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Research on Strategies to Address Urban Parking Issues in China

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Abstract

In the process of urbanization in China, the scarcity of land resources has led to an increasingly prominent contradiction between the growth of automobile stocks and parking space availability. The escalating number of private vehicles has become a significant contributor to traffic congestion. This paper aims to delve into the issue of urban parking difficulties and explore associated management strategies. Firstly, through a literature analysis approach, a comprehensive examination of domestic and international parking problems is conducted, revealing a severe situation in China that necessitates the formulation of pertinent strategies. Secondly, case studies on different regions are undertaken from the perspectives of current parking situations and management countermeasures, providing valuable insights and references for addressing China's parking challenges. In response to urban parking difficulties, this paper proposes two strategies: first, "source expansion" by increasing the supply of parking spaces, and second, "streamlining" by restricting private vehicle access. To address parking challenges, strategies such as constructing landscape eco-parking lots, intelligent multi-level garages, developing smart parking systems, and implementing tidal parking are suggested. Additionally, shared parking is considered an effective method to reduce the number of privately owned vehicles in urban areas. Furthermore, resolving urban parking issues should prioritize social benefits, advocate environmentally friendly transportation, and encourage more residents to enjoy higher-quality urban travel experiences.

Keywords

Private vehicles; Sharing; Eco-friendly parking; Multi-level garage; Tidal parking; Public transportation.

1. Introduction

In recent years, with sustained economic growth and rising per capita income, the rapid increase in the number of private cars in China has become a significant contributor to traffic congestion. Statistics indicate that the total number of motor vehicles in China has exceeded 400 million, while the supply of parking spaces is notably insufficient. In first-tier cities, the ratio of cars to parking spaces is approximately 1:0.8, and in other cities, it is around 1:0.5, significantly below the international standard of 1:1.3[2]. Insufficient consideration for long-term parking space planning during the initial stages of urban development has rendered existing city planning and design standards inadequate to meet current parking demands[3]. The imbalance between parking supply and demand is particularly acute in the central areas of first and second-tier cities[4], causing significant inconvenience for citizens' travel, negatively impacting urban environments, and hindering socio-economic development. The issue of parking difficulties has become a pressing challenge in current urban development[5].

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To address urban parking challenges, this paper conducts in-depth research on relevant domestic data, analyzing factors such as population, car ownership, parking lot quantity, and policies to uncover the root causes of parking difficulties. Through the use of diverse data sources, a scientific demonstration is provided. Addressing management challenges, practical solutions are proposed, focusing on policy, management, and resource distribution issues. Drawing insights from successful cases both domestically and internationally, the paper explores advanced urban parking management models to enhance management levels and efficiency. Innovative and feasible solutions are put forth, encompassing policies, technology, operational models, etc. Specific measures include strengthening management norms, optimizing policies and services, constructing smart parking lots, and establishing intelligent parking guidance systems[6], aiming to increase supply, enhance utilization rates, and improve management efficiency, thereby alleviating urban parking challenges.2. Analysis of Basic Research Characteristics

1.1. Domestic and International Status

According to the "China Urban Traffic Development Report" data for the year 2021, the top five cities in China with the highest traffic congestion are Beijing, Guangzhou, Shenzhen, Shanghai, and Chengdu. Beijing has the highest congestion index, reaching 2.89. Additionally, based on data from the National Bureau of Statistics and the Ministry of Public Security, as of the end of March 2023, the total number of motor vehicles in the country has reached 420 million, with 320 million being automobiles. With over 34 million new registered motor vehicles annually, China leads the world in both total and incremental numbers. Private cars constitute over 80%, yet there is still a demand gap of over 80 million parking spaces in China (Data source: Beijing News Data Center, Date: April 7, 2023). As seen in Figure 1, the growth rate of motor vehicle ownership in China far exceeds the pace of parking facility construction, resulting in a severe imbalance between supply and demand for parking spaces. Even in conditions with sufficient parking spaces, as shown in Figure 2, unclear entrances to parking lots force drivers to search for spots at low speeds on roads, not only increasing parking difficulty but also exacerbating road congestion, leading to low parking space utilization efficiency. Data indicates that Wuhan and Chengdu have the lowest parking space utilization efficiency at only 35%, while even the highest, Shenzhen, is at 55%, highlighting the issue of parking difficulties. There is considerable room for improvement in increasing the utilization rate of idle parking spaces. In 2017, the total investment in national parking Public-Private Partnership (PPP) projects reached a staggering 98.8 billion, with 174 projects (Data source: 2021 Parking Industry Development White Paper). To alleviate parking difficulties, governments in cities like Beijing and Shanghai have implemented policies such as "parking space auction listing" and the introduction of "parking space electronic maps"[7], aiming to promote fair utilization of parking resources and enhance their efficiency.

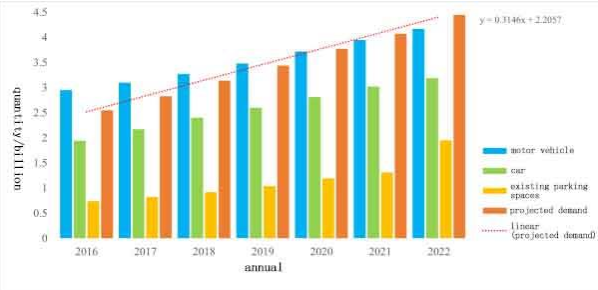

Figure 1: Trends in Motor Vehicle and Private Car Ownership, Parking Spaces, and Demand (Data Source: National Bureau of Statistics)

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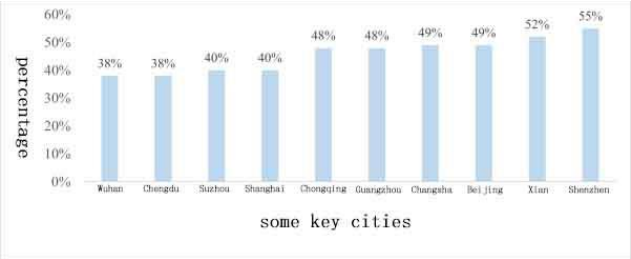

Figure 2: Parking Space Utilization Efficiency in Selected Cities
(Data Source: ETCP Smart Parking Industry Research Institute)

Due to lower population density in foreign countries, parking issues are less severe than in China, yet overseas developments in the parking sector are not lagging behind. In the United States, New York employs a shared parking model to increase parking resources, though it comes with significant management challenges. Japan implements a policy where car owners must provide their own parking spaces, constructing off-road parking lots, enacting laws, and attracting private investment to address parking problems, enhance efficiency, alleviate congestion, and create a favorable environment. Berlin, Germany, establishes an intelligent parking guidance system to improve parking space utilization efficiency[8], relying on robust information computing systems. Singapore integrates parking facility construction with urban traffic control, increasing parking costs to regulate private car usage.

This demonstrates that parking issues are prevalent globally, and various governments are taking measures to address them. China faces a particularly challenging situation in this regard. From a governmental perspective, resolving urban parking issues contributes to saving urban land, enhancing environmental efficiency, and achieving positive governance outcomes. From a citizen's standpoint, solving parking problems saves time and improves overall happiness[9].

1.2. Analysis of Publication Volume

This study utilized the CNKI and Web of Science databases to retrieve a substantial number of literature on topics such as "parking," "parking space," "Parking space," and "Parking spot." Through data processing and charting, we analyzed the annual publication volume to assess the development status and future trends in this field. The keyword highlighting diagram aided in a comprehensive understanding of research hotspots and directions.

The research findings indicate a continuous growth in the popularity of parking-related studies from 2000 to 2022, segmented into three developmental stages (Figure 3, Figure 4). In the initial development stage (2000-2006 domestically and 2000-2008 internationally), domestic studies lagged behind due to higher population density, making parking issues more impactful on people's lives. In the stable development stage (2007-2014 domestically and 2009-2016 internationally), spanning eight years, research intensity substantially increased, with 1317 domestic publications and 1644 international publications. In the significant growth stage (2015-2022), domestic publications rose to 2816 (twice the previous stage), while international publications reached 2249 (1.37 times the previous stage). The impact of parking issues on daily life has escalated with economic development. From the stage development and data perspective, domestic parking issues have become more severe than international ones in recent years, especially against the backdrop of rapid increases in car ownership, parking space supply, and demand (Figure 1). This has exacerbated the severity of parking problems, negatively impacting people's daily lives and well-being, while also increasing the management challenges for regulatory authorities. The keyword highlighting diagram from the CNKI database (Figure 5) reveals "shared parking" as a prominent and enduring research topic. Additionally, "route planning[10]" and "smart parking[11]" have gained significant attention as research directions, trailing only behind "shared parking" in terms of research intensity. This

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suggests that, with technological advancements and interdisciplinary integration, research on parking issues is gradually deepening, seeking more innovative solutions

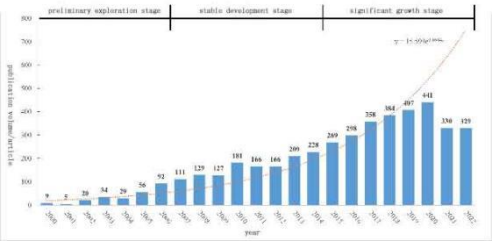

Figure 3: Annual Distribution of CNKI Literature

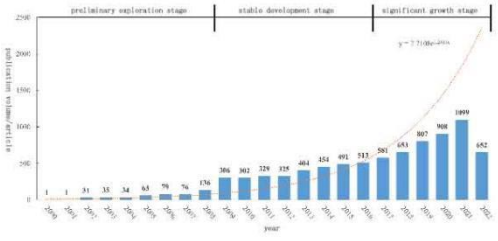

Figure 4: Annual Distribution of WOS Literature

Figure 5: Keyword Highlighting Diagram

2. Strategies

Parking issues are an inevitable urban challenge as societies progress. In China, there is a contradiction between urban development and the increasing number of motor vehicles, making it impractical to infinitely expand parking spaces. The essence of parking problems lies in resource allocation, and urban environments have their carrying capacity. Solving parking issues requires addressing the problem from both "source expansion" and "streamlining" perspectives: increasing the supply of parking spaces to alleviate parking tension and restricting private vehicle access to further ease urban parking pressure. The main strategies include:

2.1. Establish Parking Lots and Construct Intelligent Multi-Level Garages

There must be suitable parking spaces within urban areas. Drawing inspiration from foreign development strategies, the adoption of mechanical multi-level parking garages proves beneficial. This approach not only helps alleviate parking difficulties but also mitigates the pressure of overcapacity in China's steel industry while expanding employment opportunities in related sectors. Currently, China's multi-level parking garage industry is rapidly advancing, with mature and diverse technologies and products applicable across various scenarios. Multi-level garages, with comprehensive planning, offer an effective solution to parking problems, with significantly lower parking costs compared to surface parking lots. Existing mechanical garages[12] can incorporate elevators and lateral movement, suitable for large parking lots in high-end residential areas, office buildings, hospitals, malls, and other public spaces, providing an efficient parking solution.

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In addressing urban parking issues, a balance between economic and social benefits is essential. Older neighborhoods can enhance parking capacity by transforming underutilized corners or idle public buildings into multi-level garages, thus increasing the number of parking spaces[13]. Additionally, offering recreational spaces maximizes urban areas, enhancing regional development quality. However, investments in parking facilities should not overshadow future urban development needs. Only through a combination of various strategies, including parking facility construction and demand management, can we ensure the city's sustainable development

2.2. Develop Smart Parking Systems for Urban Intelligent Shared Parking

Smart parking technology effectively reduces traffic congestion, inefficient traffic flow, and shortens the time spent searching for parking spaces. According to data from Tsinghua Tongheng Planning Institute's Institute of Static Traffic Planning and Design, implementing smart parking can reduce traffic congestion by 30%, inefficient traffic flow by 15%, and shorten the time spent searching for parking spaces by 6-14 minutes[14]. Shared parking, through characteristics of parking at different times, facilitates the sharing of parking spaces between different lots, effectively alleviating conflicts in parking time and space. For example, vacant spaces in business districts during the evening can be shared at a lower cost with nearby residents or shopping centers, and residential parking areas can be shared with nearby commuters during working hours. The availability of parking spaces varies across different city zones, and technologies such as smart parking and shared parking can efficiently utilize these resources, reducing waste.

Currently, major cities are exploring public parking strategies. Cities like Nanjing, Beijing, and Wuhan are employing strategies involving compensated shared parking during off-peak hours to address parking issues, offering new insights into the development of smart parking systems. Through Global Positioning System (GPS) reservation of parking spaces, a shared parking model during off-peak hours is realized, maximizing the utilization of parking resources and optimizing parking services for vehicle owners. Establishing a unified smart parking information management platform integrates various technologies for comprehensive management and services related to city parking information. This platform facilitates real-time updates, inquiries, reservations, and navigation services for parking spaces, enhancing the utilization rate of parking resources and profitability of parking services[15]. This approach aims to make parking more convenient and efficient, ultimately improving the overall parking experience for vehicle owners[16].

2.3. Introduce Tidal Parking and Establish Parking Standards

By utilizing idle and surplus spaces during specific time intervals, cities can maximize space utilization and development, bringing both economic and significant social benefits. During the trial period, it is essential to standardize roadside parking spaces, implement tidal parking by converting daytime spaces for alternative use and reserving them for parking at night. Implement a public parking lot fee system, setting charging models (unit prices, time intervals) based on specific urban conditions. Through pricing mechanisms, this helps prevent prolonged occupation of road parking spaces by vehicles and ensures that public parking resources remain available, revitalizing urban parking resources[17]. However, the most effective way to address urban parking issues is to improve the city's public transportation network

2.4. Integrate a Landscape and Ecological Perspective, Creating Ecological Parking Environments

Cities grapple with significant traffic congestion and severe pollution issues, including noise and light pollution. The contradiction between urban parking and the environment is becoming

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more pronounced. Establishing scenic parking lots can mitigate these pollution problems and enhance both aesthetic and ecological benefits.

To properly plan and regulate parking, the layout pattern of the parking lot needs attention. Select suitable locations based on site conditions and plan parking lot road flow schemes tailored to the topography. Arrange parking spaces in a rational manner (e.g., horizontal, vertical, and diagonal parking spaces), and design pedestrian pathways to ensure safe and comfortable exit from the parking lot. A standardized and reasonable parking lot layout is a prerequisite for creating a scenic environment.

Building on a well-planned layout, efficient and regulated scenic parking environments can be constructed through landscape enhancement (see Figure 6). The focus of green parking lots is on choosing suitable plant species and arrangements. Due to the poor environmental conditions of parking spaces, which accumulate chemicals from vehicle emissions, plant species with high tolerance, wind resistance, and strong adsorption capacity, such as Liaodong oak, Chinese scholar tree, Uyeki plum, and red-leaf photinia, are recommended. Simultaneously, plant morphology should be aesthetically pleasing, with low maintenance requirements, suitable crown width and branching points, and moderate growth rates. For herbaceous plants, corrosion-resistant, cold-resistant, and aesthetically pleasing varieties such as dogtooth grass, black oat grass, early-maturing grass, and kuding tea grass can be selected. In terms of plant configuration, a combination of trees, shrubs, and grasses can be employed for larger spaces to showcase the best scenic effects, while in smaller spaces, a row-by-row arrangement with interspersed shrubs can be utilized. Increasing the planting density of trees and shrubs along the edges enhances both the scenic effect and safety of the parking lot. Overall, attention should be given to the spacing of plant distribution to ensure proper ventilation.

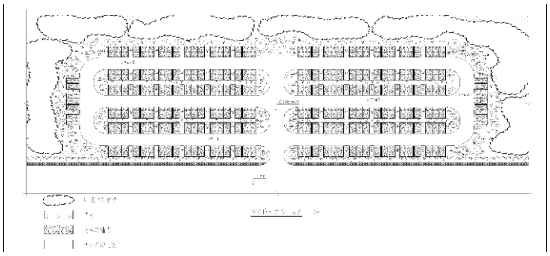

Figure 6: Ecological Parking Lot (Author's Illustration)

An ecological parking lot involves more than just the arrangement of plants; attention must also be given to other constituent elements of the parking lot. While maximizing greenery, it is crucial to consider the different ecological habits of selected plants to ensure their normal growth. In the design and construction phases of the parking lot, emphasis should be placed on energy conservation and environmental protection, promoting sustainable utilization of materials and resources, and leaving room for future development. Prioritizing rainwater collection and utilization, adopting a resource-oriented rainwater utilization pattern, and integrating rainwater collection with surrounding elements can enhance the flexibility and visual aesthetics of the parking lot. Drawing inspiration from the theory of sponge cities, respecting nature, and prioritizing ecology, the integration of green rainwater facilities with grey engineering facilities creates a resilient rainwater environment[18]. Utilizing various ecological facilities on buildings, roads, and green spaces establishes a novel rainwater regulation and reuse system, reflecting the comprehensive ecological benefits of rainwater. For instance, by constructing water-sensitive parking lots using permeable bricks or grass-embedded bricks, water is swiftly conveyed to the underground soil, reducing surface runoff and purifying rainwater, enhancing the ecological landscape of the parking lot, and providing a comfortable transportation experience for users simultaneously[19].

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2.5. Encourage Green Travel and Improve Urban Transport Network

To address urban traffic issues comprehensively, a multi-faceted approach is necessary. Firstly, promoting green travel and encouraging citizens to use public transportation are essential. Secondly, optimizing the urban transport network, enhancing transfer efficiency, and improving the quality of bus services and commuting experiences are crucial steps. At the same time, citizens should actively participate in the management and optimization of public transportation, collectively elevating the city's transportation service standards. Only through such efforts can we establish an efficient, convenient, comfortable, and sustainable urban transport system, providing citizens with a better travel experience.

To reduce the desire of urban residents to purchase private cars and consequently lower private car ownership, measures to curb private car usage need to be implemented. This includes restricting the number of car purchases, increasing the costs associated with buying and parking cars, among other strategies.

For example, strategies like Japan's approach of requiring individuals to secure a parking space before purchasing a car can elevate the threshold for vehicle ownership. Additionally, adopting tiered pricing to raise the cost of parking, strengthening penalties for illegal parking, and regulating parking behavior can effectively alleviate parking issues. These measures aim to encourage more participants in the transportation system to use public transit, reduce the number of vehicles, and ultimately address urban parking problems at their root

3. Conclusion and Discussion

Addressing parking issues requires a comprehensive consideration of multiple aspects. Firstly, increasing parking spaces is essential and can be achieved through the construction of underground parking lots, multi-story parking structures, etc. Simultaneously, optimizing parking management systems, such as introducing intelligent parking systems, is necessary to enhance parking efficiency. Secondly, promoting eco-friendly travel and encouraging citizens to use public transportation are vital. This can be achieved by optimizing public transportation routes, improving the convenience and comfort of buses, subways, and other modes of transit. The government can also provide certain incentives for public transportation, such as reducing or exempting ticket fees, to attract more citizens to choose public transit. Additionally, restricting private car access is a necessary measure. Policies like limited purchasing and usage restrictions can control the number of private cars, thereby alleviating urban traffic pressure. Strengthening penalties for illegal parking and regulating parking behavior are also essential to reduce chaotic parking practices. Finally, cities should formulate comprehensive plans for public transportation development, continuously optimizing the public transportation network and improving service quality. This includes adding routes, adjusting schedules, and upgrading vehicle facilities to meet the commuting needs of citizens. Simultaneously, reforms in private car access and parking management systems need to be strengthened.

In summary, addressing parking problems requires a multi-faceted approach, including increasing parking spaces, optimizing public transportation, restricting private car access, and enhancing parking management. Only through these measures can we create a comfortable, healthy, and sustainable urban transportation system, providing citizens with a better travel experience.

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