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Evolution of Urban Travel Demand in the New Era

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Abstract: It is important to accurately analyze the impacts of urbanization and informatization on urban travel demand and its changing trend, which is the premise for the high-quality development of urban transportation. This paper discusses the new characteristics of travel demand brought by enhanced quality of life, effective urban spatial alignment, and changes in social structure during urbanization. The paper discusses the anticipated impacts of informatization on urban mobility, transportation infrastructure facilities and urban transportation management. Finally, the paper outlines the future urban transportation characterized by demand-oriented service, integrated development, transportation equity, and new rules and regulations. The paper concludes that only reform and innovation can meet the development requirements in the new era. **DOI:** 10.13813/j.cn11-5141/u.2020.0038-en

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0 Introduction

Under the influence of both new urbanization and informatization, the trend of urban travel demand and people's expectations on future transportation will see significant changes.

On the one hand, cities have experienced a transition from rapid growth to high-quality development, with general public expecting livable urban life. Cities have long become residence for most Chinese people. By the end of 2019, the number of permanent residents in urban China was 848 million and the urbanization rate reached 60.6%. However, compared with the leapfrog development in the comprehensive transportation field, urban transportation has become a weak component in urban development. Problems such as traffic congestion, heavy pollution, crowded subways, slow transit buses, and disordered parking have substantially reduced the urban efficiency and limited the improvement in living environment as well as quality of life.

On the other hand, promoting high-quality development of urban transportation is not only an urgent need to improve the status quo, but also related to China's development goals of building a strong transportation system and realizing modernization of the country. In September 2019, the Central Committee of the Communist Party of China and the State Council issued the "Outline for Building a Strong Transportation Country," which stated that developing a strong transportation country is an important support for building a strong modern socialist state in all respects. Following the supply-side structural reform as a mainline, transportation should transit from the pursuit of speed and scale to qualityand efficiency-oriented improvement.

To develop high-quality urban transportation, the priority is to assess its development needs in the new era and analyze time-related factors and technological innovations that affect these needs. This paper starts with an analysis of new needs in future urban transportation from the perspective of urbanization. As an important part of the urban system, transportation plays a critical and fundamental role in maintaining urban operation, economic growth, and social development; it is also a necessity for meeting people's expectation on a better life. In addition, this paper presents anticipated impacts of new technologies and new business formats on urban transportation from the perspective of informatization. Finally, the paper includes expectations of future urban transportation and proposes related implementable initiatives.

1 Demand for improved transportation in the new phase of urbanization

China has entered a new era of striving for quality improvement in urbanization. With the continuous evolution of urbanization, cities need to improve the quality of development from economic, social, life and other perspectives

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related to material civilization and spiritual civilization. In this process, the following three aspects have the closest relationship with urban transportation: the need to improve people's quality of life, the efficient organization of urban space, and the diversified activity needs of different groups.

1.1 Travel demand generated from people's improved life quality

1.1.1 Basic travel demand

1) Commuting

Controlling commute time within a reasonable range is an important indication of quality life. Studies have shown that, regardless of the advanced accessibility of the transportation system, average commute time typically remains at approximately 1 hour, which reflects the Marchetti's constant. The "45-min law" is defined to reflect 45 minutes (station entry to station exit) as the maximum tolerable commute time for Beijing's residents according to a data analysis of the 2011–2017 Beijing subway card ^[1]. These cases suggest that

people's average commute time has a reasonable limit. If this limit is exceeded, people's ability to control their time can be substantially reduced and their quality of life will be negatively impacted. A 2016 study on the happiness index of British commuters has shown that, with every minute of increased commute time, people's happiness and satisfaction with daily life would decline ^[2].

The commute time of urban residents in China is obviously over-long and continues to grow. Long commute becomes very common and seriously harms the life quality of urban residents. For example, the 2014 average commute distance and time in Beijing were 10.1 km and 47.7 minutes, respectively, with a trend of continuous increase (see Table 1)^[3]. The average commute time in Jinan City rose from 26 minutes in 2004 to 33.8 minutes in 2013; the proportion of 30-min to 60-min commute trips increased from 15.4% to 35.3%; the proportion of commute trips longer than 60 minutes increased from 4% to 12.3% (see Fig. 1)^[4].

Table 1 Change of commuting traver time in Derjing (init)				
2010	2014			
75.1	74.6			
65.4	65.1			
39.5	49.1			
21.8	25.1			
15.0	15.4			
43.3	47.7			
50.1	55.8			
	2010 75.1 65.4 39.5 21.8 15.0 43.3 50.1			

Source: Reference [3].

 Table 1
 Change of commuting travel time in Beijing (min)



Fig. 1 Distribution of commuting travel time in Jinan City, Shandong Province, China Source: Reference [4].

2) Daily and leisure travel

The convenience for daily and leisure travel bears largely on the life quality of residents. Given that each person has a limited total budget for travel time, when commute time continues to grow, the time used for daily travel to meet basic needs is expected to remain as short as possible. However, the actual situation fails to make people feel optimistic. With Jinan City as an example, travel time for shopping and entertainment trips has increased from 23.3 minutes in 2004 to 25.3 minutes in 2013. Although most shopping and entertainment trips are less than 30 minutes, the proportion of trips within 10 minutes has dropped sharply, while the proportions of 10-20 minutes and 20-30 minutes have increased significantly (see Fig. 2)^[4]. A community typically has a scale of travel distance for 10-15 minutes trips. This means that increasing basic life services are accessed to outside of the community, becoming less convenient for residents.

1.1.2 Upgraded activity demand

Travel demand is essentially generated to meet certain travel purposes, and correlation exists between travel

purposes and living conditions. When transportation infrastructure and services were insufficient, people used to rely on limited transportation resources provided by cities to meet basic travel needs such as commuting and shopping. Since the 1990s and particularly the beginning of the 21st century with the standard of living transforming from requiring only adequate food and clothing to a moderately prosperous society, people's travel purposes have been increasingly diversified; the proportion of commute trips has generally declined while the proportion of daily flexible travel has increased (see Fig. 3).

With the continuous improvement of urban living conditions, people's travel demand continue to be upgraded ^[5]. All countries in the world have been experiencing a transformation of living standards from survival consumption and basic living to development and enjoyment. In this process, the proportion of food, clothing, and consumption of other necessities has gradually decreased, while the proportion of expenditures such as transportation, communication, and entertainment has grown rapidly. Urban transportation needs to adapt to the actual trend of growing travel demand and



Fig. 2 Distribution of travel time for shopping and entertainment in Jinan





Fig. 3 Changes of travel purposes in Shanghai, Beijing and London

Source: "Shanghai Comprehensive Transportation Operation Annual Report," "Beijing Transportation Development Annual Report," and "Travel in London Reports."

transforms from meeting basic travel needs to providing fast and high-quality services.

Economic and social development and technology improvement have extended people's leisure time. Given that people arrange their spare time in a flexible way to improve the quality of life, more personalized travel needs are generated. Leisure time is used for family activities and child care, for personal hobbies and continuing education, or purely for leisure entertainment. These activities generate substantially different transportation needs. Compared with commuting and daily life travel, travel demand in leisure time typically focuses on the quality of transportation services such as personalization, comfort, safety, accessibility, and experience.

1.2 Transport needs to support efficient organization of urban space

1.2.1 Support efficient organization of functional space in urban agglomeration

Urban agglomerations have become core areas and growth poles that support the development of major economies in the world. China proposes to take urban agglomeration as the main form to promote new urbanization. An important indicator for evaluating the development level of urban agglomerations is the specialized division and spatial organization efficiency of all involved cities within any urban agglomeration. The city clusters in the northeastern US can serve as an example. In this highly sophisticated functional network system, New York City is the nation's financial and commercial center, with well-developed business, manufacture, and service industries. Boston includes a large number of high-tech, finance, education, medicine, construction, and transportation services, where high-tech industries and education have the most distinctive characteristics and advantages. Washington D.C. serves as the political center and capital of the US, attracting a large number of headquarters of global financial institutions. Philadelphia is famous for its ports, education, and culture. Baltimore is characterized with national defense and manufacture industries. A functional network with close connections has been established among these cities, forming an integration of regional development space.

Urban agglomeration traffic network involves multiple levels, such as urban traffic, metropolitan traffic, intercity traffic, and interregional traffic. Each level has special characteristics and main contradictions. Interregional and intercity transportation provides services among cities with a relatively independent and systematic transportation organization. China has made great progress in the interregional and intercity transportation through high-speed rails and freeways. Metropolitan transportation connects administrative regions with urban built-up areas as the core. The limitation of administrative system has resulted in a lack of transportation services at this level. Urban transportation is at the end node of intercity transportation and closely connects the origin and destination of travel with the external transportation hubs; it also reflects the value of social and economic interaction among all levels of nodes within the urban agglomeration. Low efficiency of urban traffic can seriously reduce the efficiency of spatial organization in urban agglomeration. Therefore, the quality of urban transportation is directly related to the development benefits and overall level of the entire urban agglomeration.

1.2.2 Strengthen the transportation centrality of hub cities

With the improvement of national comprehensive transportation system, the passenger travel and goods movement among and within urban agglomerations are increasingly convenient. The role of transportation hubs has become more important as well. In addition to large seaports and airports, inland hubs relying on ground transportation network grow strongly; examples include Memphis in the US, Puebla de Zaragoza in Spain, and inland hub cities in central and western China such as Xi'an, Zhengzhou, Wuhan, Chongging, and Chengdu. These cities have reshaped the development pattern of urban agglomerations by virtue of strong service capabilities of the hub economy. For example, with The Belt and Road Initiative opening up the westward freight corridor, Zhengzhou is located in the inland area and serves as a transportation hub through aviation and railway transportation. With the improved transportation hub functions, Zhengzhou relies on goods movement to enhance the development of clustered industries, promote the high-speed rail economy and near-airport industries, and become a new logistics and economic center (see Fig. 4).

Efficient urban transportation will promote the transformation of hub cities from "urban gateway" to "urban hallway." In traditional understanding, a hub is a city's external gateway and the starting or ending point for the city's external traffic. This recognition focuses on the transportation function of the hub but ignores its spacial value. A hub is a confluence of various flow types, where different urban functions converge and concentrate in a diversified manner. These urban functions improve the value of surrounding areas of the hub and transfer the hub from an "urban gateway" to an "urban hallway." This transformation has become an important symbol of the city and an important engine that drives urban development. With La Défense, Paris as an example, the areas developed around the hub have integrated functions of business, office, shopping, living, and leisure as a single development region. It not only becomes the engine for enhancing urban functions but also serves as a main economic, financial, and commercial center in the area or even in the entire Europe.

1.2.3 Optimize the cross-border allocation of transportation resources in the metropolitan area

With the continuous development of metropolitan areas,



Fig. 4 Spatial diagram of development strategies of Zhengzhou as a hub city

Source: "Strategy Research on Zhengzhou as an International Hub City" of China Academy of Urban Planning and Design.

central cities have wider influence, and the travel demand across administrative regions continues to grow^[6]. However, China's urban development and regulation heavily rely on administrative divisions and neighboring cities face barriers. Therefore it is extremely difficult to coordinate the construction and service of transportation facilities in the metropolitan area across administrative regions.

The structure of metropolitan areas, formed based on close functional connection between the central city and its adjacent regions, is critical to strengthening the network system and enhance competitiveness of urban agglomeration. It is necessary to introduce market forces on the basis of government forces to fill the gaps of transportation among cities and maximize the allocation efficiency of resource elements in the metropolitan area. Through the combination of these two forces to enhance transportation coordination, market cooperation, and environmental co-protection, efficient operation of production elements and reasonable allocation of resources can be achieved.

1.3 Adapt to the diverse travel demand of different social groups

1.3.1 Adapt to the demand of middle-income groups

As the per-capita disposable income grows steadily, China's middle-income group continues to expand and the urban demographic structure appears to be a spindle shape with large middle and small ends. Recent estimates suggest that China has the world's largest middle-income group with more than 400 million people (see Fig. 5). In general, the middle-income group has strong consumption willingness and ability. The consumer demand from this group becomes an important force in stimulating consumption and is helpful to enhance the dependency of China's economic growth on domestic demand. With the challenge of anti-globalization, the continuous expansion of China's consumer market is conducive to enhancing China's ability to address impacts from external market risks and increase the resilience of economic growth. If the middle-income group doubles its size from 400 million to more than 800 million people, sustainable economic development will be substantially improved in terms of promoting new growth potential and upgrading economy types.

The growth of the middle-income group will bring significant changes in the social and consumption structure of cities, which further result in new travel demand. The consumption of the middle-income group has the following characteristics: strong consumption ability and desire, multiscale and diversified lifestyle, and personalized needs of goods and services for quality, diversity, and details. The consumption structure is characterized as development and enjoyment, with a large proportion of consumption expenditures on culture, entertainment, and tourism ^[7]. These types of consumer demand will upgrade the urban transportation mode from single, fixed, and limited supply to diversified, customized, and flexible supply. Quality improvement is increasingly focused after meeting the demand on quantity.

1.3.2 Accelerate construction of an elderly-friendly transportation system

Aging population is a new issue faced by future urban



Fig. 5 Development trend of China's middle-income group

Source: "Global Economic Growth Pattern Outlook in 2035" of Research Group on International Economic Patterns and China's Strategic Choices of Development Research Center of the State Council.

transportation. China's current per-capita GDP is about 9,000 US dollars, which has just crossed the threshold into a middleincome country. The proportions of China's population over 60 years old and 65 years old have reached 18% and 12%, respectively. The World Health Organization forecasted that China would become one of the most aging countries in the world by 2050 with 35% of population over 60 years old. Transportation for the elderly is an important part of the aging-population service system with the fundamental goal as solving the travel problem of the elderly. However, there are various barriers for the elderly to travel in Chinese cities. Incorporating travel demand of the elderly as soon as possible into urban planning, transportation planning, and the formulation of relevant regulation and policies has become an urgent issue ^[8].

Due to a long-term negligence of travel demand of the elderly, there has been little knowledge about the behavior patterns and travel characteristics of this age group. With the improvement of living conditions and increased life expectancy, the travel willingness of the elderly has become stronger than before and the lag has been significant in developing transportation system suitable for the elderly. Poor walking environment, inadequate safety of crossings, excessively large intersections, and unreasonable signal timing have become huge obstacles for the elderly to travel. The elderly friendliness of public transportation is only reflected in economic subsidies. Problems such as low station coverage, long departure intervals, and lack of barrier-free facilities prevent the public transportation from meeting the travel demand of the elderly. Potential safety risks and lack of management of elderly scooters result in numerous problems in traffic safety. China's urban transportation system is not yet ready to address the needs of aging population.

1.3.3 Ensure travel of vulnerable populations

Traffic fairness is an important perspective in future urban

transportation. Since traffic disadvantages are often closely related to social and economic disadvantages, ensuring the travel of disadvantaged groups is needed for social inclusion and development. A study in the UK has suggested significant inequality between low-income and high-income population groups in terms of travel modes and accessibility: While the overall average family car ownership rate is about 85%, less than 50% of the lowest-income households own a car; the annual travel distance of the non-car owners is only half of that of the car owners. Many low-income people without cars have insufficient accessibility and face social exclusion. The case of Xi'an City, Shaanxi Province, China shows that low-income families have extremely low levels of motor vehicle ownership and their travel activities rely on public transportation and bicycles. Low-income families have poor mobility, with 27% shorter average travel distance but 3% longer average travel time than those of high-income families.

Table 2Travel indicators of families with different incomes inXi'an

Family	Average number of trips per day/(trip·d ⁻¹)	Average travel distance/km	Average travel time/min
Low-income	2.46	4.0	35
Middle-income	2.53	4.8	35
High-income	2.58	5.5	34

Source: Data from the "2011 Xi'an Resident Travel Survey."

"Accessibility plans" have been added to the local planning in the UK to ensure fair transportation services and avoid social exclusion. Since 2006, accessibility evaluation has become a legal content of local transportation plan in the UK. Local transportation agencies must collaborate with other public agencies and important stakeholders to address insufficient accessibility for certain residents. In China, urban low-income families and new citizens who have just settled

down in cities often face travel disadvantages. Urban transportation system therefore needs to implement inclusive approaches to ensure affordable basic transportation services for everyone, such as balancing efficiency and equity in the planning and construction of public transportation facilities to improve public transit coverage, as well as improving walking and biking facilities.

2 Demand of urban transportation reform and development from informatization

The iterative development of information technology and its derived new business formats are reshaping the future urban transportation. With changes in urban production patterns and people's lifestyles, urban transportation demand has changed significantly. Substantial changes will be seen in service modes of the transportation system, ways of infrastructure use, and transportation system management.

2.1 Change the supply-demand adaptation mode and accuracy of urban transportation

2.1.1 Alter urban production mode and people activity mode

Information technology has enforced continuous innovations in a wide range of business areas and changed the production mode of cities. It has also gradually adjusted the industrial structure and economic operation mode to adapt to and utilize technological innovations. For example, information and communication technology, media, finance, and insurance have taken the lead in digital development. New businesses such as express delivery, food delivery, new retail, and general health are accelerating and gradually changing people's lifestyles.

New technologies are changing the modes of travel activities. Due to the real-time and cross-distance interaction, information technology, especially the virtual office and conference system such as VR/AR, has profound impact on people's activities. On the one hand, certain non-essential travel demand is reduced and online information exchange is adopted. On the other hand, with the significantly decreased communication cost and the expanded information exchange, the demand for information intensity and interaction frequency increases, which will induce face-to-face communication and travel demand.

2.1.2 Enable precise matching of transportation supply and demand through new technologies

Informatization and big data technology have a dual impact on supply and demand of urban transportation. Informatization and "Internet+," to a certain extent, have improved people's ability to obtain transportation services with higher quality and diversified choices of transportation modes through traffic information. Short-term behavior of individuals can be captured in a big data environment. Therefore, with analysis techniques such as data mining, broken and fragmented location data can be refined into continuous and complete travel information, achieving accurate matching of supply and demand.

2.2 Promote innovations in urban transportation modes

2.2.1 Shared travel

With the explosive growth of sharing economy, service modes of shared travel such as shared bicycles, shared cars, shared trips, and customized bus transit have emerged and developed rapidly. Recent statistics suggest that the proportion of single-occupancy vehicles on urban roads is as high as 60% to 70%, which results in substantial waste of traffic resources. Travel sharing based on the online car-hailing platform can consolidate social vehicle resources, make full use of vehicle fleet capacity, enable residents to travel without having to own a vehicle, and extend the function of private cars to the public transportation system. The following issues in the current shared travel technology need to be addressed: The distribution of vehicle resources is unbalanced due to asymmetry of spatial and temporal distribution of shared travel demand; the real-time deployment of shared vehicles and supply-demand matching need to be improved; the differentiated pricing strategies of shared travel must be further developed.

2.2.2 Integration of travel service

Current urban travel services are still dominated by relatively independent modes of transportation; transportation services are therefore divided and under uncooperative management. With improved technology, the service concept of improving users' mobility will force transportation service providers to make changes from offering a single service to providing integrated services. "Mobility as a Service" (MaaS) will become possible and dominate the future urban transportation.

Different from a traditional transportation supply, the MaaS system transforms transportation information from one-way controlled transmission to two-way transmission, providing users with personalized, customized, and door-to-door complete services. The MaaS system changes the focus of urban transportation from travel modes and infrastructure to response to demand of travelers' activities (see Fig. 6). Based on current real-time origin-destination (OD) needs and travel preferences of individuals, the system actively matches and recommends the optimal travel mode or a combination of multiple modes for users. As a peopleoriented travel service system, the MaaS system also provides passengers with more friendly travel services at similar or even lower travel costs.



Fig. 6 Framework of MaaS system

Source: http://telematicswire.net/mobility-as-a-service-maas-launches-first-on-demand-mobility-service-in-finland.

2.3 Optimize and tap potentials of urban transportation facilities

2.3.1 Change spacial patterns of urban transportation facilities

The wide application of information technology improves the flexibility and efficiency of spacial patterns of urban transportation facilities. For example, the popularity of autonomous driving has greatly reduced the demand for parking space. At the same time, autonomous driving has contributed to a more flexible transportation system, which has lower impact on urban space use and turns roadways and cities from car-oriented space to human-oriented space (see Fig. 7). The existing parking space and redundant traffic space can be re-developed as green spaces, parks, and other spaces suitable for living. In addition, visual technology, telemedicine, remote education, intelligent robots, and 3D printing will change the patterns of urban living spaces and create new demands.

2.3.2 Strive for maximum use of existing transportation facilities

Information technology has brought new opportunities for fuller use of existing transportation facilities. Alleviating traffic congestion by increasing road capacity is a time-consuming and costly measure. The entire process,

including environmental problem-solving, land acquisition, approval of infrastructure projects, residents' relocation, and project construction, may take several years from the conception to final implementation. However, the changes due to improved information technology and innovative measures help enhance the mobility of cities in a short period of time, without requirement on large-scale infrastructure investment. For example, real-time ride sharing enables residents to travel without having to drive alone; autonomous driving and car-to-car communication technology allow vehicles to have shorter reaction time, maintain a smaller headway during driving, and improve roadway capacity through vehicle platooning. A new type of traffic control system based on big data and complete information retention can rely on powerful computing capabilities to control travel in real time, continuously optimize traffic signal timing, improve spatial allocation of right-of-way, and optimize urban road network capacity.

2.4 Improve comprehensive management for urban transportation

2.4.1 Improve comprehensive decision-making for urban transportation

Information technology provides an intelligent and efficient deployment plan for the core system of urban transportation, making urban transportation management system



Fig. 7 Evolution of street cross-section in a self-driving era

Source: Envisioning Florida's Future: Transportation and Land Use in an Automated Vehicle World.

more efficient and refined. With the support of data collection and aggregation in the Internet-based logistics, combined with the application of new technologies such as artificial intelligence and 5G, city-level real-time computing, fusion analysis, and automatic control become possible. Through learning and abstraction of a large amount of historical data and logical synthesis of the expert system, artificial intelligence uses event-oriented clues to reflect the causality and correlation of urban transportation problems. Application of artificial intelligence can help decision-makers quickly identify and process key issues, thereby greatly improving the efficiency and science of urban transportation regulation.

2.4.2 Encourage public participation and co-governance

Information technology can also facilitate broader public participation and more effective co-governance. Urban transportation issues often involve stakeholders with different needs. The application of information technology can build connection among all stakeholders to fully analyze the issues, providing visual scenario analysis technology and eventually an acceptable solution that balances interests of all parties.

3 Vision for future high-quality urban transportation

3.1 People-oriented on-demand transportation services

3.1.1 Return to the foundation of serving people

Information technology has improved mobility and the popularization of information network has also made mobility reconstruction possible. All aspects of residents' travel have been changed by information technology and rapid development has been achieved in route planning, congestion charging, transportation management, transportation mode selection, and shared travel. However, the metric for assessing the improvement of mobility is not the technology itself; instead, the key point is whether the focus of travel services has been put on addressing people's needs. Therefore, the goal of sustainable mobility is set based on people's needs to provide services.

Future travel services will be provided in the form of appointment or customization to address individual needs and preferences of travelers. Such services will use multi-mode, networked, and collaborative organization technology to

integrate and optimize trip chains to provide differentiated, diversified, and complete service plans. They can meet the travel needs of citizens with high-quality and high-efficiency services and improve people's travel experience.

3.1.2 Meet people's sustainable mobility needs

The focus of an urban transportation system has been put on the sustainable mobility that meets the needs of individual activities through technological innovation. In the future, cities should shift from adding capacity of transportation to improving travel accessibility, fairness, and sustainability. The integration of multiple travel modes and the improvement of travel environment should be emphasized. People's travel needs are getting increasing attention from the government and service providers. The sustainable mobility planning for urban transportation will rely on multiple parties to implement individual demand-oriented service concepts and build technical support systems.

3.2 Learning and development based on interconnection and integration

3.2.1 Develop a new understanding of multi-source integration-based transportation

The retention system of urban transportation data needs to transform from passive construction and less hierarchy to deep insight and holographic perception to adapt to a complex and giant system of urban transportation in the future ^[9]. A new generation of intelligent transportation sensing system will be created through the complete digitization of all transportation-related elements of social production and life, such as people flow, logistic flow, vehicle flow, capital flow, infrastructure, urban operation, and natural environment. This system will track and collect spatial-temporal trajectories of each transportation-related element in the whole chain, with comprehensive objects, full time and space, and complete granularity features. Improved understanding will be achieved on the evolutionary laws of urban transportation system and its operation mechanisms.

New thoughts and methods are needed to reshape the understanding of urban transportation in the era of implementing big data and intelligent network. Addressing transportation analysis needs in the era of big data should be based on accelerating transformation and innovation of urban transportation theories, research approaches, and evaluation methods, as well as improving the current widely used approaches for travel demand analysis such as increasing the accuracy and ease of use for the four-step modeling and the trip-chain behavior analysis.

3.2.2 Thorough integration of transportation and urban environment

The urban environmental integration based on the Internet of Everything has become an inevitable development trend. Transportation facilities and vehicles are no longer independent; along with other service facilities in the city, they are integrated into the digital urban environment model and serve people together. According to human activity information, identifying individual activity needs and their temporal and spatial patterns will optimize urban transportation resources and service allocation to better meet people's needs. From the perspective of integrated development, the decision-making mechanism of human activities values more the satisfaction and perception of the overall service from the urban environmental system than the convenience of travel.

3.3 Fair and inclusive urban transportation services

3.3.1 Ensure basic transportation services for everyone

Cities should ensure sustainable transportation services for everyone in the future. The *New Urban Agenda (2016)* issued by the United Nations "Habitat III" Conference stated that our common vision is to share a city for all. Providing fair transportation means offering safe, convenient, and affordable transportation services to everyone. The elderly, children, the disabled, and low-income groups will not be excluded because of the significant disadvantages in age, physical ability, and economic ability. On the contrary, cities can rely on legal systems, technological innovations, and social security to improve transportation services for disadvantaged groups, so that they can get opportunities to participate in related activities. These services will also improve economic and social development and benefit all groups living in cities.

3.3.2 Provide personalized travel services

Future urban transportation services should be inclusive and balanced. People's travel behavior is dynamic and diversified. The transportation system should adapt to the needs of all aspects of the society and provide people with multiple travel options, rather than forcing people to use one or several fixed modes of travel. Personalized travel services should meet not only the daily routine travel needs such as commuting to work and school, but also other travel needs with random characteristics resulted from the improvement of people's living standards, such as leisure, entertainment, and visiting relatives and friends.

Technological innovation should be promoted to focus on sustainable mobility. The urban mobility should be improved through serving people's activity needs, ensuring transportation fairness and social inclusiveness, and guiding and standardizing the deployment of transportation service formats with application of related technologies.

3.4 Rule-making for new regulation relations

3.4.1 Innovations in rule-making thanks to technological progress

Technological innovation has brought new behavior, systems, and institutions. Therefore, successful implementation

of sustainable transportation in the future requires major changes in behavior, systems, and policies. Travel behavior can be effectively adjusted to optimize the relationship between supply and demand by establishing a reasonable pricing mechanism and strengthening travel cost incentives. With policies, regulations, and rules that direct the development of transportation technology and travel services, it is possible to standardize and guide innovative activities in the field of urban transportation. Social consensus and value system, as well as the harmonious development of cities, can be achieved through strengthening the concept of peopleoriented and sustainable development.

3.4.2 Transition from transportation management to efficient regulation

Future cities will focus more on regulation than management and emphasize transformed government services, service coordination, and creation of social values. Urban development will highlight smart regulation and smart growth. The future urban regulation system will integrate urban strategic system, spatial planning system, public policy system, smart transportation support system, and regulation mechanism system into one unit. Such regulation system will concentrate on precise control of travel demand, smart transportation management, and personalized transportation services, in order to achieve breakthroughs and better smart urban regulation in the future.

A comprehensive management system of urban transportation should be diversified. The modernization level of urban transportation regulation should be improved by developing an efficient regulation system that incorporates physical space, social structure, innovative technology, travelers, and travel activities associated with the urban transportation.

4 Conclusion

To adapt to the systematic phase changes in urbanization and informatization, the two epoch-making variables, urban transportation will not achieve high-quality development unless improvements and innovations are implemented in basic cognition, fundamental theory, applied technology, and comprehensive regulation. Improving urban transportation management will rely on reshaping understanding of urban transportation in the era of big data and intelligent network, accelerating the transformation and innovation in basic theories, research paradigms, and evaluation methods, and establishing a diversified and efficient regulation mechanism for a complex and huge urban transportation system.

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