Scientific Journals
of the Maritime University of Szczecin

Zeszyty Naukowe
Akademii Morskiej w Szczecinie

2019, 60 (132), 147–153
ISSN 1733-8670 (Printed)
ISSN 2392-0378 (Online)
DOI: 10.17402/383

Received: 05.08.2019
Accepted: 28.10.2019
Published: 18.12.2019

Impact of e-commerce on external transport costs

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Key words: efficiency of logistics processes, models of economic efficiency of transport, simulation, sustainable supply chain, e-commerce, costs of transport processes, external costs of transport

Abstract
The problem presented in this paper concerns the impact of e-commerce on transport costs, including external transport costs, compared with traditional shopping. E-commerce is a phenomenon of the modern economy that can significantly impact both the efficiency of the distribution of goods and on external transport costs. Although such a distribution system can increase the costs of freight transport to final consumers, it can also reduce traffic in cities and thus total external transport costs. In order to asses this impact, the author developed a simulation model and used it to conduct analyses. The analyses were based on available statistical data, data from the literature, and from the transportation market in Poland.

Introduction

It is unlikely that the concept of Corporate Social Responsibility will be implemented if there is a conflict between the business goals of enterprises and social (e.g., environmental) goals. Therefore, solutions should be sought that will increase the efficiency of logistics processes and productively use resources, which also indirectly reduces external costs. The key word here is "compromise", or perhaps even abandoning ambitious pro-ecological goals for real solutions that will be acceptable for the business side.

The main purpose of this article is to estimate the impact of e-commerce in the B2C segment on external transport costs. Analyses were carried out based on available statistical data and the subject literature. In order to estimate the impact of e-commerce on external costs, simulations were conducted using a model developed by the author.

Literature review

The e-commerce market impacts the efficiency of logistics processes, including transport processes. There is no consensus in the literature about the effects of e-commerce on the demand for transport services. According to some authors, e-commerce will increase freight transport (Schöder, Ding & Campos, 2016), while other authors think e-commerce may contribute to the growth of consumption (e.g. thanks to lower costs), and thus indirectly to increasing demand for transport services (Ferreira, Smith & Mead 2001). Digitization refers not only to the method of placing orders for products but some products may also have an electronic form (books, music, films) (Sznajder, 2006, s. 27; Staniszewska & Gordon, 2015, s. 92; Antonowicz, 2016). In Greece, for example, products susceptible to digitization account for around half of e-commerce sales (Basbas, 2006). This phenomenon is driven by the fact that young people have a large share of purchases made electronically and can also collect the goods themselves (Kozerska, 2014). The positive impact on external costs will be even greater if the documents are also sent electronically because the demand for paper will decrease (Dobosz, 2012).

However, even if the total volume of sales does not change significantly, the specificity of e-commerce distribution may reduce the efficiency of

transport processes, which may increase the costs of these processes, as well as external transport costs.

An important issue here is in which distribution channels these goods are transported. Distribution can take place in two main ways:

- Through existing distribution channels;
- In dedicated e-commerce channels, which may also require the use of a separate fleet (perhaps even technologically adapted to the specifics of e-commerce).

The specificity of e-commerce can also have an impact on the efficiency of transport processes if deliveries to customers are performed quickly (Nemoto, Visser & Yoshimoto, 2001). As a result, more expensive transport solutions may be used e.g., air transport, but the load capacity may be lower due to different shipment dimensions. Processes of decentralization and sub-urbanization may cause more remote and less densely populated areas to be served by smaller, underutilized vans. However, there are different views on this subject, (Hassall, 2001), and statistics do not seem to confirm such forecasts. According to Eustat data, vehicles below 3.7 tons ("light commercial vehicles") have had a constant share (82–86%) in road transport for many years in the European Union (EUSTAT) despite the fact that the e-commerce market is dynamically developing.

Another issue specific to e-commerce are returns, which according to some authors generate the largest costs (Żurek, 2015). Returns can be made as part of the return transport but can also generate additional journeys, which may also result from ineffective deliveries to customers (customer absence at home).

However, there are solutions aimed at increasing the efficiency of goods delivery processes – creating a network of transshipment points, where goods are transshipped from smaller to larger locations, using so-called secure storage boxes to enable optimization of vehicle routes. Research carried out in Germany in France confirms that such solutions can greatly benefit society and help reduce congestion and environmental pollution. In addition, it can also benefit companies by increasing the number of successful first-time deliveries, optimizing delivery rounds, and lowering operational costs (Morganti et al., 2014).

The experience is positive, and the implementation of e-commerce shopping can result in up to 30% reduction in transport performance, which means less congestion in urban areas. According to research conducted in 6% of Polish companies, e-commerce has a positive impact on costs (Wiśniewski, 2017). However, there are different views on this subject, and no consensus has been reached in the literature about the impact of e-commerce on energy consumption, and its positive environmental impact is being questioned (Basbas, 2006; Dost & Maie, 2017). Environmental effects depend on previous transport behaviors, and e-commerce can be a substitution for both individual and collective transport. In the UK, NERA (Dodgson, Pacey & Begg, 2000) have estimated that home shopping will reduce car-based shopping travel by 5% by 2005 and 10% by 2010 (European Parliament, 2002).

In the literature, the importance of Logistic Customer Service in the e-commerce industry is widely acknowledged (Esper et al., 2003; Agatz, Fleischmann & Van Nunen, 2008; Ramanathan, 2010). According to M. Szyda, logistics processes are becoming increasingly effective, which results in not only lower logistics processes costs but also better customer service (Szyda, 2014). However, according to other studies, factors such as the reliability, completeness, price, and time of deliveries, and the selection of a courier company do not affect the frequency of shopping, at least for some social groups (Gajewska, 2017).

The logistics capacity of a company significantly impacts its e-commerce logistics performance, and this potential can be increased by outsourcing logistics functions (Wilding & Juriado, 2004; Joong-Kun Cho, Ozment & Sink, 2008). However, a company performing its own distribution also has its advantages. For example, cargo space can be better utilized, especially if the load dimensions are standardized, as it is the case of manufacturers such as IKEA.

In order to achieve business goals (increase sales), enterprises may accept increased transport costs; however, reducing transport costs is also in their interest. Reducing these costs can be achieved by increasing the efficiency of transport processes – primarily by optimizing vehicle routes, increasing their tonnage and increasing their use. Thus, it can be said that in e-commerce, there can be a convergence of business and social goals, including environmental ones.

This problem will be discussed in the further, analytical part of the article.

Model of e-commerce distribution transport costs

In a traditional system, goods from suppliers are transported to a distribution center, and then to shops, from where consumers deliver the goods themselves to their own homes. In e-commerce, goods from

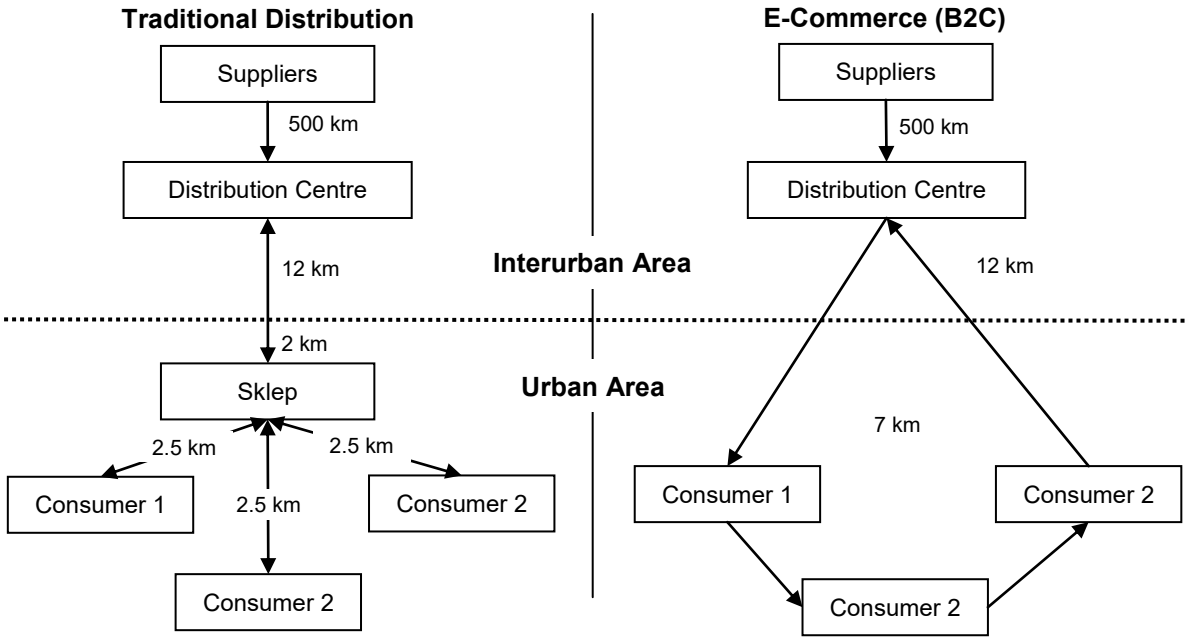

Figure 1. Distribution process of goods in a traditional distribution channel and in e-commerce

Table 1. Capacity and external costs of road vehicles (data from Polish transportation market and Maibach et al., 2008)

Efficiency of vehicles	Passenger Car Petrol 1.4–2L	< 7.5 t	7.5–16 t	16–32 t	> 32 t
Permissible gross weight [tons/vehicle]		3.5	8	16	40
Net weight [tons/vehicle]		1.6	3.7	9	25
Volume [m^3]	0.5	8	40	55	90
Freight rates [€/vkm]		0.59	0.88	0.75	1.00
External unit costs – Interurban [€vkm]		**0.16**	**0.18**	**0.18**	**0.20**
External unit costs – Urban [€/vkm]	**0.36**	**0.92**	**0.94**	**0.94**	**0.99**

a distribution center are transported to consumers by vans (Figure 1).

To calculate the economic efficiency of both systems, the author has developed a mathematical model to perform the following simulations:

1. The impact of delivery parameters in e-commerce distribution on external costs;
2. Impact of e-commerce distribution on the profitability of a company;
3. Level of reduction of external costs in the case of e-commerce distribution;
4. Identification of distances on which e-commerce distribution is more effective than traditional distribution.

The input data for all four simulations are shown in Figure 1 (distances at each stage of the distribution) and in Tables 1 and 2. External unit costs are based on the literature. Freight rates are based on information from the transportation market in Poland. Since the quality of e-commerce transport services is important in Poland, and the efficiency of transport processes is relatively lower, rates for smaller vehicles (< 7.5 t, 7.5–16 t) are 30% higher than average market rates.

To ensure comparability of calculations, it was assumed in the initial variant that distances from suppliers to a distribution center, and from a distribution center to the boundaries of a given locality, are the same in both systems. The differences concern the length of routes covered by traditional distribution consumers and by delivery vehicles in e-commerce.

Table 2. Commodity parameters

Tonnage [tons]	Volume [m^3]	Weight of a commodity [kg/pcs.]	Retail price [€/pcs.]
56 000	381 818	0.40	15

The impact of delivery parameters in the e-commerce distribution on external costs

In the first step, the impact of 4 parameters were calculated – distances of the final distribution to customers, distances from suppliers to a distribution center, the utilization of the capacity of vehicles from the final distribution, and the level of returns.

In order to ensure comparability, it was assumed that these parameters changed proportionally (10% and 20%).

Based on the assumptions, the total external transport costs were calculated. The results in Table 3 and Figures 2 and 3 vary depending on which vehicle is used. For vehicles with a lower payload (< 7.5 t), the degree of capacity utilization has the greatest impact. For larger vehicles (7.5–16 t), the most important is distance from the supplier. The distance of the final distribution to the final consumer is of average importance for both vehicle types. It may be surprising that the share of returns (which is considered significant in the literature) is of little importance, although in the last variant, the amount of returns represents 30% of sales. In the model, it was assumed that returns will generate additional transports. In fact, they can be transported together with other goods, so the returns could have an even smaller impact on costs. In the subsequent simulations, this parameter will not be considered.

Table 3. Impact of different parameters on external costs in e-commerce distribution (thous. EUR)

Capacity of a vehicle	< 7.5 t		7.5–16 t	
Changes of parameters	10%	20%	10%	20%
Longer distance in final distribution	1834	1906	1207	1233
	4.1%	8.2%	2.3%	4.5%
Increase of a distance from a supplier	1845	1929	1263	1346
	4.7%	9.4%	7.0%	14.1%
The decrease in capacity utilization	1866	1995	1219	1268
	5.9%	13.2%	3.3%	7.4%
The increase in product returns	1784	1786	1187	1194
	1.2%	1.3%	0.6%	1.2%

Impact of e-commerce distribution on the profitability of a company

The second simulation concerns the impact of e-commerce distribution on a company's profitability compared with a traditional one. With assumed margins (based on the margins of large listed companies),

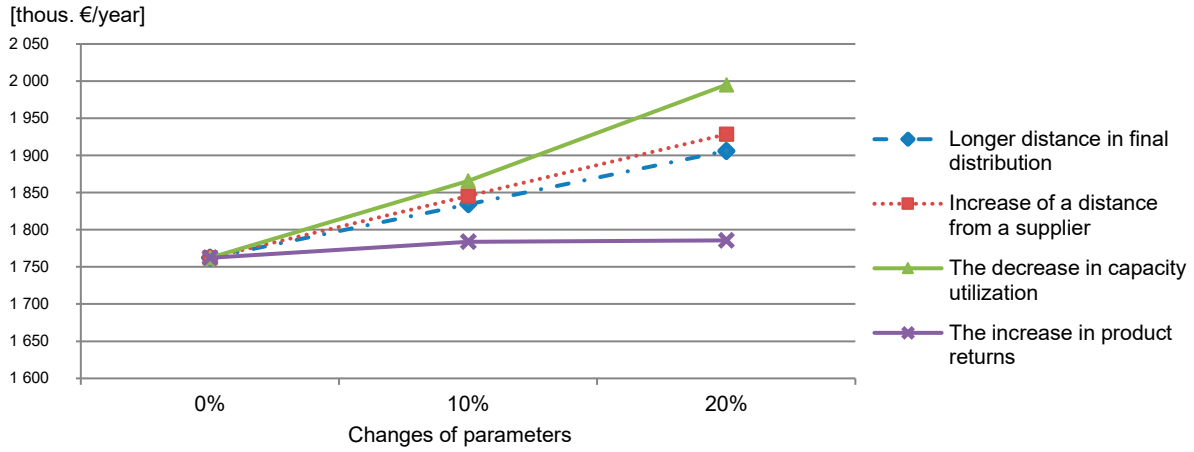

Figure 2. Factors of external transport costs in e-commerce distribution (< 7.5 t)

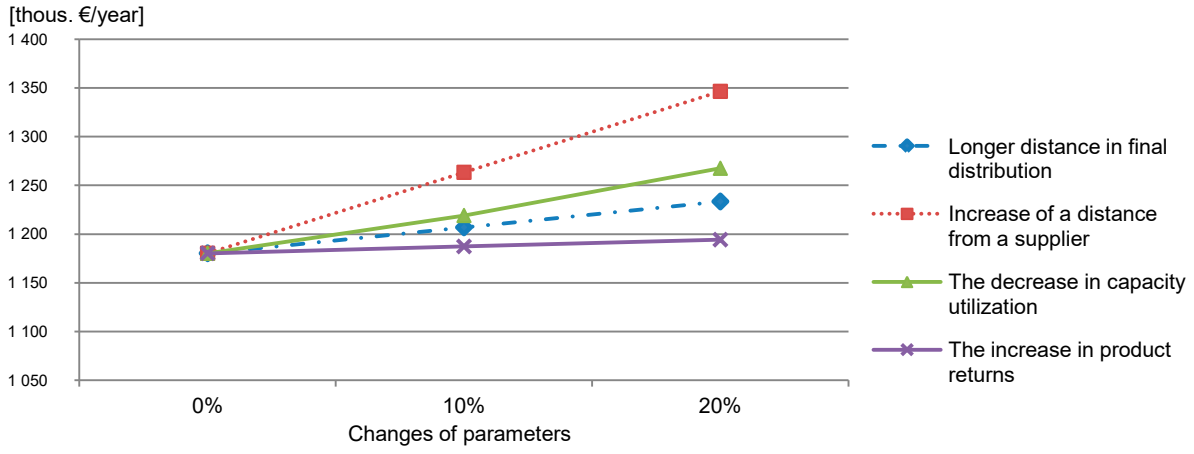

Figure 3. Factors of external transport costs in e-commerce distribution (7.5–16 t)

changes in profitability were calculated depending on the capacity of a vehicle and distances (50 and 150 km). The results are presented in Table 4.

Table 4. Impact of transport costs on profitability

Profitability of traditional distribution		5.00%	
A vehicle	Distance [km]	Utilization of vehicles	
		70%	90%
< 7.5 t	50	4.91%	4.93%
	150	4.72%	4.78%
7.5–16 t	50	4.97%	4.98%
	150	4.91%	4.93%
16–32 t	50	4.98%	4.99%
	150	4.95%	4.96%

The influence of the analyzed factors – the type of vehicle and the utilization of its load capacity and the distance of transport – is quite visible. With the assumed turnover level (Table 2), e.g., in variant 1 (using vehicles < 7.5 t, at distances up to 50 km, using 70% of their payload), the profits in the e-commerce distribution decreased compared with traditional distribution by 2 million € due to increased transport costs. Additional and comparable cost increases were caused by increased distances from suppliers, which may also be the consequence of e-commerce distribution; thus, efficient transport utilization is important, and the use of a vehicle with a capacity of 7.5–16 t, increases profits between 1.5 and over 4 million €.

However, an increase in the transport costs of e-commerce distribution can likely be compensated for by reducing the distribution costs of products (stores, employees, and warehouses) and higher revenues. For example, if sales increase by 5%, then profits would increase by over 3 million € in variant 1, with a 70% capacity utilization and almost 4 million € at 90%. This may explain the popularity of this distribution strategy.

Level of reduction of external costs in e-commerce distribution

The purpose of the third simulation was to compare the external costs of e-commerce and traditional distribution. Three variants of distances were assumed, on which consumers travel to shop: 2.5, 5, and 7.5 km. The distances travelled by e-commerce vehicles were 25%, 50%, and 100% longer. The external costs of public transport were omitted because they were very low. It was also assumed that half of consumers use cars and that 50% of these used their car's trunk. As in the previous simulations, calculations were carried out for smaller and medium-sized delivery vehicles with a 70% capacity utilization. The results of these simulations are presented in Tables 5 and 6.

Table 5. Changes in the external costs of e-commerce compared with traditional shopping

Vehicle capacity	< 7.5 t	Capacity utilization	70%
The distance of the customer from the market [km]	2.5	5	7.5
Distance in distribution: e-commerce/individual transport	Change of costs		
25%	–30.8%	–45.0%	–51.4%
50%	–27.0%	–40.2%	–46.2%
100%	–19.5%	–30.8%	–35.9%

Table 6. Changes in the external costs of e-commerce compared with traditional shopping

Vehicle capacity	7.5–16 t	Capacity utilization	70%
The distance of the customer from the market [km]	2.5	5	7.5
Distance In distribution: e-commerce/individual transport	Change of costs		
25%	–50.9%	–65.0%	–71.4%
50%	–49.5%	–63.2%	–69.5%
100%	–46.7%	–59.7%	–65.6%

External e-commerce costs are much lower compared with traditional ones, as are the distances on which the consumer moves by car. Savings are significant, even when using smaller delivery vehicles (Table 5).

Identification of limit distances on economic efficiency of e-commerce distribution

The purpose of the last – fourth simulation was to examine the maximum possible delivery distance to a customer's home without increasing external transport costs compared with traditional distribution. These distances are a measure of the effectiveness of the e-commerce distribution system. Two factors were considered in the simulation – the loading rate of delivery vehicles (70% and 90%) and distance. It was assumed that in traditional distribution, the distance from suppliers is 500 km. The results are shown in Figures 4 and 5.

Even if goods were purchased from suppliers 1000 km from the distribution center, e-commerce

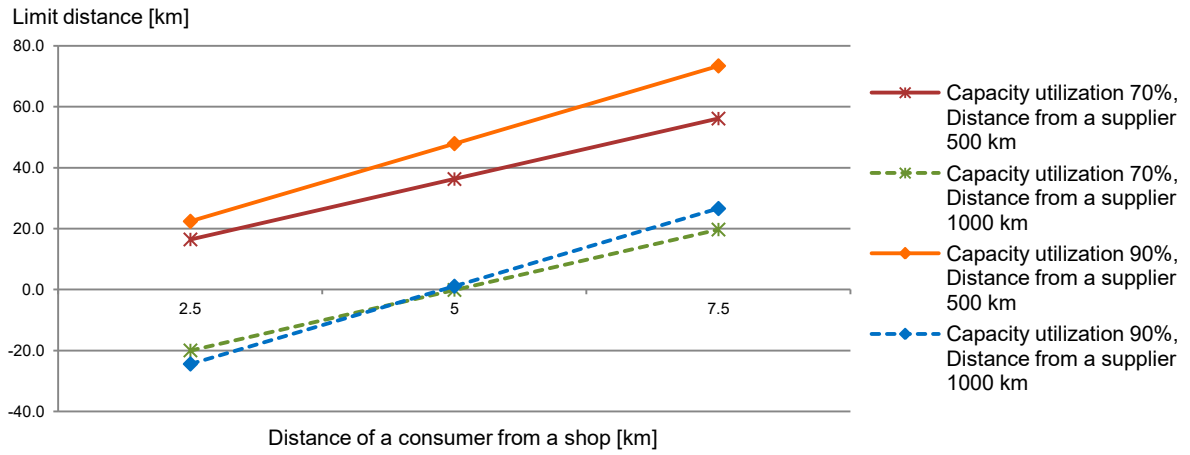

Figure 4. Limit distances in the final distribution in e-commerce (vehicles < 7.5 t)

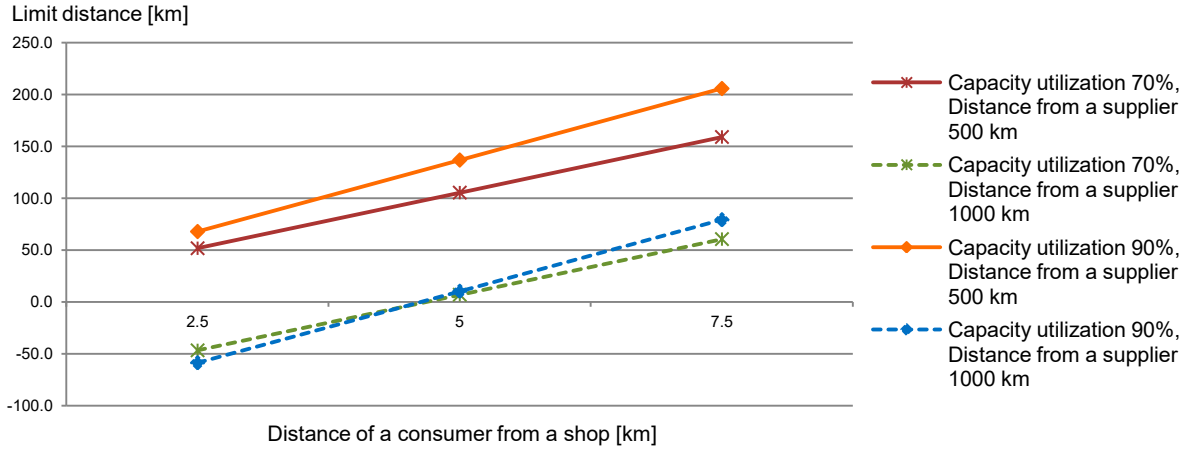

Figure 5. Limit distances in the final distribution in e-commerce (vehicles < 7.5–16 t)

still generated lower external costs, even if consumers took short car trips to stores. For example, e-commerce still generated lower external costs than traditional distribution in a variant in which vehicles up to 7.5 tons are used at 90% capacity, suppliers were located 1000 km or more (suppliers located in Europe), consumers 2.5 km from stores, and delivery vehicles were used to transport goods to consumers for distances less than 6.8 km. Additionally, if consumers were located 7.5 km from stores, delivery routes can extend up to 57 km. The use of larger vehicles provided even greater opportunities, and the border routes for the above assumptions are respectively 25 km and 163 km. The use of larger vehicles becomes possible when consumers are located outside urbanized areas (e.g., on the outskirts of cities) due to lower tonnage restrictions outside agglomerations. E-commerce can adversely affect the environment if the distances from suppliers are higher, e.g., 2000 km. If air transport becomes involved (suppliers from outside Europe) external costs would further increase.

Summary and Conclusions

E-commerce distribution can be beneficial both from microeconomic and macroeconomic points of view. If deliveries to consumers' homes in the e-commerce system contributed to reducing their car trips, this would significantly reduce external costs. The level of reduction will be greater as the efficiency of transport processes increases, which is also beneficial for e-commerce companies. Therefore, there does not have to be a "conflict of goals" between business and social goals; however, the benefits of increasing the efficiency of transport processes may be greater for society than for companies. This problem will arise if, despite a decrease in the efficiency of transport processes, companies will achieve satisfactory financial results not because of lowering their transport costs, but by increasing sales. Compared with the traditional method, this distribution method will generate higher external costs when delivery routes to customers and the distances from suppliers become significantly longer. Such

a variant, however, is quite real in the e-commerce industry for reasons independent from it. It is necessary to take into account demographic phenomena ("urban sprawl") and factors characteristic for the e-commerce industry – the possibility for consumers to search for suppliers around the world.

The results of the simulation were based on the assumptions made by the author, who tried to take into account the actual conditions as much as possible. However, in order to correctly estimate the costs and benefits for both companies and society, it is necessary to conduct research aimed at collecting data on parameters such as transport distances, utilization rates, transport costs, and rates, and also the transport and shopping behavior of inhabitants. Also, not all variants were calculated e.g., digitalization of products and its impact on transport costs.

In the end, although this was not the subject of consideration in this paper, the author would like to formulate the following hypothesis based on many years of research carried out: e-commerce distribution will be all the more cost-effective if large logistics operators are involved, who, thanks to economies of scale, are able to deliver goods to customers at lower costs without lowering the level of customer service. This can indirectly reduce the negative impacts on the environment.

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