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Impact of external factors on e-commerce market in cities and its implications on environment

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ABSTRACT

The e-commerce market in cities is currently one of the fastest-growing markets. By observing the current changes taking place in it, we have a unique opportunity to learn about its potential development directions in the future with great acceleration. Some of the recent changes caused by the ongoing COVID-19 pandemic have a chance to affect this market's development in the coming years permanently. The paper's primary purpose is to identify relationships between factors that could significantly impact sustainable e-commerce development in cities, mainly including environmental issues, on the example of the European Union Countries. For this purpose, five groups of factors (criteria), based on literature, were selected: e-commerce drivers (Internet and mobile access, macroeconomic conditions and social aspects in the country), criteria describing the e-commerce market in cities, and criteria that assess the impact of the development of the e-commerce market in cities on the environment were assessed. According to the authors' proposal, the relationships between these groups of factors were verified, taking into account the network model of connections. For this purpose, the multi-criteria decision-making method with the use of the PROMETHEE technique has been applied. The research results presented in the paper confirmed that the relations between the analyzed groups of criteria are complex. In most countries, high positions in the rankings containing criteria describing the so-called drivers of the e-commerce market also translate into high places in the order describing this market's development. At the same time, those countries where the e-commerce activity in cities is high present lower environmental conditions.

1. Introduction

The dynamic development of digitization and new technologies is currently one of the most critical factors shaping countries' economies. Their importance increased with the emergence of an epidemiological crisis globally on a scale that humanity has not had to face for years. Equipped with new technologies and Internet access, we can continue to perform our social and professional functions despite the isolation and the need to maintain social distance. It also affects market behaviour and the way of shopping, which already before the pandemic characterized by the increase of the purchases made via the Internet. According to the Eurostat data, about 7 out of 10 European Union inhabitants (about 70 %) used the Internet to purchase goods and services in the years 2018−2019. Among them, the highest percentage were people living in cities (about 62 %). The development of the e-commerce market, especially in last-mile delivery, has a great impact on cities (Lim, Jin, & Srai, 2018). There are observed growing problems in the cities regarding congestion, environmental pollution, and the increasing number of road accidents. Freight transport in the city is responsible for 25 % of CO2 emissions (ERTRAC roadmap on Urban Freigh, 2015). It is assumed to be the one that pollutes the air more than long-distance transport due to the short distances and stops required by the traffic organization and distribution in the city (Bandeira, D'Agosto., Ribeiro, Bandeira, & Goes, 2018).

According to the study conducted by Reis and Machado (2020), Europe is still the world's fastest-growing cross-border e-commerce area. Official statistics show that the Internet's contribution to the EU GDP is increasing rapidly. As noted Viu-Roig and Alvarez-Palau (2020), this situation causes the diversification of delivery channels and the growing range of services offered by retailers and logistics service operators. As a result, it has a significant impact on business models' changes, which currently pay more and more attention to the sustainable development of the e-commerce market. Dimensions of sustainable development, such as economic, social, and environmental, are more

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and more often, though to a different extent, included in the scope of the development and functioning of the e-commerce market.

In the literature subject, there are several studies (see: Awwad, Shekhar, & Iyer, 2018; Hajli, 2020), which focus on the sustainable development of the e-commerce market. However, those studies concentrate mainly on the individual factors, which assess the specific area of e-commerce (e.g., the impact of technology on profit and environment). No research discusses this issue from a wider and more complex perspective, especially which identifies the factors that influence e-commerce development and its impact on the environment. It should also be noted that the literature lacks analyses presenting the relationships between different areas affecting the development of the e-commerce market. As a rule, the researchers' attention focuses on analyzing this market development level, estimated as a synthetic variable describing the average level of this phenomenon (see: Wu, Cheng, & Qi, 2020). Only factors from one group are often taken into account, mainly economic ones (see: Amit & Zott, 2001; Damanpour, 2001). Finally, although the e-commerce market is developing, especially in cities, due to the lack of relevant data at the urban level, in the studies, only a limited set of factors is taking into account. In some studies, the development of the e-commerce market is also presented, as one of the factors describing, for example, the level of urban development (ex. Akande, Cabral, Gomes, & Casteleyn, 2019). Besides, only a part of them presents more advanced statistical methods, mainly to predict the direction of development of this market or to describe the current level of its growth. Research in this area also focused on the so-called fundamental factors, e. g. market size, density level, and Internet penetration, as well as social factors describing digital skills of the population or saving culture (Han, Zhao, Chen, Luo, & Mishra, 2017; Mohd & Salaheldin, 2009; The Nielsen Company, 2018).

In principle, no attempts have been made to describe some model approach to research in this field that could be applied to predict changes in this market and indicate the relationships between groups of factors that will condition this development to the greatest extent. Only a few of them deal with sustainable development issues and describe the level of e-commerce market development from the perspective of its three most important dimensions: economic, social, and environmental (Abukhader & Jönson, 2003; Suganthi, 2018). The identified research gap has become the basis for looking for factors that indicate how cities show the most significant development potential in e-commerce. At the same time, references to the sustainable development concept foundations were also taken into account while creating the list of factors.

The paper's primary purpose, which fulfills the research gap, is to identify relationships between factors that could significantly impact sustainable e-commerce development in cities, mainly including environmental issues, on the example of selected European Countries. For this purpose, three groups of factors (criteria), based on literature, were selected: including e-commerce drivers (Internet and mobile access, macroeconomic conditions and social aspects in the country), criteria describing the e-commerce market in cities, and criteria that assess the impact of the development of the e-commerce market in cities on the environment. Additionally, the authors proposed four research questions (RQ):

- RQ1. What factors affect and are affected by sustainable e-commerce development in cities?
- RQ2. What is each analyzed country's position in terms of e-commerce drivers, e-commerce activities in cities, and environmental conditions, and for which country particular criteria obtained the highest scores?
- RQ3. What is, if there is any, the impact of e-commerce drivers, such as the internet and mobile access, macroeconomic conditions, and social situation of the country on the e-commerce activities in cities, and what is the relation between them?
- RQ4. How, and to what extent, e-commerce affect the environment in a city?

The work's added value is research taking into account the relationships between groups of factors essential for the development of the e-commerce market in cities and the factors that became the effects of this activity. For this purpose, the multi-criteria decision-making method with the use of the PROMETHEE technique has been applied. Besides, to investigate the relationships between values and position Pearson's and Kendall correlations have been conducted, respectively.

The paper's structure in the remaining part consists of: section 2, which presents the literature review in terms of identifying the main factors affecting e-commerce development; section 3, which introduces the research design, including stages of the study, criteria, and the PROMETHEE technique; section 4, which presents the study results. The paper ends with a discussion and conclusions.

2. E-commerce activity in cities in terms of its drivers and environmental results – literature review and authors proposal

Factors determining the development of e-commerce in cities and its impact on environment are presented in the literature on the subject from various points of view (e. g. Fichter, 2002; Popescu, 2015). Popescu (2015) investigated that ICT has a strong influence on e-commerce, which, in turn, has an impact on social sustainability. The impact of ICT infrastructure (mobile and internet access) on e-commerce development has also been presented by Reis and Machado (2020) as well as by Rui (2014). However, Fichter (2002) found out that information and communication technologies are not enough to improve sustainability. His study shows that the environmental performance measurement is essential to enhance the understanding of the consequences of e-commerce on the environment. Gregory, Karavdic, and Zou (2007) divided the factors influencing the development of the e-commerce market into internal e-commerce drivers (product online transferability and e-commerce assets) and external e-commerce drivers (export market e-commerce infrastructure and demand for e-commerce). Besides, Sfenrianto, Oktavianni, Putra, and Khoerintus (2019) to the external e-commerce drivers included also government policy, finance, ICT infrastructure, payment system, and physical environment. Li, Luan, Zhang, and Guo (2018) investigated that GDP also has a significant impact on the e-commerce market. While Gajda (2020) as well as Kuswanto and Sudarsono (2016), drew attention to the essence of trust in the e-commerce market. In turn, Hamed, Ball, Berger, and Cleary (2008) indicated that there are many drivers, which can also be treated as barriers to the e-commerce market, e. g. cost, infrastructure, time, information, legislation and regulation, etc. Their assessment depends primarily on the current situation in individual markets.

Factors determining the development of the e-commerce market in cities located in EU countries are also used in many reports published by various types of business organizations (e.g. The Nielsen Company, 2018; WorldPay's Global Payments Report, 2020). Their goal is to identify markets with the greatest development potential in the field of e-commerce. These reports include e-commerce drivers' so-called fundamental factors, including Internet and mobile access, which are the basis for assessing the development opportunities of individual markets in general and factors dedicated to the e-commerce market, describing e. g. the volume of sales or purchases made in these markets.

However, according to Khoo, Ahmi, and Saad (2018), who conducted the review on e-commerce research, the most investigated papers focused mostly on the factors which encourage to the introduction of e-commerce, a few of them focused on the impact of e-commerce on the environment. Therefore, the authors of this paper point out that in addition to factors that affect the development of e-commerce in cities, a group of factors that is the effect of it should also be taken into account. Among them, can be distinguished factors determining the level of environmental pollution. There are not many papers that discuss the relationship between e-commerce and the environment in the literature review. Most of them focus on the impact of last mile delivery (which is related to e-commerce to a large extend) on the environment. For

example, Siragusa, Tumino, Mangiaracina and Perego (2020) attempted to assess the impact of electric vehicles' introduction in the last mile delivery in B2C e-commerce. Ecological issues related to the last mile delivery on the e-commerce market were also discussed by Awwad et al. (2018), Bates, Friday, Allen, and Cherrett (2018), and Jiang, Chang, Zhao, Dong, and Lu (2019). All these authors focus mainly on last mile delivery and its impact on the reduction of environmental pollutions.

Thus, based on literature review, it can be assumed that the development (functioning) of e-commerce in cities is influenced by the so-called e-commerce drivers, which are related to internet and mobile access, macroeconomic conditions, and social aspects. In turn, e-commerce activity influences the environmental conditions of cities and the entire country. This approach to data aggregation allows comparing the overall situation and the current level of development in selected dimensions and directly describe the development of e-commerce markets in cities of EU countries. Graphically, this model can be represented as in Fig. 1.

The basis for specifying these factors is not only publications related to the e-commerce market but also the new market growth, not yet sufficiently recognized. Table 1 presents the results of the review of publications collected in the Web of Science and Scopus databases, which discuss factors that may have a significant impact on the e-commerce market's sustainable development.

According to the information presented in Table 1, the development of the e-commerce market can be analyzed from many different perspectives. In the literature, however, there are no analyses in which the development of the e-commerce market considers interactions between considered factors. In some papers, only two groups of factors were taken into account, most often economic and related to Internet access. Besides, there was no relation analyzed between those factors. Therefore, in this paper, the authors propose the analyses of the relationship between five groups of factors that influence the development of the e-commerce market, assuming the same importance of each analyzed group and the multidimensional nature of the relationships between them.

3. Research design

3.1. Research stages

The purpose of the paper is to identify relationships between factors that could significantly impact sustainable e-commerce development in cities and the relationships between those groups of factors. Additionally, the authors proposed four research questions (RQ):

- RQ1. What factors affect and are affected by sustainable e-commerce development in cities?
- RQ2. What is each analyzed country's position in terms of e-commerce drivers, e-commerce activities in cities, and environmental conditions, and for which country particular criteria obtained the highest scores?
- RQ3. What is, if there is any, the impact of e-commerce drivers, such as the internet and mobile access, macroeconomic conditions, and social situation of the country on the e-commerce activities in cities, and what is the relation between them?
- RQ4. How, and to what extent, e-commerce affect the environment in a city?

In order to obtain the objective, a three-stage research design was applied (Fig. 2).

In the first stage, critical literature analyses have been conducted. Based on the literature, factors that affect and are affected by the development of the e-commerce market in cities have been identified. These factors, which affect the growth of the e-commerce market, were named drivers. Based on the literature, the authors distinguished: Internet and mobile access, macroeconomic conditions, and social aspects. To the group of factors affected by the development of the e-commerce market, the authors included those related to the city's environmental condition. The group of e-commerce activity in cities consists of those factors, which relate to online purchases. A detailed description of all factors has been presented in section 3.2.

In stage 2 the MCDM method with the use of PROMETHEE technique has been utilized. This analysis's primary purpose was to conduct a comparative analysis of countries in terms of e-commerce drivers (three groups of factors), e-commerce activities in cities, and environmental conditions. For each factor, the net flow has been provided and the position in the ranking. Each ranking enables identifying each country's position in terms of internet and mobile access, macroeconomic, social, and environmental conditions, and e-commerce activity in cities. The detailed description of the PROMETHEE techniques has been described in section 3.3.

In the third stage, the relationships between the results obtained in the analyses conducted with the PROMETHEE technique were identified. This stage aimed to assess these relationships' strength and direction in the model, taking into account the division into the indicated groups of factors described in the previous section. Pearson's linear correlation coefficient was used to examine the relationship between net flow values obtained through the PROMETHEE technique. Besides, relations between positions obtained in constructed rankings were assessed based on the Kendall correlation coefficient.

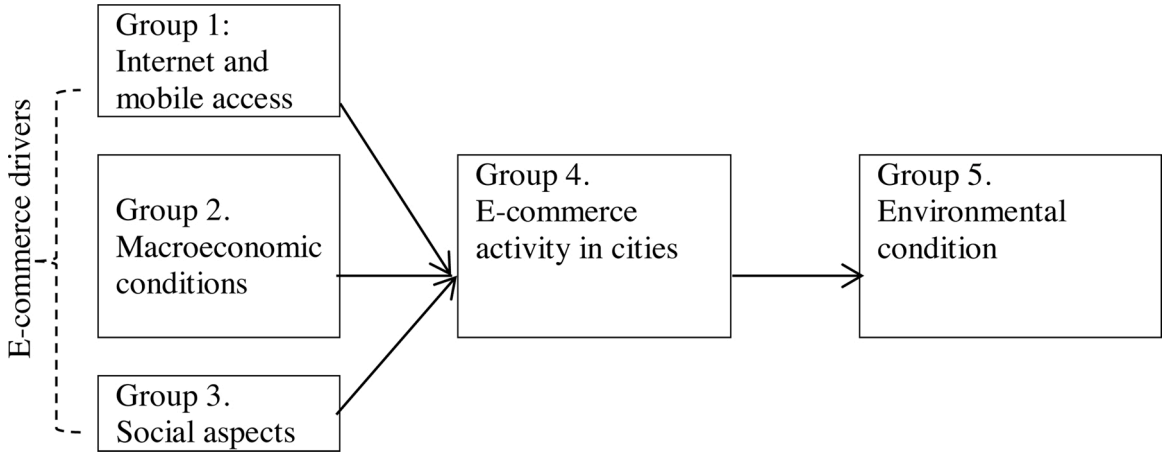

Fig. 1. Model of network connections between factors determining the development of the e-commerce market in cities.
Source: own elaboration.

Table 1
Literature in the area of group of e-commerce factors' identifications.

Group of factors	Aspects analyzed	References
Group 1: Internet and mobile access	identification of potential drivers and obstacles to online sales: cost of use (internet access fees), limited computer/internet experience, and poor connection speed (low bandwidth connections), analysis of Internet and mobile infrastructures' development analysis of cashless payments in bolstering cross-border trade, analysis of the impact of internet coverage on e-commerce development	Anckar (2005) Martens (2013) Reis and Machado (2020) Rui (2014) Gomez-Herrera, Martens, and Turlea (2014) Fichter (2002) Pan, Giannikas, Han, Grover-Silva, and Qiao (2017)
Group 2. Macroeconomic conditions	assessment of the impact of macroeconomic factors (GDP per capita) on the development of the e-commerce market, presentation of market characteristics of specific countries, the study of the relationship between macroeconomic characteristics such as net monthly earnings, inflation and household consumption and e-commerce market development	Martens (2013) Sandberg and Håkansson (2014) Gomez-Herrera et al. (2014) Cardona et al. (2015) Falk and Hagsten (2015) Kim, Dekker, and Heij (2016) Li, Luan, Zhang, and Guo (2018) Rincon-Garcia, Waterson, Cherrett, and Salazar (2020)
Group 3. Social aspects	identifications of social trust, especially in business-to-business (B2B) e-commerce as a primary social criteria of e-commerce market' development, the influence of low digital skill level on the slow adoption of e-commerce by German, including generational change (aging society), information and communication behaviour, the study of the influence of social networks and online services (internet banking, use of digital public services), as well as the development of digital skills on the e-commerce market, cultural factors influencing e-commerce market development	Qu, Pinsonneault, Tomiuk, and Wang (2015), Senarathna, Warren, Yeoh, and Salzman (2014), Hajli (2020), Alqahtani, Goodwin, and de Vries (2018) Gajda (2020) Kuswanto and Sudarsono (2016)
Group 4. E-commerce activity	presentation of consumer activity on the internet, presentation of new business models based on digital platforms	Biagi and Falk (2017), Falk and Hagsten (2015) Alberti-Alhtaybat, Al-Htaybat, and Hutaibat (2019)
Group 5. Environmental Condition	the impact of the e-commerce market on energy consumption and CO2 emissions, environmental impact of e-commerce	Steinker, Hoberg, and Thonemann (2017), Köster, Ulmer, Mattfeld, and Hasle (2018), Siragusa et al. (2020), Awwad et al. (2018), Bates et al. (2018) Jiang et al. (2019).

3.2. Characteristics of criteria

For analysis, the authors used criteria that were divided into five groups. The first three groups refer to e-commerce drivers (groups1–3). Another group 4 concerns activities related to e-commerce in cities, and the last one group 5 refers to environmental conditions as a result of freight transport. Due to difficulties in obtaining statistical data for cities, the first three groups of indicators and the fifth relate to the entire country. In contrast, indicators relating to e-commerce activity refer to the cities' level in the countries studied. It is assumed that the macroeconomic and social condition of the country and the level of access to mobile phones and the Internet have an impact on the development of the e-commerce market in cities. In turn, since in many European countries, e-commerce primarily concerns cities, its growth affects the country's environment. Individual groups of criteria were divided by the authors as follows:

- Group 1: Internet and mobile access: x_{11} – Internet bank account penetration (% of all individuals), x_{12} – Internet users (% of adult population), x_{13} – individuals use smartphone for private purposes (% of all individuals), x_{14} – mobile cellular telephone subscriptions (per 100 population), x_{15} – mobile broadband subscriptions (per 100 population), x_{16} – fixed-broadband Internet subscriptions (per 100 population), x_{17} – fibre-to-the-home/building Internet subscriptions (per 100 population),
- Group 2: Macroeconomic conditions: x_{21} – purchasing power adjusted GDP *per capita,* real expenditure *per capita* (in PPS – purchasing power standard for EU 28), x_{22} – population density (persons per km^2), x_{23} – domestic market size (1–7 best), x_{24} – market capitalization (% of GDP).
- Group 3: Social aspects: x_{31} – legal framework's adaptability to digital business models (1–7 best), x_{32} – digital skills among active population (1–7 best), x_{33} – trustworthiness and confidence (1–7 best), x_{34} – gross national savings (% of GDP),
- Group 4: E-commerce activity in cities: x_{41} – Internet use: selling goods or services (% of population living in cities), x_{42} – last online purchase in the 12 months (% of population living in cities), x_{43} – online purchases from sellers from other EU countries (% of population living in cities), x_{44} – online purchases from sellers abroad (other European countries, non-EU countries), (% of population living in cities), x_{45} – online purchases from sellers from the rest of the world (non-European countries), (% of population living in cities), x_{46} – Internet use: e-commerce activities, (% of population living in cities), x_{47} – E-participation Index (0–1 best), (% of population living in cities).
- Group 5: Environmental aspects: x_{51} – mean population exposure to PM2.5 (micrograms per cubic metre), x_{52} – percentage of population exposed to more than 10 micrograms /m^3, x_{53} – carbon dioxide from transportation and storage (kilograms *per capita*), x_{54} – noise from neighbours and from the street (% of population).

3.3. PROMETHEE technique

In order to conduct an analysis, the PROMETHEE technique has been used. This technique enables, based on thresholds of equivalence and preferences, to compare the two analyzed variants (in this case 28 countries), including the family of criteria (In the study, a total of 18 different criteria assigned to 5 areas were analyzed). The comparison of variants included negative and positive preference flows, which allowed determining the level of exceeding a given option over others and the extent of yielding to other variants. This enables identifying optimal decision alternatives in partial (PROMETHEE I) or complete (PROMETHEE II) order. The PROMETHEE technique consist of several steps (Author, 2019):

- Step 1. Defining the family of criteria – K for the analyzed countries – V and developing the coefficients of importance for individual criteria (in the research all analyzed criteria are equally important, hence $V = 1$).
- Step 2. Determining the function and preference thresholds. For all criteria linear function was applied. Incomparability thresholds of Q and preference of P were also determined for each criterion.

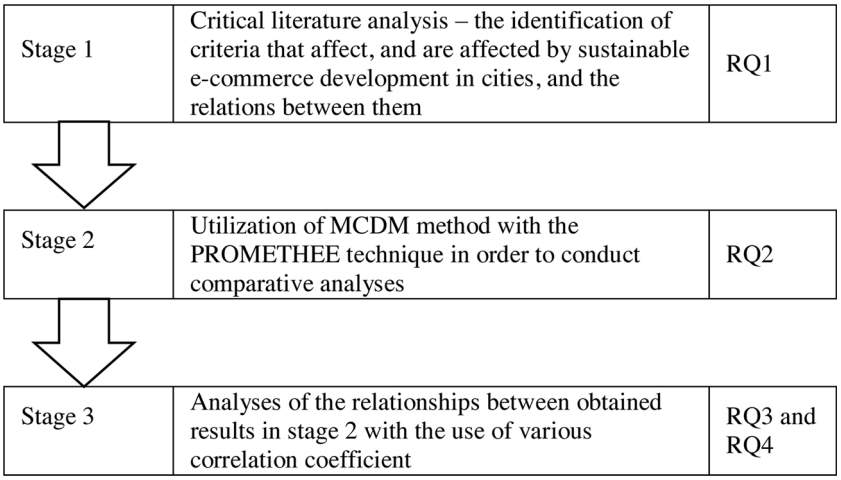

Fig. 2. Research design's stages.

- Step 3. Comparison of individual variants in pairs. The first step calculation of the multi-criteria preference index π, by the following equation:

$$\pi(a,b) = \sum_{j-1}^{k} w_j \times P_j(a,b) \quad (1)$$

where:

$w_j > 0$is the normalized weight assigned to the K_j *criterion* (the greater w_j, the more important f_j), P_j *(a,b)* is the value of the preference function for the *Kj* criterion when variant *a* is compared with variant *b*.

The index, with the value between 0 and 1, specifies how much option *a* is preferred to option *b*, considering the criteria and standardized weights. So: $\pi(a,b) \approx 0$means that there is an insignificant advantage of variant *a* over *b*, $\pi(a,b) \approx 1$means that there is a significant advantage of variant *a* over *b*,

- Step 4. Calculation of the final rankings for five groups, which include negative and positive preference flows with Visual PROMETHEE computer software usage.

Preference flows are calculated to consolidate the results of compared variants in pairs and rank them from the best to the worst. There are three rankings three flows of preferences calculated, such as:

- Phi + (Ø +), positive flow: it indicates to what extent the family a given country (a) is preferred over the other (n-1) concerning the same family of criteria. This value shows the strength of the country in the field of the group of criteria. The higher the value of Ø + (a), the better the country's position:

$$\varphi^{+}(a) = \frac{1}{n-1}\sum_{b \neq a} \pi(a,b) \quad (2)$$

- Phi- (Ø-), negative flow: it indicates how a given country n-1 is preferable to a country a. Its value shows the weak position of a country *a*. The lower the value of Ø- (*a*), the better position of a country *a*:

$$\varphi^{-}(a) = \frac{1}{n-1}\sum_{b \neq a} \pi(a,b) \quad (3)$$

- Phi (Ø): net flow: Ø (*a*) = Ø + (*a*) - Ø- (*a*); net flow is the difference between positive and negative flows. It aggregates the positive and negative flows of a given country in order to obtain final ranking. The higher the Ø (*a*), the better the better position of a country in the ranking. Net flow value can be in plus or in minus.

$$\varphi(a) = \varphi^{+}(a) - \varphi^{-}(a) \quad (4)$$

The detailed description of PROMETHEE technique can be found in many papers e.g. Gournas and Lygerou (2000), Instruction of the PROMETHEE method, Visual PROMETHEE 1.4 Manual (2013), Corrente, Figueira, and Greco (2014), Rao and Patel (2014), Wu, Wang, Chen, Chuanabo, and Lingwenving (2017), Author (2019, 2020).

4. Study results

The purpose of the analysis with the use of the PROMETHEE technique was to obtain separate rankings for five groups: internet and mobile access (Group 1), macroeconomic conditions (Group 2), social conditions (Group 3), e-commerce activities by inhabitants living in cities (Group 4) and environmental conditions (Group 5). The first three groups belong to e-commerce drivers, and the last one describes the level of ecological pollutions in terms of freight transport. The results of the final rankings obtained with the use of the PROMETHEE technique were presented in Table 2.

Based on the conducted analysis, it can be observed that those countries which obtained high scores in rankings for Groups 1–3 also received top positions in the ranking related to e-commerce activity. Among countries whose e-commerce activities in cities are the highest are: Denmark, (80 %), United Kingdom (77 %), Netherlands (75 %), Luxemburg (70 %), and Sweden (69 %). Denmark obtained the best result for the criterion "last online purchase in the 12 months" (87 %) and "internet use: e-commerce activities" (80 %).

So, Denmark as the most active country in the field of purchasing via the internet by people living in cities, where it is the best access to the internet and mobile phones. In this country, there is the highest number of internet users, 100 % of residents subscribe mobile phone, and over 86 % of inhabitants subscribe to internet access. At the same time, Romania and Bulgaria, countries which obtained the lowest positions in the ranking in terms of e-commerce activities (28 and 27 respectively) are also located on the bottom place regarding internet and mobile access, as well as macroeconomic condition. However, those countries obtained average scores in terms of social conditions. Therefore, it can be assumed that e-commerce activities in cities are related to the country's macroeconomic situation and internet and mobile phone access. The better financial conditions of citizens and their access to modern technology, the better their activity on the e-commerce market. There is some exception from these rules, such as Ireland, which obtained low scores in terms of internet and mobile access (23rd position) but a great location in terms of e-commerce activity in cities (6th

Table 2
Study results based on PROMETHEE technique.

Country	E-commerce drivers						E-commerce activities in cities		Environmental condition (results)	
	Group 1		Group 2		Group 3		Group 4		Group 5	
	1	2	1	2	1	2	1	2	1	2
Austria	0.002	12	−0.034	15	0.101	10	0.102	12	−0.014	15
Belgium	−0.095	18	0.148	9	0.010	12	−0.120	17	−0.030	16
Bulgaria	−0.292	27	−0.203	24	−0.063	17	−0.436	27	0.028	13
Croatia	−0.349	28	−0.170	22	−0.341	25	−0.093	16	0.215	4
Cyprus	−0.007	13	−0.252	28	−0.295	24	−0.289	23	0.335	2
Czech Republic	−0.019	14	−0.097	16	0.092	11	−0.294	25	0.426	1
Denmark	0.512	1	0.173	7	0.317	5	0.458	2	−0.269	25
Estonia	0.205	5	−0.244	27	0.323	4	0.274	7	0.130	8
Finland	0.344	3	0.126	11	0.429	2	0.361	4	−0.060	18
France	−0.031	16	0.251	4	−0.039	16	0.149	11	−0.102	21
Germany	0.060	11	0.155	8	0.294	7	0.206	10	0.154	6
Greece	−0.130	20	−0.118	19	−0.671	28	−0.306	26	−0.131	24
Hungary	−0.236	24	−0.134	20	−0.225	23	−0.284	22	0.090	10
Ireland	−0.206	23	0.180	6	0.238	8	0.252	9	0.096	9
Italy	−0.098	19	0.037	12	−0.400	26	−0.293	24	0.146	7
Latvia	0.128	8	−0.243	26	−0.079	18	−0.227	21	0.041	11
Lithuania	−0.048	17	−0.189	23	−0.010	19	−0.157	18	−0.313	27
Luxembourg	0.091	9	0.275	3	0.313	6	0.485	1	0.031	12
Malta	0.186	6	0.010	13	0.136	9	0.280	6	−0.542	28
Netherlands	0.217	4	0.306	1	0.375	3	0.405	3	−0.275	26
Poland	−0.257	26	−0.026	14	−0.171	22	−0.221	20	0.206	5
Portugal	−0.026	15	−0.010	17	−0.408	27	−0.213	19	0.288	3
Romania	−0.237	25	−0.105	18	−0.001	13	−0.651	28	0.013	14
Slovak Republic	−0.174	21	−0.163	21	−0.035	15	0.048	13	−0.098	20
Slovenia	−0.184	22	−0.206	25	−0.108	20	0.002	15	−0.085	19
Spain	0.077	10	0.141	10	−0.136	21	0.013	14	−0.126	23
Sweden	0.383	2	0.192	5	0.450	1	0.253	8	−0.041	17
United Kingdom	0.183	7	0.293	2	−0.007	14	0.296	5	−0.107	22

Note: 1 – is net flow (the summary results of the PROMETHEE technique), 2 – position in the ranking.

position). However, this country also obtained high scores in macroeconomic conditions (6th position) and social (8th position).

The other interesting observation is that e-commerce activity in cities is associated with the country's environmental conditions. Those countries, where the e-commerce activity in cities are high, obtained much lower scores in the Group 5 "Environmental condition". The worst position in this field captured Malta, where the e-commerce activities in cities were assessed as high (6th position). In Group 5, Malta received the most top scores for two criteria "noise from neighbors" (28.2) and "percentage of population exposed to more than ten micrograms/m3″ (100). This country, next to Denmark and Luxemburg, emits one of the highest amounts of carbon dioxide from transportation and storage per capita (4,821.28 kg *per capita*).

The following tables present assessments of Pearson's correlation coefficients r (for net values of flows obtained in the analyses with the PROMETHEE method; Table 3), and Kendall τ (for positions occupied by the examined countries in constructed rankings, Table 4). The information presented in them shows that the assessment of correlation coefficients between groups of factors forming the so-called e-commerce drivers (Groups 1–3). Also, the results obtained for the area describing the level of development of the e-commerce market in cities located in the countries studied (Group 4) are relatively large ($r > 0.6$), the largest for group 3 - social aspects ($r = 0.717$). It confirms the significant impact of these groups of factors on the development of the e-commerce market in EU cities. Also interesting are the signs of correlation coefficients. In most cases, they are positive and indicate an increase in the average level of development of the e-commerce market in EU cities as a result of the improvement in the factors included in group 1 (Internet and mobile access), group 2 (macroeconomic conditions) and group 3 (Social aspects.) Opposite relations were identified between group 4 (e-commerce activity in cities) and group 5 (environmental conditions), which means that the development of e-commerce markets may harm the natural environment. These negative correlations between these groups of indicators are the lowest, which means that a relationship of this kind occurs but is not strong.

Table 3
Matrix of r Pearson coefficients for the results of ordering EU countries in 2018.

	Group 1	Group 2	Group 3	Group 4	Group 5
Group 1	1.000	0.473	0.634	0.694	−0.380
Group 2	0.473	1.000	0.512	0.662	−0.312
Group 3	0.634	0.512	1.000	0.717	−0.257
Group 4	0.694	0.662	0.717	1.000	−0.427
Group 5	−0.380	−0.312	−0.257	−0.427	1.000

Table 4
Matrix of Kendall τ correlation coefficients for the results of ordering EU countries in 2018.

	Group 1	Group 2	Group 3	Group 4	Group 5
Group 1	1.000	0.307	0.497	0.492	−0.243
Group 2	0.307	1.000	0.365	0.444	−0.238
Group 3	0.497	0.365	1.000	0.529	−0.175
Group 4	0.492	0.444	0.529	1.000	−0.286
Group 5	−0.243	−0.238	−0.175	−0.286	1.000

The detailed results in each of the considered groups can also be presented for some countries concerning cities. The highest results in the first three groups (e-commerce drivers) and even in the group 4 (e-commerce activities in cities) and one of the worst results in the last group (environmental conditions) can be observed in the case of Sweden (respectively: 2, 5, 1, 8 and 17 positions in rankings) or Denmark (respectively: 1, 7, 5, 2 and 25) (Figs. 3 and 4). The opposite situation can be observed in most countries in the south (e.g., Croatia) or the East (e.g., Poland) of Europe. These countries outperformed the first four rankings, but their negative impact on the natural human environment was lower (Figs. 5 and 6).

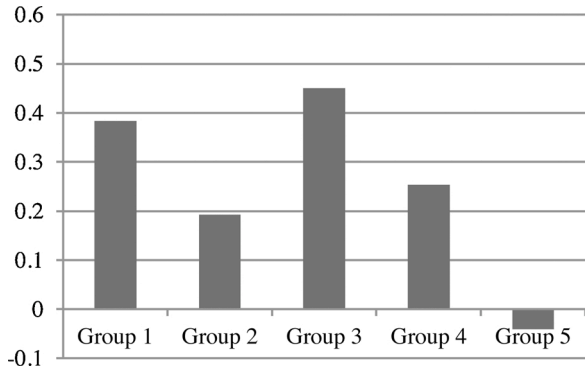

Fig. 3. The net flow value in each considered groups calculated for Sweden, concerning cities.

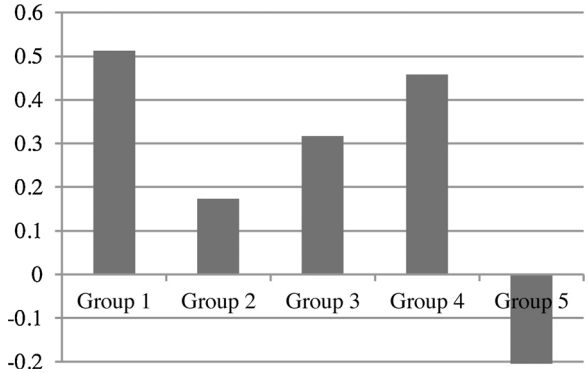

Fig. 4. The net flow value in each considered groups calculated for Denmark, concerning cities.

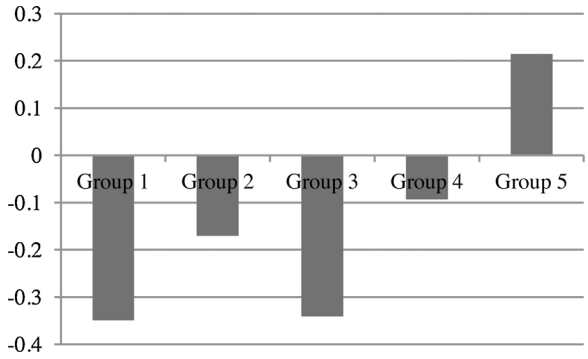

Fig. 5. The net flow value in each considered groups calculated for Croatia, concerning cities.

5. Discussion and conclusions

E-commerce development in the city is increasing very fast. Since COVID-19 occurred in Europe, online shopping became even more popular among citizens. More and more publications describing the changes in the e-commerce market after the appearance of a pandemic appear in the literature (e.g., Hasanat et al., 2020; Negreiro, 2020). It is worth pay attention that according to Bluecore's Covid-19 Retail Trends report, the number of first-time purchases placed through the e-commerce sites belonging to traditional chain stores grew by a whopping 119 % compared to April last year. At the same time department stores experienced a decline of 24 % in this area. It suggests most first-time purchases take place instore rather than online in this instance (COVID-19 Retail Trends in An All-DTC Wocld, 2020). It is the way this

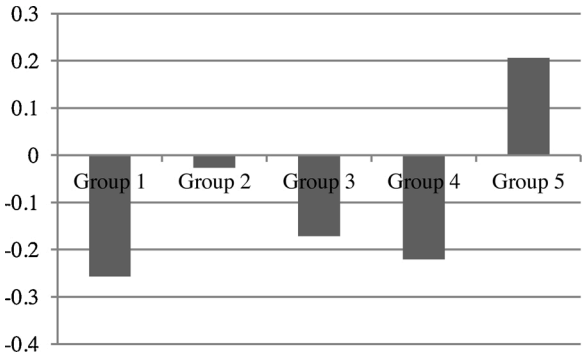

Fig. 6. The net flow value in each considered groups calculated for Poland, concerning cities.

research area becomes more important and relevant. It also means that the knowledge about the factors influencing the growth of this market becomes more critical. Current changes in this market, due to the pandemic, accelerated its growth and development. Therefore, the knowledge of the factors determining this market's development, especially in cities, is even more needed.

The purpose of the paper was to identify relationships between factors that could significantly impact sustainable e-commerce development in cities, especially including environmental issues, on the example of selected European Countries. What distinguished this work is that the authors included a group of factors related to sustainable development, dividing them into drivers (those which influence e-commerce development in cities) and factors associated with the environmental condition (those which are results of e-commerce activities).

The group of factors were identified on the basis of literature review, and were divided into five groups, three of them were classified to e-commerce drivers (Group 1: Internet and mobile access, Group 2: Macroeconomic conditions, Group 3: Social aspects), one to e-commerce activity in a city (Group 4) and one to environmental condition (Group 5).

Created groups were compared within five rankings with the PROMEHTEE technique usage. This method enables the classification of variants (countries) in terms of each group separately or for all of them. Besides, it allows the investigation of each country in terms of particular criteria more thoroughly. It also allows to include both quantitative and qualitative indicators.

According to the conducted study, the greatest positons for the criteria belonging to e-commerce drivers were mainly Scandinavian countries, such as Denmark, Finland, Netherland, Sweden, and Estonia. These countries were classified on the top of the ranking in Group 1″ Internet and mobile access" and 3 "Social aspects". In group 2 "Macroeconomic conditions," the highest positions obtained such countries as Netherlands, United Kingdom, Luxembourg, France, and Sweden. Those countries which received top places in groups belonging to e-commerce drivers also obtained a high position in the Group 4 "e-commerce activities in cities". So it can be assumed that the internet and mobile access, macroeconomic conditions, and social situation of the country may influence online shopping in cities. This relation was also observed in the assessments of Pearson's and Kendall's correlation coefficients. There was observed a strong correlation between these four groups of indicators. The correlation between those three groups of factors and online shopping hasn't been investigated in the literature so far. However, Reis and Machado (2020) and Rui (2014) found out in their research that internet and mobile access influence e-commerce development, while Li et al. (2018) investigated that macroeconomic condition has an impact on this area too. Also, Gajda (2020), Kuswanto and Sudarsono (2016) pointed out the importance of social aspects, such as trust, regarding the e-commerce market.

Opposite relation, to above mentioned, was observed between Group

4 “e-commerce activities in cities” and Group 5 “environmental condition”. According to study an increase in online shopping in cities may affect environmental degradation. In those cities were the e-commerce activity is high, the worst environmental condition is. This relationship is also confirmed in the assessment of Pearson’s and Kendall’s correlation coefficients. There are some papers in the literature which focus on solutions which can decrease environmental degradation on e-commerce market. Most of them focus on last mile delivery (Jiang et al., 2019; Siragusa, Tumino, Mangiaracina, & Perego, 2020).

Therefore, it can be assumed that on the one hand, some factors influence e-commerce activity in cities, but from another - e-commerce, affects other factors (such as environment). This relationship, especially in terms of the negative impact of e-commerce on the environment, was already noticed by Golicic, Davis, McCarthy, and Mentzer (2002) and Caudill, Luo, Wirojanagud, and Zhou (2000).

The analyses conducted by the authors provide useful information for local authorities and e-commerce stakeholders, such as e-service companies, retailers, transport companies, e-customers, etc. For transport companies, it is essential to consider the introduction of environmentally friendly delivery. It is especially essential for local authorities, who are responsible for the quality of life in cities. According to Schöder, Ding, and Campos (2016), local authorities should consider the implementation of various measures, which can decrease environmental degradation, and at the same time, won’t harm the e-commerce market. In these studies, it was noted that the e-commerce market dependents on factors that determine its growth, at the same time, it affects many different processes in cities related, for example, to environmental protection, congestion, organization of transport in the city.

The main limitation of the research presented in the paper is the access to statistical data on the city level. Public database statistics contain only limited information at this level of data aggregation. A great source of profound knowledge in this area can be the primary research, also planned by authors. It is also worth emphasizing that the usually used modelling and forecasting methods in research on the development of various markets, mainly because of dynamic changes in the e-commerce market, will also require modification. Authors of other studies (Cardona, Duch-Brown, Francois, Martens, & Yang, 2015; Sandberg & Håkansson, 2014) also point out that the macroeconomic factors (GDP *per capita*, inflation rate, unemployment rate, household savings), usually taken into account in this kind of modelling and forecasting of new market development, may in conditions of changes caused by the pandemic do not have such strong impact on the development of relatively new markets, as the e-commerce. It is also worth emphasizing that although this market is currently developing mainly in cities, its intensive development will also apply to smaller towns.

In further research, the authors aim to conceptualize a model of sustainable city logistics in the field of last mile delivery and the returns on the e-commerce market, including the perspective of all groups of stakeholders. The model will include the tools that motivate change stakeholders’ preferences regarding the last mile delivery, and goods return to be organized sustainably (environmentally, socially, and economically). To develop the model, the authors will survey all stakeholders, especially among customers, to investigate which factors influence their decision regarding online shopping – environmental issues or price or/and time delivery.

Declaration of Competing Interest

The authors declare no conflict of interest.

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