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Development of pricing policy for car parking in Ukrainian cities

Opracowanie polityki cenowej parkingów w miastach ukraińskichj

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Abstract. The purpose of the paper is to develop effective approaches to improving hourly parking pricing policies in Ukraine, considering both local and international best practices. The paper poses the following research problem: how to design a parking pricing system that efficiently manages demand, reduces urban congestion, and aligns with sustainable development goals. The paper poses the following hypothesis: performance-based pricing, incorporating factors such as parking demand, duration, and purchasing power, is more effective in managing urban parking resources than traditional fixed-rate systems. The research presented in the paper fills a research niche in the field by addressing the lack of dynamic pricing models in Ukrainian cities and their integration with broader urban planning and post-war reconstruction efforts. The study analyzed parking prices in Ukraine and selected European countries, both in nominal terms and adjusted for the purchasing power index, highlighting significant disparities and the need for localized solutions. The main conclusions of the research are that dynamic pricing strategies, supported by advanced technologies such as smart parking meters and automated data collection systems, can enhance the efficiency of parking management. Such approaches not only optimize parking space turnover but also influence driver behavior, contributing to reduced congestion and emissions. However, their implementation requires substantial financial and human resources, which are currently limited in Ukraine. As such, broader application of these strategies may only become feasible after the completion of the war and with increased involvement of international donors. The findings provide a foundation for improving parking pricing policies in Ukraine, particularly in the context of urban logistics and sustainable development.
Keywords: parking, macroeconomics, urban planning, investments, tariff policy

Abstrakt. Celem artykułu jest opracowanie skutecznych podejść do poprawy polityki cenowej godzinowego parkowania na Ukrainie, biorąc pod uwagę zarówno lokalne, jak i międzynarodowe najlepsze praktyki. Artykuł stawia następujący problem badawczy: jak zaprojektować system cenowy parkingu, który skutecznie zarządza popytem, zmniejsza korki miejskie i jest zgodny z celami zrównoważonego rozwoju. Artykuł stawia następującą hipotezę: cennik oparty na wynikach, uwzględniający takie czynniki, jak popyt na parking, czas trwania i siła nabywcza, jest skuteczniejszy w zarządzaniu zasobami parkingowymi w miastach niż tradycyjne systemy o stałej stawce. Badania przedstawione w artykule wypełniają niszę badawczą w tej dziedzinie, zajmując się brakiem dynamicznych modeli cenowych w miastach ukraińskich i ich integracją z szerszym planowaniem urbanistycznym i powojennymi wysiłkami na rzecz odbudowy. W badaniu przeanalizowano ceny parkingowe na Ukrainie i w wybranych krajach europejskich, zarówno w wartościach nominalnych, jak i skorygowanych o wskaźnik siły nabywczej, podkreślając znaczące dysproporcje i potrzebę lokalnych rozwiązań. Główne wnioski z badań są takie, że dynamiczne strategie cenowe, wspierane przez zaawansowane technologie, takie jak inteligentne parkomaty i zautomatyzowane systemy gromadzenia danych, mogą zwiększyć wydajność zarządzania parkingiem. Takie podejście nie tylko optymalizuje rotację miejsc parkingowych, ale także wpływa na zachowanie kierowców, przyczyniając się do zmniejszenia korków i emisji. Jednak ich wdrożenie wymaga znacznych zasobów finansowych i ludzkich, które są obecnie ograniczone na Ukrainie. W związku z tym szersze zastosowanie tych strategii może stać się wykonalne dopiero po zakończeniu wojny i przy zwiększonym zaangażowaniu międzynarodowych darczyńców. Wyniki stanowią podstawę do poprawy polityki cenowej parkingów na Ukrainie, szczególnie w kontekście logistyki miejskiej i zrównoważonego rozwoju.
Słowa kluczowe: parking, makroekonomia, planowanie urbanistyczne, inwestycje, polityka taryfowa

Introduction

In Ukraine, mobility problems are one of the key challenges: road quality issues and constant congestion in major cities led to many negative consequences, both economic and social. The government has tried to improve situation and even had some success, but most of the problems in the sector persist, and are even exacerbating, as it is almost impossible to effectively implement policies aimed at improving the state of mobility in the context of military invasion. Nevertheless, it is already

important to formulate some recommendations to improve the state of this area. This study assessed the possibilities for implementing an hourly parking rate pricing policy to reduce traffic congestion and increase the efficiency of parking (Bogucka and Landmann, 2022; Klasa, 2021).

C. Zhou et al. (2022) considered the possibilities of optimising on-street parking in the historical heritage of Lviv. The researchers noted that chaotic parking prevails in the city, although it is decreasing over time. They also proposed the Krakow approach of charging for all parking within the paid zone without special markings. A. Katrenko et al. (2021) explored the possibilities of solving the parking problem in Lviv. They suggested using the Smart Parking system, which was developed through comprehensive analysis and design using various technologies. This system aims to optimise traffic flow and maintain urban transport infrastructure, functionality, and efficiency. I.O. Pazynenko and O.O. Kholodova (2020) assessed the general global experience of how parking problems in cities can be solved. Researchers have noted that problems can arise from inefficient use of transport networks, incorrect location of large transport hubs, shortcomings in state regulation of transport, irrational traffic management, underutilisation of public transport, and a ban on parking in city centres. They also showed that in Europe, the solution to such problems usually involved three stages: increasing the level of management, introducing paid parking, and integrating parking policy into the overall urban transport management strategy. Considering this, the application of this approach to solving parking problems in Ukraine could also be effective. As for the security component of the road transport sector, A.A. Kashkanov and M.D. Korniychuk (2023) worked on its assessment. The researchers noted the presence of considerable problems in the country due to the massive number of road accidents every day. They also noted that, to improve traffic safety in Ukraine, new vehicle designs need to be developed, namely, to ensure their reliability, efficiency, dynamism, cross-country ability, stability, ease of operation, and environmental friendliness. I.M. Kopotun and M.M. Rudyk (2022) also described this problem. The researchers noted that the problem of road traffic accidents is critical in the country, they occur frequently and take many lives. In this regard, they recommended the development of a national road safety strategy based on science, consistency, social orientation, and economic feasibility.

Thus, although Ukraine pays a lot of attention to the transport sector overall, including the mobility issues, the issue of parking, and especially its pricing, is ignored. In this regard, the purpose of this study was to conduct an assessment aimed at exploring such approaches. The research problem is the lack of effective and dynamic parking pricing policies in Ukrainian cities. The hypothesis is that integrating performance-based pricing models can enhance parking efficiency and urban mobility. The study addresses a research niche by proposing solutions tailored to Ukraine's post-war urban development and transport challenges.

Materials and Methods

The following research methods were used in the study: comparative analysis to examine parking prices across Ukraine and selected EU countries, data collection and conversion to ensure uniformity in currency representation, statistical adjustments to calculate average parking prices in Kyiv, and the application of purchasing power index-weighted calculations to standardize comparisons across countries. The study examined the average parking prices in Ukraine and some EU member states, namely Portugal, Italy, Sweden, Spain, Austria, France, Finland, Denmark, Norway, Germany, and the Netherlands, in euros. Notably, the data for Ukraine was compiled based on price information in Kyiv; furthermore, depending on the type of parking, there are three different prices for a parking space in the capital. The study used the average of these values in UAH, converted to EUR as of November 2022. The information was used specifically for 2022 due to the limited availability of both new data on this issue and publicly available statistical information on car parks in general. Nevertheless, the information as of the end of 2022 is also quite relevant for the assessment, considering that the situation has not changed significantly over the past period. Furthermore, using data from Kyiv is important because it is the largest city in Ukraine with the highest traffic and the highest demand for parking spaces, making it representative of general parking trends.

Considering that the selected countries have different standards of living, it was decided to compare not only the nominal parking rate, but also the purchasing power index-weighted rate. This indicator generally shows how the exchange rates of two or more currencies can be compared in relation to a set of certain services, but it can also be used for other purposes, such as assessing how expensive the prices of certain goods or services are in different countries in terms of the purchasing power of the population. Data on this index was taken from the Numbeo website (Local purchasing power..., 2024). The index ranges from 182.5 (for Luxembourg) to 2.3 (for Cuba). The new values for the level of parking prices were derived using formula (1):

$$P_r = \frac{P_n}{\left(\frac{I}{100}\right)}, \tag{1}$$

where: P_n – the nominal parking price per hour; P_r – the real parking price per hour; I – the index value.

Thus, if the index value was greater than 100, the real price of parking decreased, and if it was lower, it increased. This helped to compare the price of a parking space per hour across different countries more fairly.

Results

Pricing policy is the strategic framework that a company or organisation uses to determine the prices of its products or services. It covers the principles, guidelines, and methodologies that determine how prices are set, adjusted, and communicated to customers. The principal objectives of pricing policy usually include maximising revenue, achieving competitive advantage, ensuring customer satisfaction, and maintaining market stability. Digital policy plays a vital role in the development of the car parking industry, as it facilitates the introduction of innovative technologies and improves the efficiency of parking space management. Pricing, when done properly, achieves three important goals: it allocates scarce transport resources in a way that reduces congestion and makes the entire transport system more efficient, reduces potentially market-distorting subsidies that have caused excessive car travel, and creates a revenue stream that can be invested in improving of accessibility, which can reduce parking (and driving) demand. Parking pricing can be a powerful tool, especially when used in conjunction with other travel demand management strategies, to influence travellers' decisions about whether to drive alone, carpool, or use non-motorised modes of travel: specifically, reducing car trips can subsequently reduce emissions and congestion. Overall, there are two main types of pricing: free and fixed-rate pricing and performance-based pricing. These approaches can be used to improve travel efficiency and parking choices.

Cities have considerable amounts of space that are often used for free parking, which leads to inefficient use of parking spaces: parked cars occupy massive areas of land (Parmar et al., 2020; Khalid et al., 2021). In this regard, the introduction of paid parking can reduce the area occupied by cars and generally improve the efficiency of parking management. Historically, the city has been provided with free parking to compete with the suburbs, but this strategy reduces land values and slows down the pace of urban development (Fahim et al., 2021). However, fixed parking rates have insignificant effect on reducing congestion or improving accessibility, especially when prices do not reflect demand. Therefore, modern approaches focus on a comprehensive strategy, considering all modes of transport and setting parking tariffs to achieve concrete goals. Such data-driven policies allow cities to quickly adjust prices based on real demand, ensuring efficient use of parking resources and improving overall access and congestion management. The introduction of fixed parking tariffs has been a standard option for cities since the introduction of parking meters, but they have their limitations. While this approach is easy to use and does not require additional equipment or data collection costs, as noted above, it does not effectively manage parking demand. Performance-based pricing allows cities to better manage parking resources (Amin et al., 2020; Mo et al., 2021). Considering that, to reduce traffic congestion, a portion of parking spaces in each quarter should

stay free (depending on the estimate from 10% to 20%), parking prices should be variable to discourage drivers from parking during peak times. Depending on the purpose, different tariff schemes can be used: price increases over time, variation depending on the location and time, or a combination of the former two.

To implement a performance-based pricing policy, it is important to understand the local parking context and balance supply and demand. Supply and demand data help to set suitable tariffs, but they can only be determined empirically (Stenin et al., 2020). Thus, this approach ensures the maximum price of parking during peak hours, while at night parking can be free (due to minimal demand). Differences in pricing may also occur due to the day: on weekends, the rate will be lower than on weekdays. The time-based approach is also time-related, but the logic behind it is different: in this case, the price increases with the length of time a driver uses the parking lot. Thus, this pricing ensures that drivers park only briefly, which helps to reduce congestion during peak hours. Cities typically have to set clear targets for parking performance, aiming to achieve a certain level of parking space turnover or availability (Kunakh et al., 2020). The key purpose is to enable people to find a parking space with minimal search time. Turnover of parking spaces is difficult to measure, especially if relevant technologies (sensors) are not installed. The availability of parking spaces is easier to measure using manual counts and parking meter payment data, but such information is not accurate enough to be relied upon completely. Many cities also impose parking time limits to achieve the desired level of turnover, but these restrictions are often violated (Trofymchuk et al., 2022). Technological innovations simplify data collection, installation, and price adjustments. New smart parking meter systems can use multiple forms of payment, set variable rates, and record usage data (Kiurchev et al., 2023). These parking meters can be complemented by sensors and automated number plate recognition (ANPR) technologies, allowing cities to determine parking occupancy with varying degrees of success. Implementing different pricing strategies does not necessarily require advanced technologies, but it makes the process much easier and more reasonable.

The current situation with parking in Ukraine, especially in cities, is undergoing considerable changes due to planned post-war reconstruction and urban planning initiatives. The state of parking and urban planning is influenced by several key factors: the extensive damage caused by the war has prompted large-scale efforts to rebuild Ukrainian cities. These efforts include the reconstruction of critical infrastructure and urban spaces, which affects the availability and organisation of parking facilities. The reconstruction plans aim to integrate sustainable and resilient urban development practices to better meet future needs and will continue to be actively implemented in the future, after the war ends. In urban regeneration, special attention should be paid to integrating ecological and environmental solutions into urban planning: this includes rethinking public spaces, improving green spaces and

integrating innovative urban mobility solutions that can affect parking strategies (Shults et al., 2020). For instance, the introduction of green infrastructure and smart city initiatives aims to create a more efficient and environmentally friendly urban environment (Zharkenov et al., 2017). Ukrainian cities are also facing challenges such as managing the increased demand for parking due to the growing use of private vehicles and ensuring efficient use of urban space. Innovations in urban planning, such as smart parking systems and improved public transport, are being explored to address these challenges (Turemuratov et al., 2024). Overall, the parking situation in Ukraine is closely linked to broader efforts to restore and develop cities with a focus on sustainability. Ongoing projects and international support are expected to lead to considerable improvements in urban infrastructure, including parking, but such improvements can only be expected after the war is fully over and foreign donors are more actively involved.

Considering the price of parking in Ukraine, its rate is quite ambiguous compared to other countries. The data can be evaluated in the context of the average parking price in different countries as of 2022 in Table 1.

Table 1. Prices for parking in selected countries of the European Union and Ukraine as of 2022, euros

Country	**Parking price**	**Country**	**Parking price (according to the purchasing power index)**
Ukraine	0.59	Portugal	1.18
Portugal	0.75	Sweden	1.22
Italy	1.5	Ukraine	1.49
Sweden	1.52	Spain	1.65
Spain	1.52	Finland	1.69
Austria	1.86	Austria	1.82
France	1.92	France	1.88
Finland	2	Italy	1.92
Denmark	2.6	Denmark	2.04
Norway	2.78	Norway	2.42
Germany	3.4	Netherlands	2.79
Netherlands	3.48	Germany	2.83

Source: compiled by the authors of this study

As Table 1 shows, the nominal price of parking in Ukraine is lower than in other European countries. Nevertheless, it is important to assess not only the nominal value, but also how large it is in the context of a given country. Having evaluated the data with the purchasing power index, it was concluded that parking in Ukraine is quite cheap compared to other European countries, but, nevertheless, considering the level of income of citizens, residents of Portugal and Sweden have relatively lower parking prices than Ukraine. In Ukraine, the procedure for pricing paid parking services is regulated by Resolution of the Cabinet of Ministers of Ukraine No. 258-r "On Approval of the Procedure for Pricing Services for the Use of Paid Parking Areas" (2010). The primary purpose of the resolution was to empower local governments to apply coefficients to tariffs that would allow for differentiation of parking fees. However, the lack of clear recommendations on the establishment and calculation of these coefficients has necessitated further research in this area and development of recommendations on the organisation of parking tariff policy in Ukrainian cities.

Several important factors should be considered to improve the efficiency of the use of designated parking areas and increase the share of paid parking: a clear organisation of the payment and season ticketing process, strict control over payment, as the lack of constant supervision reduces the motivation to pay for a service that was previously free, and a balanced parking fee that covers the cost of maintaining parking spaces. However, the principal goal of a city's parking policy should not be to increase parking revenues alone. It is important to match the level of car use with the capacity of the city's transport system, which will reduce delays and improve the quality of services for all users (Bekenov et al., 2020; Shults et al., 2023). This will bring considerable socio-economic benefits and potentially increase the gross regional product. To achieve this result, it is necessary to set suitable parking tariffs. The Resolution of the Cabinet of Ministers of Ukraine No. 258-r "On Approval of the Procedure for Pricing Services for the Use of Paid Parking Areas" (2010) established a mechanism for calculating prices for paid parking services. The parking fee is defined as the cost of providing services for one paid parking space during a specified period, considering the location of the parking space, the duration of its use, the type of vehicle and the category of persons parking vehicles on the territory. Final prices are set by local authorities and may differ between allocated and specially equipped plots.

The scope of services is determined considering the availability of free parking spaces for vehicles as defined in Part 6 of Article 30 of the Law of Ukraine No. 875-XII "On the Fundamentals of Social Protection of Persons with Disabilities in Ukraine" (1991), spaces for electric vehicles, as well as free or privileged parking spaces allocated according to the legislation and decisions of the relevant city or village council, as well as the factual occupancy of the parking space. The occupancy rate is determined by local authorities depending on the location of the site and is based on occupancy monitoring. The cost of services is calculated according to the

parking tariff policy established by the local government. Currently, in Ukraine, the cost of parking (T) is calculated using the following formula (2):

$$T = \frac{C_a * C_{p1} * C_{p2} * C_{p3} * C_{p4}}{V_a * C_l}, \quad (2)$$

where: C_a – the annual cost of services; V_a – the annual volume of services rendered; C_l – the parking lot load coefficient, Cl and 0.5; C_{p1} – a coefficient that considers the location of the parking site; C_{p2} – a coefficient that considers the time of use of the parking site; C_{p3} – a coefficient that considers the type of vehicle placed on the parking site; C_{p4} – a coefficient that considers the category of persons who place vehicles on the parking site.

According to formula (1), the value of T (parking price) is inversely proportional to the value of C_l (parking lot load coefficient), i.e., as C_l increases, the parking price decreases. However, the authors of this study argue that this approach contradicts the existing urban planning principles of parking in Ukrainian cities, as well as international best practice, and should be revised. They propose to move C_l to the numerator of formula (1) to establish a direct proportional relationship between T and C_L, resulting in the following formula for determining the cost of parking (3):

$$T = \frac{C_a * C_{p1} * C_{p2} * C_{p3} * C_{p4} * C_l}{V_a}. \quad (3)$$

Using this approach to parking pricing will help to manage demand and reduce congestion in the city or in specific areas by adjusting pricing, a strategy supported by international practices in urban parking management. Next, the study considered the key approaches in the best practices of organising parking tariffs. Therefore, several key factors should be considered when developing tariff policy in Ukrainian cities. Thus, drivers are willing to choose cheaper parking if it is only 1-2 minutes further away from their destination than they currently choose. However, if alternative parking is 10 minutes away or more, drivers are more likely to park in a more expensive but more convenient location. The desire to change travel and parking habits depends on the purpose of the trip. Business travel is generally less sensitive to tariff increases than travel for other purposes (cultural, recreational). Therefore, when setting parking tariffs, it is important to consider the intended use of parking areas. If the approach to tariff setting is based on the parking zone in which the parking space is located, the focus should not be on precise calculations, but on classifying parking spaces by zone, considering several influencing factors. The location factor should increase in arithmetic progression, starting from 1 and multiplied by a certain constant. A positive example is the experience of Budapest, where the cost of a round-trip public transport ticket is used as such a constant. Considering this, it is worth recommending the introduction of an additional indicator – the dynamism coefficient (C_5). This coefficient will reflect the interaction

between the tariff and changes in parking demand. Based on the experience of San Francisco, it is recommended to use average occupancy for different "peak periods" of parking space use. With this approach, the formula for calculating the tariff will look as follows:

$$T = \frac{C_a * C_{p1} * C_{p2} * C_{p3} * C_{p4} * C_l * C_5}{V_a}, \quad (4)$$

where: C_5 – the dynamism coefficient.

C_5 can range from 0 to infinity ($0<K\_5<\infty$). When C_5 is equal to 1, it means that the dynamic parking tariff is not used, while $C_5 \neq 1$ indicates that it is used. Concrete quantitative values of C_5 for Ukrainian cities require further investigation. Further research could benefit from surveys to assess the willingness to pay for on-street parking and corresponding pricing levels, possibly using a survey of Ukrainian car users' preferences. One of the proposed ways to implement this is to revise the formula for calculating parking tariffs, as stated in Resolution of the Cabinet of Ministers of Ukraine No. 258-r "On Approval of the Procedure for Pricing Services for the Use of Paid Parking Areas" (2010). Within the framework of these changes, it is recommended to include a load factor (C_l) in the numerator of the formula to establish a directly proportional relationship between the tariff and parking demand. It is also proposed to introduce a dynamism coefficient (C_5) to promptly influence the level of occupancy of parking spaces and improve the efficiency of urban transport management. These proposed changes are aimed at improving the management of parking demand in Ukrainian cities by clarifying tariff adjustments.

Thus, the development of a parking pricing policy involves several key steps and considerations to ensure that it meets the needs of both the parking operator and users. Specifically, this requires an understanding of the supply and demand for the service, which requires market research, namely in the context of demand, including peak times, average occupancy rates, and user preferences (Basu and Ferreira, 2021; Gu et al., 2020). It is also worth identifying distinct categories of users (e.g., daily commuters, short-term visitors, long-term parkers) and developing different pricing levels based on duration (hours, daily, monthly), vehicle type, and time of day (peak vs. off-peak).

Discussion

The current study focused on how to maximise the overall efficiency of parking spaces, concluding that the best method is to provide dynamic pricing for parking spaces based on certain indicators such as time of day, geographic location. J. Vuelvas et al. (2021) described a time-of-use pricing strategy for managing clusters of electric vehicles. The researchers noted that the game-theoretic model proposed in the study

captures the interaction between the unit and the owners of electric vehicles to develop retail tariffs considers demand uncertainty and spot prices, while consumer behaviour is modelled by an optimisation problem using historical traffic patterns instead of demand elasticity or utility functions. An aggregated virtual battery model reflects the energy intensity and flexibility of groups of electric vehicles: this approach models EV owners as clusters of behaviour, including driving patterns, without detailed individual models (Panchenko et al., 2023). Thus, researchers believe that the application of this approach will maximise the efficiency of electric vehicle management.

S. Saharan et al. (2020) considered methods of dynamic pricing for an intelligent transport system in smart cities. Researchers have noted that dynamic pricing is crucial in modern intelligent transport systems to address issues such as congestion control, peak load reduction, and efficient mobility management for both conventional and electric vehicles. It allows creating an environmentally friendly environment by optimising vehicle route planning. However, their implementation is also challenging, as poor dynamic pricing can lead to considerable negative effects, such as misdirection of vehicles, increased waiting times, pollution, and wasted energy, while effective strategies satisfy all stakeholders.

H. Wang et al. (2020) studied the impact of pricing policies on the nature of parking on Nanning streets. The researchers noted that higher parking prices lead to a reduction in the duration of parking with an increasing elasticity over time. The impact on parking space turnover varies due to vehicle ownership trends. In this regard, it was concluded that pricing models should consider trends in consumer demand for parking to improve the efficiency of parking pricing in cities.

Z. Mei et al. (2020) evaluated various parking pricing strategies. They noted that a strategy that provides differentiated pricing based on the availability of a parking space is the best, offering the highest total benefit. This strategy sets lower prices when parking resources are plentiful and higher prices to influence driver choice and avoid parking space failure when resources are scarce. These findings suggest that this approach optimises the use of parking resources and can guide government agencies or researchers in evaluating and optimising their parking strategies. Thus, the conclusions drawn in a series of studies are quite similar to those obtained in the current study. This supports the conclusion that a more active use of the dynamic price approach is effective in the long run in ensuring the optimised use of available spots. Therefore, in Ukraine, a more active implementation of these systems, including the use of the latest technologies, is important, particularly after the end of the war.

V. Simic et al. (2022) considered a neutrosophic type 2 model based on CRITIC and MABAC for the selection of a public transport pricing system. The researchers noted that the pricing of public transport services is multifaceted, as it needs to consider various criteria, such as decentralisation caused by lower rents in areas far from the city and operating costs for longer transport routes, which complicates the

process of finding a fair price. It was also shown that there are four main types of pricing: fixed tariff, remote, zonal, and rental. The proposed system was intended to simplify the decision-making process, to draw conclusions about which type of rent is the most profitable. Although no analogous models have been developed in the context of parking pricing in Ukraine, it is agreed that the application of such innovative approaches can increase the efficiency of parking in the region. Nevertheless, this also requires significant financial and other investments. Considering this, the use of such methods in Ukraine seems improbable at present.

J. Rosenblum et al. (2020) considered future trends in the development of the parking sector. The researchers showed that, despite the focus on transport network companies and autonomous vehicles, considerable innovations in parking still exist, although information about them is not actively disseminated. These include technological advances, policy reforms, and design innovations. The significance of these changes in shaping the future of urban mobility and land use was also emphasised. The current study also pointed out that, in the long run, addressing how the government handles parking issues is important to avoid logistical problems in the region (city). The use of innovative methods and approaches that would maximise the efficiency of individual parking spaces would help reduce traffic congestion and thus increase the economic efficiency of the city's functioning and the level of satisfaction with the life of the population. Therefore, the state authorities should pay much more attention to these issues than they did as of 2024.

S. Saharan et al. (2020) considered the possibility of creating a smart pricing system in the city. The researchers described the global problem of finding parking spaces due to the increase in the number of vehicles. Furthermore, the significance of providing advance information on the availability of parking spaces was emphasised to optimise motorists' journeys and reduce congestion and pollution. In the study, the researchers proposed a scheme for predicting the occupancy of parking spaces and dynamically adjusting on-street parking prices and showed that it is quite effective compared to existing methods.

J. Wang et al. (2020) studied a management system with parking pricing using a parking permit. The researchers pointed out that parking permit management can eliminate competition for limited parking spaces at destinations by formulating it as a system optimisation problem: it is achieved by using an algorithm that determines the optimised distribution of parking permits in areas. This approach reduces travel costs and congestion, especially in scenarios with a limited number of parking spaces. The latter approaches, such as the provision of parking spaces through permits, are relatively new and more difficult to implement. Nevertheless, they can also be used in Ukraine to improve the efficiency of parking along with the approaches already mentioned in the present study.

Conclusions

Thus, a strategic pricing policy is vital for the efficient management of parking resources and sustainable urban development. Implementing a well-defined pricing policy involves setting prices that balance the supply and demand for parking spaces, thereby reducing congestion, promoting efficient use of land, and generating revenue for further infrastructure improvements. The use of digital technologies stays important in this context. Overall, the study concluded that the most effective approach to pricing is one based on results. It uses time-of-day, location, and length--of-stay data to determine which price level is most effective at a given time. This approach not only optimises the use of parking spaces, but also influences driver behaviour, reducing congestion. This approach allows authorities to maintain a balance between available parking spaces and user demand, ensuring that resources are used efficiently.

The study proposed the introduction of a dynamic C_5 coefficient, which would increase the sensitivity of parking tariffs to fluctuations in demand, ensuring that prices reflect the value of parking spaces in real time. This approach may be particularly useful in post-war Ukraine, where urban planning is undergoing considerable changes and parking demand is expected to grow rapidly as cities recover. However, the effectiveness of any pricing strategy depends on the local context. Thus, empirical research, including user preference surveys and demand studies, is essential to tailor these strategies to the unique needs of Ukrainian cities. The proposed changes to the current tariff formula, specifically the inclusion of a load factor (C_l) in the numerator and the introduction of a dynamism factor (C_5), represent major steps towards a more adaptive and efficient parking demand management system.

It is relevant to find approaches to improve the level of road conditions in Ukraine, including in times of war. It is also important to continue research in the field of car parking to find better, more suitable options for pricing, controlling supply and demand for parking spaces.

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