Z E S Z Y T Y N A U K O W E P O L I T E C H N I K I P O Z N A Ń S K I E J
Nr 87 Organizacja i Zarządzanie 2023

Karolina OLEJNICZAK[*], Anna DĘBICKA[**], Jakub ZIELEWICZ[***], Julia URBAŃSKA[***], Marta SCHAB[***], Sylwia NOWAK[***]

GREEN LOGISTICS IN E-COMMERCE: GOALS AND CHALLENGES

DOI: 10.21008/j.0239-9415.2023.087.07

Amidst the booming e-commerce industry, the issue of its environmental impact is increasingly being raised. The fight for green solutions has become a hot topic in the wider e-commerce industry. The aim of this article is to determine the goals and challenges of green logistics taking into account the specificity of the e-commerce industry and to formulate conclusions for business practice in terms of green solutions. The research method used in this paper is the literature review, documentary method, the analysis of statistical data and desk research, analysis of industry reports and analysis of legal acts. The research material consisted of scientific publications, as well as Eurostat statistics, domestic and foreign reports, and expert opinions of national and international institutions. The obtained data and ex post results were the basis for own considerations. The results concern the comparison of traditional trade and e-commerce and their impact on the natural environment, the goals and challenges facing current green logistics. Next, the possible solutions for business practitioners are indicated.

Keywords: sustainable development, environment, challenges, e-commerce, green logistics, traditional trade

1. INTRODUCTION

The growing global problem that arose with the development of civilization, as well as its impact on the natural environment, more and more often leads to reflection

[*] Politechnika Poznańska, Wydział Inżynierii Zarządzania. ORCID: 0000-0003-3563-8015.
[**] Politechnika Poznańska, Wydział Inżynierii Zarządzania. ORCID: 0000-0001-9885-0799.
[***] Absolwent, Politechnika Poznańska, Wydział Inżynierii Zarządzania.

on the direction of activities of enterprises, organizations, societies and their constant growth, both economic and civilizational.

Today, businesses cannot act solely to profit at the expense of the environment, society, economy, consumers, and workers. There is an unquestionable need not only for businesses, but also for consumers, to take more ecological measures that have a much lower impact on the natural environment.

In recent years, companies in the TSL industry introduced many solutions to reduce the negative impact of transport on the environment. They introduced, among others, ecological packaging, parcel lockers, optimizing loading or replacing the fleet of vehicles with combustion engines for electric ones. All these activities reduce CO2 emissions to the atmosphere and respond to customers' growing ecological requirements.

This article presents concepts, activities, and ecological solutions in the area of e-commerce logistics in line with the need for conscious changes. Numerous searches inspired the work for ecological solutions by consumers and enterprises, and the growing interest of societies in logistics based on pro-ecological activities.

The aim of this article is to determine the goals and challenges of current green logistics taking into account the comparison of traditional trade and e-commerce and to formulate conclusions for business practice in terms of green solutions. The research method used in this paper is the literature review, documentary method, the analysis of statistical data and desk research, analysis of industry reports and analysis of legal acts.

The paper consists of several parts. In the first steps we overview the e-commerce definitions. Then we present the research material and methods. In the next step we compare e-commerce and traditional trade. Next, we formulate the goals of green logistics inherent in e-commerce and contemporary challenges. Finally solutions proposed for enterprises are presented and possible further directions for the development of green logistics are indicated.

2. OVERVIEW OF E-COMMERCE DEFINITIONS

The word e-commerce comes from the English language and means electronic commerce, which includes both online stores and portals, platforms, forums, groups and social media (Peatzold, 2010).

The Eurostat Handbook (Eurostat, 2017) provides a variety of explanations on potential interpretation issues. As an example, reservations used in certain sectors of the economy (e.g., for accommodation) are treated as “orders”. The manual also states that orders placed via electronic data interchange (EDI) messages essentially characterize B2B e-commerce. B2C interactions, on the other hand, usually take the form of online transactions. It also states that online sales can be made through an

online store (website, e-commerce exchange), web forms on a website or extranet, or "app" through various types of internet access (computer, laptop, mobile phone, etc.).

The definition used by the US Census Bureau (2018) is similar. It adds that e-commerce may also include sales where the price and terms of sale are negotiated over the Internet, mobile device (m-commerce), extranet, EDI network, e-mail or other comparable online systems. As with the OECD and Eurostat definitions, payments can be made online or offline. Although this approach is a bit broader, it should be noted that it focuses on the method of initiating a purchase. The form of delivery and the nature of the product are of secondary importance.

According to Statistics Canada (2016), e-commerce is any sale of goods and services, if the order and the commitment to purchase takes place over the Internet. Payment may be made in a different way. This definition also clarifies that e-commerce includes orders placed over the Internet, extranet or EDI, excluding orders placed by telephone, fax or e-mail.

The Japanese Ministry of Economy, Trade and Industry (METI) (2016) defines e-commerce in a narrow and broad sense. In the narrow sense, e-commerce are transactions understood as orders issued via computer network systems using Internet technologies. Contract amounts are recorded in these systems. In a broader sense, "the Internet" is replaced by "computer network systems".

In private sector research, the term e-commerce is often not defined in detail at all. For example, in the DHL study (2017), e-commerce is defined as the shipment of physical products from the warehouse of the selling company directly to consumers in another country in the form of a package. Definitional ambiguities also appear in business literature and the media. Depending on the audience, e-commerce refers to either B2B transactions, e.g., in the context of global value chains, or B2C transactions as retail, not both.

The e-commerce work program of the World Trade Organization (WTO) defines e-commerce very broadly as "the production, distribution, marketing, sale or supply of goods and services by electronic means" (WTO, 1998). In terms of trade in services, according to the WTO, e-commerce is: the provision of Internet access services, the provision of services by electronic means and the use of the Internet as a service distribution channel, i.e. services are purchased via the Internet, but then delivered to consumers in a form other than electronic. Of these three types of services, only the use of the Internet as a distribution channel would fall under today's OECD definition. The other two options would only be covered to the extent that these services were procured over a computer network.

Due to the complexity of the issue, in particular from a trade policy perspective, the term "digital commerce" has been used more and more in recent years. Digital commerce includes digital transactions of goods and services that can be delivered both digitally and physically (López González & Jouanjean, 2017). This definition covers e-commerce transactions as defined by the OECD, but also several distinct types of cross-border transactions such as digitally provided services, regardless of

how they are ordered. This categorization of digital trade is currently used for statistical purposes by the international community (OECD, 2017) and also to measure the contribution of digital transformation to gross domestic product (GDP).

As a result, e-commerce is just one element of a broader topic. In the discussion of cross-border trade policy, the term e-commerce is often used in line with the more comprehensive understanding of the WTO. When it comes to measuring trade, the use of the term usually follows the OECD definition and generally focuses on the procurement process.

There are six types of e-commerce:

1) B2B (business to business) – includes any electronic transfer of products or services between companies. This is the approach used by manufacturers, distributors and traditional wholesalers.
2) B2C (business to consumer) – trade in partnership between companies and end customers, e-commerce shopping section where conventional retailing usually takes place. Partnership styles can be more or less complex, repetitive or sporadic.
3) C2C (customer to customer) – involves the trading of goods or services by electronic means between customers. The exchange is most often done by a third party offering an online trading forum.
4) C2B (consumer to business) – inverted normal context of the exchange of goods. An e-commerce method widely used in crowdsourcing companies that target certain types of services or items and individuals sell their services or products, e.g., places where artists ask for several logo designs, only one of which is selected and purchased.
5) B2A/B2G (business to administration/government) – covers all online transactions between businesses and the government. This is a range of diverse programs, especially in the areas of taxation, healthcare, legal documentation, registries, etc. These areas have been greatly expanded in recent years with e-government spending.
6) C2A/C2G (consumer to administration/government) – covers all electronic purchases between governments and individuals. The most important applications are e.g., education – disseminating information, distance learning; social security – distributing information, making payments; taxes – filing tax returns, payments, etc. (Jain et al., 2021; Zhang et al., 2017).

However, the listed types of e-commerce do not exhaust the list of existing partnerships. Due to the dynamic development of e-commerce, we can distinguish new types (Fig. 1), among them:

– B2M – (business to manager) – unlike the other types, the target group is the company or the product seller instead of the final consumer (He et al., 2018).
– B2E – (business to employees) – includes the use of the network to provide employees with information about products or services (Payton, 2003).

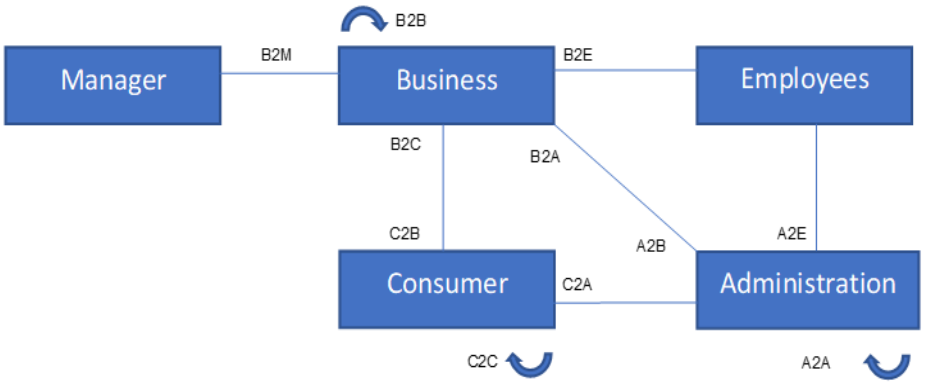

Fig. 1. Types of models in e-commerce (own elaboration based on He et al., 2018; Payton 2003; Zhang et al., 2017)

Every product can be sold through e-commerce, from food, toys, and clothes, to cars and raw materials. If the product cannot be ordered over the Internet, companies limit themselves by presenting offers on the website and further contact with the customer.

3. RESEARCH MATERIAL AND METHODS

The research problem and the adopted research goal required the use of different research methods. This study uses the literature review, the documentary method, the analysis of statistical data and desk research, analysis of industry reports and analysis of legal acts. The research material consisted of scientific publications, as well as Eurostat statistics, domestic and foreign reports, and expert opinions of national and international institutions. The obtained data and ex post results were the basis for own considerations.

The results obtained, though not based on quantitative predictions, can be a starting point for future scientific discussion. They can also be used in business practice, in particular by management boards of trade, transport, and logistics companies. Our considerations are also intended to provide information to enterprises that have to make certain decisions well in advance in order to adapt better for upcoming changes. These considerations are also intended to provide certain recommendations regarding the research problem.

4. COMPARATIVE ANALYSIS OF E-COMMERCE AND TRADITIONAL TRADE

The dynamic development of the Internet and modern technologies has significantly influenced the development of e-commerce worldwide. The pandemic and the temporary closure of brick-and-mortar stores intensified the rapidly growing e-commerce industry. Online shopping, as opposed to traditional commerce, is inextricably linked with delivery to the end customer (Antonowicz, 2016). Along with the popularisation of e-commerce, the requirements of consumers are also growing, including those related to limiting the impact on the natural environment. The question arises, how does e-commerce affect the natural environment. Reflecting on this topic, one can see piles of plastic and foil packaging that quickly turn into waste that is unfavourable to the environment. Many people see non-ecological solutions in the use of fossil fuels that increase the emissions of exhaust gases into the atmosphere during transport. In reality, however, e-commerce differs significantly from the expectations of a potential customer (Kawa, 2014).

The e-commerce sales model is much more favourable regarding savings and emissions to the atmosphere in terms of transport than in traditional trade (Escursell et al., 2021). Combining parcel deliveries maximizes the number of goods transported within the city, thus reducing transport emissions and ensuring more efficient distribution (Prologis, 2019). The comparative analysis between e-commerce and traditional trade is presented below (Fig. 2).

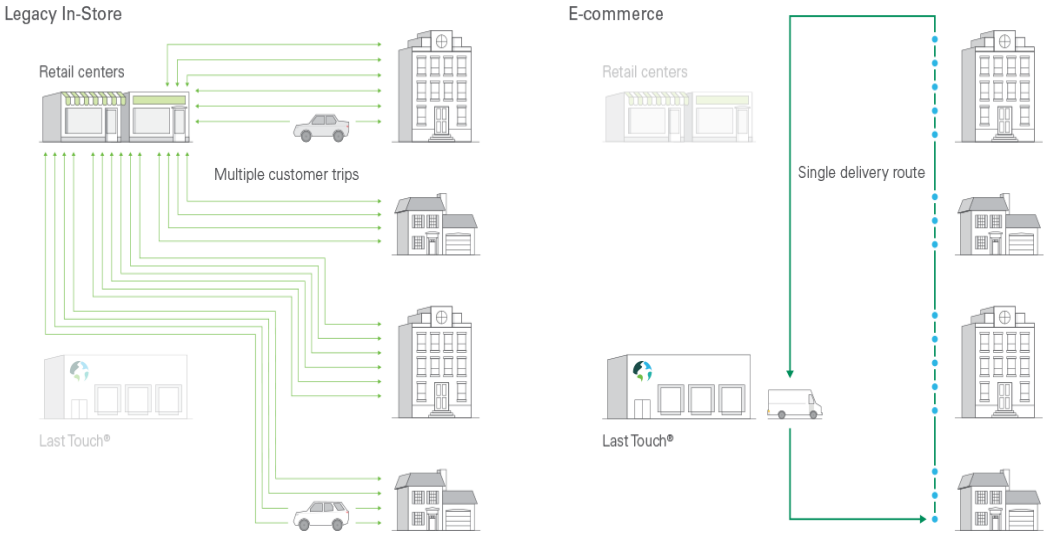

Fig. 2. Comparison of e-commerce and traditional trade (Prologis, 2019)

An environmental analysis of Internet shopping in the United States conducted by the Center for Transportation and Logistics (MIT) (Weideli, Cheikhrouhou, 2013) in terms of carbon footprint proves that e-commerce produces significantly less carbon dioxide than traditional commerce. The study considered the impact of factors such as packaging, last-twist transport, delivery to the customer, and the operation of physical stores and the data centre, comparing e-commerce with traditional commerce. Consolidating the flow of goods into an optimized network for e-commerce provides a much smaller carbon footprint than traditional commerce. This means that e-commerce is more sustainable than point-of-sale in this sense.

CO2 production in the case of stationary shopping is several times higher than in the case of e-commerce. A consumer ordering a product via the Internet does not have to visit the store thus, it reduces the emission of exhaust gases into the atmosphere. In e-commerce, individual orders are combined with orders from other customers and delivered along the same route. This delivery method is much more efficient than individual trips to a stationary store, often several times (Prologis, 2019). A comparison of the amount of carbon dioxide emissions depending on the trading model is presented in Fig. 3.

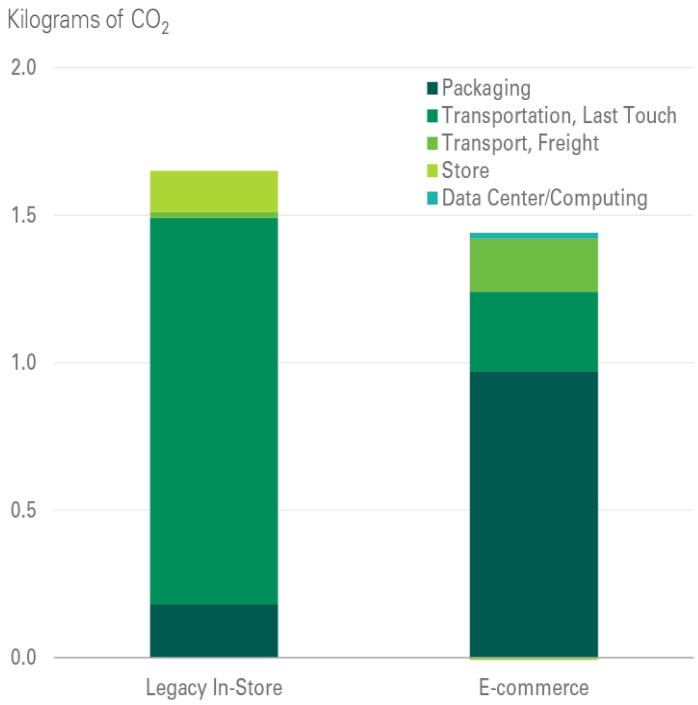

Fig. 3. Comparison of carbon dioxide emissions depending on the trading model (Prologis, 2019)

In e-commerce, however, we deal with much more packaging than in the case of stationary trade. It accounts for more than 50% of the total carbon dioxide emissions released into the atmosphere due to e-commerce. However, compared to the carbon footprint of traditional transport, this value is 25% lower. It is estimated that by purchasing online, retail trade reduces its overall negative impact on the environment by approximately 15% while supporting sustainable operations. By replacing trips to stationery stores, home deliveries or a parcel locker, help reduce carbon dioxide emissions into the atmosphere, even considering additional packaging or a higher return rate (Prologis, 2019).

To sum up, e-commerce is a branch of the economy that offers great opportunities for both sellers and buyers, but it is directly related to transport logistics, without which the ordered goods would not be able to reach customers (Gay, Hembrooke, 2004). A study by the Center for Transportation and Logistics in the United States (Weideli, Cheikhrouhou 2013) shows that e-commerce, in terms of ecology, has a significant advantage over traditional commerce in many respects. However, some aspects of e-commerce have a negative impact on the environment due to their growing importance in the general exchange of goods. These are factors related to non-ecological packaging and transport to the customer. In order to reduce the negative impact of e-commerce on the environment, the TSL industry started working to introduce ecological solutions. Scheduling deliveries, warehousing goods, and limiting returns are e-commerce processes that still need to be optimized to increase environmental protection through, for example, reducing carbon dioxide emissions as much as possible. The next chapter is devoted to explaining the goals and challenges of green logistics.

4. GREEN LOGISTICS

4.1. Goals of green logistics

The so-called green logistics includes pro-ecological solutions and solutions reducing CO2 emissions. Green logistics as an area of activities covers all efforts to minimize the negative impact of logistics activities on the natural environment (Hammond, 2001). The SARS-CoV-2 pandemic, which since 2019 has strongly marked the position of electronic commerce on global markets, also contributed to the increase in the popularity of pro-ecological solutions (Jinru et al., 2022).

There are many green logistics goals for which it is increasingly used in enterprises, but the most important include:

(1) Reducing the negative environmental impact in logistics processes. It is related to shaping and protecting the natural environment in the processes undertaken in a way that benefits both the economy and society. This applies to those logistic

principles that are synonymous with maintaining sustainable development. Sustainable development is a concept that focuses on economic progress but in a way that is the least harmful to natural resources as possible. At the same time, activities under green logistics should be tantamount to lowering operating costs, which should positively impact the increase in profits in a logistics, distribution, or transport company (Witkowski, Pisarek 2017, United Nations, 2015).

(2) Analysing the current supply chain with respect to ecological principles. Redesigning or adapting such a supply chain should enable activities such as reducing water and soil pollution and noise emissions. A fundamental goal of green logistics is the use of available resources in a rational and environmentally sound manner (Krzywda, 2012).

(3) Reducing the environmental burden by changing the method of selecting the means of transport, reducing the amount of waste generated, or supporting recycling in the products and packaging used.

(4) Calculating and analysing the carbon footprint generated by the organization during the execution of the supply chain and all logistic activities. Operators must use the PN-EN 16258: 2013 standard "Methodology for the calculation and declaration of energy consumption and GHG emissions of transport services (freight and passengers)" or its equivalents that define the methodology for measuring the pollutants generated. The results of this measurement are the basis for introducing actions that aim to reduce the carbon footprint. Among the gases, the emissions, in addition to CO2, are also methane and nitrogen dioxide. Forecasts say that by 2050 the volume of freight transport may increase by about threefold, which means that measures to eliminate air pollution must be taken as soon as possible.

(5) Selecting suppliers who also use ecological solutions. By acting together and encouraging good practice, achieving the goal of caring for the environment that people benefit from together is more accessible.

The indicated goals require a number of changes in the business. It is worth emphasizing that the need for changes is noticed not only by enterprises but also by more aware consumers who, by influencing the former, contribute to the development of logistics in a more sustainable and ecological direction.

4.2. Challenges of green logistics

Introducing the principles of green logistics in enterprises is not easy, as it is associated with many paradoxes and challenges (Cudziło, 2020). First, introducing new solutions in logistics processes, warehousing, changing infrastructure, or automating processes initially requires investing significant financial contributions, which enterprises are unwilling to do. Using low margins by competitors does not help generate additional funds for further investments. The widespread use of fossil fuels has no rational alternatives in many countries (Axsen et al., 2020; Brand et al.,

2021), although there are options that are more beneficial to the environment, such as biofuels. However, for financial or ergonomic reasons, implementing them on a larger scale is not profitable yet. The use of electric vehicles will also not work currently in this industry because of the very high costs.

When using green logistics, many entrepreneurs also indicate external factors that are not dependent on them, such as traffic jams or bottlenecks. The infrastructure used very often does not favour ecological solutions. These are, for example, selected hours for reloading.

The biggest paradox is that the customer in the e-commerce industry, is both the driving factor and the enemy of green logistics. At the same time, consumers are increasingly more ecologically aware and notice such wastage in enterprises as using foil packaging, attaching paper return forms, packing small products into large packages, or sending parcels in batches from the same place. In addition, in the eyes of conscious customers, companies that care about green logistics are gaining more and more recognition, which may soon lead to the creation of a competitive advantage in the industry.

On the other hand, even informed customers do not always want to pay for the company's ecological activities (more expensive deliveries to collection points, ecological packaging of products at shipment) and would prefer to pass these costs on to the supplier and producer. At the same time, customers who choose to buy in the e-commerce industry most often expect express delivery, even within 24 hours after placing the order, preferably at the price of the purchased products. Time is a key factor for consumers, and they are unaware of how complex the supply chain is from placing an online order to receiving it. Given such requirements, planning "green routes" and managing a fleet of vehicles is extremely difficult and is nowadays a huge challenge for companies in the logistics industry.

A related problem is also the *last mile,* which adversely affects the increase in urban traffic, which is filled with delivery vans from courier companies. These companies, responsible for the last part of the supply chain, i.e., delivery to the end customer, generate enormous air pollution, primarily within cities. In the next 10 years, the situation may look even worse, as the emission of pollutants by courier companies in the world's largest cities may increase by approximately 30% (Tsemekidi, Tzeiranaki et al., 2023).

Another problem faced by logistics are the so-called *empty runs*. According to Eurostat (EUROSTAT, 2021), in 2020, about 20% of the transport in the European Union was empty trucks, which thus covered about 35 billion unnecessary kilometres. Here, digital data analysis can be useful to identify common points during transport or cooperation programs that enable sharing of transport through information about common transport points. Due to this, it is possible to eliminate fuel consumption and the number of delivery vehicles in use, which positively affects CO2 emissions. It is extremely important as the forecasts say that extra-urban road transport in 2050 will achieve an increase of 0.2 billion tons of CO2 emissions. Currently, this emission is high and amounts to 1.5 billion tons.

Among the problems of green logistics is the policy issue, which includes requirements and regulations. They may be concerned about the lack of harmonization between European countries, which adversely affects the unification of the principles of introducing green logistics.

One of the main challenges facing e-commerce is also giving up non-recyclable packaging, such as plastic or foil. Apart from the European Parliament's guidelines (Directive (EU) 2019/904) on the ban on single-use plastics, an important aspect is also changing preferences and increasing customer awareness. The Loyalty360 study (Brohaugh, 2015) found that 73% of US consumers refused to buy a product they believed had a negative impact on the environment. Consumers expected ecological responsibility on the part of distributors and more and more often chosen eco-delivery, even if it involved additional costs (NielsenIQ, 2019).

Taking into account the reports on corporate social responsibility (CSR) and ethics in e-business made by the Chamber of Electronic Economy in Warsaw (Izba Gospodarki Elektronicznej, 2021), more than half of consumers, when choosing an online store, consider whether a given enterprise follows the principles of sustainable development. According to research, e-consumers are more likely to buy in an online store that minimizes its negative impact on the natural environment. As many as 71% of Poles buying online declare that they note whether the parcel they receive is packed in an ecological manner, and 49% of respondents would pay extra for such a solution. It is an aspect that makes the company more competitive in the market.

5. SUMMARY AND CONCLUSIONS

Nowadays, enterprises place great emphasis on reducing the negative impact on the environment. Compliance with environmental protection requirements imposed by, among others, the European Union is no longer just an unpleasant obligation but one of the key aspects of competitive advantage on the market. In addition, the EU introduced the obligation to report on the implementation of sustainable development principles in enterprises (Directive 2013/34/EU and Directive of the European Parliament and of the Council 2014/95/EU amending the directive 2013/34/) regarding disclosure of non-financial information and information on diversity by some large units and groups.

On the other hand, consumers are not only more willing to use but increasingly require companies to use environmentally friendly solutions. In order to meet their expectations, the TSL industry dynamically develops green solutions. Research shows that the impact of e-commerce on the environment is much less harmful in terms of fossil fuel emissions into the atmosphere than traditional trade. However, e-commerce generates vast amounts of foil packaging, thus negatively affecting the industry's perception in terms of ecology. That is why it is so important to introduce

modern, ecological solutions, such as parcel lockers, electronic fleets of vehicles, or drones in terms of deliveries to the customer.

The e-commerce industry has a number of solutions that replace foil or plastic with ecological solutions such as cardboard boxes, paper, or plant packaging. The change of packaging to ecological alternatives is not only a trend dictated by the current fashion. It is also a serious investment in a better natural environment condition, which can pay off in the form of significant profits for a given company (Hnatyszyk, Paszek, 2021). Ecological e-commerce packaging finds the perfect compromise between the excellent quality of the material used and the reduction of harmfulness to the ecosystem. These solutions are also dictated by the green logistics policies (GLP), which aim to progress green logistics, promote green growth, and implement sustainable development (Zhang et al., 2020).

The environmental impact of *last mile* logistics also significantly impacts e-commerce. The end of the supply chain is the most problematic and costly part of transport, thus being a powerful source of carbon dioxide emissions into the atmosphere. One of the key trends is the increase in the use of parcel machines. They turned out to be a convenient, flexible, and safe alternative to traditional courier deliveries to the door. Compared to door-to-door deliveries, parcel lockers significantly reduce CO2 emissions in urban areas by almost 66%. Along with the development of parcel machines during the pandemic, companies in the TSL industry began investing in a fleet of electric vehicles, reducing both fuel-related costs and the negative environmental impact of fossil fuels (Smyk, 2020).

Transport companies looking for ecological solutions that improve transport to the customer are focused on optimizing the loading of cars. Many trucks are not loaded efficiently. This results in wasted kilometres travelled, a waste of money, and additional CO2 emissions. To reduce the number of empty vehicles on the road, drivers can use freight exchanges and take additional orders for the return journey. Such ecological logistics facilities are developing increasingly, enabling companies to share transport and packaging, reducing the number of empty journeys (Marczewski, 2019).

Courier services are one of the fastest-growing areas of freight transport (Pyza, Jachimowski, 2015). Therefore, it is advisable to look for newer and newer solutions both by owners of logistics companies and by owners of online stores. In recent times, trends in logistics can also be observed, such as increased environmental awareness, waste flow management (Seroka-Stolka, Ociepa-Kubicka 2019, Sosnowski, Cyplik, 2022), product personalization, or the development of technology that reduces the negative effects on the environment (Strandhagen et al., 2017, Tobola, 2022).

Artificial intelligence is the fastest growing technology in the world (Różanowski, 2007). Artificial intelligence, in particular machine learning, can help sellers accurately forecast demand for various products (Lingam, 2018) and better monitor demand and replenishment time to prevent, for example, wasting resources. Artifi-

cial intelligence is also used in the e-commerce warehouse (Zhang, 2021). It increases the productivity of the processes taking place there, especially in combination with the Warehouse Management System (WMS) that manages inventories more efficiently and allocates goods in the warehouse based on various important factors and dependencies, such as the appropriate room temperature, affecting product shelf life. Artificial intelligence also helps to develop appropriate route optimization to reduce the carbon footprint.

Another technological innovation that is currently being researched are drones, i.e., unmanned aerial vehicles that are controlled or autonomously flying. They can be used for the transport of light consignments. Drones would deliver *last mile* logistics in highly urbanized or inaccessible areas, i.e., at the stage generating the most pollution. The food sector also considers the possibility of using them to service the *last mile* – e.g., delivery of take-away meals prepared by restaurants or delivery of catering to the customer's door, as well as delivery of food products purchased online (Giones, Brem, 2017).

Predictive Analytics is an area that has grown in importance in recent times. It includes forecasting trends, phenomena, consumer behaviour, and anomalies based on data from past activities and company results. This type of implementation allows for the accurate allocation of resources and investments in the enterprise. Thanks to predictive analysis, various systems can analyse data, draw conclusions based on it and accurately forecast future sales results (Usmani, 2017). For example, building forecasts based on observations to reduce empty cargo spaces (Viellechner, 2022) or optimize cargo transport to reduce the carbon footprint.

Taking into account the results of our considerations, further development towards green logistics is a necessity and the only right path. To make it possible, it seems that also educational and development activities on the part of enterprises, consumers and policy makers are needed.

REFERENCES

Antonowicz, M. (2016). Warszawa Handel internetowy – implikacje dla logistyki. *Handel Wewnętrzny*, 2(361), 5-16.

Axsen, J., Plötz, P., Wolinetz, M. (2020). Crafting strong, integrated policy mixes for deep CO2 mitigation in road transport. *Nature Climate Change*, 10(9), 809-818, https://doi.org/10.1038/s41558-020-0877.

Brand, C., Götschi, T., Dons, E., Gerike, R., Anaya-Boig, E., Avila-Palencia, I., Nazelle, A. d., Gascon, M., Gaupp-Berghausen, M., Iacorossi, F., Kahlmeier, S., Int Panis, L., Racioppi, F., Rojas-Rueda, D., Standaert, A., Stigell, E., Sulikova, S., Wegener, S., Nieuwenhuijsen, M.J. (2021). The climate change mitigation impacts of active travel: Evidence from a longitudinal panel study in seven European cities. *Global Environmental Change*, 67, 102224-15, https://doi.org/10.1016/j.gloenvcha.2021.102224.

Brohaugh, B. (2015). Green Marketing Remains Important to Customers–But Can Raise Skepticism. Retrieved from: https://loyalty360.org/content-gallery/daily-news/survey-green-marketing-remains-important (05.05.2023).

Brdulak, H., Michniewska, K. (2009). Zielona logistyka, ekologistyka, zrównoważony rozwój w logistyce. *Logistyka*, 10, 8-15.

Cudziło, M. (2020). Zielona natura logistyki. *Logistics Manager*, 6, 24-31.

Czuchaj-Łagód, K., Duk, K., Dzięciołowska, A. (2020). Green Generation Raport, Mobile Institute. Retrieved from: https://eizba.pl/wp-content/uploads/2020/01/GreenGeneration_WspolnieNaRzeczZiemi.pdf (23.05.2023).

DHL (2017). The 21st century spice trade – A guide to the cross-border e-commerce opportunity, DHL Express. Retrieved from: http://www.dhl.com/content/dam/downloads/g0/press/publication/g0_dhl_express_cross_border_ecommerce_21st_century_spice_trade.pdf (23.05.2023).

Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment. Retrieved from: https://eur-lex.europa.eu/eli/dir/2019/904/oj (23.05.2023).

Escursell, S., Llorach-Massana, P., Roncero, M.B. (2021). Sustainability in e-commerce packaging: A review. *Journal of Cleaner Production*, 280, 124314, https://doi.org/10.1016/j.jclepro.2020.124314.

EUROSTAT (2021). *A fifth of road freight kilometres by empty vehicles*. Retrieved from: https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20211210-1 (23.05.2023).

EUROSTAT (2017). Methodological Manual for Statistics on the Information Society, Luxembourg: Office for Official Publications of the European Communities. Retrieved from: https://circabc.europa.eu/sd/a/d88ef865-c2a2-4f83-a9d1-671adc8bf477/MM2018_Part_I_Enterprise%20survey.zip (23.05.2023).

Gay, G., Hembrooke, H. (2004), Activity-Centered Design: An Ecological Approach to Designing Smart Tools and Usable Systems, The MIT Press, https://doi.org/10.1162/leon.2005.38.3.261.

Giones, F., Brem, A. (2017). From Toys to Tools: The Co-Evolution of Technological and Enterpreneuial Development in the Droge Industry. *Business Horizons*, 60(6), 875-885.

Hammond, K. (2001). B2c e-Commerce 2000-2010: What Experts Predict. *Business Strategy Review*, 43-50.

He, D., Li, Z., Wu, C., Ning, X. (2018). An E-Commerce Platform for Industrialized Construction Procurement Based on BIM and Linked Data. *Sustainability*, 10(8), 2613.

Izba Gospodarki Elektronicznej (2021). *Odpowiedzialny e-commerce*, 4-6. Retrieved from: https://eizba.pl/wp-content/uploads/2021/11/Raport-Odpowiedzialny-E-commerce-2021.pdf (28.08.2023)

Jain, V., Malviya, B., Arya, S. (2021). An Overview of Electronic Commerce (e-Commerce). *Journal of Contemporary Issues in Business and Government*, 27(3), https://doi.org/10.47750/cibg.2021.27.03.090.

Jinru, L., Changbiao, Z., Ahmad, B., Irfan, M., Nazir, R. (2022). How do green financing and green logistics affect the circular economy in the pandemic situation: Key mediating role of sustainable production. *Economic Research-Ekonomska Istraživanja*, 35(1), 3836-3856, https://doi.org/10.1080/1331677X.2021.2004437.

Krzywda, J. (2012). Oni mają zielone pojęcie. Koncepcja „zielonej logistyki" oczami niemieckich przedsiębiorców branży logistyczno-spedycyjnej. *Logistyka*, 3, 1215-1221.

Kawa, A. (2014). *Logistyka E-Handlu w Polsce*, Poznań: Uniwersytet Ekonomiczny w Poznaniu.

Leszczyński, T. (2010). Zielona Logistyka – nowe spojrzenie na ekologię. *TSL Biznes*, 11.

Lingam, Y.K. (2018). The role of Artificial Intelligence (AI) in making accurate stock decisions in E-commerce industry. *Int. J. Adv. Res. Ideas Innov. Technol*, 4(3), 2281-2286.

López González, J., Jouan J.M. (2017).Digital trade: Developing a framework for analysis. *OECD Trade Policy Papers*, 205, http://dx.doi.org/10.1787/524c8c83-en.

Marczewski, J. (2019). *Zastosowanie ekologicznych rozwiązań w kompletacji i załadunku przesyłek metodą optymalizacji kosztów w transporcie międzynarodowym*. Bydgoszcz: Wyższa Szkoła Gospodarki w Bydgoszczy.

METI Japan (2016). *Retail e-commerce in Canada*. Ministry of Economy, Trade and Industry, Canada. Retrieved from: http://www.meti.go.jp/english/press/2016/0614_02.html (23.05.2023).

NielsenIQ (2019). *A 'natural' rise in sustainability around the world*. Retrieved from: https://nielseniq.com/global/en/insights/analysis/2019/a-natural-rise-in-sustainability-around und-the-world/ (23.05.2023).

OECD (2017). Summary of responses of the advisory group: Survey on digital economy typology, OECD, Paris. Retrieved from: http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=STD/CSSP/WPNA(2017)1&docLanguage=En (23.05.2023).

Paetzold, K. (2010). *Corporate Social Responsibility (CSR) an International Marketing Approach*, Diplomica Verlag, Hamburg.

Paszek, M., Hnatyszyn, B. (2021). *Zielone opakowania dla e-commerce – przegląd dostępnych rozwiązań*, Logistyka, 1, 51-53.

Payton, F.C. (2003). e-Health Models Leading to Business-to-Employee Commerce in the Human Resources Function. *Journal of Organizational Computing and Electronic Commerce*, 13(2), 147-161.

Pyza D., Jachimowski, R. (2015). *Modelling of parcels' transport system*. In: 19th International Conference Transport Means, 22-23.

Prologics (2019). *Logistics real estate and e-commerce create sustainability advantages*. Retrieved from: https://prologis.getbynder.com/m/59b2eafd08339273/original/Logistics-Real-Estate-and-E-commerce-Create-Sustainability-Advantages.pdf (23.05.2023).

Różanowski, K. (2007). *Sztuczna inteligencja: rozwój, szanse i zagrożenia*. Warszawa: Warszawska Wyższa Szkoła Informatyki.

Seroka-Stolka, O. (2014). The Development of Green Logistics for Implementation Sustainable Development Strategy in Companies. *Procedia – Social and Behavioral Sciences*, 151, 302-309, https://doi.org/10.1016/j.sbspro.2014.10.028.

Seroka-Stolka, O., Ociepa-Kubicka, A. (2019). Green logistics and circular economy. *Transportation Research Procedia*, 39, 471-479, https://doi.org/10.1016/j.trpro.2019.06.049.

Smyk, S. (2020). *Dystrybucja fizyczna przesyłek kurierskich, ekspresowych i pocztowych jako kluczowe przedsięwzięcie „Logistyki ostatniej mili"*. 18, 6, 1529-1535, CD, Instytut Naukowo-Wydawniczy „SPATIUM" Sp. z o.o.

Statistics Canada (2016). *Retail e-commerce in Canada*. Retrieved from: http://www.statcan.gc.ca/pub/11-621-m/11-621-m2016101-eng.htm (23.05.2023).

Strandhagen, J.O., Vallandingham, L.R., Fragapane G., Strandhagen, J.W., Stangeland A.B.H., Sharma, N. (2017). Logistics 4.0 and emerging sustainable business models. *Adv. Manuf*. 5(4), 359-369, https://doi.org/10.1007/s40436-017-0198-1.

Sosnowski, P.C., Cyplik, P. (2022), Closed loop supply chains and circular economy – the possibilities of interplay. *Logforum*, 18(4), 413-420, https://doi.org/10.17270/J.LOG.2022.784.

Surmacz, T. (2014). Kreowanie zielonych łańcuchów dostaw – proponowany model integracji. *Logistyka*, 5, 2099-2104.

Tobola, A., Cyplik, P., Roszyk, K. (2022). Analysis of the Effects of Automation of Warehouse Processes – Building the Concept of Simulation Tests. *EUROPEAN RESEARCH STUDIES JOURNAL*, XXV(2B), 106-115, https://doi.org/10.35808/ersj/2940.

Tsemekidi Tzeiranaki, S., Economidou, M., Bertoldi, P., Thiel, C., Fontaras, G., Clementi, E.L., De Los Rios, C.F. (2023). The impact of energy efficiency and decarbonisation policies on the European road transport sector. *Transportation Research Part A*, 170, 1-25, https://doi.org/10.1016/j.tra.2023.103623.

United Nations (2015). UN Global Compact Office and BSR Executive Summary: Practical Steps to Supply Chain Sustainability.

US Census Bureau (2018). *E-commerce statistics (E-STATS)*. Retrieved from: https://www.census.gov/programs-surveys/e-stats/about/faqs.html (05.05.2023).

Usmani, Z. A., Manchekar, S., Malim, T., Mir, A. (2017). A predictive approach for improving the sales of products in e-commerce. In: 2017 Third International Conference on Advances in Electrical, Electronics, Information, Communication and Bio-Informatics (AEEICB). *IEEE*, 188-192.

Viellechner, A.M. (2022). *The new era of predictive analytics in container shipping and air cargo* (doctoral dissertation, WHU-Otto Beisheim School of Management).

Weideli, D., Cheikhrouhou, N. (2013). *Environmental analysis of US online shopping*. Lausanne: Ecole Polytechnique Fédérale de Lausanne (EPFL).

Witkowski, J., Pisarek, A. (2017). Istota zielonych łańcuchów dostaw – Propozycja systematyzacji pojęć. *Zeszyty Naukowe Uniwersytetu Ekonomicznego w Katowicach*, 315, 11-26.

WTO (1998). Work Programme on Electronic Commerce, World Trade Organization, Geneva, WT/L0274, Geneva. Retrieved from: https://www.wto.org/english/tratop_e/ecom_e/wkprog_e.htm (05.05.2023)

Younisa, H., Sundarakani, B., O'Mahony, B. (2020). Investigating the relationship between green supply chain management and corporate performance using a mixed method approach: Developing a roadmap for future research. *IIMB Management Review*, 32(3), 305-324, https://doi.org/10.1016/j.iimb.2019.10.011.

Zhang, B., Le, Y., Xia, B. Skitmore, M. (2017). Causes of Business-to-Government Corruption in the Tendering Process in China. *Journal of Management in Engineering*, 33(2), https://doi.org/10.1061/(ASCE)ME.1943-5479.0000479.

Zhang, D., Pee, L.G., Cui, L. (2021). Artificial intelligence in E-commerce fulfillment: A case study of resource orchestration at Alibaba's Smart Warehouse. *International Journal of Information Management*, 57, 102304.

Zhang, W., Zhang, M., Zhang, W., Zhou, Q., Zhang, X. (2020). What influences the effectiveness of green logistics policies? A grounded theory analysis. *The Science of the Total Environment*, 714, 136731, https://doi.org/10.1016/j.scitotenv.2020.136731.

ZIELONA LOGISTYKA W E-COMMERCE: CELE I WYZWANIA

Streszczenie

W dobie dynamicznie rozwijającej się branży *e-commerce* coraz częściej podnoszona jest kwestia jej wpływu na środowisko. Dziś przedsiębiorstwa nie mogą działać wyłącznie dla zysku kosztem środowiska, społeczeństwa, gospodarki, konsumentów i pracowników. Wśród przedsiębiorstw i konsumentów można zauważyć niewątpliwą potrzebę podejmowania ekologicznych działań, które mają znacznie mniejszy wpływ na środowisko naturalne. Z tego powodu walka o ekologiczne rozwiązania stała się gorącym tematem w szeroko rozumianej branży *e-commerce*. Artykuł poświęcony jest określeniu celów i wyzwań zielonej logistyki z uwzględnieniem specyfiki *branży e-commerce*. Sformułowano w nim wnioski dla praktyki biznesowej w zakresie „zielonych" rozwiązań. Zastosowaną metodą badawczą jest przegląd literatury, metoda dokumentacyjna, analiza danych statystycznych i *desk research*, analiza raportów branżowych i aktów prawnych. Materiał badawczy stanowiły publikacje naukowe, statystyki Eurostatu, raporty krajowe i zagraniczne, a także ekspertyzy instytucji krajowych i międzynarodowych. Uzyskane dane oraz wyniki *ex post* były podstawą do sformułowania własnych rozważań. Zaprezentowane w artykule wyniki dotyczą celów i wyzwań stojących przed współczesną „zieloną" logistyką. W artykule wskazano też możliwe rozwiązania dla praktyków biznesu.

Słowa kluczowe: zrównoważony rozwój, środowisko, wyzwania, e-commerce, zielona logistyka, handel tradycyjny

BY SA