC provided advance construction funds. The return to private sector capital included the general contracting contract, ticket revenue, operating space leasing, and government subsidies, distributed as dividends to the project company. This model is suitable for cities with low levels of urbanization, high fiscal pressure at the local level, and large areas of construction land available for development. It is also a typical model adopted in the TOD development of station areas in second-tier cities in China.

Hong Kong SAR (Rail + Property)

Research suggests that the Rail + Property model of financing rail construction projects by the Mass Transit Railway (MTR) in Hong Kong SAR can be divided into two modes: government-led and MTR-led (figure 1). In the government-led mode of the Rail + Property model, the government coordinates the entire development process, holding the transportation infrastructure and related commercial properties; MTR enjoys government-purchased services and corresponding subsidies for operation. In the MTR-led mode, MTR pays the government for the market value of the land, obtains the concession to develop the subway project and adjacent plots, and assumes all risks related to market fluctuations and operations.

Figure 1: Two Modes of Rail + Property Financing in Hong Kong SAR



Source: China Sustainable Transportation Center, *Financing Study of Urban Rail Transit Projects in Tianjin under the TOD Model: Summary Report*, 2022.

Shenzhen (PPP and BOT combined with Rail + Property)

In the case of Shenzhen Metro Line 4, government capital helped finance Shenzhen Metro Group through the use of land value as capital. By bundling revenue rights and BOT financing and construction tendering, the rail transit company and developers jointly introduced private sector capital. The main methods of land acquisition were targeted tendering and auction (such as for the Qianhai vehicle section) and land value as capital (such as in the Qianhai hub project). Investment returns included ticket revenue, property operation income, and land/property appreciation income. This model is suitable for cities with moderate fiscal pressure on the government and relatively scarce land resources in the urban area that are appreciating, in which case land income can support rail transit construction.

Shenzhen (REIT)

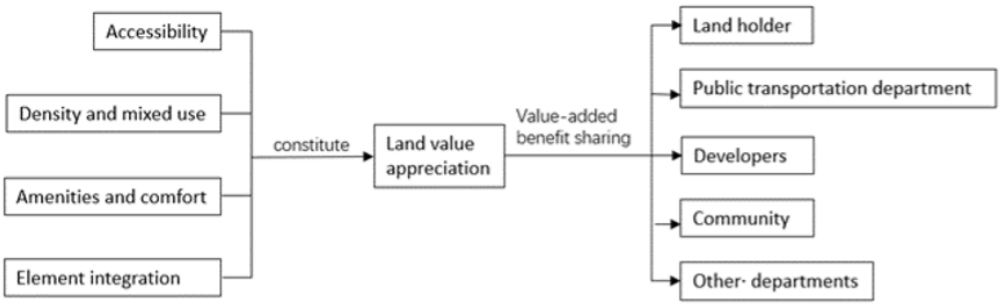
In April 2020, the China Securities Regulatory Commission and the NDRC issued Notice on Advancing Pilot Work Related to Real Estate Investment Trusts (REITs) in the Infrastructure Sector, with pilot projects primarily focused on infrastructure shortfalls in industries such as transportation, municipal services, and new infrastructure. REITs can solve the problem of the exit path for project capital providers,[1] reduce hidden government debt, and substantially reduce the amount of funding needed from private sector capital. Shenzhen Metro Group appointed Shenzhen Capital Group as the leading professional service organization for its REIT project. Hongtu Innovation Fund Management, a wholly owned subsidiary of Shenzhen Capital Group, served as the public fund manager, further establishing a "public offering + ABS + private offering" transaction structure. This model is suitable for rail projects with clear ownership; and it provides rail projects (excluding properties) with a stable cash flow during operation.

1 See, for example, https://www.linkedin.com/pulse/from-refinancing-reits-diverse-exit-paths-commercial-property.

Part 2: Financing Analysis and Tools for Rail Transit TOD Projects

TOD is a concept pioneered in the early 1990s in the United States by a founding figure of the New Urbanism, Peter Calthorpe.[2] Its strategy is centered around transit stations and walkable destinations. It creates mixed-use areas, including work, commerce, culture, education, and residences within a radius of approximately 400–800 meters (about a 5¬–10-minute walking distance). In following the TOD strategy, rail transit construction implements comprehensive land development along rail lines. In the process, it increases land values, part of which can be redistributed to help fund project construction and operation. The process forms a "virtuous cycle" (figure 2) that enables the sustainable development of rail transit construction.

Figure 2: Model for Distribution of Land Value Appreciation



Source: Beijing Jiaotong University.

2 Peter Calthorpe, *The Next American Metropolis: Ecology, Community, and the American Dream (Princeton, NJ: Princeton Architectural Press)*, 1993.

1. Principles and Processes of Rail Transit Financing

Rail transit construction and operation have high costs and long payback periods. Traditional financing models solely relying on local land finances are difficult to sustain. Starting in 2014 with the Ministry of Finance's *Notice on Promoting the Use of Government and Private Sector Capital Cooperation Models* (Caijin No. 76), diversified financing models, mainly based on government and private sector capital cooperation, have rapidly developed. They evolved from mere project construction models into investment and financing models. The current principles for financing urban rail transit are as follows:

Low Government Outlay

Government general budget expenditure should be minimized through the use of government bonds, land consolidation, and income from secondary land development. Private sector capital participation in rail transit construction through the Rail + Property model can alleviate the government's direct investment pressure and solve project construction funding issues.

Avoid Increasing Implicit Government Debt

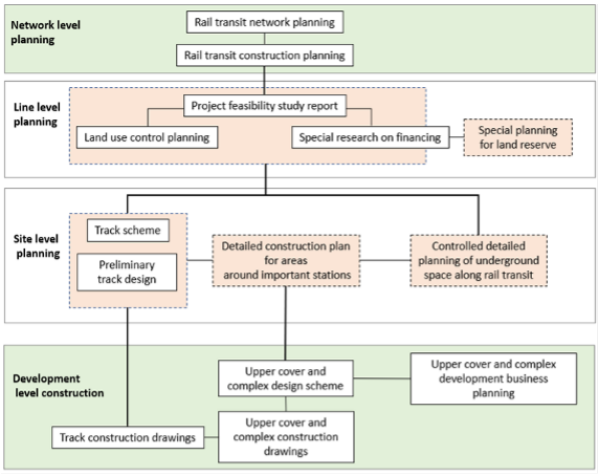
According to the 2018 Government Accounting Standards No. 8: Liabilities (Caiwu No. 31), obligations arising from future economic transactions or events do not belong to current obligations and should not be recognized as liabilities. Through the design of rational and effective transaction models, raising government debt levels can be avoided.

Feasibility

The financial feasibility of an urban rail construction project can be assessed by studying existing national and city-level policies on urban planning and rail transit construction planning and through research on limitations in investment and financing conditions.

In general, urban rail development can be divided into four levels (figure 3). The first is planning at the network level, which focuses on the rail transit network and overall construction planning. The second is the line level, which involves assessing feasibility through land use planning and financial research, including financing methods, funding sources, and calculation of development income along the route. This level also involves implementing land reserve planning. The third level is the station level, where track schemes and designs, detailed planning for station surroundings, and control planning for underground station spaces are carried out. The final level is the development and construction level, which includes drawings, business development, and construction.

Figure 3: Four Levels of Urban Rail Transit Development



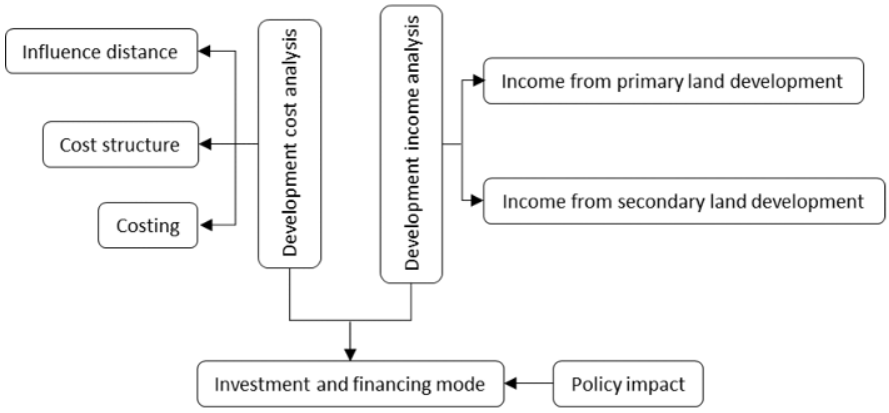
Source: Beijing Jiaotong University.

2. Project Cost and Income Estimation Model

Under the TOD model, rail transit projects increase the land values and development income along the route through comprehensive land development. These increments can then be reinvested into the full life cycle of rail transit construction and operation. To estimate these amounts, the technical team constructed a model containing each cost and income category, aiming to provide an accurate basis for the financial evaluation of such projects (figure 4).

As discussed below, the cost model consists of the development costs of line and station construction and operation and the costs of surrounding land development. The revenue model consists of subway development revenue, focusing on ticket sales and advertising revenue, plus income derived from selling or leasing land and buildings.

Figure 4: Model for Estimation of Rail Transit TOD Cost and Income



Source: Beijing Jiaotong University.

Subway Development Costs = Line Construction + Line Operations

Line construction: These costs include the construction expenses for rail line projects, construction expenses for other rail construction projects, contingency expenses, and special expenses. It is calculated as the cost per kilometer of rail lines from an engineering project perspective, including construction expenses for subway stations, construction expenses for operating segments, and installation expenses for public equipment and facilities.

Line operation: These costs comprise labor remuneration, electricity (for traction, power, and lighting), repairs, operations (such as station service, vehicle operation, protection equipment for labor, low-value consumables, and staff travel), and management expenses (such as compensation for management personnel, labor union expenses, office expenses, and staff education expenses).

TOD Development Costs = Land Development + TOD Operations

Primary land development: These costs include land acquisition, demolition compensation for buildings, and land reorganization costs.

Secondary land development: These are the various expenses required for the development and construction of real estate during the development period. They include costs for land, preliminary engineering, infrastructure construction, building installation, financing, and management.

TOD operations: This covers the operational costs of self-owned properties (such as power costs for lighting and office equipment), employee salaries, management expenses, marketing expenses, and repairs. Tax expenses related to property sales and rental income are also generally included in this category.

Metro Development Income = Fare Income + Other Business Net Income

Fare income: Revenue from ticket sales, estimated according to passenger volume, average distance traveled, and fare.

Other business net income: Income from advertising in stations and train cars and commercial development income associated with station facilities.

TOD Development Income = Property Sales + Self-Owned Property Income + Property Service and Advertising

Property sales: Income from the sale of residential, commercial, and office properties after the secondary land development is completed.

Self-owned property: Income from leasing commercial spaces, offices, hotels, and parking lots.

Property service and advertising: Includes rentals of advertising space.
In the early stages of TOD development, property sales form a major part of income, whereas in the later stages, income from self-owned properties becomes primary.

Part 3: Introduction to TOD Financing for the Tianjin Metro

Tianjin is administered directly by the central government of the People's Republic of China; it contains a free-trade zone and is the largest coastal city in northern China. Tianjin is chosen here as a case study for metro financing for the following reasons: (1) As a directly administered municipality, Tianjin meets current national standards for urban metro development. (2) The operating deficits and public subsidies implied by existing models of rail transit finance have nearly reached the upper limit as a proportion of government budget income, making it difficult to support the development of metro systems. (3) Tianjin is one of the cities that initiated early reforms of metro investment and financing in China; in recent years, it has accelerated the planning and construction of metro systems, continuing to develop innovative financing to address bottlenecks in financing for metro development.

1. Current Situation of Tianjin Metro Financing

The Tianjin metro plays a vital role in enhancing the city's quality of life and forms the backbone of Tianjin's transportation system. As of November 2022, Tianjin's metro system consisted of nine lines with a total length of 286 kilometers and 181 stations (counting transfer stations only once).

As of August 2021, the annual construction cost of Tianjin's metro projects was approximately CNY 10 billion per kilometer. After all the metro lines are fully operational, the annual operating cost will be two to four times the annual construction cost. TOD projects have an extended timeline because of their diversified nature, complex construction technology, long planning and design periods, and government coordination challenges. The financial consequence is a longer cash flow turnaround period than conventional rail construction and significant operational risks. Simultaneously, TOD-based metro operations will generate substantial operating costs for established metro networks each year, leading to funding shortfalls. These factors, when combined, result in a high demand for project funding, a low profit margin, and a long payback period.

Depending on the project characteristics, Tianjin mainly uses government investment and public-private partnership (PPP) models to help finance its metro projects (table 3). Government investment is primarily for large-scale projects with long construction periods, wide scope, and strong public interest. They are funded through various channels, including the government budget and net government land revenue. New metro projects financed with the PPP model use the "A + B" model: The government covers all "A" investment and part of "B" investment, with the government's total contribution accounting for 40 percent of the total project investment, and private sector capital the rest.

Table 3: Methods of Financing Urban Rail Transit in Tianjin as of 2020, by Metro Line

Metro Line	Status	Financing Mode
Line 1	Operating	Traditional government investment
Line 2	Operating	TOT after traditional government investment
Line 3	Operating	TOT after traditional government investment
Line 5	Operating	Traditional government investment
Line 6	Operating	Traditional government investment
Line 9 (Jinbin Light Rail	Operating	Traditional government investment
Line 4 (south section)	Construction	TOT shifted during traditional government investment
Line 4 (North section)	Construction	PPP (BOT)
Line 6 (Phase 2)	Construction	EPC
Line 7 (Phase 1)	Construction	PPP
Line 8 (Phase 1)	Construction	PPP
Line 10 (south section of Phase 1)	Construction	Traditional government investment
Line 11 (Phase 1)	Construction	PPP
Line B1 (Phase 1)	Construction	Government led under cost regulation
Line Z4 (Phase 1)	Construction	PPP

Note: TOT = Transfer-Operate-Transfer; EPC = Engineering Procurement Construction; PPP = Public-Private Partnership; BOT = Build-Operate-Transfer.
Source: China Sustainable Transportation Center, Tianjin TOD Financing Report, 2020.

2. Issues with Current Financing Models

Metro construction and operations continue to place a heavy burden on city finances. PPPs have not eliminated the burden, and low passenger flows and an inadequate fare structure add to the financial pressure.

Heavy Financial Pressure on Metro Construction and Operations

By 2030, Tianjin plans to have a total of 1,380 kilometers of metro lines, which is nearly triple the total length of lines currently under operating or under construction. This will exert significant financial pressure on the city's budget. Beginning in 2020, Tianjin faced the need to raise CNY 88 billion for metro construction by 2026. The government's capital investment already accounts for an average of 4.8 percent of public income. This level is nearly at the maximum proportion specified in Document 49 of the National Development and Reform Commission: "the proportion of government capital in public income should generally not exceed 5 percent."

Subsidies under the PPP Model Straining Government Financial Capacity

To alleviate financial pressure, Tianjin in 2019 gradually began introducing the PPP model for metro projects. Although PPPs can relieve Tianjin's immediate financial pressure, the government will still need to allocate a certain budget for project subsidies in the long term. According to estimates, from 2020 to 2050, a total of about CNY 365 billion in financial subsidies will be needed, with an average annual subsidy of nearly CNY 12 billion. Currently, all PPP projects in Tianjin are close to the upper limit of general public expenditure (not exceeding 10 percent). After the second phase of metro construction planning is completed, Tianjin will need to construct more than 800 kilometers of metro lines. In the long term, the PPP model faces the issue of exceeding the government's financial capacity and becoming unsustainable.

Low Passenger Flows and Weak Fare Structure

Although the total passenger flow on Tianjin's metro network is increasing, but traffic on some lines is still too low. Several factors are limiting the growth of passenger traffic. Most of the land sold for urban development is far from metro stations. The metro network's coverage in peripheral areas of the central city is relatively low. Compared with other Chinese cities, Tianjin offers only limited preferential measures to encourage the integrated use of its metro system and other modes of public transportation.

The problem of Inadequate fare income arises from charging passengers according to distance traveled rather than a flat fare, which results in lower fares for traveling certain distances, leading to lower metro operating income.

Response of Tianjin's Government

In summary, Tianjin's metro projects face significant financial pressure. In the face of a significant demand for metro construction in the long term, Tianjin urgently needs to explore other metro financing models to expand financing channels.

In December 2019, the Tianjin Municipal Commission of Housing and Urban-Rural Development and six other departments issued the Notice on Printing and Distributing the Implementation Opinions on Promoting the Comprehensive Development and Utilization of Tianjin Metro Stations and Surrounding Land Based on the TOD Model (Trial). It proposed using the TOD model to promote the comprehensive development and utilization of Tianjin metro stations and surrounding land and to use the proceeds to support metro construction and operation.

In the same month, the Tianjin Municipal Finance Bureau and six other departments issued the Tianjin Municipal Special Funds Management Measures for Urban Metro Development, which stated that existing funds for urban metro construction in Tianjin (including major repairs and updates) would be based on the construction investment amount excluding demolition and relocation costs. The financial contribution from the government would be shared by the city and the districts involved in a 6:4 ratio. Guided by these policies and drawing on financing models from other cities, Tianjin has begun to explore metro financing cases based on the TOD model.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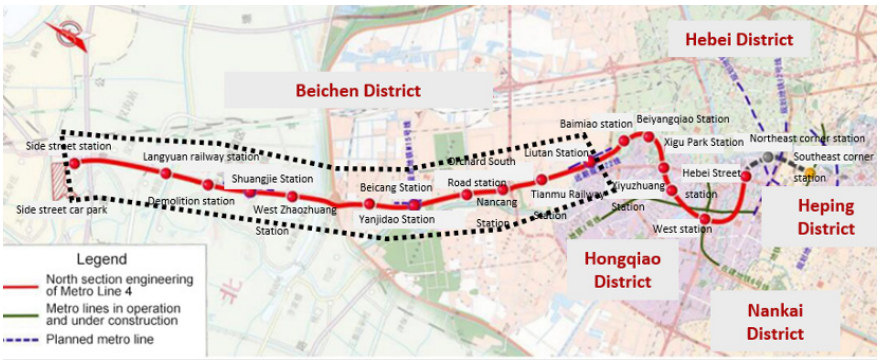
Part 4: Tianjin Corridor TOD Financing

When complete, Tianjin Metro Line 4 (Xiaojie Station to Xinxingcun Station) will be the seventh city metro line to be put into operation. It passes through the main urban area of Tianjin, with a total length of about 43 kilometers and 32 stations. The northern section of the line (Xiaojie Station to Hebeidajie Station), currently under construction, passes through Beichen District, Hebei District, and Hongqiao District, with a total length of 22 kilometers and 18 stations (figure 5).

The technical team selected the Line 4 corridor within the Beichen District to conduct a study on corridor financing under the Tianjin TOD model, in which city and district governments jointly provide land resources. The Beichen section, with 11 stations, contains many undeveloped or underdeveloped areas. The study identified the impact area of the Line 4 corridor in the Beichen District, assessing the capacity of the metro infrastructure and conducting concept planning and passenger flow forecasts. On the basis of those assessments, the study analyzed corridor TOD financing costs, estimated income, and designed a financing approach.

The study concluded that the project should develop the land in the Beichen portion of the corridor in five phases. Starting in 2021, each phase will have a construction period of three years, with completion expected by 2035.

Figure 5: Project Scope for Northern Section of Line 4



Source: China Sustainable Transportation Center, *Research on the Financing of Urban Rail Transit Projects in Tianjin Using the TOD Model: Summary Report*, 2022.

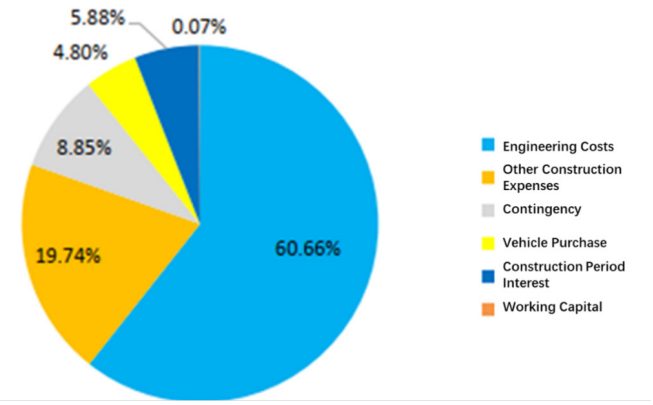
1. Cost and Income Estimates for Rail Development

Rail development costs are for construction and operation. The single biggest element of construction costs is engineering expenses (figure 6). Operational costs include expenses for employee salaries, power, maintenance, operations, management, depreciation, amortization, and interest.

The estimated total operating cost for the Beichen portion of Line 4 is CNY 19.5 billion (for the operating period 2025 - 49), and the average annual operating cost over the 25 years is CNY 780 million.

Rail development income consists of ticket sales and "other income" (mainly advertising and underground commercial revenues). Estimates of ticket sales are based on an average fare of CNY 0.4 per passenger per kilometer multiplied by passenger flow forecasts. Other income is estimated at 15 percent of the ticket sales. For the 25-year period 2025–49, total rail development income for the Beichen portion of Line 4 totals about CNY 330 million, for an average of about CNY 13.4 million per year.

Figure 6: Composition of Rail Construction Costs for Tianjin



Source: China Sustainable Transportation Center, *Summary Report on Research on Financing Urban Rail Transit Corridors Using the TOD Model*, 2021.

2. Cost and Income Estimates for Corridor Land Development

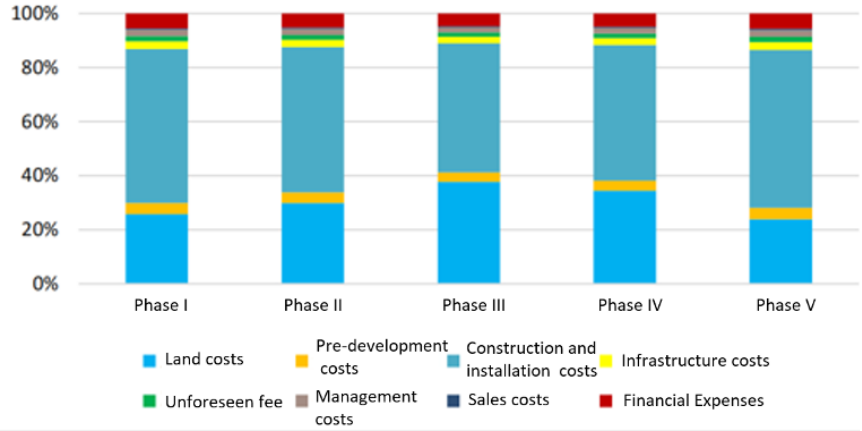
Costs for land development in an urban rail corridor under TOD cover primary and secondary land development.[3] Secondary land development also includes operating costs as defined in the preceding section on rail development. According to the TOD planning scheme, land development includes construction of residential, commercial, and office buildings. The total cost of primary land development for the 11 stations of Line 4 in the Beichen District over five three-year phases (2021–35) is about CNY 5.6 billion. The static (that is, excluding operating expenses) investment for secondary land development over that period is about CNY 24.5 billion.

In the cost breakdown for TOD land development, expenses for construction and installation are the highest, at about 45–60 percent, followed by land costs, at about 20–40 percent (figure 7). The operating costs for secondary development are calculated as a proportion of TOD development revenue. The total operational cost for secondary development through 2049 is about CNY 31 billion, with an average annual cost of about CNY 1 billion.

3 Primary land development involves essential groundwork and infrastructure preparation. Secondary land development encompasses the subsequent construction that results in the creation of functional, habitable spaces.

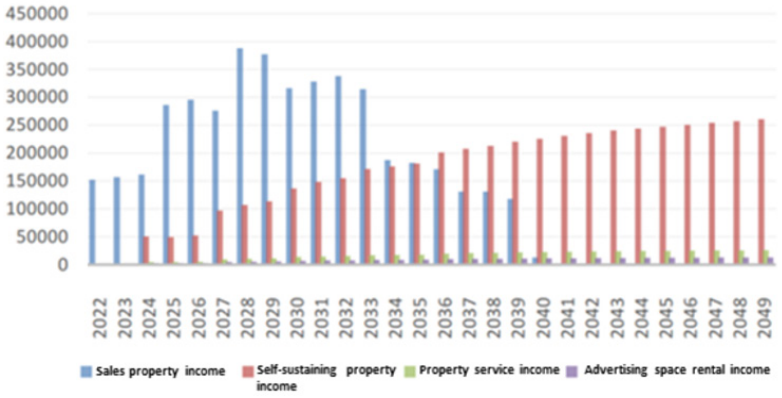
TOD operating income mainly includes property sales, property leasing and service, and advertising income. Data were collected on income elements (including property rents, office rents, residential sales, and advertising) for areas around existing rail transit stations in Tianjin. For the stations in the Beichen District section of Line 4, the study projected income through regression analysis, applying six variables to the existing income data.[4] The results showed that TOD operating income would be about CNY 98 billion through 2049, with an average annual income of about CNY 3.4 billion (figure 8).

Figure 7: Composition of Land Development Costs for Line 4 in Beichen District



Note: Each phase lasts for three years. Phase I begins in 2021, and Phase V ends at year-end 2035.
Source: China Sustainable Transportation Center, *Summary Report on Research on Financing Urban Rail Transit Corridors Using the TOD Model*, 2021.

Figure 8: Analysis of TOD Operating Income for Line 4 in Beichen District



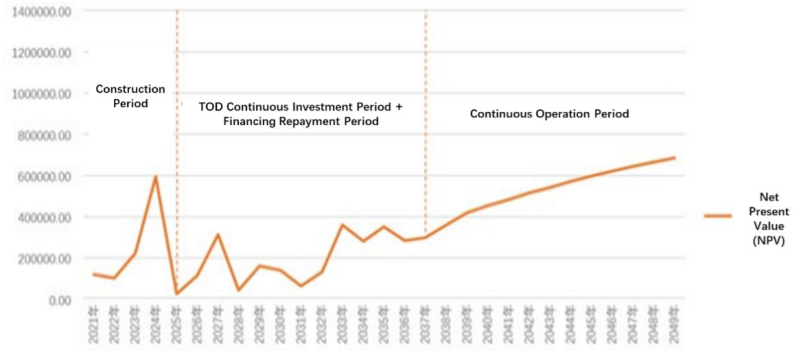
Source: China Sustainable Transportation Center, *Summary Report on Research on Financing Urban Rail Transit Corridors Using the TOD Model*, 2021.

4 Population density, entry and exit quantities, road network density, job density, connecting bus quantities, and index of functional mix of land use.

3. Financial Evaluation

According to the project financing plan for the Beichen District portion of Line 4, the average annual gross profit through 2049 is about CNY 10.8 billion, and the average annual net profit is about CNY 8.1 billion. The internal rate of return (IRR) after tax for project capital is about 8 percent. The post-tax investment payback period is about 16 years (2021–36, including the four-year construction period 2021–24), which is less than the project calculation period. The post-tax net present value is about CNY 406 billion.

Figure 9: Cumulative Net Present Value Trend for Line 4 in Beichen District



Source: China Sustainable Transportation Center, *Summary Report on Research on Financing Urban Rail Transit Corridors Using the TOD Model*, 2021.

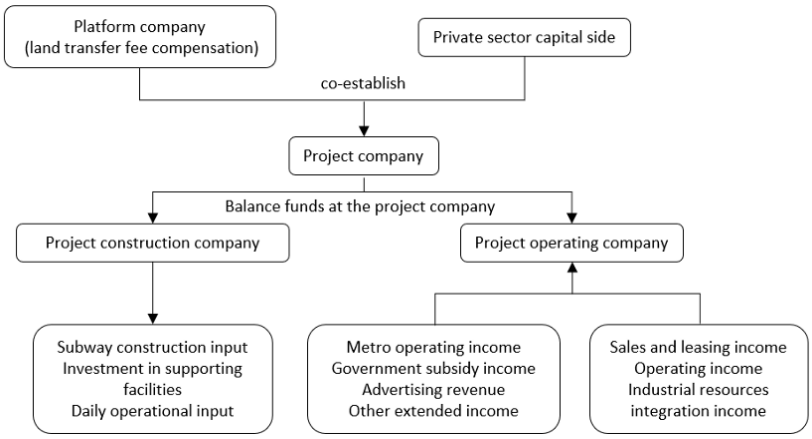
The project's net present value timeline can be roughly divided into three periods (figure 9):

1. Rail construction (2021–24): This is also the period in which the first phase of TOD development will be finished. Rail operating income, TOD property sales, and self-sustaining property income are relatively low in this period, which can create financial pressure.
2. Continuous TOD investment and financing repayment (2025–36): Continued investment in TOD development, significant land investment arising from construction activities, and pressure for the repayment of early construction. The years 2027–28 should be particularly monitored as the third phase of TOD development begins.
3. Continuous operation (2037–49): Operational activities gradually reach their designed levels; revenue and costs stabilize. During this period, project construction investment, operational income, operational costs, land acquisition prices, and land development areas are forecasted, but there is a potential for change, making them uncertain.

4. Financial Resilience

A PPP + TOD financing model is recommended by the case study of the Beichen District section of the Line 4 TOD corridor project. Government and the rail company, partly through a financing entity called a platform company, will enlist private sector capital, jointly establish a project company, and jointly develop and construct this section of the Line 4 corridor and surrounding plots. After project completion, the profits generated from subway ticket sales, commercial revenue, and income from surrounding land development will offset the losses incurred by the operation of the line, achieving a balanced project budget and thus relieving government financial expenditure pressures (figure 10). If a shortfall remains, subsidies for rail operation can be provided by the government through cost regulation. If, after the start of operations, private sector capital makes an early exit, further financing can be done through REITs.

Figure 10: TOD Corridor Financing Framework for Line 4 in Beichen District



Source: China Sustainable Transportation Center, *Summary Report on Urban Rail Transit Corridor Financing Research Using TOD Model*, 2021.

Project Investment

Investment will be shared by the government, rail company, and private sector capital. The government can inject capital through land pricing or compensation to investors for land transfer fees it receives by allocating the land resources surrounding the Beichen District portion of Line 4. The rail company's capital portion will be taken from special funds for urban rail transit construction or raised by subway construction bonds. Private sector capital can be introduced through open bidding. Large state-owned enterprises—with their strong financial capabilities and extensive experience in subway construction, operation, and real estate development—can be brought in to cooperate with the platform company jointly established by the government and the rail company to establish a PPP project company.

Project Return Mechanism

The revenue from the development of the Beichen District section of the Line 4 corridor and surrounding land will include ticket sales and commercial revenue from subway operation. It will also include revenues from three phases of land development:

- Primary development: The return of land transfer income to the district government
- Secondary development: Sales income after land development and construction by the project company
- Tertiary development: Operating income after land development and construction by the project company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Part 5: Tianjin Station TOD Financing

The southern section of Tianjin's Metro Line 4 (Dongnanjiao Station to Xinxingcun Station) commenced operations on December 29, 2021. It is 19.4 kilometers long and has 14 stations. The technical team selected three of these stations with three distinct TOD levels to assess the financial profiles of varied development schemes. Using a screen of seven evaluation indicators, the three chosen stations and their TOD density were Dongbeijiao Station (high density), Chenglindao Station (medium density), and Yuejin Beilu Station (low density).[5] These stations are within the core and edge areas of Tianjin's central urban area (figure 11).

Figure 11: Stations in Southern Section of Line 4 Chosen for Analysis

Source: China Sustainable Transportation Center, *Research Report on Financing of Urban Rail Transit Projects in Tianjin Using TOD Model: Inception Report*, 2020.

5 The seven screening indicators were location attributes, functional positioning, population conditions, customer structure, consumption status, area market operation conditions, and station development difficulties.

1. Description of TOD Development Modes for the Stations

Guided by TOD planning and design principles, the development modes of the three stations were based on their actual conditions.

Dongbeijiao Station (High Density)

Dongbeijiao Station forms an interchange between Line 4 and Line 7. It is adjacent to the Haihe River, the Tianjin Ancient Cultural Street Tourist Area, and the Tianzijin Ferry Site Park. The land to the south of the subway station consists mostly of newly built residential areas and historical and cultural facilities. They will be preserved in their current state. The communities above the subway station were built earlier and are recommended for demolition, with encouragement for residents to relocate. The traditional commercial area along the Dahu Tong Street will be preserved and upgraded to promote mixed functions.

TOD planning describes the character of Dongbeijiao Station as a high-density, urban-center station. The design for the station area aims to form a street block with a cultural theme that integrates the area's history and culture. Facilitated by green travel resources, the area will be a magnet for cultural tourism along the Haihe River and Grand Canal. Specific development strategies include (1) comprehensive development above the station that increases the floor-area ratio, (2) opening public passages to optimize road resources, (3) adding subway entrances and exits, (4) adding public service facilities, and (5) accessing existing park spaces and opening new ones to create high-quality areas for public activity.

Chenglindao Station (Medium Density)

Chenglindao Station is located about 600 meters north of Dongfeng Interchange Bridge in Hedong District, serving as an interchange between Line 4 and Line 5. Two parcels of undeveloped land around the station are each planned for a combination of commercial and residential use. Two other areas are suggested for demolition and reconstruction: the triangular plot between Jingjiang Road and Jiasheng Road and the existing mixed residential and public management land on the east side of Hongxing Road.

TOD planning describes the character of Chenglindao Station as a medium-density station. Integrating under- and above-ground development at the station will produce high-end business, shopping, and leisure functions to form a regional center that promotes a balanced distribution of work and living areas. Specific development strategies include (1) expanding underground space to connect surrounding parcels, (2) adding office facilities, (3) adjusting bus stop locations, (4) increasing road network density, and (5) opening up green spaces.

Yuejin Beilu Station (Low Density)

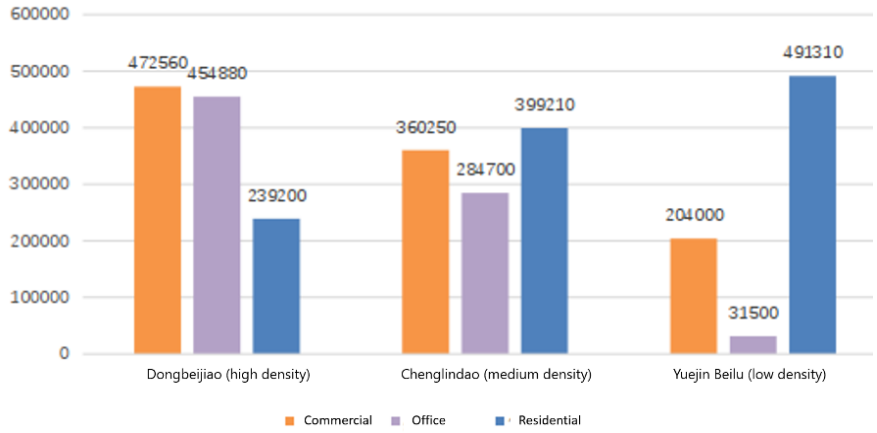
Yuejin Beilu Station is located about 850 meters west of the intersection of Jinbin Avenue and Haihang Road in Dongli District. The newly built residential communities that occupy most of the land on the south side of the station will be preserved. Both the north and south sides contain green spaces, old residential areas, nearly completed buildings, and a small amount of industrial warehousing; demolition in those areas will be minimal, but there is considerable development potential.

TOD planning describes the character of Chenglindao Station as a low-density station. The planning focuses on creating high-quality residential areas supplemented by supporting facilities such as supermarkets, exhibitions, hotels, community parks, and health centers. The plan aims to make the station area a community center for "residence, transportation, and leisure." Specific development strategies include (1) converting the green space on the north side of the station to urban construction land, (2) increasing road network density, (3) adding supporting service facilities, (4) increasing connecting bus routes and improving bus stop design, and (5) adding green spaces.

2. Cost and Revenue Estimates for Station TOD

In the planning and design schemes for the three target stations, the high-density station mainly features office and commercial spaces, with a smaller proportion of the total floor area—about one-fifth—devoted to residential development (figure 12). The areas around the middle- and low-density stations have a progressively higher proportion of total space allocated to residential development; for the low-density station, residential space accounts for about two-thirds of the development. These distributions of land-use types broadly reflect the geographic spread of property proportions in Tianjin, where the core area is primarily devoted to commercial and office structures, and the proportion devoted to residential use increases with the distance from the core.

Figure 12: Floor Area Planned for Property Types around Three Selected Stations



Source: China Sustainable Transportation Center, *Research Report on Financing of Urban Rail Transit Projects in Tianjin Using TOD Model*, 2021.

Station TOD Construction-Period Costs

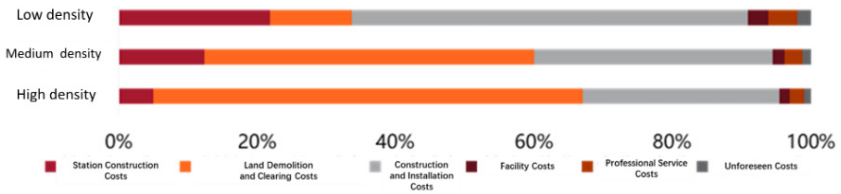
Given the above allocations of land use, the technical team estimated the construction-period investment costs for the TOD areas around each station as follows:

- Dongbeijiao, CNY 25 billion
- Chenglindao, CNY 15 billion
- Yuejin Beilu, CNY 6 billion

The three largest components of total construction-period costs for TOD around stations are (1) station construction, (2) TOD demolition and clearing, and (3) TOD construction and installation (figure 13). At each level of development density, these three elements together account for about 90–95 percent of the total.

The proportions of total construction-period costs attributable to station construction and to construction and installation decline with the increase in TOD density. The proportion for demolition and clearing rises with density.

Figure 13: Distribution of Construction-Period Costs, by Station TOD Density



Source: China Sustainable Transportation Center, *Presentation on Financing Research of Urban Rail Transit Projects in Tianjin under TOD Model*, 2022.

Station TOD Revenue

At similar rankings for development proportion, the level of overall (property sales and operating) income at the high-density Dongbeijiao Station is 1.7 times that of the medium-density Chenglindao Station and around 3 times that of the low-density Yuejin Beilu Station.

High- and medium-density stations generally complete property sales within five years, while sales at the low-density station are completed in six to seven years. Operating income exceeds sales income at the high-density station; the opposite is true at the low-density station; and the two components are roughly equivalent at the medium-density station. At all three stations, land income accounts for about 5–7 percent of the total, while station operating income accounts for about 0.1 percent.

Rate of return and payback period: To make projects reasonably attractive for investment generally requires an IRR greater than 6 percent after tax, which is the discount rate; that IRR requires a development proportion greater than roughly 80 percent for station TOD at high- and low-density stations and 89 percent for middle-density stations (table 4).[6]

Table 3: Methods of Financing Urban Rail Transit in Tianjin as of 2020, by Metro Line

	High-Density Station			Middle-Density Station			Middle-Density Station		
Development proportion (percent)	100	82	55	100	89	70	100	79	75
IRR (percent)	9.20	6.00	0.10	8.80	6.20	1.10	15.20	6.60	1.20
Static payback period (years)	6.1	6.9	27.7	5.6	5.8	26.0	5.6	5.7	5.8
Dynamic payback period (years)	16.0	27.9	29.0	6.3	27.1	29.0	6.0	6.2	29.0

Note: Development proportion is the share of the TOD-defined station area that undergoes development or redevelopment.
IRR = internal rate of return.
The static payback period is usually used for short-term profitability forecasts, whereas for longer durations, investors typically pay more attention to the dynamic payback period.
The dynamic payback period refers to the time required to recover the initial investment considering the time value of money, while the static payback period refers to the total time needed to offset the original total investment with the net cash flow from operating the investment project.
Source: China Sustainable Transportation Center, *Summary Report on Urban Rail Transit Corridor Financing Research Using TOD Model*, 2021.

At a development proportion of 82 percent, the high-density station has the longest dynamic payback period (about 28 years) and an IRR of 6 percent (figures for the middle-density station are roughly comparable). In contrast, with a development proportion of 79 percent and an IRR of 6.6 percent, the low-density station has the shortest dynamic payback period due to lower early demolition costs.

6 Development proportion is the share of the TOD-defined station area that undergoes development or redevelopment.

3. Suggestions for Station TOD Financing Strategies

Assuming that profitability for the transit-oriented development of stations should be attained with the completion of the secondary stage of development, the core issue in Tianjin is that all three levels of station area TOD density require a development proportion of more than 80 percent to be financially attractive to private sector investment (see table 4).[7] However, such a development proportion has generally not been possible in Tianjin nor in China as a whole because of financing obstacles. For station TOD, it is urgent to achieve participation from the government, developers, various sources of private sector capital, and operating entities. Specific financing suggestions, based on revenue and sensitivity analyses for the high, medium, and low levels of station density previously discussed (see table 4), are as follows.

High-Density Stations

The maximum IRR for development is 9.2 percent. A development proportion greater than 82 percent is required for the IRR to be greater than 6 percent, which is the discount rate, and thus be profitable. In terms of sensitivity analysis, cost elements from highest to lowest are demolition cost > operating cost > construction cost > financial cost > land cost. On the revenue side, the impact of property sales on overall project income is greater than that of operating income.

Capital financing can adopt a model consisting of "policy bank" + government fund or special bonds + bond issuance by the operating platform company + commercial bank loans. There is significant initial cash flow pressure, and risk management and support for financing need to be strengthened. In the later stages, methods like REITs can be considered.

Middle-Density Stations

The maximum IRR for development is 8.8 percent, and an 89 percent development proportion is required for the IRR to be greater than the discount rate. The cost and revenue sensitivity analysis is the same as for high-density stations, as is the suggested model for capital financing. However, compared with high-density station projects, the financial pressure near the end of sales is greater in this case, and it is necessary to strengthen guarantees.

Low-Density Stations

The maximum IRR for development is 15.2 percent, and a development proportion of 79 percent is required for the IRR to exceed the discount rate. In terms of sensitivity analysis, cost elements from highest to lowest are construction cost > operating cost > demolition cost ≈ financial cost > land cost. On the revenue side, the impact of property sales on overall project income is greater than that of operating income, and the ability of sales income to withstand pressure is extremely low. It is necessary to focus on ensuring if not increasing the development proportion.

Capital financing can adopt a model consisting of government funds or special bonds + commercial bank loans. The higher proportion of residential development in low-density TOD station areas, which are outside the core area, mean that the available space for financing is smaller. At the same time, attention should be paid to the continuous operation period and the performance of property prices; and annual profit during the operation period should be kept within expectations.

7 Recall that the technical team found that an after-tax IRR of 8 percent could be achieved through TOD in the Beichen District portion of the northern Line 4 corridor.

SHANGHAI

Summary

In 2022, 55 cities in mainland China operated urban rail transit with a total length exceeding 10,000 kilometers. The rapid development of urban rail transit in China has played a crucial role in optimizing urban spatial structure, alleviating urban traffic congestion, and promoting socioeconomic development. As urban rail transit construction advances, a substantial amount of government funding has been allocated, but it is not adequate given the high investment demand, low profitability, and long payback period of rail transit construction. Therefore, broadening financing channels and exploring suitable financing models for urban rail transit is the key to overcoming the funding bottleneck in rail transit construction. This report reviewed the development process of urban rail transit in China and its existing financing models. It used Tianjin—one of the seven pilot cities of the GEF-6 China TOD project—as a case study, exploring the application of the TOD model to financing at the corridor and station levels. The main experiences are as follows.

TOD-based rail transit financing is an important direction for future urban rail projects. The demand for additional urban rail transit continues to expand, but the traditional financing model relying on government finance alone cannot support it. New financing models are urgently needed. By implementing comprehensive land development, TOD-based urban rail transit can enhance the value of land along the rail transit line and thereby generate development income. In turn, that income can support the construction and operation of rail transit projects.

A replicable framework and tools for rail transit TOD financing have been designed. Based on the Chinese context, general principles for rail transit financing have been proposed here, and a comprehensive rail transit construction process has been designed. This framework has a certain level of applicability to other Chinese cities. Cost-benefit calculation models for rail transit TOD projects have been established at both the station and corridor levels.

The case study of Tianjin provides a Chinese example for cities in similar situations and in other developing countries. In recent years, Tianjin has accelerated the planning and construction of rail transit, guided by the TOD philosophy, transforming the development concept of urban rail transit, revitalizing subway resources, and exploring solutions to the bottleneck problem restricting rail transit construction financing. Taking Tianjin Metro Line 4 as an example, financing recommendations have been provided at both the corridor and station levels. The recommendations have value for other cities in China and other developing countries.

However, TOD development entails higher requirements for real estate developers in terms of business models and management methods. Developers need to establish a joint venture for profitably financing front-end planning, mid-term construction, and back-end operation if they are to realize the implementation of the TOD development model.

In addition, urban land in China belongs to the state and urban land transfer involves an auction system. Land transfer fees have become the main source of off-budget revenue for local governments, and accounting for them in TOD-based financing models is important in China. When considering the lessons of urban rail TOD financing in China, cities in other developing countries should pay attention to any differences in national conditions and institutional mechanisms between countries.

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