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Spatial Accessibility of Parcel Lockers as a Driver of E-Commerce Development in Urban and Rural Areas

The rapid growth of e-commerce constitutes one of the key challenges of contemporary retail, influencing both the structure of the market and the organization of distribution systems, as well as the accessibility of services for residents of areas with diverse settlement patterns. Global digital transformation, the growing availability of Internet access, and the widespread use of mobile devices have contributed to significant changes in consumer behavior. Consumers increasingly expect convenient, flexible, and fast delivery options, which in turn forces retailers and logistics operators to seek new, more efficient distribution models.

A particularly important factor accelerating the adoption of online sales channels was the COVID-19 pandemic, which in a short period led to a rapid increase in the number of e-commerce users and the frequency of online purchases across many social groups. A

s a result, e-commerce is no longer perceived merely as a complement to traditional retail channels but is increasingly becoming a primary source of access to everyday goods, especially for residents of areas with limited availability of brick-and-mortar stores.

At the same time, the dynamic growth in parcel volumes generates new challenges in last-mile logistics, which is widely considered the most expensive and complex stage of the supply chain. The traditional model of home delivery involves many courier trips, low route efficiency, and high levels of emissions. These problems are particularly evident in densely urbanized areas, where the increasing number of delivery vehicles intensifies pressure on transport infrastructure and public space. Conversely, in rural and peripheral areas, home deliveries are often costly, time-consuming, and associated with a higher risk of failed delivery attempts.

In this context, parcel lockers are playing an increasingly important role in e-commerce distribution systems, representing a form of point-based infrastructure that enables self-service parcel collection and dispatch. This solution reflects broader trends related to shared logistics, delivery consolidation, and the search for more sustainable models of transport and distribution. Parcel lockers can be considered both as an element of local service infrastructure and as an important component of the retail system in the context of ongoing digitalization and the restructuring of retail networks.

The aim of this study is to analyze the spatial distribution and accessibility of parcel lockers as a factor supporting the development of e-commerce in both urban and rural areas. In particular, the study seeks to assess the level of spatial diffusion of parcel locker infrastructure and to identify differences in access between areas with different settlement structures. This analysis contributes to a better understanding of the extent to which modern logistics infrastructure can help reduce inequalities in access to retail services and support the further development of e-commerce at local and regional scales.

In the existing literature, parcel lockers are commonly regarded as an effective alternative to traditional home deliveries. It is emphasized that their proper location enables parcel consolidation, reduces the number of courier trips, and improves route efficiency. As a result, this leads to lower carbon dioxide emissions, reduced noise levels, and decreased transport pressure in urban areas. However, the effectiveness of parcel lockers largely depends on their spatial accessibility, particularly their availability within walking distance or their integration into daily mobility patterns, such as commuting to work, school, or shopping.

Previous research has focused primarily on urban environments, analyzing the impact of parcel lockers on public space, spatial order, and service accessibility. Many studies highlight the risk of uncoordinated placement of parcel lockers, especially in highly visible locations such as transport corridors, shopping centers, or residential areas. At the same time, parcel lockers are recognized as having the potential to strengthen local service centers and support the concept of the “15-minute city,” where essential services are accessible within a short distance from home.

In contrast, the role and potential of parcel lockers in rural and peripheral areas remain relatively underexplored. This is particularly important because e-commerce may play a crucial role in mitigating retail and service exclusion in such areas. Many regions are experiencing the gradual disappearance of small local shops, which reduces access to basic goods, especially for elderly residents and households without access to private cars. In this context, the option to order goods online and collecting them at nearby parcel lockers may partially compensate for the limited availability of local retail services.

The analysis of parcel locker accessibility requires consideration not only of their spatial distribution but also of the actual ability of users to reach them. Accessibility should be assessed not only in terms of physical distance but also in relation to travel time, road network structure, terrain conditions, and public transport availability. In urban areas, walking and cycling accessibility are particularly important, while in rural areas dependence on private cars and connections to local service centers play a dominant role.

Another important aspect concerns the socio-demographic characteristics of users. The use of parcel lockers requires not only physical access but also digital skills, Internet access, and trust in electronic services. In regions with a higher share of elderly residents or lower levels of education, the adoption of e-commerce may remain limited despite relatively good physical accessibility of parcel lockers. Conversely, in rapidly developing suburban areas characterized by high mobility and economic activity, parcel lockers may become one of the primary channels for receiving online purchases.

The spatial distribution of parcel lockers largely reflects the market strategies of logistics operators, who seek to maximize accessibility to potential users while minimizing installation and operational costs. As a result, the highest density of parcel lockers is typically observed in city centers, large residential areas, and near major transport nodes and retail facilities. In rural areas, parcel lockers are much less frequent and are usually located in larger villages that serve as local service centers or along major transport routes.

Such a development pattern may contribute to the persistence of spatial inequalities in access to e-commerce services. Residents of more remote and peripheral areas remain dependent on home deliveries, which are less efficient, less flexible, and often more expensive. In some

cases, limited access to parcel lockers may discourage the use of e-commerce and contribute to unequal participation in the digital economy.

From a regional development perspective, parcel lockers may serve as infrastructure that supports the integration of peripheral areas into broader economic networks. They facilitate not only parcel collection by consumers but also parcel dispatch by local entrepreneurs, farmers, and small producers. In this way, parcel lockers can support the development of local entrepreneurship and enable small businesses to access regional, national, and even international markets.

An important issue is also the integration of parcel lockers with other spatial functions, particularly transport and service infrastructure. Locating parcel lockers near public transport stops, schools, offices, or local retail centers enables users to combine multiple activities within a single trip, thereby reducing additional travel demand. In rural areas, locating parcel lockers near key community facilities, such as local shops or community centers, may be particularly beneficial.

The results of spatial accessibility analyses make it possible to assess the extent to which parcel locker infrastructure contributes to reducing inequalities in access to retail services. They also help identify underserved areas where planning interventions or cooperation between local authorities and logistics operators could improve accessibility. Incorporating parcel locker infrastructure into local and regional planning policies may therefore form part of broader strategies aimed at improving service accessibility and reducing spatial and digital exclusion.

In conclusion, parcel lockers are becoming an increasingly important component of modern distribution systems and a key factor influencing the further development of e-commerce. Their role extends beyond improving last-mile logistics efficiency in urban areas and includes the potential to enhance service accessibility in rural and peripheral regions. Spatial disparities in the distribution of parcel locker infrastructure may significantly influence the development of e-commerce at local and regional levels, reflecting broader global challenges related to retail transformation, sustainable development, and the creation of more inclusive service systems.

Keywords: parcel lockers, spatial accessibility, last-mile logistics, urban-rural divide, retail exclusion

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