Inevitability of Strengthen the Development of Public Transport in Large Cities from the Perspective of Security Resilience

Wang Jiang
Affiliation:Tongji University
Email:594328498@qq.com

Abstract
In recent years, extreme weather, geological disasters, infectious diseases and other emergencies have put forward higher requirements for the normal functioning of cities. Large cities with high population density and high construction intensity are facing the dual pressure of disaster emergency support and economic production guarantee. As the carrier of most traffic activities, the public transportation system has the characteristics of closed space, high crowd density and high mobility of personnel, thus is easy to become a high-risk and disaster-stricken area in sudden disasters. This paper analyzes the development trend of individual transportation and public transportation, taking into account the characteristics of the two travel modes, the travel characteristics of large cities, the impact of sudden disasters on public travel, and the value orientation of policy strategies. This paper proposes that ensuring the sustainability of public transportation capacity is an inevitable choice in the face of travel demand, ensuring the safety and controllability of public transportation is the basis for resuming work and production after sudden disasters, and the value orientation of public transportation plays an important role in restoring normal urban life after disasters. At the same time, combined with the existing public transportation system and the attempt of new public transport products, the possible directions for the strengthening and development of public transport in the future are proposed.

Keywords
security and resilience, public transport, individual transportation, travel needs

Full text
Emergency events such as extreme climate, geological disasters, and infectious diseases have brought severe blows and security threats to large cities with high density of people. Public transportation space, as the carrier where most transportation activities take place, has the characteristics of closed space, high crowd density, and high mobility of people. It can easily become a high-risk area and disaster-stricken area in sudden disasters. Taking the COVID-19 epidemic as an example, as the prevention and control stages change, the public transportation systems in China's major cities have successively gone through the stage of high-risk transmission without measures, the stage of suspension of operations under the isolation policy, and the prosecution and resumption stage. Taking the "7.20 Incident" in Zhengzhou as an example, due to problems such as the quality of transportation facilities and traffic scheduling, Metro Line 5 was besieged and became a severely affected area. However, whether it is the normal life needs of residents from the perspective of individual travel, or the needs for efficient urban operation from the perspective of economic efficiency, they all have a high dependence on the public transportation system as the blood vessel of the city. On the one hand, large cities have high population density, complex population sources, and large commuting needs, which make it necessary to further develop public transportation. On the other hand, large cities have a relatively complete public transportation construction foundation and strong intelligent prosecution equipment layout capabilities, making it feasible to further develop public transportation. This paper will discuss this in detail from aspects of necessity, feasibility, and importance.

1. Necessity: The sustainability of public transportation capacity makes it an inevitable choice when facing travel needs

1.1 Characteristics of public transportation and individual transportation

Public transportation refers to transportation services open to the public, of which buses and rail transit are the main parts. Public transportation provides low-cost, high-quality services by integrating similar travel needs in a centralized form. After the preliminary construction of site facilities and network planning is completed, the public transportation system can carry most of the passenger traffic in the central areas of large cities with smaller maintenance costs and lower negative environmental impacts.
Individual transportation refers to a form of transportation in which the vehicle is owned by an individual. It usually has the characteristics of low transportation volume, convenience, flexibility, and good privacy. The early purchase of equipment requires individual residents to have certain financial strength, and in daily operation, the per capita occupation of urban traffic space is large.

Comparing the performance characteristics of public transportation and individual transportation (Figure 1), from the perspective of citizens' travel, the overall cost of public transportation is lower and the service distance is longer. However, buses and rail transit adopt a fixed-station model. Although the station network coverage in large cities is wide and the departure interval is short, there are still station blind spots and a certain waiting process. It is not as good as individual transportation in terms of getting on the bus nearby and getting on the bus immediately. From the perspective of overall urban transportation operations, public transportation has a large volume, a wide range of services, and a small occupation of road space. At the same time, it is more environmentally friendly than private cars and is an efficient mode of transportation to ensure basic urban transportation activities.

便捷度（站点密度、停放需求）	舒适度（乘车环境、天气限制）	是否门到门	费用水平	优势距离（km）	运行速度（km/h）	交通方式		高峰时乘客数（人）	人均运行占道面积（m²）	人均停泊占地面积（m²）
中	中	否	中	<40	35	轨道交通	公共交通	1800	0.67	0.3
中	低	否	低	3.5-20	25	公共汽车		30	0.3	1
高	高	是	高	>3.5	40	出租车网约车		1	3	10
低	低	是	低	<4.5	12	共享单车		1	2	1.5
中	高	是	高	>5	40	私人汽车	个体交通	1.25	2.4	8
高	低	是	中	<8	20	非机动车		1	2	1.5
高	中	是	低	<3	4	步行		1	0.4	0

运量较高　　运速较高　　运距较远　　占地较少

Figure 1 Comparison of the characteristics of public transportation and individual transportation (left side is from the perspective of passengers, right side is from the perspective of urban transportation system)

Public transportation carries most (especially low-cost) long-distance travel needs and is an indispensable part of the urban transportation system (Figure 2). In addition to limited coverage distance, low-cost options in individual transportation are strongly affected by external factors such as weather. They are more likely to turn to public transportation in extreme weather conditions. This part of the travel demand is also a potential service target of public transportation. The travel efficiency of private cars, which are the most maneuverable among individual transportation, is severely limited by urban road space resources. At present, China's big cities are facing severe road traffic pressure and vehicle parking pressure. Considering that existing roads in big cities are difficult to expand on a large scale in a short period of time, and

the city's motor vehicle capacity is nearly saturated, further promoting the development of private cars will not have positive benefits. Another important component of individual transportation, electric vehicles, as a transitional method between walking and car travel, have the advantages of low price, high mobility, long distance and fast running speed. However, parking and charging are also inconvenient, making it a compromise choice for many low- and middle-income people with frequent travel needs. From the perspective of overall management of the urban transportation system, the chaotic parking of electric vehicles, serious interference with road traffic capacity at intersections, and low driving safety have caused certain damage to the urban traffic environment in terms of road resources and traffic order. The incompleteness of relevant regulations and the complexity of mixed traffic in road planning have put urban electric vehicles in a gray area that is difficult to manage, resulting in the reality that they gain their own convenience at the expense of other modes of transportation. To a certain extent, the large number of citizens choosing electric vehicles is due to the imperfection and incomplete coverage of the public transportation system. We should realize that this seemingly convenient individual transportation mode is not feasible for popularization in large cities with huge motor traffic and tight road resources, nor is it sustainable for carrying major commuting trips.

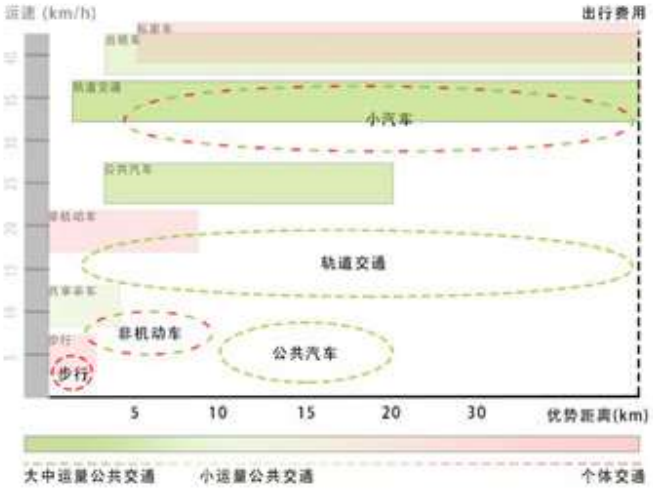

Figure 2 Passengers' willingness to choose travel mode

1.2 Travel demand characteristics of big cities

Big cities integrate the flow of more people within a larger geographical space. Its transportation system faces longer transportation routes, denser commuter crowds, higher traffic intensity, and more complex and diverse circulation options. Under the highly intensive development, the strong attraction of public services and commercial office functions in central urban areas is accompanied by extremely high land rents and housing prices. This makes the phenomena of job-housing separation, commuting peaks, and tidal traffic particularly significant. In addition, the siphon effect of big cities across the country continues to attract young talents and low-level migrant workers from other provinces and cities. These migrant populations do not have strong economic strength but have long-term willingness to settle, making them more dependent on public transportation for daily commuting. Generally speaking, the travel demand in big cities is characterized by long commuting routes, large instantaneous passenger flows, and heavy reliance on large-capacity, intensive and efficient transportation systems. However, the high per capita road area occupied by individual traffic makes it difficult for the city's limited road

space to withstand the traffic flow during peak commuting periods. This part of the daily peak passenger flow must be shared by public transportation with large or medium capacity, especially rail transit using underground space. At the same time, compared with individual transportation that is limited by road space resources, public transportation with adjustable departure frequency and vehicle grouping is also more flexible and can better adapt to the imbalance of daily traffic flow.

In addition, price-sensitive people account for an important part of the complex population structure of big cities. They have a certain spirit of hardworking and are also the main group of urban commuters. Their requirements for the convenience and efficiency of the travel environment are much higher than comfort, thus having a strong dependence on public transportation. Their commuting and employment provide important basic services for the normal operation of the entire city. The guarantee of their travel needs is also a part that cannot be ignored in the urban transportation system.

To sum up, most travel needs in big cities must and can only rely on public transportation to a large extent. The inefficient mode of individual transportation lacks sustainable carrying capacity in terms of road space resources, public economic strength, and natural ecological environment, making it difficult to promote and develop it as the main form of urban transportation.

2. Feasibility: The safety and controllability of public transportation make it the basic guarantee for resuming work and production after sudden disasters

2.1 Traffic characteristics in different periods of sudden disasters

After a disaster breaks out, it goes through different periods such as the disaster emergency period, the post-disaster rescue period, and the post-disaster recovery period. Each stage puts forward different functional requirements for the urban transportation system (Figure 3). Overall, the disaster emergency period truly reflects the ultimate carrying capacity and risk resistance of the transportation system. The long period of rescue and reconstruction after the disaster has had a great impact on citizens' living habits and travel needs.

相关要素		突发灾害阶段		
		受灾应急期	灾后救援期	灾害后恢复期
交通系统职能		应急救援	防控工作	生产生活
道路空间		富余	富余	不足
公交供给		运能空闲	运能空闲	中高水平
出行需求		伤者就医	伤者就医 医护、环卫、社区工作人员到岗	恢复正常通勤、娱乐出行
目的		疾病救治	疾病救治 基本生活保障	复工复产、消费娱乐
强度		低	中	高
替代方案		应急调度	物流配送系统	办公娱乐线上化
空间分布	目的地	医疗点	部分工作岗位 物资供应点	工作岗位 商业休闲场所
	特点	目的地集中	距离短、范围近	复杂多样
时间分布	出行时间	不定时	定时	不定时
		无规律	存在不显著早晚峰	存在显著工作日高峰、早晚高峰
	特点	紧急	可控	可控
出行方式	公共交通	无	集中统筹 利用富余运能进行专线调度	安全检控
		救护车	救护车	恢复正常
	个体交通	步行、非机动车、私人汽车		
		高度依赖	高度依赖	高度倾向
出行决定权主体		政府	政府 社区、单位	个人
出行优先权主体		获批个体	获批个体 专用公交	无
出行方式选择标准		可达性	可达性 可持续性/便利性	安全性 可持续性
交通问题	**现象**	患者就医难 医护就职难	其他患者就医难 其他岗位就职难	效率降低
	原因	个体交通 覆盖不全	优先出行权分配不周	保障安全

Figure 3 Characteristics of traffic elements at each stage of sudden disasters

Passengers' choice of transportation mode is comprehensively affected by multiple factors such as travel purpose, transportation conditions, and personal purchasing power (Figure 4).

Take Wuhan, where the COVID-19 epidemic first broke out, as an example. As the first place and hardest-hit area of the epidemic, the initial stage of the lockdown was a disaster emergency period, which coincided with the Spring Festival holiday, thus there were no problems with the supply of basic daily necessities in the short term. Under the circumstances at that time, the needs of ordinary citizens for commuting, daily consumption and entertainment travel disappeared. The main purpose of travel became emergency medical treatment for fever patients and commuting for work for medical staff. Coupled with the complete shutdown of the public transportation system, patients and medical workers are highly dependent on individual transportation for travel. Facts have proven that the coverage of private cars and the accessible distances for bicycles or walking in the city are extremely limited, which resulted in a difficult commuting situation for a large number of medical staff in the early stages of the city's lockdown, some of whom had to cycle across the river to work. In big cities, there is a certain

mismatch between the coverage of individual transportation and the people with basic commuting needs. The actual traffic situation during this emergency period truly reflects that under the current economic structure and population structure, individual transportation does not have the supply guarantee for emergency needs, not to mention the transportation demand that has increased dramatically in intensity and complexity after the resumption of work and production.

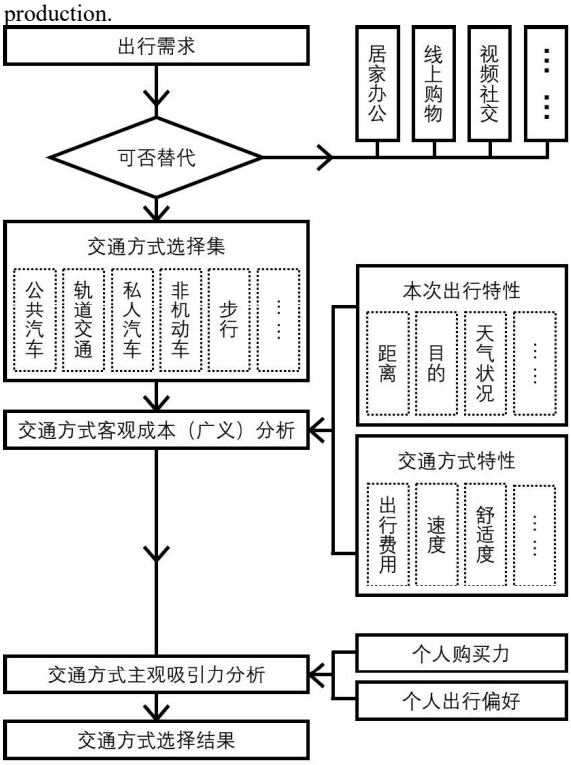

Figure 4 Passenger transportation mode selection flow chart

When severely infected people were basically treated, the number of infections peaked, and the scale of the epidemic was basically controlled, Wuhan launched a two-month home-based prevention and control measure, that is, entering the post-disaster rescue period. This stage lasts for a long time, and the various needs of daily life gradually emerged. The citizens' first principle for the transportation system has changed from "accessible at any cost" in the early emergency period to "accessible and sustainable". Medical treatment for patients with mild symptoms, medical treatment for other diseases, and purchasing basic daily necessities have become the main travel purposes. At the same time, due to the systematic development of anti-epidemic work, a large number of party members, community workers, and sanitation workers were required to commute to work. At this stage, the government uses the surplus road space resources and bus transportation capacity to provide customized buses for hospitals and other units in need to ensure the effective progress of anti-epidemic work. At the same time, the community collected residents' material needs and medical needs in a unified manner, and provided services such as collective procurement and special medical vehicles. At this stage, citizens' travel mode choice set has been significantly reduced, and the substitutability of each

mode has been greatly reduced. At the same time, the purpose of travel determined whether the right to travel can be obtained. The interruption of low-price public transportation and the competition for travel rights increased objective costs (in a broad sense). Purchasing power became the main basis for determining travel mode. The traffic control measures at this stage have greatly affected citizens' long-term living habits and travel concepts. Network technologies such as home office, online shopping, video social networking, and material distribution systems transform the spatial flow of people into the flow of information and goods. Small-capacity door-to-door public transportation methods such as customized buses and community buses have improved safety and convenience compared with traditional buses. Limited by travel policies and individual transportation capacity, citizens' willingness to seek medical treatment and purchase goods nearby rather than at long distances increased significantly. The flow of people gathered in large hospitals and shopping malls had been divided into various residential areas. This travel habit of weakening intensity, shrinking distance, and reducing mix has also continued in the post-epidemic period after the isolation.

	公共交通	个体交通
使用者	公众	工具所有者
	开放	私密
运量	大	小
	人员流动、集聚	人员固定
范围	固定站点	门到门
优点	低费用	安全性
缺点	受灾风险	覆盖人群有限

Figure 5 Characteristics of public transportation and individual transportation during the post-disaster reconstruction period

After the unblocking of Wuhan, public transportation resumed normal operations, but a temperature measurement and code verification process was added at each station to ensure safety in a visible way and at the same time make the transmission path traceable. At this time, the travel mode choice set regained its diversity, but the characteristics of each transportation mode had changed (Figure 5). For example, the addition steps of temperature measurement and code verification had changed the operating efficiency of the public transportation system. The proportion of safety factors in citizens' travel preferences had increased, while the proportions of efficiency and cost had decreased. The purchasing power of citizens had partly declined due to the impact of the national economy, but the sense of depression after not spending for a long time and the concept of life safety first had weakened their price sensitivity and increased their willingness to consume.

2.2 Public transportation safety controllability during the post-disaster recovery period

Although public transportation does have dangerous factors such as dense crowds, it can be effectively dealt with by formulating complete emergency plans, monitoring operating conditions in real time, and accurately dispatching emergency resources. On the other hand, in the context of the demand for normal social and economic operation, it is meaningless to cut off the contact gathering of large flows of people by strengthening individual transportation to completely eliminate the risk of collective disasters. Transforming and improving safety based on the existing public transportation system, rather than turning to the development of "absolutely safe" individual transportation, has absolute advantages in both scientific and economic efficiency.

3. Importance: The value orientation of public transportation plays an important role in supporting the normal life of urban operations in the context of disaster response

The post-disaster reconstruction period means that the city's economic and cultural activities should gradually return to normal operations. As an important part of normal urban life, public transportation has also been a key component of the city's intensive development. Adhering to the development of public transportation systems in large cities has both scientific significance and positive value orientation.

3.1 Establish confidence in preventable and controllable reconstruction

We can all feel the psychological and emotional impact of policy guidance at all stages of disaster response. The positive significance of targeted support, targeted donations, and official media reports from other provinces and cities is largely reflected in the attitude and psychological stimulation of people in disaster areas. Psychological care and confidence building are of great significance in the aftermath of disasters. The enhanced development of public transportation in the context of disaster response is not only an implementation of actions to restore normal life, but also reflects the preventable and controllable value orientation, providing citizens with positive and stable beliefs for resuming work and production.

3.2 Demonstrate concern for public welfare and people's livelihood

As a public welfare urban infrastructure, public transportation is an important part of people's livelihood projects. Its low price and strong transportation capacity provide travel guarantee for many low- and middle-income groups. Among various types of disasters, low-income groups are more severely affected by economic impacts, as they are more price sensitive and more dependent on public transportation. Strengthening the development of public transportation is also a practical concern for people with limited purchasing power and difficulty in paying for individual transportation.

3.3 Continue the environmentally friendly decontamination concept

Strengthening the development of public transportation has always been an important strategy for large cities. Existing urban problems such as road congestion, exhaust pollution, noise pollution, and traffic accidents are mostly caused by inadequate public transportation and oversaturation of individual transportation. From a long-term perspective, a slow-travel-friendly environment based on walking and cycling must also rely on a strong public transportation background. True decentralization, environmental optimization, and future health cannot exist without a strong public transportation system.

On the one hand, the starting point of avoiding the risk of clustered disasters is highly consistent with the original efforts in the city to ease travel, avoid crowded places, and stagger peak hours. Flexible working, home working and other methods can be continued.On the other hand, in limited spaces, the dispersion of people should be based on the optimization of the public

transportation environment, ensuring safe distances and personal space, and achieving intensive and efficient evacuation. It is not feasible to turn to extensive and unsustainable individual transportation, otherwise it will only cause extreme deterioration of the urban traffic environment for the so-called "absolute safety" and bring about more severe environmental safety problems.

4. Possible directions to strengthen the development of public transportation

Strengthening the development of public transportation is essentially to improve the efficiency and quality of citizens' travel. From the overall perspective of urban development, certain intervention and regulation should be carried out on citizens' travel decisions (Figure 6). Optimizing their travel modes from the root (such as shortening daily travel routes through improving basic living facilities, etc.) and optimizing the citizens' travel environment in the process (such as building a slow traffic system to encourage green travel, etc.) will have a good effect on the overall transportation and will also provide a better background environment for urban public transportation.

出行阶段	调控焦点	干预手段
出行产生	交通发生源	土地控制
		现代网络通信技术（线下活动转线上）
出行分布	交通吸引源	土地控制
		优化生活基础配套（就近解决）
出行方式	低容量运载方式	激励政策（费用补贴/增收）
		优化高容量环境
空间路线	拥挤空间	实时路况信息
		硬性路障
时间路线	高峰时段	错时调峰

Figure 6 Regulation methods for citizens' travel decisions

4.1 System improvement and environmental optimization

Controlling the upper limit of the number of passengers in public transportation spaces and ensuring a relatively sufficient personal safety distance have put forward requirements for the waiting and riding environment of public transportation stations. Improving the coverage of the existing line network and improving the smoothness of the connection between rail transit and ground transportation can also effectively disperse the concentrated passenger flow and improve the quality of citizens' travel.

4.2 Personalized services for small and medium-sized transport volumes

Some cities in China, such as Beijing, Jinan, and Kunming, have tried to promote customized buses and temporary routes. This point-to-point transportation mode with small and medium-sized transportation volume and multi-vehicle dispatching serves people with the same or similar needs, avoiding excessive agglomeration of people. This model also relies on the information collection and integration of the Internet platform and the real-time information

exchange system to give full play to the intensive and efficient performance of public transportation through a static reservation mode and a timely response mode, while making up for the blind spots of existing public transportation.As of April 2023, the cumulative number of registered customized bus users in Beijing has reached 90000, and 173 customized bus lines have been opened, with a daily departure volume of 191 buses.
Compared with the traditional single operation model of fixed lines and unified vehicles, small and medium-volume public transportation that adopts a demand response model based on user demand data has the characteristics of high quality, efficiency, comfort and accuracy. It can integrate personalized and differentiated travel services and high-quality bus experience while ensuring efficiency.

4.3 Marketization of operation management

Compared with the traditional urban bus operation model monopolized by state-owned enterprises and subsidized by local governments, market-oriented attempts may be better able to provide personalized and precise services in line with the diverse travel needs of passengers. While adhering to the attribute of public transportation as the basic guarantee of urban public services, two or three public transportation enterprises can be established through area division and other methods. Use social capital and market rules to seek the optimal model based on passenger needs, encourage new public travel products, and achieve diversification of public transportation.

5. Summary

In summary, in the context of sudden disasters such as extreme climate, geological disasters, and infectious diseases, public transportation is fully capable of providing safety guarantees that are no less than the city's overall prevention and control level. Strengthening Developing public transportation is the only and wise choice for my country's big cities, taking into account the high dependence of the normal operation of large cities on public transportation, the sustainability of public transportation from a long-term perspective, the decentralization concept of public transportation under policy guidance, the existing relatively complete bus network system, as well as the trial of diversified bus products.

References

1. 杨琦, 张雅妮, 周雨晴, 白礼彪, 2022. 复杂网络理论及其在公共交通韧性领域的应用综述. 中国公路学报 35, 215–229. https://doi.org/10.19721/j.cnki.1001-7372.2022.04.018
2. 王作航, 2023. 多灾害风险下城市交通基础设施网络韧性评估与治理研究（硕士). 长安大学. https://doi.org/10.26976/d.cnki.gchau.2023.000808
3. 韩霜, 傅惠, 2020. 即时响应式定制公交调度优化. 公路交通科技 37, 120-127+158.
4. 马昌喜, 王超, 郝威, 刘晶, 张兆磊, 2020. 突发公共卫生事件下应急定制公交线路优化. 交通运输工程学报 20, 89–99. https://doi.org/10.19818/j.cnki.1671-1637.2020.03.008
5. 黄启翔, 陶银辉, 易陈钰, 2022. 后疫情时代韧性综合交通体系建设浅析——以深圳市为例, in: 绿色·智慧·融合——2021/2022 年中国城市交通规划年会论文集. 中国城市规划学会城市交通规划学术委员会, p. 11. https://doi.org/10.26914/c.cnkihy.2022.059303