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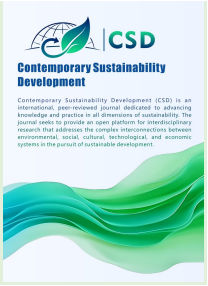

Article

The spatial governance dilemma and sustainable solutions to the problem of "difficult parking" in cities

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Abstract: With the acceleration of global urbanization, the problem of "parking difficulty" in cities has become increasingly prominent, affecting traffic efficiency, environmental quality and residents' quality of life. This article systematically analyzes the current situation, causes, and spatial governance challenges of urban parking problems, and explores sustainable solutions from multiple perspectives such as systems, policies, funding, resources, and technology. Research has shown that parking difficulties are related to complex factors such as supply-demand imbalance, lagging planning, policy failure, and insufficient technological application. This paper proposes to build a multi-level governance system through cross sectoral collaboration, intelligent technology integration, policy innovation and spatial optimization, hoping to provide theoretical reference and practical guidance for urban sustainable development, and promote the development of urban parking system in the direction of efficiency, fairness and sustainability.

Keywords: Difficult parking; Spatial governance; Sustainable transportation; Intelligent parking system; Policy innovation

1.Introduction

The urban parking problem is not only a traffic management problem, but also a comprehensive management problem involving land use, environmental sustainable development and social equity. Against the backdrop of rapid global urbanization and the rapid increase in the number of motor vehicles, the demand for parking far exceeds the supply, resulting in a series of intuitive phenomena such as traffic congestion, resource waste, and environmental pollution(Chen et al., 2025). The ratio of parking spaces to motor vehicles in Beijing is only 1:2.5, far below the internationally recognized reasonable standard of 1:1.3(Yan-ling et al., 2016). This contradiction is particularly prominent in historical urban areas, business centers and other space limited areas, and has become one of the key factors restricting the sustainable development of cities.

Traditional governance methods such as increasing the supply of parking facilities or price control can alleviate adverse effects in the short term, but they are difficult to fundamentally solve the problems of unreasonable and systemic inefficiency in spatial resource allocation(Shoup, 2006). In recent years, researchers have begun to re-examine parking issues from the perspective of spatial governance, emphasizing the need to optimize resource allocation through institutional design, technological innovation, and policy coordination(Fahim et al., 2021). The severity of the global parking problem is closely related to the stage of urban development: the situation in developed countries is characterized by low management efficiency and uneven resource allocation, while the problems in developing countries are concentrated in inadequate infrastructure and lack of management systems. This difference emphasizes that solutions must be tailored to local conditions, drawing on international experience while also incorporating local realities. In a rapidly urbanizing country like China, parking issues have evolved from simple traffic management problems to comprehensive problems that affect urban operational efficiency, residents' quality of life, and even social stability.

Due to being in such a complex situation, the research objective of this article is to systematically analyze the underlying reasons for the imbalance between parking supply and demand, and to construct a sustainable governance framework that takes into account the interests of multiple parties. The core question that arises from this is: why is it difficult to fundamentally solve the parking problem by simply increasing supply or price control under the conditions of limited space resources and a surge in the number of motor vehicles? How to break through the governance dilemma of institutional fragmentation, policy conflicts, and technological silos, and achieve spatiotemporal optimization of parking resources allocation? At the same time, the study has important practical significance and academic value in solving the problems of how to balance traffic efficiency, environmental quality and social equity in the process of rapid urbanization.

2.The current situation of "difficult parking" in cities

2.1 Global parking supply-demand imbalance intensifies

The fundamental contradiction is that the demand for parking far exceeds the supply of parking. In cities of developed countries, about 30% of train trips are generated to find parking spaces, with an average driver spending 17 hours a day searching for parking spaces(Shoup,

2006). Emerging economies are even more severe. According to statistics, the additional fuel consumption caused by parking difficulties accounts for about 15% of Beijing's transportation energy consumption, which is about 700 million liters of gasoline(Grzenda et al., 2023). There are significant differences between different types of cities, and the urban population and functions of many large cities in mega cities are too concentrated, which puts pressure on both historical legacy issues and new development needs. For example, the old city of Beijing has requirements for building preservation and cannot increase parking lots on a large scale, and newly built business districts have not kept up with the planning and construction of parking facilities;The overall pressure of small and medium-sized cities is not great, but local parking problems will occur, such as hospitals, schools and other places. The uneven distribution of different urban spaces leads to uneven distribution of parking difficulties, thus requiring differentiated governance. The research results in Xi'an city show that there are a total of 1.08 million parking spaces within a land area of 359.9km2 within the Third Ring Road. The imbalance between parking space supply and demand has caused vehicles to constantly patrol and find parking spaces during peak commuting hours, which may also cause problems such as exhaust pollution(Shen et al., 2020).

Figure 1. Discounted diagram of positioning time and traffic impact

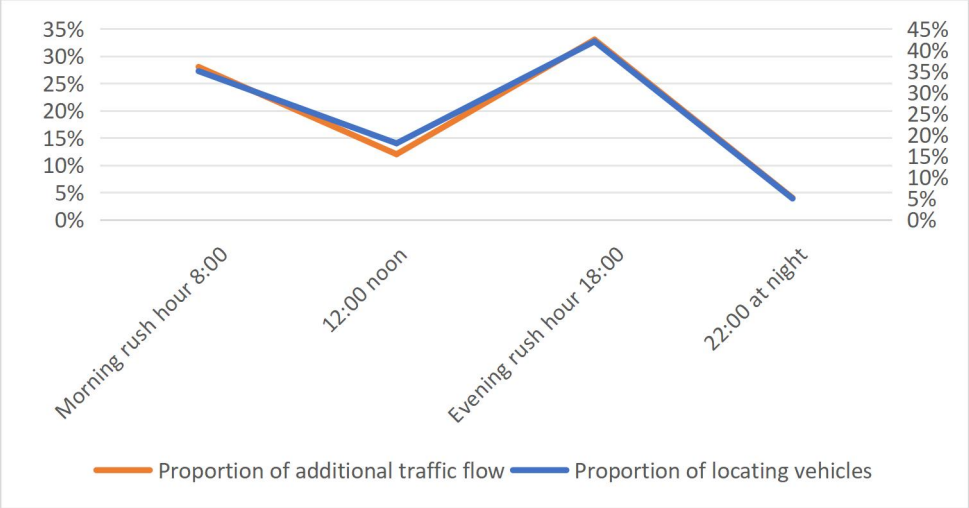
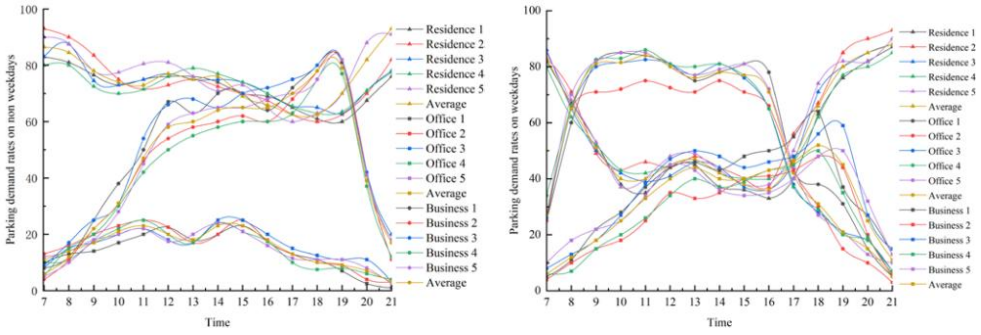


Figure 2. Scatter plot of parking demand on weekdays and non working days



As shown in the figure, the parking demand rate of residential, office and commercial land varies greatly between working days and non working days, and the spatial and temporal

distribution is extremely uneven, which is likely to cause oversupply or oversupply in some areas.

2.2 Uneven spatial distribution exacerbates local congestion

The parking problem is a typical manifestation of spatial heterogeneity. For example, parking saturation occurs in bustling areas such as commercial districts, medical centers, or transportation hubs. However, due to existing planning conditions and high land prices, it is difficult to increase parking facilities, resulting in the problem of central collapse. For example, during peak hours, the proportion of parking spaces occupied by San Francisco's financial district exceeds 95%, while some nearby residential areas have up to 40% of available parking spaces during the day(Zhang et al., 2025). On the other hand, this structural contradiction between supply and demand will also affect the rationalization of resource allocation, leading to potential safety hazards such as parking occupying non parking spaces and blocking fire passages.

Figure 3. Parking Purpose Pie Chart

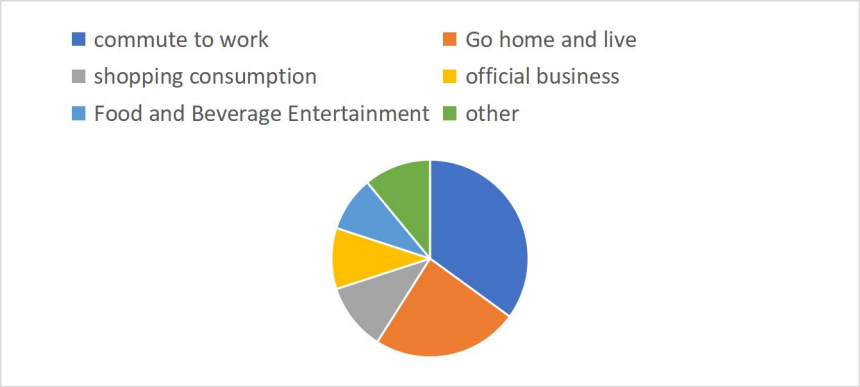


Figure 4. Bar chart of parking duration

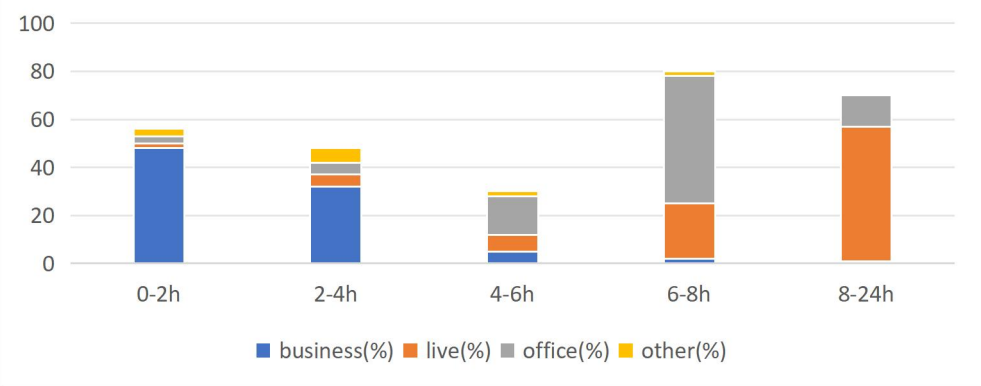
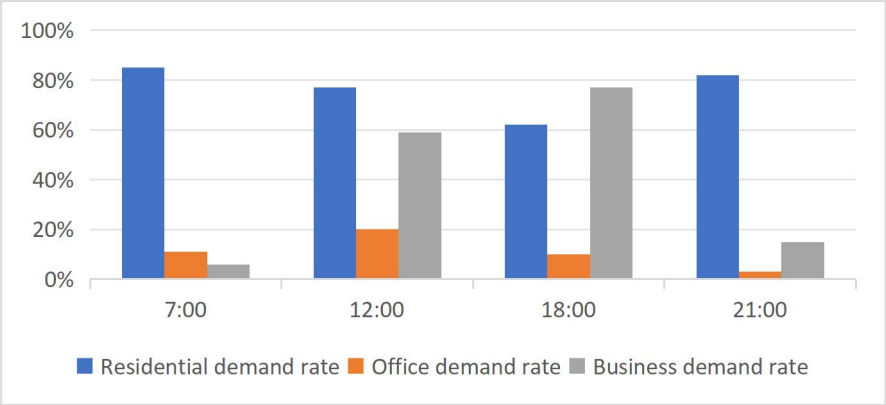


Figure 5. Bar chart of tidal parking characteristics



From a temporal perspective, there are still obvious tidal characteristics in parking demand: during peak hours in the morning and evening, there are difficulties in parking in densely populated office areas, and a large number of vacant parking spaces in residential areas; The situation at night is exactly the opposite. The large spatial and temporal distribution differences lead to inefficient resource utilization, for example, the daytime parking demand in Lujiazui Financial District is much greater than the nighttime parking demand (the daytime demand is more than three times that of the nighttime), and current management methods cannot achieve efficient allocation of spatiotemporal resources.

2.3 Insufficient application of technology limits management efficiency

Although intelligent parking technology (such as sensors, APP guidance, etc.) has gradually become popular, its application depth and breadth are not sufficient, and most urban parking data is relatively fragmented, making it difficult to update and achieve interactive sharing in real time. Research has shown that only 30% of public parking lots in London can upload status information of vehicle parking spaces, and current drivers spend an average of 5-8 minutes searching for parking spaces(Jelen et al., 2021). Traditional parking meters and manual management methods are unable to make reasonable adjustments to the use of management resources in response to changes in actual traffic volume, and there are regional differences in the application of technology. Beijing, Shanghai, Guangzhou, and Shenzhen, which are first tier cities, have all started deploying intelligent parking systems on a large scale, but most of the parking management in third - and fourth tier cities still adopts manual management methods. There may also be differences in the application of technology within the same city. The central urban area or some bustling areas of the same city may have all implemented intelligent management, but in suburban or urban-rural areas, the original manual toll collection method is still used for parking. This technological gap greatly limits the overall management efficiency of parking. In the research in Xi'an, although billions of traffic speed data were obtained using Baidu Maps API, the linkage between parking data and dynamic road network was low, resulting in the model only covering about 51 residential areas. This is a typical technical integration dilemma that limits the effectiveness of global control(Shen et al., 2020).

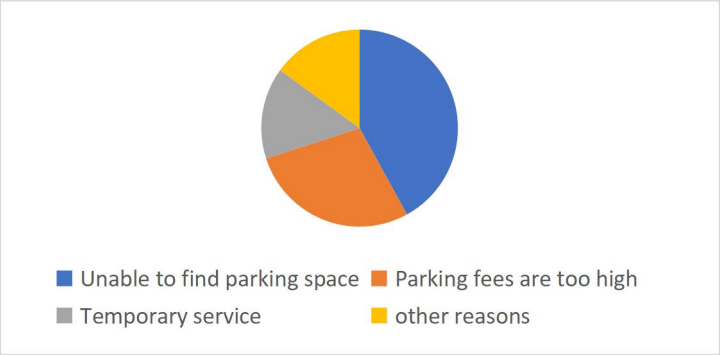
3. Analysis of the spatial governance dilemma of urban parking difficulties

3.1 System level: fragmented management and unclear rights and responsibilities

3.1.1 Multi head management leads to coordination failure

Parking management is the responsibility of multiple departments including transportation, planning, and urban management, but lacks a unified coordination mechanism. For example, in Wuhan, on road parking belongs to the Traffic Management Bureau, while off road parking lots are mostly owned by different enterprises. Different areas within the same area may be governed by their own rules and regulations(Kirschner & Lanzendorf, 2020). This fragmented system is determined by traditional departmental division of labor: the planning department makes design plans, the construction department builds facilities, the transportation department operates facilities, the pricing department sets prices, and fragmented subcontracting leads to a lack of coordination and continuity in policies. Each department develops for its own benefit maximization, and it is difficult to get the optimal results. It must be coordinated by the highest level to achieve the integration of "planning, construction, and management".

Figure 6. Analysis pie chart of reasons for illegal parking violations



3.1.2 Laws and regulations lag behind practical needs

Many cities' parking management regulations are based on the planning and design formulated in the last century, without taking into account the growth of motor vehicles and spatial limitations. The existing parking standards in Beijing do not differentiate by jurisdiction, with more in the central area and fewer in the surrounding areas(Yan-ling et al., 2016). Moreover, some places strictly regulate illegal parking, while others have only the rule of law but no law enforcement personnel, resulting in blind spots in law enforcement; In addition, legislation lacks foresight and there is a gap in the lack of regulation for new business models. Currently, there is no legal protection for the promotion of innovative models such as shared parking and staggered parking; At the same time, the construction standards failed to make flexible arrangements based on regional needs and spatial constraints, resulting in oversupply and supply shortage in some areas.

3.2 Policy level: Short term orientation and single tool

3.2.1 Supply oriented policies exacerbate spatial contradictions

The traditional policy is often to increase the supply of parking to increase the opportunities for car supply. In cities with very tight land use, on the contrary, the more parking

spaces are built, the worse the situation will be. For example, the construction of parking lots in the central area of Melbourne has the effect of attracting more cars, resulting in a vicious cycle of building more and more cars(Campisi et al., 2022).Moreover, the policy also completely ignores the negative impact of public transport, because the construction of too many parking facilities is essentially an implicit subsidy for car travel, which leads to the decline of the competitiveness of public transport; The large number of parking lots built next to the rail stations, although convenient for P+R conversion, will also increase the pressure on the roads. Therefore, it is necessary to correct and reflect on the current practice of adopting supply oriented policies.

3.2.2 The price mechanism fails to reflect the true cost

At present, parking fees are generally low and cannot reflect the opportunity cost of land and environmental externalities. The average rate of on road parking in New York City is only one-third of that of off road parking lots. Low on-road parking fees will also reduce vehicle turnover(Shoup, 2006). Free parking is essentially a disguised charge for motor vehicle use, which deviates from the concept of bus priority. The pricing mechanism is not differentiated: most cities have a single charging standard that does not differentiate between regions, time periods, or vehicle types, and does not play a role in guiding the temporal and spatial distribution of demand. Further improvement of differentiated charging is urgently needed.

3.2.3 Insufficient implementation of bus priority policy

Since the public transport priority strategy in most cities has not been implemented in place, the parking supply has been increased without effectively reducing the parking demand for private cars. Among them, Shenzhen is the most typical, with an increase of about 20% in parking supply around many subway stations (nearly 20% more than other towns), which clearly violates the development concept of TOD(Biyik et al., 2021). Therefore, the phenomenon of gradual loss of public transport passenger flow due to the lack of good transfer methods and facilities after getting off the bus has formed, making more citizens use private cars for travel. In addition, the issue of shuttle travel within the last 1km has not been given enough attention. The roads for cycling and walking have not been repaired, properly managed, and bicycles are placed haphazardly and cannot be parked near the station, making it difficult for the public to accept the practice of discounted bus fares and increasing the number of passengers getting on and off at this station.

3.3 Capital level: insufficient investment and single financing channel

3.3.1 Public investment tends to favor hardware facilities

Urban transportation investment mainly focuses on road network construction ("hard"), while parking management, as a "soft" link, has insufficient investment. The parking management funds in major Chinese cities are insufficient to cover 5% of the total transportation investment, and the lack of funds for updating and upgrading intelligent facilities has led to a lag in the update of intelligent devices(Ma et al., 2024). Meanwhile, due to the lack of stable special funding channels and even maintenance funds, the problem of outdated facilities is severe. In addition, the main investment target of urban transportation construction is

construction rather than operation. At present, many cities have built parking lots with a large amount of funds, but there is no post operation and maintenance fund guarantee, "it can not afford to be built", and the utilization rate is very low. This investment model should be changed.

3.3.2 The market-oriented financing mechanism is not sound

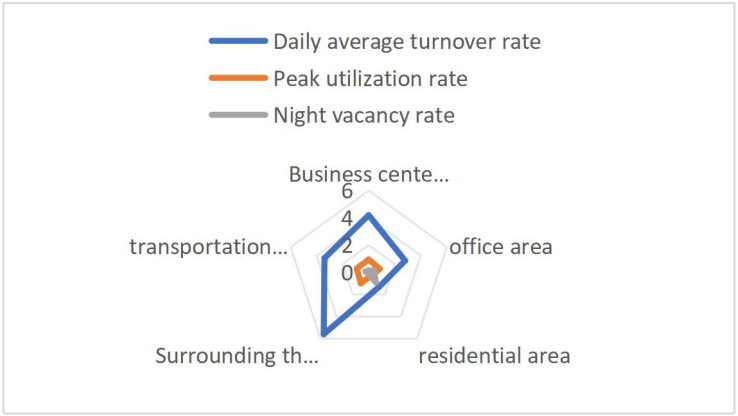
The construction of parking projects has a long investment cycle, high investment risks, weak willingness for social capital participation, and limited use of PPP models. For example, the first smart parking lot PPP project in Wuhan was halted midway due to difficulties in determining expected returns(Baran et al., 2021). Lack of policy support for financial innovations such as asset securitization has limited financing channels; The financing channels still rely too much on government investment, resulting in excessive financial burden and difficulty in sustainable operation. In the future, we should explore a mechanism that combines multiple measures such as user payment, commercial support feedback, and land appreciation feedback, establish a multi-channel guarantee mode guided by the government, break through the limitations of the single fee model, and use value-added services such as advertising and charging to overcome the shortcomings of insufficient single fees.

3.4 Resource level: spatial constraints and land competition

3.4.1 Difficulties in spatial renewal of historical urban areas

Due to the high building density and narrow roads in the old city area within the historical protection zone, there is already physical space that cannot be expanded. For example, in the center of Paris, currently available land prices exceed 10000 euros per square meter, and new parking lots lack economic viability(Campisi et al., 2022). At the same time, in order to meet the requirements of cultural preservation, further excavation is not allowed. In addition, when considering underground, there will inevitably be some current constraints: firstly, there are many and complex underground pipelines; Secondly, there are a large number of cultural relics and sites distributed, and construction will disturb the people and increase social costs, which cannot be planned and designed according to conventional new district projects.

Figure 7. Radar chart of parking space utilization in different areas

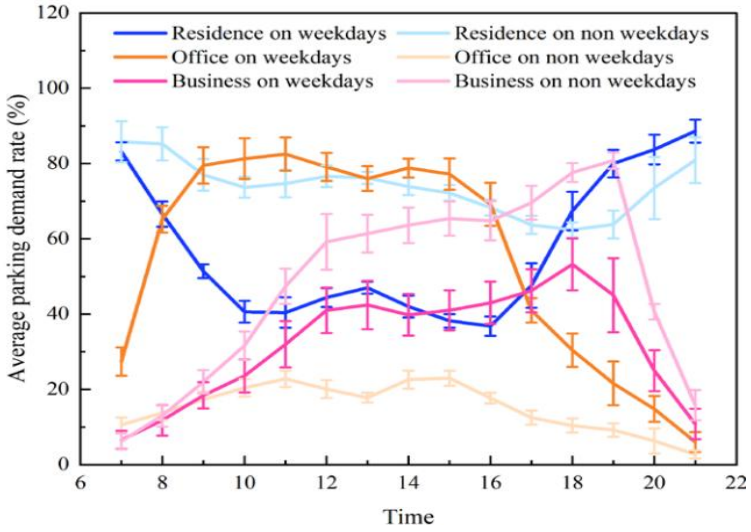


3.4.2 Priority misalignment in land competition

The shortage of land resources makes the competition between parking facilities, housing and greening more fierce. Giving priority to the development of Commerce in high-quality urban plots has led to the parking lot being far away from densely populated areas and falling into geographical corners, which has exacerbated the difficulty of parking. Secondly, it is reflected in the mismatch of priority order - discrimination in land use nature: parking lots belong to the category of "transportation facility land", and the land transfer and construction fees are higher than those of commercial and residential land. Parking lots face the problem of being unable to be built in new construction, and should be included in the scope of urban infrastructure and supported by preferential policies.

According to the survey, there are significant differences in the spatial tense of parking demand in various functional areas of the Wuhan subway complex: the nighttime demand rate in residential areas is greater than 85% on weekdays, while the daytime demand rate in office areas is less than 20%~30%. Due to the inability to match and utilize resources reasonably, the utilization rate is relatively low(Feng et al., 2024).

Figure 8. Line chart of parking demand in different functional areas



For example, the complementary timing of parking demands for different types of land as shown in the above figure, but currently lacks a unified and effective linkage management mechanism.

3.5 Technical aspect: Data silos and insufficient integration

3.5.1 Fragmentation of intelligent technology applications

Based on the current situation, although advanced technologies such as the Internet of things and big data are used, due to the non interoperability of various systems, the phenomenon of "data island" appears. For example, different parking lot management systems in San Francisco use different data standards, making it impossible to achieve global parking space sharing(Arora et al., 2019). In addition, the upgrading of some technologies and facilities will increase large expenditures, and it is more difficult for small and medium-sized cities with

relatively backward economy to invest funds. Therefore, the main reason for the "data island" is the inconsistency of technical standards. Different manufacturers use different communication protocols and data formats for their equipment, and governments, enterprises, and navigation platforms all build their own data exchange standards. There is no unified data exchange standard, causing data to be divided and utilized, thus affecting the optimal allocation of parking resources. It is urgent to introduce national standards and unify data platforms.

3.5.2 Traditional planning methods lag behind

At present, parking planning is mostly based on static demand, without combining dynamic traffic behavior with land use. The research results indicate that traditional models have a prediction error of 30% -40%, which cannot reflect the real situation well(Xiao et al., 2021). At the same time, there is no effective guidance for the development direction of new models such as shared parking and flexible parking. At the same time, the planning method ignores the new changes in traffic, that is, some new traffic modes such as network car hailing, bicycle sharing and automatic driving are relatively easy to bring about some changes in travel. However, there are few considerations about this phenomenon. For example, automatic driving is still in the initial stage of development and may have a disruptive impact in the next decade. This aspect has not been reflected in the existing theory.

4.Sustainable solutions for urban parking difficulties

4.1 Institutional Innovation: Building a Collaborative Governance System

4.1.1 Establish a specialized agency for parking management

Suggest establishing an interdepartmental parking management committee to coordinate the organization, construction, and operation; Following the example of Transport for London (TfL), establish a Parking Strategy Department to organize and formulate policies on parking fees, enforcement, and sharing, driving a 25% increase in parking turnover in the city center(Kirschner & Lanzendorf, 2020), can be used for learning. To establish an authoritative organizational structure that can coordinate the interests of different departments such as planning, construction, and transportation, and connect all parties together; Scientific decision-making should be conducted through expert consultation and public participation to avoid situations of multiple management and lack of accountability.

4.1.2 Improve the legal and regulatory system

Reform and improve parking standards, implement differentiated management by region, such as implementing upper limit parking restrictions in the central area of Singapore, while providing appropriate protection in peripheral areas(Fahim et al., 2021). Improve the standards for illegal parking enforcement and adopt electronic police 24-hour full coverage law enforcement; Pay attention to planning ahead for the legislative construction of traffic regulations, and gradually fill in the gaps in local small passenger car restrictions, policies and measures for the use of new energy vehicles, etc. in practice; Promote the improvement of laws and regulations, accelerate the exploration of relevant new business regulatory supporting system construction, promote off-site law enforcement methods, improve dispute resolution and

complaint reporting mechanisms, ensure the implementation and effectiveness of the system, and earnestly safeguard the legitimate rights and interests of the people.

4.2 Policy Optimization: Demand Management and Economic Leverage

4.2.1 Implement performance-based pricing and congestion pricing

Dynamically floating rates based on real-time occupancy rates to improve resource utilization efficiency; The SFpark project will control the occupancy rate of designated areas in real-time at around 60% -80%(Shoup, 2006), combining congestion pricing (such as the London congestion fee zone) can further regulate the traffic flow in each district. According to the differences among the four, different regions are distinguished and different price standards are adopted, namely zoning, time-sharing, and vehicle model price differences. The key is that prices in the city center are higher than those in the suburbs, peak hours are higher than off peak periods, and large vehicle prices are higher than small vehicle prices. Reasonable dynamic price adjustment and price hearing procedures are also set up.

4.2.2 Strengthen the integrated development of public transportation

Parking management must be closely integrated with TOD. Tokyo requires strict control of parking supply within 1 kilometer of rail stations, and by improving the quality of bus services, the travel rate of rail transit has reached 60%(Campisi et al., 2022). Simultaneously launching the "parking+transfer" (P+R) mode to control the inflow of peripheral vehicles into the city; To further improve the establishment of the connecting system, including improving pedestrian and bicycle transportation facilities, and enhancing the convenience and accessibility of the slow traffic system; construct the microcirculation system of public transport; Introduce new modes of transportation such as shared bicycles to achieve seamless connection; Strictly control the parking supply around the station; Appropriately control the number and scale of buses, and improve the attractiveness by shortening the departure interval and prolonging the operation time.

4.2.3 Promote sharing and flexible parking

The parking spaces of organizational agencies, enterprises, institutions, and commercial facilities are shared at different times. Seoul increases parking space utilization by 40% through shared platforms, reducing rigid demand(Jelen et al., 2021)). Develop the way of using the school playground as a temporary parking space at night to revitalize idle resources. Shared parking requires breaking down the institutional barriers behind it: clarifying legal definitions and responsibilities, establishing a mechanism for distributing benefits, developing more convenient shared parking platforms, allowing government departments such as public security, procuratorate, and judiciary to take the lead in setting a model for shared parking, strengthening supervision to prevent unit style leasing, creating new profit points, and lowering parking barriers.

4.3 Financial Security: Innovative Financing and Benefit Sharing

4.3.1 Establish parking improvement zones and special funds

Define the parking improvement zone, charge parking vehicles, and use the collected funds specifically for local parking facility management and updates, as well as public transportation subsidies (which exist in cities such as New York and Los Angeles in the United States)(Baran et al., 2021). The source of funds can also be established by residents who contribute a certain proportion to establish a fund, which is determined by the community on how to allocate funds, and the funds are mainly used for local needs. Policies should reflect fairness, cost levels should be carefully considered to avoid increasing the burden on residents, income and expenditure should be made public and subject to social supervision, project selection should seek residents' opinions, priority should be given to solving issues of concern to the public, and a mechanism for residents to participate in decision-making should be established by drawing on the experience of community planning.

4.3.2 Expand market-oriented financing channels

Promote parking asset securitization, REITs and other tools to attract social capital. Chicago parking lot securitization project raises up to $300 million in financing, effectively easing government pressure(Biyik et al., 2021). Develop supporting commercial facilities around parking facilities to achieve complementary parking through commercial means. Due to the involvement of many factors and instability in market-oriented financing, it is necessary to control risks while carrying out market-oriented financing, establish a scientific and reasonable income evaluation system, and strictly prohibit excessive packaging; Establish a sound regulatory system to ensure that investors' rights and interests are not harmed; To establish reasonable risk prevention and risk mitigation measures to prevent systemic risks from occurring; We cannot provide a fixed rate of return that is too high, and we must adopt a method of sharing benefits and risks.

4.4 Resource optimization: spatial integration and efficient utilization

4.4.1 Develop three-dimensional and underground parking

Maximize the use of vertical space for development and promote the use of mechanical three-dimensional garages. The proportion of three-dimensional parking lots in the central area of Tokyo has reached 35%, and the land utilization rate has increased threefold(Zhang et al., 2025). Developing urban underground spaces in an orderly manner in conjunction with urban renewal, such as Helsinki having a well-established underground parking network connecting major buildings in older areas; Three dimensional parking should be done well: the size of the parking space, lighting and ventilation, and easy access should be ensured. The mechanical garage should be of good quality, reliable, and have a maintenance system in place; Underground parking garages should take measures such as flood control and drainage, strengthen safety facilities, and increase the comfort of parking users through careful and detailed design.

4.4.2 Promote mixed use of land

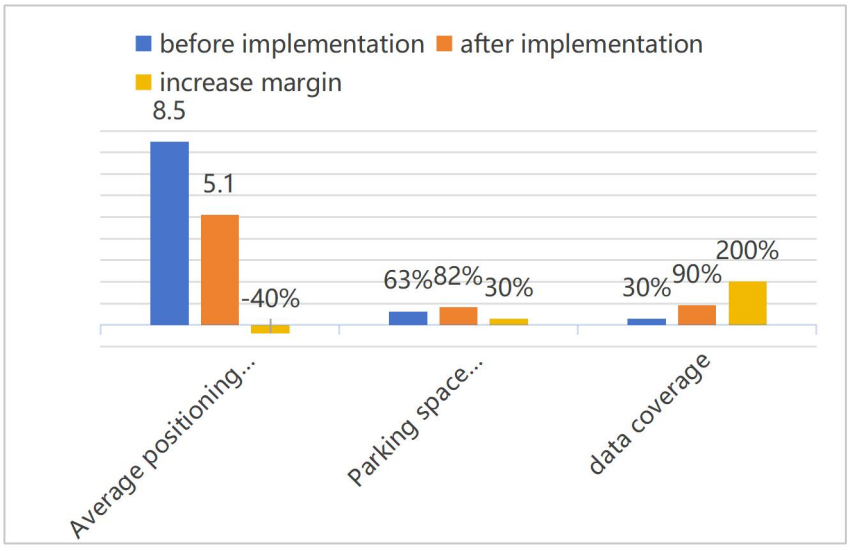
By planning to promote the integration of parking with commercial, residential, and other functions, and drawing inspiration from Singapore's "parking community center" model, the parking lot, vegetable market, and community service center will be integrated, with a focus on fully leveraging their functional value for composite land(Fahim et al., 2021). Pay attention to functional coordination, avoid mutual interference, coordinate the parking needs of commercial (short-term, efficient), office (long-term, stable), and residential (nighttime security), improve the ownership and revenue distribution of co built facilities, and effectively alleviate the problem of parking difficulties.

4.5 Technology Empowerment: Intelligent Systems and Data Driven

4.5.1 Build city level parking platforms

Integrate all parking resources in the jurisdiction to create an online real-time platform for querying, booking, and payment. In 2019, over 90% of Barcelona's parking resources were connected, reducing the average time for drivers to find parking spaces by 40%(Xiao et al., 2021). Encourage innovative applications by opening APIs to third-party applications. The platform needs to consider the user experience: simple interface, convenient operation, multiple payments, ensuring the stability of the platform during peak hours, data security, privacy protection, and reserved function upgrade interface.

Figure 9. Bar chart of implementation effect of intelligent system



4.5.2 Application prediction and scheduling algorithms

Predict parking space based on historical data and real-time information, and use intelligent guidance. By applying machine learning models in Los Angeles and translating assumptions into actual situations, the accuracy of the model can reach 85%, achieving the goal of regulating traffic flow distribution(Arora et al., 2019). Use the Internet of vehicles to realize vehicle parking coordination. Consider from two aspects of prediction and scheduling: the prediction model considers accuracy and timeliness, and the scheduling algorithm needs to consider conditions such as distance, price and duration, and add a feedback mechanism to optimize the

algorithm, ensure the fairness of the algorithm itself, and eliminate systematic discrimination factors.

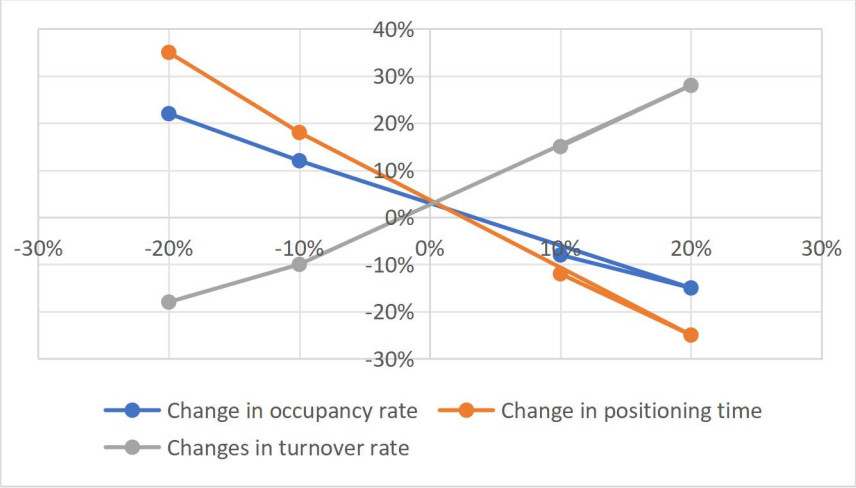
5.Conclusion and Suggestions

Urban "parking difficulty" is a problem caused by factors such as spatial resource mismatch, policy failure and technical service lag in the process of urbanization. It is necessary to coordinate among different departments to formulate an overall solution to the parking problem on the basis of system, policy, capital, resources and technical experience. Based on relevant international practices, this paper puts forward several specific measures:

5.1 Strengthen top-level design and improve the collaborative governance system

It is recommended to establish a city level parking management special agency, which will be responsible for the planning, construction, and operation management of parking facilities, breaking the previous situation of departments acting independently; Accelerate the improvement of relevant laws, regulations, policies, and systems to provide strong institutional guarantees for promoting innovation; Drawing on the successful experience of international metropolises, establish a city parking management office directly led by the municipal government, and assign cross departmental coordination responsibilities to the parking management office; Accelerate the legislative work on parking, clarify and regulate the rights and obligations of various entities.

Figure 10. Scatter plot of price adjustment effect



5.2 Innovate policy tools and highlight demand management

Implement economic measures such as performance-based pricing and congestion pricing, and strengthen TOD oriented parking supply regulation. Improve the efficiency of existing resources through sharing and elastic modes. Price policies need to be more refined, and a differentiated charging system based on zoning, timing, and vehicle types should be established. Supply management should be more targeted, with strict restrictions in the central area and moderate guarantees in the peripheral areas. The most important thing is to strengthen demand

management and fundamentally reduce parking demand by improving public transport and improving the slow traffic environment.

5.3 Improve and expand financing channels and activate market forces

On the basis of establishing a parking improvement fund, explore diversified financing methods such as asset securitization, encourage public-private partnerships to reduce government financial pressure, introduce social capital through franchising, pledge of income rights, and other means, while doing a good job in preventing financial risks and excessive leverage; Provide financial subsidies for basic parking needs based on the special attributes of old urban areas and shantytown redevelopment areas.

5.4 Optimize the allocation of space resources and develop intensive facilities

Prioritize the use of three-dimensional and underground solutions. Promote mixed use of land and enhance spatial composite benefits. In the construction of new urban areas, it is necessary to plan parking facilities in a forward-looking manner and leave sufficient space for development. In the old urban area, we should tap the potential through urban renewal and add parking spaces at every turn. Special attention should be paid to the coordination between parking facilities and urban design to avoid damage to the urban landscape.

5.5 Build intelligent parking lots with the help of technical advantages and build a city level parking cloud platform

Intensively integrate parking resource data, and use AI and big data means for intelligent prediction, allocation and scheduling. Accelerate the development and use of data standards and specifications, and accelerate the elimination of barriers and obstacles between various systems. Make good use of new technologies to overcome the problems caused by the digital divide. Technology research and development has always been from the perspective of users, aiming at the problem of difficult parking to make technological progress and innovation.

Based on the current research status and development trend, future research work should focus on the impact of new forms such as autonomous driving and sharing economy on parking systems, as well as the existence of different governance methods according to different city sizes and development stages. It is also necessary to strengthen the analysis of the future under the influence of emerging technologies, such as autonomous driving greatly reducing the demand for parking, shared cars possibly changing parking modes, etc. On the basis of carrying out multi-faceted innovation and full chain promotion, we should create highlights of urban parking services, solve the crisis of urban parking "management", promote the construction of humanistic urban transportation, and help achieve a beautiful and livable park city.

AUTHOR CONTRIBUTIONS

Peng Yang: Data collection; investigation; data curation; preliminary analysis； Gong Jun: Conceptualization; research design; methodology; supervision; project administration; writing – review & editing； Zhuofu Zhou: Formal analysis; statistical analysis; validation; visualization; writing – original draft.

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CONFLICT OF INTEREST STATEMENT

The authors declare that there are no commercial or financial relationships that could be construed as a potential conflict of interest.

DATA AVAILABILITY STATEMENT

The data generated and analyzed in this study are available from the corresponding author upon reasonable request. All data will be provided without undue restriction.

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