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Smarter Mobility for Better Urban Development: An Exploration of Urban Smart Transportation Governance Based on International Comparison

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Abstract

Smart mobility is essential in achieving sustainable urban development during the (upcoming) digital era. This study focuses on exploring an integrated governance approach for the development of smart mobility through the comparison of international cases. Specifically, we examine six cities—Amsterdam, Singapore, New York, Beijing, Shanghai, and Shenzhen—through text collection and analysis. This study reveals three key findings. First, the urban features of each city, especially the relationship between the land and population, significantly impact the direction and design of smart mobility development. Second, while the development of smart mobility systems in various cities shows similarities, specific differences still exist. Third, the contrast in governance patterns between Chinese and non-Chinese cities lies in the government's role. This kind of difference also differs from one Chinese city to another, especially in the relationship between the local government and relevant businesses. Finally, based on the study, we offer some insights for future studies in this field.

Keywords: smart mobility, urban transportation, governance, China

1. Introduction

In recent years, the world is experiencing a new wave of technological revolution and industrial transformation, with the digital economy and artificial intelligence serving as strong supporters. The application of new technologies such as 5G, big data, and the Internet of Things has become increasingly important for the transportation sector (Khamis, 2021). Urban transportation has become a crucial area for the implementation of new innovations as it is fundamental to ensure smooth and efficient travel and goods flow (Kakderi, Oikonomaki, & Papadaki, 2021). Indeed, the development of a new urban traffic operation and governance model has attracted significant academic attention in recent years(Y. Guo, Tang & Guo, 2020a). In the coming digital era, it is imperative to enhance mobility management and create a sustainable traffic pattern that caters to new requirements and situations.

Throughout history, urban traffic and its management system experienced several iterations to keep up with technological advancements (Finger & Audouin 2019). The history of transportation management evolved from the conventional on-demand management approach with a primary focus on road expansion to the implementation of traffic control systems represented by the three-color signal lights in the early 20th century. Following this stage, the 1960s were marked by the introduction of intelligent traffic management through the Intelligent Transportation System (ITS). Today, the pursuit of developing advanced "smart mobility" solutions remains an ongoing process. Smart mobility refers to a new and revolutionary way of thinking about how we get around based on the innovation and adoption of foundational technologies, especially information and communications technologies (ICT)(Khamis, 2021). The development of smart transportation and logistics is a feasible direction for cities worldwide (Flügge, 2017). For achieving sustainable mobility, more attention should be paid to mobility governance rather than management (Kennedy et al., 2005), with a focus on public service transformation, collaboration, and social value creation. The dual sustainability of society and the environment is the key concern for seeking to better serve people's travel needs while encouraging collaborative participation (Marsden & Reardon, 2017).

The continuous advancement of information technology has facilitated greater participation of various stakeholders within the transportation field (Jiang, Geertman & Witte, 2022). This is achieved through enhanced convenience, transparency, and comprehensive participation, in order to create an efficient, equitable, and healthy urban transportation environment. The key elements of this approach are centered on co-governance (G. Wang et al., 2022). Specifically, it entails the establishment of a smart travel service platform that is built jointly and shared amongst multiple actors. The Mobility as a Service (MaaS) concept presents the future trend for urban transportation services, whereby a unified service system that integrates various modes of transportation is created, thereby achieving information integration, operation integration, and payment integration (Alonso-González et al., 2020). The system is designed to prioritize travelers' experience, with a focus on minimizing waiting, response, and state switching time while providing integration, service, sharing, and guidance features (Hirschhorn et al., 2019). Additionally, multi-subject cooperation and joint participation are required in the construction of travel services, which includes the government, market, social forces, and citizens (Finger & Audouin, 2019). In the coming years, the development of urban transportation across the globe will be impacted by both the technological advancements brought on by the digital age and the practical needs of post-epidemic era transportation (Cresswell, 2021). This study draws on the experiences of several international cities to present an integrated and applicable governance approach for smart urban mobility in the digital age.

2. Urban Smart Mobility Development and Governance in the (Coming) Digital Era

2.1 Smart Mobility in Smart Cities

As human settlements continue to grow in size and progress in areas such as population, economics, science, and technology, cities have become vital components of a nation's economic and cultural development (Sun & Zhen, 2013). However, traditional urban development, which relied on technological advancements like industry and electricity, has resulted in several issues such as energy depletion, environmental degradation, and urban congestion (Y. Guo, Tang & Guo, 2020b). In 2009, IBM proposed the "smart earth" concept and later introduced the "smart city" as its embodiment. Scholars in this field also predicted the technical requirements, infrastructure construction, and resource allocation of future urban development, the term "smart city" gave further context on how to develop, design frameworks, and allocate resources (Curtis et al., 2019; Hirschhorn et al., 2019; Marsden & Reardon, 2017; Hettikankanama & Vasanthapriyan, 2019).

The concept of smart cities is perceived in various ways. From a technical standpoint, it is based on advanced information technologies that rely on a large number of basic sensors to collect real-time data on urban operations (Docherty, Marsden & Anable, 2018). The data is then uploaded to a cloud computing platform where it undergoes storage, calculation, and analysis, and is used for decision-making. Thereafter, the decision-making is decentralized to the urban operation system at the bottom automation facility (T. Y. Guo et al., 2014). The technical foundation of smart cities is built upon the information model of digital cities and cyberspace, coupled with the Internet of Things and cloud computing technology. The smart city operation system consists of three layers, namely the perception layer, network layer, and application layer (Jiang, Geertman & Witte 2022; Putra & van der Knaap, 2018). The perception and network layers comprise various types of sensors and the Internet of Things, with specific requirements for digitalization and interconnectivity. On the other hand, the application layer serves as the "client" for residents and users by integrating data and catering to the specific functions of the city.

The transformation of urban economic and social development, production, and lifestyle through technological innovation is at the heart of smart city construction (Khamis, 2021). This is an essential manifestation of economic development model innovation in a specific space. Numerous studies indicate that the conception and actual construction of smart cities advances the economic development of cities in several aspects (G. Wang et al., 2022; Alonso-González et al., 2020; Hirschhorn et al., 2019; Gao, Wang & Gu 2020). These include the optimization of the urban economic structure, the creation of new growth points, and the expansion of emerging industries and technological innovation (Wu & Yang, 2010; Alonso-González et al., 2020). The significance of smart city construction extends beyond economic growth to mark a significant milestone in the development of urban construction (J. Wang & Hu, 2011). Smart cities help to improve the city's suitability and livability. By promoting equal and efficient public services, enabling operational interaction, and encouraging low-carbon and green development models, smart cities provide residents with a better living environment, contributing to the creation of a better city life (Banister, 2008). While information technology is vital to smart city development, the emphasis is on meeting the needs of residents and upholding the spirit of humanism where people are at the core. Researchers believe that the development of smart cities is multi-dimensional, including elements such as smart residents and smart ecology (Sagaris, 2014).

In China, smart transportation represents an innovative and ongoing undertaking that revolves around the creation of a transportation system leveraging cutting-edge technologies such as big data and the Internet of Things (Ma, 2019). The system aims to evolve in line with the demands and characteristics of the information society and offers multi-participant collaboration under the guidance of the Chinese government (Wu & Yang 2010; Curtis et al., 2019). The system comprises various constituent components, including smart transportation comprehensive service centers, smart road comprehensive service centers, urban traffic smart centers, smart port and shipping comprehensive service centers, and other systems (Y. Wang, Yang & Fan, 2015). At its core, smart transportation seeks to continuously employ rapidly advancing technologies to govern the transportation system and incorporate crucial aspects such as low-carbon environmental protection, people-centricity, efficiency, and convenience, characterized by transformation, integration, wisdom, green, comprehensive (Xin Zhang & Yang, 2015). The development of smart transportation is a critical measure for improving China's transportation system, with potential benefits such as linking traffic demand to vehicles and roads through modern high-tech systems, systematically solving traffic problems, reducing traffic congestion and accidents, enhancing traffic quality, promoting green environmental protection, energy saving, and carbon reduction in public transportation (Cai, 2013).

The origins of the concept of smart transportation can be traced back to the Intelligent Transportation System (ITS) of the 1980s. ITS is a comprehensive real-time management system that integrates various information processing and computing interconnection technologies with the aim of enhancing the effectiveness of transportation services (Chin & Ong, 2015). With the evolution towards intelligent transportation, a more advanced set of technologies have been integrated including the Internet, big data, and wireless sensing. These technologies are utilized for purposes such as identifying and perceiving traffic elements, creating intelligent transportation clouds, data processing, and integration technology (Putra & van der Knaap, 2018). By leveraging these technologies, they offer benefits such as coordination between people, vehicles, and roads, thereby making travel more efficient, convenient, and smart.

The notion of a smart city and intelligent transportation represents a focus on urban and transportation development, represented by a powerful technology platform that enhances the feasibility and implementation effectiveness of the idea (Khamis, 2021). This involves the use of real-time sensor detection, data transmission, and the creation of diverse predictions through algorithms and big data mining governance models (S. Liu & Zhang, 2020). Studies support the notion that digital and intelligent technologies make a more significant contribution to traffic congestion governance compared to traditional decree-driven methods with multiple restrictions (Y. Guo, Tang & Guo, 2020a). Concurrently, the academic community is continually applying new models to assess old policies and improving the accuracy of iterative and optimized algorithms (Chen & Liu, 2022). They are exploring more appropriate ways to utilize technical systems better.

2.2 The (co-)Governance of Urban Smart Mobility

A metropolis is a complex and intricate system that operates with precision through interlocking links. The problems within the mobility dimension in a given city can inevitably disrupt its customary functioning (Kennedy et al., 2005). Advanced transportation technologies, such as traffic recognition algorithms, computer vision detection, and big data analysis based on trajectory and social data, offer both opportunities and changes to mobility governance (Marsden & Reardon, 2017). MaaS plays a vital role in the development of smart transportation and smart cities, and scholars highlight the importance of personalization based on user habits, the intermediary of multi-functional service links, or the systematic management of different services (J. Zhang, Sun, & Xie, 2019; Hirschhorn et al., 2019). However, all these interpretations revolve around individual users and their specific travel needs, and different service designs are formulated accordingly. Presently, young people with higher education who rely on information travel are more inclined to use MaaS services (Alonso-González et al., 2020). The advantage of MaaS lies in its ability to provide high-density integration services for scattered information, which can empower disadvantaged groups who may be excluded in the information age. In addition to user adoption, the government is actively promoting MaaS, seeking collaboration with the market to expand service provision and enhance its role in transportation (Curtis et al., 2019).

In the early stages of urban traffic governance, it was primarily driven by top-down government regulations that aimed to control travel demand by means such as congestion charges and differentiated parking (Docherty, Marsden & Anable, 2018). Furthermore, the structure of urban traffic facilities was optimized through public transport investment to achieve efficient management of traffic supply (Putra & van der Knaap, 2018). However, with the development of cities, public awareness and engagement in urban traffic governance have grown. The academic community generally views public participation as a positive phenomenon, as it reduces resistance to transportation policies (Banister, 2008) and enhances the vigilance and performance of management personnel

(Sagaris, 2014). Therefore, the government should actively encourage and guide the public's participation in public transportation decision-making processes, thereby ensuring effective institutional channels for participation (Lin, 2011). Cities in China face increasingly complex urban traffic problems, causing significant differences in traffic conditions, and administrative management methods have become inadequate for resolving these perennial complicated problems (Ma, 2019). It is essential to move toward modern traffic governance and to update the urban traffic governance theories and discipline system, which should intersect and collaborate from multiple dimensions.

Smart traffic governance involves utilizing modern technology to optimize traffic data resources, integrate traffic governance resources, and facilitate collaboration among various traffic management departments (Docherty, Marsden & Anable, 2018; Marsden & Reardon, 2017). There are different models of governance, each with its own approach. The government-led model emphasizes the government's leading role, given its strong resource scheduling and integration capabilities and the prominent public nature of urban transportation, which enables the government to easily integrate various social forces into the collaborative governance system (Jiang, Geertman & Witte 2022). The parallel subject model stresses equal negotiation among multiple parties, recognizing that urban transportation policies involve the interests of various stakeholders and that balancing these interests is necessary for effective urban development (Lee et al., 2019). The multi-driven model prioritizes the initiative of different subjects, highlighting their autonomy and independence in forming multiple spontaneous governances. However, this model also emphasizes the need for a new type of core value-trust-cooperation relationship between the government, enterprises, and the public in defining their respective rights and responsibilities for service co-construction and sharing of transportation (Gao, Wang & Gu 2020). In addition to governance subject participation, some scholars also point out the challenges that future transportation governance may face from regional integration, rapid technology iteration, and various kinds of risks (Barns, 2016).

3. Data Collection and Analysis

The empirical data presented in this paper was gathered through a systematic process of searching and analyzing Chinese and English academic literature, policy documents, and other related materials. The English texts were initially searched using keywords such as "*smart mobility*", "*smart mobility governance*", and "*smart mobility program*" in the Web of Science database. The smart transportation development in Tokyo, San Francisco, Singapore, New York, and several other cities were analyzed. Based on the consideration of case representativeness, reference value, and richness of data, we selected three overseas cities of Amsterdam, Singapore, and New York as cases for exploration. We collected relevant empirical research literature on these cities from multiple databases, as well as policy texts and related public reports from the case city government websites and public media websites.

For texts about China, we conducted relevant searches on city-level smart transportation construction via widely-used databases such as CNKI, Wanfang, and Weipu. Beijing, Shanghai, and Shenzhen were chosen as the cases following the same screening process as mentioned earlier. Then targeted data collection was conducted, including research papers, policy documents, and related reports.

The researchers undertook coding analysis for all the collected text data, focusing on the innovation and application of smart transportation technology, such as new infrastructure construction, new travel modes, and new data-sharing analysis platforms. Additionally, we focused on governance stakeholder participation patterns in case cities, including government roles and actions, market forces, and social forces, and interactions between different parties, to classify information and enable comparative analysis.

4. Findings

Smart transportation plays a vital role in the sustainable development of several foreign cities, as it forms an integral part of the "smart city" concept. Based on a comprehensive analysis of the development strategies and specific measures of smart transportation employed by various cities, it is evident that these initiatives primarily revolve around technological and governance model advancements (Khamis, 2021). Firstly, foreign cities are emphasizing basic technological innovations such as the Internet of Things, blockchain, and wireless communication, as well as technological carriers like smart infrastructure, autonomous vehicles, and new energy vehicles. Additionally, innovation at the service level, through the provision of new transportation modes like ridesharing and travel-as-a-service, has also become a key area for the development of smart transportation (Bouton et al., 2017). Secondly, the governance of smart transportation is shifting towards diversified and collaborative models involving the participation of varied stakeholders, including the government, enterprises, society, and citizens (Docherty, Marsden & Anable, 2018). Lastly, the development of smart transportation overseas focuses on coordinated governance of different spatial dimensions, ranging from the local to the city to the regional to the national and ultimately worldwide interconnection, to promote interregional synergy (Papa, Fistola & Gargiulo, 2018).

4.1 Urban Characteristics and Their Impact on Smart Mobility

With the ongoing increase in urban population and the consequential rise in motorization, smart cities encounter issues related to sustainable development. These issues include but are not limited to traffic congestion, air pollution, and public transport supply and demand imbalances. In light of this situation, several case cities have proposed and implemented their own smart transportation plans and projects. For instance, Amsterdam has formulated a Smart Urban Mobility Program, while Singapore is planning to establish an Intelligent Transport System for its urban areas. Similarly, New York has initiated the Efficient Mobility in NYC Smart City Plan. Moreover, in the 14th Five-Year Plan of Beijing, Shanghai, and Shenzhen, smart transportation is highlighted as a crucial task and direction for the advancement of the transportation sector.

Cities face similar urban issues and propose comparable solutions, but the context of politics, economy, culture, resources, and technology differs between them. Amsterdam, New York, and Singapore face challenges regarding population density and limited land resources, with the latter two cities experiencing more significant pressures (Chin & Ong 2015; New York State Department of Transportation, 2006). The emphasis on smart transportation in these cities is centered on optimizing existing transportation networks. The city's cultural background plays a critical role in the formulation of policies with unique characteristics (Noori, Hoppe, & de Jong, 2020). In Amsterdam, smart transportation solutions leverage modern technologies while also developing straightforward solutions that build on the city's strengths, such as its long-standing tradition of bicycle travel (van Waes, Farla, & Raven, 2020). In comparison, the multiculturalism of New York places emphasis on promoting inclusivity, such as providing multilingual navigation and signage systems for non-English speakers during infrastructure modernization (Amsterdam Government, 2019).

Beijing, Shenzhen, and Shanghai are highly populated megacities with limited land resources, sparking the need for a shift from traditional transportation development strategies to alternate models (Deng, Li & Liu, 2015; Y. Liu, Yao & Li, 2018). The expansionary growth model has reached its limit, and as a result, the three cities have encountered "urban disease", including traffic congestion and increased levels of pollution. Therefore, prioritizing the development of public and green modes of transportation has emerged as a common solution. However, despite this common goal, each city's particular urban positioning and resource ownership impact its unique approaches to smart transportation construction. Beijing is the country's political, cultural, and international center, emphasizing the need to coordinate transportation with urban development to create an efficient, convenient, and green transportation system. Shanghai, as the economic capital, puts considerable attention on developing freight transport while also focusing on passenger transportation. With a strong background in economy and technology, Shanghai plans on promoting vehicle-road coordination and intelligent network connection as key areas of growth. Shenzhen, as a special economic zone and technology and industrial innovation hub, focuses on cultivating transportation technology to become a leading comprehensive transportation hub that connects the region and provides service to the whole country (Xiaochun Zhang, Shao & Huang, 2020).

4.2 Smart Mobility Development Approaches

The urban smart transportation construction of several cities demonstrates noticeable commonalities. Cities such as Amsterdam, Singapore, and New York are responding actively to the all-inclusive transportation development model based on MaaS. Amsterdam aims to employ a user-friendly MaaS-based application to utilize a singular platform covering all public transport and shared mobility options available in the city, thereby providing the convenience of planning, booking, and paying for journeys combining these modes (Amsterdam Government, 2020; Hirschhorn et al., 2019). Singapore enhances its intelligent transportation system and diversifies travel services for residents by constructing a slow traffic system, enabling vehicle-to-vehicle communication and processing vehicle-mounted telematics (Mazars, 2020). Meanwhile, New York has modernized its extensive public transportation system to ensure inclusivity and fulfill the varying travel needs of its citizens. Additionally, New York is actively developing a payment platform application that integrates multiple transportation modes, facilitating the daily commute of residents. Intelligent transportation systems and platforms are a common focus of Beijing, Shanghai, and Shenzhen. These cities possess big data platforms that function as the core of smart transportation planning, management, and services. Efforts are also concentrated on the construction of public transportation smart facilities, such as GPS and information collection devices for buses, one-card ETC. Furthermore, the construction of an integrated platform for green travel is being fast-tracked in these cities, highlighting the optimization of green travel services for citizens.

There are certain variations in the specific ways that smart urban transportation is developed across different cities. Generally, Amsterdam and New York both adopt a "problem-oriented" approach in the process of constructing smart transportation systems. Amsterdam, known as the "bicycle capital of the world", prioritizes the development of sustainable bicycle traffic as a key challenge facing the city (PwC Netherlands, 2014). This has led to the implementation of projects such as smart bicycle parking lots at various stations and machine-non-separation facilities in street planning to enhance the safety and comfort of cyclists (Amsterdam Bike City, 2020). In contrast, New York has proposed several street improvement measures aimed at ensuring pedestrian safety in response to its high slow traffic death rate. Conversely, Singapore places greater emphasis on system construction and interaction between systems in the development of urban smart transportation (Lee et al., 2019). Beijing focuses on controlling traffic congestion through the development of smart parking, subway, and bus projects, while Shanghai prioritizes the development of smart ports, vehicle-road coordination, and intelligent networking. Finally, Shenzhen prioritizes building a soft environment for smart transportation development and establishing itself as a global transportation technology innovation highland, while also focusing on building high-quality international comprehensive transportation hubs. The development focuses of these different cities are influenced by the cities' positioning and resource ownership.

4.3 Smart Mobility Governance Patterns

Regarding smart transportation governance patterns, it is important to note that Amsterdam, Singapore, and New York all highlight the significance of diverse governance actors. Firstly, cooperative governance involving multiple participants is a shared characteristic of the three cities studied in relation to smart traffic governance. For instance, the Amsterdam Government advocates for strengthened partnerships across three levels: city, national, and global. This involves partnering with the government, academic research institutions, local entities, and other organizations (Amsterdam Government, 2019). Similarly, in the Smart Transportation 2030 strategic plan, Singapore also emphasizes the participation and coordination of government, enterprises, and academic research institutions in governance initiatives. Likewise, New York places great value on collaboration between various parties, including government departments, enterprises, academic research institutions, and the general public, in its smart transportation build-out. Consequently, multiple entities have actively participated in cooperative projects (Amsterdam Government, 2019).

In the development of smart transportation in various urban settings, each subject's collaboration method has distinct characteristics. In New York, where governance and politics play a vital role, the construction of smart transportation reflects a functional diversity model, which is reliant on horizontal networks of collaborative governance established on the basis of mutual consultation and trust among various subjects (Gil & Navarro, 2013). On the other hand, Amsterdam follows an "innovation-driven" smart city development model that focuses on the bottom-up innovation of various subjects in the private sector during the process of developing urban smart transportation (Hirschhorn et al., 2019). Singapore, however, places more emphasis on the leading role of the government in the governance process. Therefore, the "Smart Transportation 2030" strategic plan proposes that the government and other public institutions should take the front seat in promoting crucial measures and programs for the construction of the urban smart transportation system. This top-down governance approach is further observed in the government-enterprise cooperation process where Singapore adopts the "government construction, enterprise operation" model for public transportation facilities, and consequently, the revenue generated from charging is transferred to relevant management departments (Lee et al., 2019).

It is noteworthy to highlight that the three cities have prioritized the establishment of information-sharing platforms as a means to realize multi-subject collaborative governance. Notably, Amsterdam has implemented the Amsterdam Smart City living lab as a data-sharing platform (Putra & van der Knaap, 2018). Similarly, Singapore's Open Data Platform has provided a traffic data platform utilized by citizens, enterprises, and academic institutions, while New York's implementation focus on integrating ICT, big data, and other technologies into traffic management (Barns, 2016).

The development of smart transportation in China's three case cities is primarily led by the government, with relevant departments playing key roles in its coordination and operation. Beijing Traffic Operation Coordination and Command Center, Shanghai Traffic Information Center, and Shenzhen Municipal Transportation Commission are responsible for overseeing the construction, operation, and management of these intelligent transportation platforms, as well as liaising with relevant entities and driving investment. Additionally, both private firms and the public are encouraged to participate in this process to some extent. These cities predominantly utilize an "engineering-oriented" and "top-down" governance approach, with the government issuing directives to plan key development priorities and oversee their execution through transportation departments in collaboration with businesses. Perhaps most notably, they share a common recognition that such initiatives must be developed with a "people-oriented" and service-first approach that engages and benefits the community as a whole. This trend is exemplified through the MaaS platforms in Shanghai and Beijing, the "Suishoupai" program in Beijing promoting public supervision and feedback, and Shenzhen's focus on serving the livelihoods of its residents.

There are discernible disparities among the smart traffic management models employed by Beijing, Shanghai, and Shenzhen. In Beijing, the government assumes a more commanding position in the establishment of intelligent transportation. The Beijing Municipal Transportation Commission primarily oversees smart transportation ventures and recognizes corporate contributions where applicable. The government enforces strict policies like limitations on vehicle use when required. Conversely, Shanghai features more state-owned enterprises, wherein companies are frequently assigned a primary role in the setup of smart transportation initiatives. In this scenario, the transportation committee takes the lead while private and state-owned enterprises are actively involved. Collaborations involving two-two and three-party arrangements are commonplace. For instance, Beijing's MaaS proceeded through a strategic partnership between the Beijing Municipal Transportation Commission and AutoNavi Maps, while Shanghai Suishenxing Smart Transportation Technology Co., Ltd. is the primary entity behind the MaaS platform. Additionally, transportation-related platforms in Beijing and Shanghai are managed by corresponding government-run entities, whereas Shenzhen Urban Traffic Planning and Design Research Center along with Huawei and other organizations oversee this city's consolidated intelligent platform. However, all three regions have yet to substantially involve the public in the development of these initiatives.

In summary, the current smart traffic governance models employed by Beijing, Shanghai, and Shenzhen are characterized as being government-led and project-oriented, taking a top-down approach. As these models have evolved alongside social development, they have shifted towards joint governance, although public participation remains relatively limited. Notably, government and enterprise actors are the primary participants in these patterns, with the strong-weak relationship characterizing their cooperation. For instance, in Beijing, the government plays a leading role with insufficient enterprise participation, employing both administrative and market methods. Meanwhile, in Shanghai, state-owned enterprises take the lead with market-oriented means. In Shenzhen, under governmental guidance, enterprises participate more in smart mobility governance and employ more market-based methods. The comparison of the development and governance of smart mobility in the six case cities was shown in Table 1.

Table 1. Comparison of the development and governance of smart mobility in six case cities

	Amsterdam	**Singapore**	**New York**
Innovative Practices	(1) Construction of new infrastructure ("Future City Site" plan) (2) Exploration of new travel modes (MaaS; on-demand transport service; creating a safer and accessible bicycle riding system) (3) Build a new data sharing and analysis platform	(1) Smart passenger transportation (informatization, interaction, assistance and greenization of the system; interconnection between vehicles and infrastructure; new energy vehicles and green infrastructure) (2) Smart port construction (digital connection, automation application and intelligent system)	(1) Modernization of the public transport network (2) Smart congestion control and emission reduction (car sharing; electric vehicle charging infrastructure network) (3) Regional transportation integration (efficient connection between different types of transportation) (4) Smart Freight
Main directions of development	Transportation network expansion and slow traffic development	ITS system construction and interconnection between existing systems	Improve the efficiency of the existing traffic system and efficient inter-regional traffic intercommunication
Governance pattern	Problem-oriented, top-down, the government, enterprises, academic institutions, and citizens cooperate with each other	Strong government-lead, top-down, non-government joint participation	Government-lead, multi-party participation, and project cooperation

Beijing	**Shanghai**	**Shenzhen**
(1) Construction of intelligent public transportation facilities (2) Smart transportation platform construction (Traffic Operation Coordination and Command Center,	(1) Smart Platform Construction (Shanghai Traffic Comprehensive Information Platform) (2) Vehicle-road collaborative construction and development of	(1) Integrate cross-industry and cross-department traffic big data resources (Shenzhen comprehensive traffic big data platform)

TOCC) (3) Develop smart green travel (Beijing transportation green travel integrated service platform) (4) Beijing-Tianjin-Hebei transportation coordinated development	intelligent networked vehicle terminals (3) Smart port construction	(2) Projects based on 5G, Internet of Things, artificial intelligence, BIM and other technologies in transportation services (3) Promoting the open sharing of traffic big data with local regulations (4) Implement the strategy of "transportation talents" and cultivate market innovation subjects
Smart platform construction and regional coordinated development	Smart platform construction and smart networking industry	Smart transportation system construction and transportation technology innovation industry
Government-led, integrated planning	Government-lead, state-owned enterprises involved	Government planning, market-oriented, multi-party enterprise participation

5. Discussion and Conclusion

In the post-epidemic context, a pressing matter for urban transportation construction is to ensure a rapid, safe, healthy, and environmentally friendly flow of people and goods (Cresswell, 2021). To achieve this objective, smart mobility proposes the sharing of varied data via a big data platform. This approach establishes standardized data access protocols, integrates data, and creates highly shared data information. Through data sharing, barriers to accessing data and administrative silos between departments can be broken down, promoting the coordinated operations of various government departments. Drawing from international cases, this study identifies the current focus areas and directions of representative cities in the field of smart transportation, highlighting exploration in both technological and governance model innovation. Presently, while many cities have developed their "urban brains", they are primarily used for a few independent functions, such as enforcing traffic violations, and have not yet fully served the role of an organic brain. To enhance collaboration further, data exchange mechanisms should expand, management systems should connect, and unified technical specifications should be established. Achieving interdepartmental information exchange, data sharing, common utility, and feedback are key considerations. Lastly, as residents generate traffic data information, it is imperative to ensure that they benefit from its use.

It is essential to strengthening the management of data security (Barns, 2016). This pertains to the valuable data collected from various travel activities that should be judiciously utilized for efficient traffic management, ultimately benefiting the public's travel experience. In strengthening data security management, it is imperative to safeguard users' crucial travel-related information to prevent unwanted disclosure or exploitation of personal data. Moreover, in the pursuit of smart transportation development, the government must demonstrate respect for the individual's privacy rights, ensuring protection against any potential abuse of power, personal intrusion, or compromise of personal freedom.

The primary objective of smart transportation construction is to better meet the travel needs of the public. The level of urban governance can be enhanced through the depth and breadth of public participation. Therefore, it is crucial to fully mobilize the subjectivity and constructiveness of the public in the process of smart transportation governance. To facilitate public participation, the government should establish a dedicated or dual-use information platform, promote relevant scientific knowledge, and enhance the transparency and openness of smart transportation construction. Enhanced dialogue between urban residents and relevant subjects of smart transportation will result in the realization of public needs and wishes. Timely collection and feedback will provide the basis for improving the level of smart transportation services. While big data technology's development and application provides a convenient means of collecting travel-related information, it is essential to avoid relying solely on quantitative data and instead seek qualitative opinions from the public. By doing so, the original intention of smart transportation construction to serve the people and boost government administrative service efficiency can be achieved.

Currently, numerous cities recognize the crucial role of multi-subject cooperative governance in the implementation of a smart traffic governance system. Nonetheless, some cases exhibit an overemphasis on government leadership, leading to the relative marginalization of other collaborating entities. In the future, we must prioritize developing a multi-subject governance model comprising government, enterprises, academic institutions, and citizens, among others. We should find inspiration from successful implementations in other cities globally and experiment with various methods in specific construction projects. This approach emphasizes governance over management, highlighting the government's service and leading position, and embracing diverse strategies to spark innovation and initiative among entrepreneurs and other entities guided by the government. Moreover, the government must expand financing sources, strengthen enterprise operations, and optimize the diversified investment structure of smart transportation construction. It's crucial to establish an information-sharing platform that ensures effective cooperation among various entities to facilitate collaborative governance of urban smart transportation.

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