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Last-mile logistics: between consumer expectations and the illusion of sustainable development

Logistyka ostatniej mili: między oczekiwaniami konsumentów a iluzją zrównoważonego rozwoju

Abstract. The article addresses the issue of last-mile logistics in the context of the dynamic growth of e-commerce and the influence of economic, technological, and social megatrends. The starting point is the identification of the growing role of e-commerce in shaping new patterns of consumption and the related consumer expectations – concerning the speed and flexibility of delivery, process transparency, as well as the ecological character of services. The subsequent sections discuss key pro-environmental solutions applied by logistics enterprises, including fleet electrification, the introduction of electric bicycles, the development of parcel locker networks, and the use of packaging made from recycled materials. It is emphasized that these activities are of both operational and reputational significance, becoming an important element of building competitive advantage in the market. However, the analysis revealed that there are sometimes significant discrepancies between corporate declarations and actual environmental outcomes. In this context, the phenomenon of greenwashing is examined, understood as the ostensible engagement in environmental issues that is not reflected in operational practice. It is underlined that growing consumer awareness necessitates the transparent reporting of activities and the presentation of measurable indicators of emission reduction and environmental impact mitigation. The conclusions drawn from the study indicate that the future of last-mile logistics will depend on the ability of enterprises to translate pro-environmental strategies into tangible, measurable results. Only such an approach will allow companies to avoid the risk of greenwashing and to establish the foundations for genuinely sustainable development in the e-commerce sector.

Keywords: last-mile logistics, e-commerce, e-consumer, megatrends, sustainable development, greenwashing

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Synopsis. Artykuł podejmuje problematykę logistyki ostatniej mili w kontekście dynamicznego rozwoju handlu elektronicznego oraz oddziaływania megatrendów gospodarczych, technologicznych i społecznych. Punktem wyjścia jest wskazanie rosnącej roli e-commerce w kształtowaniu nowych wzorców konsumpcji oraz związanych z nimi oczekiwań konsumentów – dotyczących szybkości i elastyczności dostawy, transparentności procesów, a także ekologicznego charakteru usług. W dalszej części omówiono kluczowe rozwiązania proekologiczne stosowane przez przedsiębiorstwa logistyczne, w tym elektryfikację flot, wdrażanie rowerów elektrycznych, rozwój sieci paczkomatów oraz stosowanie opakowań z materiałów wtórnych. Zwrócono uwagę na fakt, że działania te mają znaczenie zarówno operacyjne, jak i wizerunkowe, stając się istotnym elementem budowania przewagi konkurencyjnej na rynku. Analiza wykazała jednak, że między deklaracjami firm a realnymi efektami środowiskowymi występują niekiedy znaczące rozbieżności. W tym kontekście podjęto dyskusję nad zjawiskiem greenwashingu, czyli pozornego zaangażowania w kwestie ekologiczne, które nie znajduje odzwierciedlenia w praktyce operacyjnej. Podkreślono, że rosnąca świadomość konsumentów powoduje konieczność transparentnego raportowania działań oraz przedstawiania wymiernych wskaźników redukcji emisji i ograniczania wpływu na środowisko. Wnioski płynące z artykułu wskazują, że przyszłość logistyki ostatniej mili zależeć będzie od zdolności przedsiębiorstw do przekucia strategii proekologicznych w faktyczne, mierzalne rezultaty. Tylko takie podejście pozwoli uniknąć ryzyka greenwashingu i stworzyć podstawy dla realnie zrównoważonego rozwoju w sektorze e-commerce.

Słowa kluczowe: logistyka ostatniej mili, e-commerce, e-konsument, megatrendy, zrównoważony rozwój, greenwashing

JEL codes: R41, L81, O33, Q01, M14

Introduction

E-commerce represents one of the most dynamically developing segments of the contemporary economy. Its expansion is the result of the synergy of several processes – the widespread availability of Internet access, the growing digitalization of everyday consumer practices, as well as social and demographic changes that foster greater openness to new forms of shopping. Online purchases are becoming not only a convenient alternative to traditional sales channels but, in many cases, the primary form of acquiring goods and services. Increasingly, e-commerce is no longer regarded as a supplement to the retail market but as a distinct ecosystem in which new patterns of consumption, logistics models, and customer service standards are being shaped.

This phenomenon is accompanied by growing consumer awareness, with individuals attaching increasing importance not only to the product itself but also to the quality of the entire purchasing process. Crucial factors include the speed and timeliness of delivery, the possibility of choosing a flexible place and time of receipt, service transparency, and compliance with environmental and social values. The last-mile delivery stage becomes particularly critical – it closes the logistics chain and directly influences the final consumer experience. It is precisely at this stage that both opportunities for building customer loyalty and risks associated with dissatisfaction materialize.

These requirements pose growing challenges for enterprises operating in the e-commerce sector. Global megatrends – such as advancing digitalization and automation, the green transformation of the economy, regulatory pressure regarding environmental protection, and changing models of work and consumption – create new conditions for the functioning of logistics. Companies are compelled to combine cost efficiency with operational flexibility and ecological responsibility. Moreover, in an era of intensifying competition and consumer pressure, declarations concerning "green logistics" and pro-environmental solutions increasingly fall within the scope of critical debate on the authenticity of corporate actions, with the phenomenon of greenwashing becoming one of the key reference points in the analysis of contemporary market practices.

The purpose of this article is to provide a critical analysis of last-mile delivery processes in e-commerce, both from organizational and consumer perspectives. Particular attention is devoted to identifying the megatrends shaping delivery models, examining e-consumers' preferences regarding parcel collection methods and packaging, as well as assessing the significance of solutions associated with sustainable development. The article attempts to juxtapose market declarations with the actual practices of enterprises in order to evaluate the extent to which the green narrative of logistics is reflected in operational reality.

On this basis, the following research questions have been formulated:

– What technological, social, and environmental megatrends are currently influencing the shaping of last-mile delivery models?
– In what way do e-consumers' preferences regarding deliveries and packaging redefine service standards in e-commerce?
– Do practices described as sustainable represent a genuine factor influencing consumer purchasing decisions, or do they serve primarily a marketing function, reflecting the phenomenon of greenwashing?

Challenges of business development in a dynamic environment – sectoral context

Contemporary enterprises operate under conditions of rapid volatility and unpredictability. The energy transition, geopolitical tensions, advancing digitalization of processes, and rising consumer expectations increasingly render classical models of organizational management inadequate. In their place emerges the necessity of continuous adaptation, flexibility, and anticipatory responses to disruptions and ongoing changes. In logistics – serving as the backbone of the modern economy – environmental volatility translates into operational and strategic challenges related to costs, delivery times, supply chain structures, and the growing importance of the ecological dimension. The expanding share of e-commerce, the shortening of product life cycles, the progression of urbanization, and ESG requirements impose entirely new demands on logistics enterprises [Ejdys et al. 2023, p. 19].

A characteristic feature of the modern market environment is its complexity and the difficulty of unambiguously predicting the direction of change. This is commonly referred to as VUCA conditions – volatility, uncertainty, complexity, and ambiguity [Gao et al. 2021, p. 467]. Enterprises must operate in the context of ongoing transformations

and numerous external shocks. Examples include disruptions to global supply chains during the COVID-19 pandemic, the consequences of the war in Ukraine, and climate change effects impacting transport infrastructure.

The ongoing digital transformation is also of considerable significance. It represents one of the main currents of change, introducing technologies such as the Internet of Things (IoT), blockchain, predictive analytics, artificial intelligence, and operational automation into the economy – including logistics sector. Their application enables route optimization, inventory management, real-time temperature monitoring, and forecasting of delivery disruptions. These technologies also open broad opportunities for managing customer relations, for instance in terms of monitoring delivery times or tracking shipment routes [Nowicka 2025, p. 4–5]. At the same time, however, such technologies generate new challenges. They require investment, process redesign, digital competencies, and cybersecurity measures. Many logistics operators, particularly in the SME sector, lack the resources to fully implement digital solutions, which deepens the divide between transformation leaders and entities with limited flexibility. The ability to meet the demands of digital transformation may thus be one of the key aspects influencing the competitive potential of enterprises providing logistics services, especially those catering to individual consumers. This approach assumes an understanding of a company's competitiveness in a dynamic dimension – the fundamental capacity to perceive changes both in the external and internal environment and to adapt to them in such a way that the resulting profit flows ensure the long-term functioning of the enterprise [Garelli 2003, p. 5].

Another element determining the operating conditions of enterprises, including those in the logistics sector, is regulation. The European Union is implementing ambitious climate goals under the Green Deal and the "Fit for 55" package. The transport and logistics sector is one of the main sources of greenhouse gas emissions, which results in pressure for decarbonization and the adoption of a circular economy model. Operators must adapt their fleets to new requirements (e.g., electric vehicles, biofuels), develop return and recycling systems, and report their environmental footprint [Pilszyk et al. 2024, p. 13]. In this context, rising consumer environmental awareness may also be of significance, as it often compels producers or service providers to adopt specific behaviors. In the broadly understood logistics industry, consumer expectations are increasingly driving the provision of green delivery options (e.g., parcel lockers, low-emission vehicles) [Sallnäs, Björklund 2020, p. 1177].

With the digitalization and automation of logistics, there also arises the necessity to change organizational structures and work culture. Traditional hierarchical models are giving way to flexible project teams operating within so-called adaptive architectures – ready to respond immediately to environmental changes. The capacity for experimentation, iterative development, and real-time testing of solutions is becoming one of the fundamental competencies of future-oriented firms [Senge 1990, pp. 4–5, 17–18]. Although such aspects may be invisible from the customer's perspective, they nonetheless shape the final offer that responds to contemporary market challenges. This, for instance, may involve the need to develop so-called green competencies, which, depending on the sector of activity, may take different forms [Grabowski et al. 2025, pp. 6–8].

Parallel to the transformational challenges of ecology and digitalization, serious social challenges are also emerging – related to courier working conditions, job automation,

and growing employment instability. Work in the so-called last mile is increasingly based on civil law contracts, which reduces job security and lowers workers' sense of social safety [Fairwork 2024, pp. 7–8, 16–17]. Customer pressure for low prices and fast deliveries translates into cost pressure on employees.

Importantly, individual customers are increasingly guided by social and environmental values when choosing service providers. Transparency, ethical certifications, zero-emission operations, and even the working conditions of couriers may become decisive criteria for consumer loyalty [infuture.institute 2024].

In summary, it can be indicated that logistics enterprises, operating in a dynamic environment, must redefine their roles by transforming from operators of physical processes into complex organizations managing risk, data, and customer experience. Development in this sector is not about geographical expansion – it is about profound adaptation to megatrends, social expectations, and standards of responsibility.

Megatrends as determinants of business decisions

Management under conditions of uncertainty requires a strategic orientation toward the future. One of the fundamental analytical tools used for this purpose is the identification of megatrends – long-term, global forces of change that shape markets, social behaviors, and business models [Przybylski 2019, p. 233]. In the logistics sector, the role of megatrends is particularly significant, as this industry constitutes the direct interface between technology, the economy, and the consumer.

Megatrends operate with great inertia, yet their consequences are difficult to ignore. According to the latest analyses by infuture.institute presented in the "Trend Map 2024" [infuture.institute 2024], the most important trends influencing logistics include: digitalization and automation, electromobility, decentralization, the redefinition of work, data transparency, the economy of time, personalization, urbanization, and the green transformation. These are systemic factors that permanently alter companies' operational models and modes of business decision-making.

One of the most dominant technological megatrends is digitalization. In the logistics sector, it signifies not only the introduction of digital technologies into selected processes but, above all, the transition to real-time data management, system integration, and event prediction. Technologies such as AI, IoT, machine learning, and predictive analytics enable data-driven decision-making [Aryal et al. 2020, p. 141]. In practice, this translates into dynamic route planning, warehouse automation, inventory optimization, the identification of supply chain risks, and customer service supported by chatbots. Digital logistics allows companies to better manage risk, reduce operating costs, and shorten order fulfillment times. Moreover, digitalization has also become the foundation of operational transparency and an element of building trust with customers.

A second important trend is automation. This aspect can influence various industries to differing degrees, depending on the technological processes applied. In logistics, automated warehouse systems, autonomous guided vehicles (AGVs), drones, and robotic sorting stations are particularly significant. These technologies increase efficiency and reduce errors, but also require a redesign of warehouses' physical and process archi-

tecture [Ellithy et al. 2024, p. 16]. Examples of implementing such solutions can be found among global logistics operators, who, thanks to automation, are able to handle millions of shipments daily while maintaining high quality standards. Automation may also extend to customer service processes, enabling clients to manage deliveries without the involvement of employees, for instance, by selecting delivery locations or scheduling delivery times.

The third pillar of technological transformation is data integration and security. In an era of rising cyberattacks, logistics companies must safeguard information concerning shipments, customers, contractors, and operations. The application of blockchain in logistics enhances the security and immutability of information while also enabling the automation of certain processes [Ran et al. 2024, p. 152873]. Transparency thus becomes a market value in its own right. It should be noted, however, that the implementation of these technologies is not free from challenges. It requires substantial investment, new expertise, the transformation of management models, and the reorganization of entire operating systems. Frequently, the key barrier lies not in the technologies themselves but in organizational culture and the absence of a strategic vision for integrating megatrends into corporate activity.

Beyond technological megatrends, social and environmental megatrends are increasingly influencing business decisions in the logistics sector. These processes affect the values, expectations, and attitudes of both consumers and employees – redefining the foundations of market relations and organizational models. One of the most influential trends is the transformation of consumption. Consumers increasingly expect fast, inexpensive, and environmentally friendly deliveries, while at the same time becoming more socially and environmentally conscious. There is growing acceptance of de-consumption models based on minimalism, reuse of resources, and localism, as well as of strategies that appeal to consumer emotions by aligning with their worldview [Jasiulewicz 2015, p. 420]. In logistics, this may translate into customer expectations that deliveries be carried out sustainably – using low-emission vehicles, biodegradable packaging, and solutions that reduce the carbon footprint.

Equally important is the economy of time. This phenomenon leaves its mark on virtually every sphere of life, epitomized by the common phrase that "the world has accelerated". In the logistics context, the economy of time manifests itself in consumers valuing not only delivery speed but also the ability to select time windows, track shipments precisely, and access flexible collection channels (e.g., parcel lockers, click & collect). Personalization and delivery control are becoming key factors of customer satisfaction, forcing logistics operators to invest in predictive systems, real-time communication, and automated interactions [Meidutė-Kavaliauskienė et al. 2014, p. 338]. This trend is reinforced by urbanization and changes in household structures. Last-mile delivery is becoming the most costly yet also the most socially sensitive link in the entire logistics process. Challenges such as restricted access to city centers, increasing traffic congestion, legal constraints, and environmental pressures necessitate new solutions – such as microhubs, bicycle deliveries, shared vehicles, and logistics models based on shipment consolidation [Fegde 2025, p. 1].

Environmental megatrends, such as climate change, rising air pollution, and the need for decarbonization, directly influence the investment priorities of logistics firms. Com-

panies are implementing CO_2 reduction strategies, transitioning fleets to electric or hydrogen vehicles, utilizing renewable energy in warehouses, and investing in zero-emission solutions. Some logistics operators are establishing their own packaging recycling centers or return programs, thereby supporting the circular economy [Kedla et al. 2025, pp. 57–59].

An equally important megatrend is the redefinition of work. The labor market is changing under the influence of automation, demographics, and new generational expectations. Younger generations demand flexibility, a sense of purpose in work, diversity, and transparent employment conditions. Logistics companies must respond to these needs by offering new models of collaboration, investing in organizational culture, and implementing sustainable HR standards [Grabowska, Jastrzębowska 2024, pp. 35–37].

At the intersection of technological, social, and environmental megatrends, new business models are emerging. Increasingly, logistics is described as a hybrid service – combining physical transport, digital experiences, and ethical values. The future of the industry depends not only on innovation but on the ability to integrate it with market expectations and responsibility toward the environment. Dynamic technological, social, and environmental transformations are redefining the foundations of logistics enterprises. Whereas competitive advantage was once primarily based on scale, costs, and delivery speed, today it depends more on operational flexibility, the capacity to absorb innovation, openness to megatrends, and sensitivity to consumer needs. From the end customer's perspective, it is no longer just about whether a parcel arrives, but also how, when, in what form, and with what environmental and social consequences. Consumers expect the logistics process to be not only fast and inexpensive but also transparent, environmentally responsible, and consistent with their values. The phrase "fast, cheap, sustainable" is therefore not merely a slogan – it represents the actual matrix of expectations within which logistics companies must now operate.

An integrated approach to megatrends requires that companies' strategic decisions are not made solely in response to short-term market signals, but on the basis of deep analysis of long-term processes. Critical here is the implementation of foresight mechanisms – that is, the systematic identification and interpretation of signals of change and their transformation into concrete action strategies [Rohrbeck 2010, pp. 6, 15–18]. Companies that successfully integrate megatrends into their operational models – both technological and organizational – gain not only a competitive advantage but also systemic resilience. Examples can be found among operators that have transformed their distribution centers into automated predictive logistics hubs, deployed zero-emission fleets, or established networks of urban micro-logistics centers supporting bicycle deliveries. Importantly, this approach should not be reserved exclusively for large corporations. An increasing number of medium-sized firms and local operators are implementing micro-innovations – for example, flexible delivery slot systems, integration with e-commerce platforms, route optimization based on weather data, or infrastructure sharing with other entities. The future of logistics lies not in centralization but in the intelligent distribution of responsibility and knowledge.

Finally, we observe a transition from logistics being perceived as a technical service to logistics as a component of the consumer journey. Delivery becomes the final and often

the most crucial touchpoint with a brand. Negative experiences in this area may undermine the positive perception of the entire commercial offering [Fakher 2025, pp. 1–3, 6–7]. Therefore, adaptation to megatrends cannot be selective. Only enterprises that treat them as an integrated system of interdependencies – encompassing technology, people, values, and the environment – will be able to meet the rising demands of the market. As one of the sectors most exposed to change and social expectations, logistics today faces a choice: either become a creator of sustainable, fast, and inclusive solutions, or be pushed aside by more flexible and attentive players.

The consumer in the e-commerce market

The contemporary consumer market is increasingly shifting toward the digital space, with online shopping becoming a daily practice for a significant portion of society. E-commerce is no longer a complement to traditional sales channels – it has become an equivalent and, in many areas, a dominant model for the exchange of goods and services. Global forecasts indicate that in the coming years, e-commerce will be one of the key drivers of the digital economy, contributing to the redefinition of relationships between providers and consumers. In Poland, similar tendencies are observed: broader Internet access, growing digital competencies, and changing lifestyles mean that online shopping now spans diverse social groups and is becoming an element of everyday consumption [GUS 2024, pp. 109, 124].

One of the evident patterns is that e-consumption is most strongly associated with the level of educational capital. Individuals with higher education are significantly more likely to shop online than other groups, which may be linked to greater openness to technological innovations as well as better financial conditions enabling access to devices and stable Internet connections. At the same time, there is a gradual increase in participation among those with lower educational attainment, suggesting that e-commerce is becoming increasingly inclusive, although it still does not fully eliminate the barriers of digital exclusion [GUS 2024, pp. 109, 124].

Equally clear is the relationship between consumer age and the intensity of online shopping. Younger generations – raised in a digital world and treating online shopping as a natural way of acquiring goods – are the most strongly represented. This group shapes market standards, forcing companies not only to digitalize processes but also to introduce solutions that enhance the convenience, speed, and personalization of deliveries. Middle-aged individuals are increasingly adopting these patterns, which points to the growing universality of e-commerce in society. Older age groups remain less active; however, even within this segment, participation is gradually increasing – partly due to simpler shopping tools and partly as a result of social and family pressures [GUS 2024, p. 124].

Occupational activity is another factor differentiating consumer behavior online. The most active participants remain employees and students, for whom the Internet is an integral part of daily life and work. E-commerce enables them to manage time flexibly and adapt shopping to their fast-paced lifestyles. Self-employed individuals also make use of online shopping, though their growth dynamics are weaker – potentially reflecting

more traditional business models or preferences for direct purchasing. Among the economically inactive and retirees, interest in e-commerce is noticeably lower, confirming the thesis that digital competencies and socio-economic capital are key to adapting to new forms of consumption [GUS 2024, p. 124].

Interesting regularities can also be observed with respect to the place of residence. While city dwellers have long been the natural target group for e-commerce, the growing availability of the Internet and logistics infrastructure means that residents of smaller towns and rural areas are increasingly engaging in online shopping. This phenomenon points to a progressive homogenization of the market – e-commerce is gradually ceasing to be the domain of urban centers and is becoming a standard accessible nationwide. At the same time, regional differences persist, which may result from varying levels of development in local courier services, logistics, or consumer awareness [GUS 2024, pp. 125–126].

The structure of online purchases highlights further characteristic features of the e-consumer. The greatest interest is shown in products that are easy to present online and relatively simple to handle logistically, such as clothing, footwear, cosmetics, or household accessories. Consumers simultaneously expect convenience, flexibility in the choice of delivery options, and the possibility of quick returns. There is also a noticeable rise in the importance of non-price factors: transaction security, transparency of the purchasing process, and the alignment of seller practices with social and environmental values. E-consumers are becoming more conscious – treating a purchase not only as the acquisition of a product but also as an experience that should align with their expectations, lifestyle, and beliefs [Jaciow, Wolny 2011, pp. 12–13].

In summary, the development of the e-commerce market in Poland is shaped by processes deeper than the mere growth in the number of transactions. Educational, age, and occupational factors, as well as place of residence and digital competencies, play a key role. Online trade, on the one hand, promotes the democratization of access to goods, while on the other hand, it reveals disparities in the adoption of new forms of consumption. Enterprises operating in this field must therefore not only invest in technology and logistics but also understand the complex needs and preferences of diverse customer groups. The e-consumer is no longer just an anonymous recipient of an offer – they are becoming an active market participant whose expectations redefine business models, logistics processes, and communication methods. Addressing these expectations is a prerequisite for maintaining competitiveness in an increasingly demanding digital environment.

The specificity of the last-mile delivery process and consumer trends

Until recently, last-mile delivery was analyzed primarily in the context of B2B relations, that is, between enterprises. With the growth of online commerce, however, the service of individual customers (B2C) has gained increasing importance. The key element of this stage is the final segment of the supply chain – from the moment an order is placed

to the delivery of the product at the location chosen by the consumer [Lim et al. 2018, p. 310].

This process is considered the most demanding element of logistics service. This results from the diversity of shipments, the growing intensity of orders, and the need to adapt services to the individualized expectations of recipients. Logistics experts emphasize that last-mile delivery generates the highest costs within the entire logistics chain and, at the same time, is particularly burdensome for the environment [Smyk 2017, p. 1529; Gevaers 2009, p. 4]. This stage involves specialized courier companies and express parcel operators, forming the CEP (courier, express, parcel) segment [Książkiewicz 2011, p. 89].

In the scientific literature, last-mile delivery is primarily analyzed in three dimensions: effectiveness, costs, and environmental sustainability [Mangiaracina et al. 2019, p. 4]. Consumer expectations toward this stage of the process are constantly increasing – they now encompass not only delivery speed and flexibility but also convenience, ecological responsibility, and alignment with a particular lifestyle. Dissatisfaction at this stage may result in the loss of customer loyalty, making it a strategic area for entities operating in e-commerce.

Research indicates that a key factor encouraging online shopping is the availability of convenient delivery options. The most popular solutions are those that provide flexibility of collection – above all, parcel lockers, which allow consumers to decide on the time and place of pickup. Ranked lower are courier deliveries directly to the home or workplace and collections at partner points. Solutions that require the customer's presence at a specific time and place – such as traditional delivery by postal worker or in-store pickup (click & collect) – are less favored [Gemius 2024, p. 109].

Among additional factors motivating online purchases, consumers primarily highlight the proximity of pickup points, the ability to track shipments in real time, flexibility regarding delivery times and days, and the option of managing shipments through a mobile application. Contactless pickup, which increases users' sense of safety and convenience, is also gaining importance. Although mentioned less frequently, the ecological aspect has its place in the hierarchy of expectations – most often in the form of preferences for parcel locker deliveries, which are perceived as more environmentally friendly [Gemius 2024, pp. 121, 145–146].

These preferences translate into the actual choice of delivery options. Parcel lockers remain the most frequently selected solution, developing extremely dynamically in Poland and becoming a part of the everyday landscape. The popularity of this option stems both from its widespread availability and from the ability to align parcel collection with one's daily schedule. Consumers are increasingly reluctant to treat a personal receipt from a courier as a convenient solution – especially in situations where working or study hours prevent them from being at home at the time of delivery [Gemius 2024, p. 115].

Another area of growing expectations is delivery speed and cost. Customers expect free or low-cost shipping while simultaneously demanding that orders be fulfilled as quickly as possible – often even on the same day. This combination of price and time pressures creates significant challenges for logistics companies, which must reconcile economic efficiency with high service quality.

Packaging is also an important element of the last-mile process. It serves not only a protective function but also marketing and aesthetic purposes, influencing the customer

experience. In an era of rising environmental awareness, consumers increasingly expect eco-friendly solutions – biodegradable packaging, reusable materials, or options suitable for repurposing. Packaging thus becomes not only a practical carrier but also a tool for building customer relationships and confirming the values that guide the company [Szymonik, Nowak 2018, p. 96; Mruk 2012, p. 126].

In summary, last-mile delivery in the B2C market is becoming a space where technology, logistics, ecology, and consumer expectations converge. This stage is particularly sensitive – even small shortcomings can determine customer satisfaction and future brand loyalty. The ability to shape this process in a flexible, convenient, and sustainable way is emerging as one of the key determinants of competitiveness in the rapidly developing e-commerce sector.

Research methodology

The article has a theoretical-analytical character and is based on the method of content analysis and literature synthesis. The starting point was the identification of the conditions shaping the functioning of logistics processes in e-commerce, with particular emphasis on last-mile delivery, considered a key element of the consumer experience. Both academic studies in logistics, management, and marketing and industry reports, public statistics, and consumer research findings published by institutions such as the Central Statistical Office (GUS) and international analytical firms were taken into account.

The research procedure comprised three stages. The first involved a review of academic and industry literature, with particular attention to publications on economic megatrends, urban logistics, digitalization, and sustainable development. The second stage consisted of an analysis of statistical reports and empirical research results on e-consumer behavior, preferred delivery methods, ecological and packaging expectations, and factors influencing consumer loyalty. In the third stage, a synthesis of the collected data was conducted, combining conclusions from quantitative studies with a qualitative interpretation of values, attitudes, and market narratives.

A critical approach was applied in the analysis, meaning that not only the declared practices and strategies of logistics companies were verified, but also their consistency with actual activities. Particular attention was paid to discrepancies between market communication and the actual level of process sustainability, with the phenomenon of greenwashing analyzed in this context. This made it possible to identify situations in which marketing strategies associated with ecology may play a merely superficial role, without full reflection in operational practice.

The selection of source material was purposeful – focusing on publications and reports that present the latest trends in e-commerce in Poland and worldwide, as well as those that allow the capture of transformational processes in logistics. A comparative analysis of international and domestic data made it possible to place Polish experiences within the broader context of global megatrends.

The adopted methodology enabled the formulation of conclusions at both the practical level, concerning consumer preferences and market development directions, and the critical level, addressing ecological and social consequences. Thus, the article combines

a desk research perspective with theoretical reflection on the role of last-mile delivery processes in building competitive advantage and corporate credibility in the eyes of contemporary consumers.

Practical ecological solutions in the last-mile delivery process to end consumers

In this part of the analysis, the focus is placed exclusively on the ecological aspects of last-mile logistics. Earlier sections of the article also addressed other megatrends, such as digitalization, automation, personalization, and the redefinition of work. However, environmental issues were selected for in-depth analysis, as in recent years they have been particularly emphasized both in the strategies of logistics enterprises and in consumer expectations. Ecology is also an area where the discrepancy between corporate marketing declarations and actual practices is most evident. Concentrating on this dimension, therefore, allows not only the examination of specific actions but also a critical reflection on the risk of so-called greenwashing.

The implementation of ecological solutions has become one of the key activities of logistics enterprises. A strategic orientation toward sustainable development stems not only from environmental and regulatory requirements but also from economic and reputational considerations. Companies strive to present their positive environmental impact as an element of building competitive advantage and a source of customer loyalty. For this reason, ecology is becoming an integral part of the communication policy and CSR strategies of many operators.

One of the most important ecological solutions in last-mile logistics is the reduction of transport-related emissions. In practice, this translates into the electrification of vehicle fleets and experiments with alternative means of transport, such as electric bicycles. In recent years, Poland's largest logistics companies have been consistently implementing such investments. For instance, InPost currently operates nearly 1,300 electric vehicles, DHL around 400, and DPD Polska approximately 500. Electric bicycles are also being tested – five pilot routes have been selected to examine how bicycles may facilitate deliveries to hard-to-reach locations. Earlier, DPD Polska had already expanded its DPD Pickup Urban Branch network, where parcels are delivered on foot, by bicycle (including cargo bikes), or by scooter[1].

The development of electric fleets, however, requires significant financial investment, making it difficult at present to determine what percentage of total vehicles in individual companies are electric. Nevertheless, most companies' strategic documents highlight objectives related to reducing CO_2 emissions and investing in eco-friendly transport solutions. It should also be stressed that the real environmental impact of electric vehicles depends on the energy sources used for charging. Only when powered by renewable energy can they be considered fully zero-emission. Logistics companies increas-

[1] https://inpost.pl/sites/default/files/docs/dla-prasy/20240828_InPost_powiekszyl_swoja_flote_o_250_elektrycznych_Fordow_E_Transit.pdf; https://www.dhl.com/pl-pl/ecommerce/o-dhl-ecommerce/zrownowazony-rozwoj.html; https://fleetlog.pl/aktualnosci/500-samochodow-elektrycznych-w-dpd-polska/; https://www.dpd.com/pl/pl/o-dpd/o-dpd-polska/ [accessed: 16.09.2025].

ingly report data on the share of renewables in their energy mix. InPost, for example, declared that in 2024 renewables accounted for 45% of its energy consumption, representing a 10-percentage-point increase compared to the previous year. The company also reported that its absolute greenhouse gas emissions had decreased by 15% compared to 2021, with a long-term goal of achieving climate neutrality across the entire value chain by 2040 [InPost 2025, pp. 8, 28, 138]. Similar commitments are announced by other operators – the owner of DPD Polska, Geopost Group, declares its pursuit of carbon neutrality, while DHL Group has set 2050 as its target year for reaching net-zero emissions[2] [Geopost 2024, p. 11].

The second key ecological solution in the area of last-mile logistics is the development of parcel locker networks. These systems allow shipments to be consolidated and delivered to a single location, thereby reducing the number of courier trips and, consequently, emissions. According to InPost data, deliveries to parcel lockers can reduce CO_2 emissions by as much as 75% compared to direct home deliveries [InPost 2025, p. 23]. By the end of the first quarter of 2025, there were approximately 53.7 thousand parcel lockers operating in Poland, more than 25.7 thousand of which belonged to InPost. Other operators – such as DPD, Orlen, DHL, Allegro, and Poczta Polska – are also expanding their own networks[3]. However, for parcel lockers to fulfill their ecological role, they must be used appropriately – shipments should be collected "on the way", for example, on the commute to work or during daily shopping trips, and the distance from the consumer's home should allow for access on foot or by bicycle. InPost reports that 64% of parcel lockers in Poland are located within a 7-minute walking distance, with this figure reaching nearly 90% in urban areas [InPost 2025, p. 26].

Another important area of ecological initiatives concerns packaging. Companies aim to ensure that packaging is recyclable, produced from secondary materials, and, in some cases, reusable for other purposes. DHL, for instance, offers packaging that is fully recyclable and made entirely or largely from recycled materials (e.g., cartons, poly mailers, envelopes)[4]. InPost applies similar solutions, declaring that its packaging is also derived wholly or partly from recycled sources [InPost 2025, p. 153].

Pro-ecological solutions also include other operational measures, such as reducing energy consumption in sorting centers through process automation or the use of energy-efficient lighting. Additional initiatives worth mentioning serve both environmental and branding purposes. DHL, for example, runs the "PaczULE" project, under which five beehives (a total of 250,000 bees) were installed at the company's headquarters in Warsaw. The company also participated in tree planting with the Klub Gaja initiative – planting 250 pine trees in the Bogatki Forest District. Furthermore, DHL highlights its possession of certifications confirming compliance with energy management (ISO 50001) and environmental management standards (ISO 14001)[5]. InPost, within its sustainable development programs, implements initiatives such as eco-returns, the InPost Green City program, the installation of parcel lockers in hospitals and airports, participation

[2] https://group.dhl.com/en/sustainability/sustainability-roadmap.html [accessed: 16.09.2025].
[3] https://www.cashless.pl/16806-automaty-paczkowe-liczba-1-kwartal-2025 [accessed: 20.07.2025].
[4] https://www.dhl.com/pl-pl/ecommerce/o-dhl-ecommerce/zrownowazony-rozwoj.html [accessed: 16.09.2025].
[5] Ibid.

in clean-up campaigns in the Polish mountains and the Baltic Sea, testing of packaging return systems, and other activities. The company also holds ISO 14001:2015 certification for environmental management[6].

To systematize the examples of environmental activities presented and indicate their broader strategic context, the key megatrends affecting last-mile delivery models are summarized below. The table organizes both the main directions of change in the technological, social, and environmental spheres, as well as their practical implications for the logistics sector. It also includes examples of solutions implemented by companies operating on the Polish market and the potential risks associated with their implementation, including the phenomenon of greenwashing, which increasingly undermines the authenticity of pro-environmental declarations. This overview shows that last-mile delivery processes are at the intersection of real transformation and marketing narratives, and their effectiveness depends on both technological innovation and the credibility of communication with stakeholders.

The summary presented in the table confirms that pro-environmental activities in last-mile logistics should be analyzed in the broader context of technological, social, and environmental megatrends. The solutions implemented – from fleet electrification to the development of eco-packaging – are an important step towards reducing the negative impact of last-mile logistics on the environment, but their actual effectiveness depends on their consistency with the company's long-term strategy and the scale of implementation. In many cases, green initiatives are fragmented and focus on areas that are most visible to the customer, which helps to build a positive image but does not always translate into measurable environmental results. Therefore, when assessing the effectiveness of pro-environmental measures, attention should be paid not only to their communicative appeal, but above all to actual data on emissions reduction and resource consumption. Only such an approach will allow us to distinguish genuine sustainable development practices from those that are part of greenwashing rhetoric.

When considering the environmental aspects of logistics, it is therefore essential to remember the need to take a holistic view of the product life cycle. Pro-environmental actions must encompass not only the operational phase but also production and subsequent disposal. At the same time, consumer behavior plays a critical role, such as collecting parcels in environmentally friendly ways (e.g., on foot), proper segregation of packaging, or its reuse.

In summary, the range of ecological initiatives in last-mile logistics is broad, covering investments in transport infrastructure and devices, changes in packaging, and internal operations. However, the question of their actual impact remains open. Are these measures implemented on a scale sufficient to bring about genuine environmental improvement, or do they primarily serve a communication function? To avoid accusations of greenwashing, logistics enterprises must demonstrate not only appealing initiatives but, above all, measurable effectiveness in reducing emissions and lowering their environmental footprint.

[6] https://inpost.pl/strategia-esg; https://inpost.pl/sites/default/files/docs/dla-prasy/2024-04-17_Paczkomat_InPost_w_szpitalach.pdf; https://inpost.pl/sites/default/files/docs/regulaminy/certyfikat-iso-9001-2015-iso-14001-2015-922272.pdf [accessed: 20.09.2025].

Table 1. Megatrends influencing last-mile delivery models and their implications for logistics practices
Tabela 1. Megatrendy wpływające na modele dostaw na ostatniej mili i ich implikacje dla praktyk logistycznych

Megatrend area	Key phenomena/ directions of change	Impact on last--mile delivery models	Examples of solutions in practice	Potential risks/challenges (including greenwashing)
Technological	Digitalization of processes, internet of things (IoT), artificial intelligence (AI), automation, predictive analytics, blockchain	Improved route planning and monitoring, warehouse automation, real-time data integration, enhanced customer service	InPost – automated sorting centers; DHL – predictive systems; DPD – parcel tracking apps	High implementation costs, lack of system interoperability, cybersecurity threats, dependency on technology providers, risk of superficial "innovation"
Social	Urbanization, time economy, service personalization, lifestyle changes, redefinition of work	Growing demand for fast and flexible deliveries, development of pickup point networks and parcel lockers, need for better customer communication	Partner points (Żabka, Orlen, Ruch); Click & Collect; mobile parcel management apps	Cost pressure, courier over-exploitation, work-life imbalance, "green consumer paradox" – eco-declarations without behavioral change
Environmental	Green transition, decarbonization, circular economy, ESG reporting	Fleet electrification, expansion of parcel locker networks, use of eco-packaging, carbon footprint reduction initiatives	InPost – 1,300 electric vehicles, Green City program; DPD – 500 electric vehicles, cargo bikes; DHL – GoGreen program, ISO 14001 and 50001 certificates	Risk of greenwashing (claims without data), limited scale of pilot projects, lack of unified emission measurement methods, selective reporting of achievements
Consumer (interdisciplinary)	Growing environmental awareness, demand for transparency, personalization of shopping experience	Shaping standards of "fast, cheap, and eco-friendly" delivery, focus on convenience and delivery control	Widespread use of parcel lockers, shipment tracking options, development of eco-returns	Inconsistency between declarations and actual behavior (e.g., home delivery instead of parcel locker), image-driven rather than substantive change

Source: own elaboration
Źródło: opracowanie własne

Conclusions

The analysis of last-mile logistics processes shows that the shaping of delivery models is now largely determined by technological, social, and environmental megatrends. Ongoing digitalization and automation of transport processes, urbanization, and increas-

ing regulatory pressure regarding climate protection compel enterprises to redefine their strategies. Fleet electrification, the testing of electric bicycles, and the development of parcel locker networks are responses to the need to reduce emissions, while at the same time serving as tools for building competitive advantage and shaping the image of companies as socially responsible entities.

In this process, the preferences of e-consumers play an increasingly important role. Expectations regarding the speed and flexibility of deliveries, as well as growing emphasis on ecological and packaging aspects, are redefining service standards in e-commerce. Consumers demand transparent information, the ability to track shipments, convenient access to parcel lockers, and packaging that can be reused or recycled. At the same time, actual consumer choices – such as the preference for free home deliveries instead of consolidated pickup points – reveal a paradox: pro-environmental declarations do not always translate into real behavioral changes that support sustainable development.

Finally, the analysis exposes a tension between corporate declarations and the actual effects of their actions. Some initiatives are limited to pilot projects or symbolic CSR activities, whose environmental impact is difficult to measure. In such cases, ecological narratives serve primarily a marketing function, fitting into the phenomenon of greenwashing. This risk undermines the credibility of the entire sector if pro-environmental claims are not supported by transparent data and long-term emission reduction strategies.

In conclusion, the future of last-mile logistics will depend on the ability of enterprises to authentically integrate sustainable practices into operational models, along with a parallel shift in consumer attitudes. Only then will green logistics cease to be an element of PR narrative and become a real factor influencing purchasing decisions, as well as a tangible contribution to environmental protection.

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