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Innovation activity and the outcomes of B2C, B2B, and B2G E-Commerce in EU countries

Marinko Skare^{a,b,*}, Beata Gavurova^c, Martin Rigelsky^d

^aJuraj Dobrila University of Pula, Faculty of Economics and Tourism Dr. Mijo Mirkovic, Zagrebacka 30, 52100 Pula, Croatia

^bUniversity of Economics and Human Sciences in Warsaw, Okopowa 59, 01-043 Warszawa, Poland

^cFaculty of Management and Economics, Tomas Bata University in Zlin, Mostni 5139, 760 01 Zlin, Czech Republic

^dUniversity of Prešov, Faculty of Management and Business, Konstantinova 16, 080 01 Prešov, Slovak Republic

* Corresponding author at: Juraj Dobrila University of Pula, Faculty of Economics and Tourism Dr. Mijo Mirkovic, Zagrebacka 30, 52100 Pula, Croatia. E-mail addresses: mskare@unipu.hr (M. Skare), gavurova@utb.cz (B. Gavurova), martin.rigelsky@unipo.sk (M. Rigelsky).

ABSTRACT

This study quantifies the relationships between innovation activity and the outcomes of business-to-consumer (*B2C*), business-to-business (*B2B*), and business-to-government (*B2G*) e-commerce by companies and the economic development of EU member countries. The relationship of e-commerce with innovation activities and the economic development of countries was evaluated. The analysis input was represented by annual data from the EU from 2013 to 2021, and the indicators of the e-commerce companies (where *B2C*, *B2B*, and *B2G* represent one variable) were classified according to company size. Twelve e-commerce indicators were analyzed in total. The panel regression analysis confirmed that a higher rate of innovation is associated with a higher rate of e-commerce, which, in turn, is associated with a higher rate of economic development in countries. Most of the relationships explored were confirmed. Nevertheless, when specifying them, it is necessary to consider the specifics of *B2C* and *B2B* with *B2G*. The the cluster analysis demonstrated that Bulgaria and Romania are among the countries that should pay more attention to this issue.

1.Introduction

Globalization processes are accompanied by the dynamic use of information and communication technologies (*ICT*), which has also prompted changes in global economic activities. The use of the Internet and *ICT* has brought many opportunities and challenges for companies. This has enabled companies to make better use of assets, streamline supplier-customer relationships, and bring innovations to the market faster (Apostolov & Coco, 2021). The possibilities for electronic communication between businesses, as well as between businesses and consumers, have radically expanded (Andersen et al. 2022). The individualization of trade and international business transactions have expanded, and the transfer of research and development knowledge into practice has

accelerated. Knowledge capital is increasingly coming to the fore, highlighting its explicit impact on productivity (**Ciasullo & Lim, 2022**; Agostini et al. 2020). *ICT* is an important type of knowledge capital essential for business management. Although the available experts and research studies present an intensive study of the impact of *ICT* on economic growth or macroeconomic indicators, studies examining the impact of e-commerce on economic development are much more limited. Those that are available have limited research trajectories and are dominated by statistical outputs. We can conclude that the existing literature does not sufficiently clarify the impact of e-commerce on economic development or on individual e-commerce types (business-to-business or *B2B*, business-to-consumer or *B2C*, and business-to-government or *B2G*), as noted by **Duraković and Cosic (2019)**, **D'Andrea et al. (2019)**, **Biemans and Griffin (2018)**, among others.

Studies show a strong preference for academic research on *B2C* markets and a strong imbalance in academic research between *B2B* and *B2C* (**Lilien, 2016**). According to experts, a strong focus on the dimensions of *B2B* innovation, *B2B* buying and *B2B* analytics is needed.

E-commerce is the use of the Internet to carry out commercial transactions at both the national and international levels. Gradually, it became a mechanism to replace many economic activities carried out within companies, and its initial function as an effective intermediary and aggregator of information became even more pronounced. E-commerce also strongly supports the competitiveness of companies and the economic development of countries. It can affect the economic development of countries unevenly, which is conditioned by their specificities. Regulations of financial systems and various mechanisms for financing R&D, the system of government support, and the economic policies of countries can help in this process. The quality of the business environment, the regulatory environment influencing the openness of trade, and innovation incentives also depend on countries' economic policies (**Zatonatska & Novosolova, 2017**; **Birlea & Capatina, 2017**).

Innovative incentives led by the government can eliminate the negative effects of market openness. The time perspective, the rate of use of e-commerce, and the starting economic position of countries also play a significant role in studying the impact of e-commerce on the economic development of countries.

In many countries, e-commerce is a key driver in the development of business systems (**Kabango & Asa, 2015**). The role of both social and economic reforms in the intensified development of e-commerce and social media has been increasingly highlighted. E-commerce is often associated with research and development, allowing the exploration of multidimensional research trajectories tied to productivity. The role of governments in the development of e-commerce is also perceived differently in research studies, which is determined by historical aspects and their strength within different types of policies (**Pradhan et al. 2021**). However, government interventions are insufficient to dynamically develop e-commerce use. Administrative, legal, and economic infrastructure, and a system of interventions to compensate for market failures are also very important. Government interventions can have both positive and negative effects on e-commerce (**Huang et al., 2022**). Their impact must be systematically explored and evaluated. Country governments should adopt appropriate policies and provide optimal conditions for the development and support of *ICT* in e-commerce.

The available research studies lack a systematic examination of the impacts of innovation on the outputs of online commerce as well as the effects of online commerce on economic development. These consequent facts were motivated by the implementation of our study, which aimed to quantify the relationships in the trajectory of the innovation activity of countries; the outputs of *B2C*, *B2B*, and *B2G* within e-commerce; and the economic development of EU member states aimed at creating effective public policies.

2. Literature review

Within the scope of international research, there exists a wide-ranging corpus of studies exploring the different dimensions of *ICT* use in terms of connectivity with innovation, e-commerce, and business platforms in relation to qualitative as well as quantitative aspects of business and management. This creates space for the formulation of research trajectories, with penetration into many scientific fields and disciplines. The issue of innovative development in connection with business aspects and macroeconomic indicators is becoming increasingly multidisciplinary. This is also why research studies in a given field are highly heterogeneous, influenced by the target focus of research and research teams, and access to structured data. The advantage of this heterogeneity of research studies is the possibility of defining a new research space and accurately identifying the research gap. This can positively impact the development of new concepts, methodologies, and models that support international comparative analyses.

When studying the solved issue related to the objective of our study, three research dimensions were defined, which were translated into the research questions presented in the methodological section. The first part of the literature review aims to study the link between the innovation activity of EU countries and the results of e-commerce. The second part examines the relationship between e-commerce results and economic development in EU countries. The third part analyzed studies on the differences in the companies' results for *B2C*, *B2B*, and *B2G* between EU countries in relation to innovation and economic development.

Auboin et al. (2021) explore the specific roles of innovation policies and their differences. The authors state that the processes of globalization and digitalization have a significant impact on economic competition and that it is therefore necessary to rethink industrial policies. The role of trade has also changed rapidly in the context of the 2019 pandemic, which has created a pressure to change traditional industrial policies and trade rules. **Berisha-Shaqiri (2014)** sees the process of informatization as a means for the expansive development of business and the processes within it. Radical changes are visible in supply chains, customers, and international trade. This is confirmed by **Fernández-Portillo et al. (2020)**, who find that the dynamics of *ICT* deployment and use affect the economic growth of advanced European economies. **Melitz and Redding (2021)** consider market size, economic competition, comparative advantage, competition, comparative advantage, and knowledge spillovers; they hold that international trade is a key determinant of a company's profitability and survival and plays a significant role in creating incentives for innovation and the rate of creative destruction. **Shu and Steinwender (2019)** examine the impact of trade liberalization on innovation-related outcomes. The results of the analyses show that trade liberalization stimulates innovation as well as productivity in emerging countries. In more productive companies, the positive effects of trade on innovation were confirmed; in less productive companies, the negative effects were more pronounced.

Cai and Santacreu (2022) also draw attention to the sectoral interactions among business, innovation, and knowledge diffusion, and discover strong heterogeneity of these relations between countries, as well as within countries and between sectors. Similarly, **Akcigit et al. (2018)** explore the cross-sectoral allocation of R&D resources using a multi-sectoral growth model. The optimal path for the allocation of science and research resources is addressed in this study. Past innovations in one sector can benefit future innovations in other sectors. Belzberg and Mtar (2020) also investigate the causal relationships among trade openness, innovation, financial development, and economic growth across 27 OECD countries. They find a neutral relationship between economic growth and innovation, between innovation and financial development, and between innovation and trade.

A one-way relationship has also been identified between economic growth and financial development and between financial development and trade, which is a critical point for policymakers. **Mtar and Belazreg (2021)**, for example, discuss such a one-way relationship between economic growth and financial development, trade and economic growth, and innovation and financial development. The results of the analyses are a strong appeal to improve the regulatory environment and increase support for innovation and productivity by governments.

Haaland and Kind (2008) draw attention to optimally coordinated policies with R&D subsidies. It is optimal for governments to provide higher subsidies for R&D and lower trade costs. **Prahdan et al. (2021)** investigate the endogenous links between financial development, innovation, and economic growth in OECD countries. They confirm that financial development and innovation support long-term economic growth and that short-term dynamics are linked to the diverse links between financial development, innovation, and economic growth. **Pradhan et al. (2017)** explore the financial depth and trade openness-economic growth nexus. According to the authors, the study of longterm economic growth must consider the openness of trade, financial depth, foreign direct, and gross capital formation. These findings are consistent with **Raghutla's (2020)** study. **Koellinger (2008)** conducts an extensive empirical study to examine the relationship between the use of Internet technologies, different types of innovation, and company-level performance. All types of Internet-enabled innovation were positively linked to the company's turnover and employment growth. However, innovation is not always associated with higher profitability. According to **Panasenko et al. (2021)**, the innovative development of a modern company should provide intellectual capital, which is also an indicator of the economic system.

Anvari and Norouzi (2016) explore the impact of e-commerce, R&D, and other variables on economic development in 21 selected countries. The results of their study confirm that e-commerce and research and development have a positive impact on gross domestic product (GDP), with e-commerce having a stronger effect on economic development compared with research and development. **Choi and Yi (2018)** examine the impact of the Internet on the relationship between R&D spending and economic growth using panel data from 105 countries. Their results show that the impact of R&D spending on economic growth is positively influenced by the Internet. The impact of the Internet on economic growth is positively influenced by an increase in R&D spending. **Kabango and Asa (2015)** claim that the effectiveness of information technology is essential for the success of e-commerce, and that the introduction of government infrastructure to support e-commerce is essential. **Boateng et al. (2008)** conceptualize the link between e-commerce and socioeconomic development, and confirm the importance of exploring another factor, the cultural perspective, in justifying the adoption of e-commerce at the national level. E-commerce contributes to supporting a company's performance through organizational innovation."

Recent studies also confirm that e-commerce negatively impacts carbon emissions in the middle and higher quantiles (**Xie et al. 2022; Cheba et al. 2021; Chen & Yan, 2020; Escursell et al. 2021**), and, therefore, policies supporting e-commerce should be part of environmental sustainability programs. In addition, in the area of financial services, there have been changes due to innovative developments (**Gomber et al. 2018**). The whole industry, as well as fintech start-ups, is looking for optimal business models and approaches to transform services to customers. Many authors also explore technological innovations in relation to employment and the labor market. According to **Su et al. (2022)**, the relationship between innovation and employment is complicated and, knowing this, they explore the interactions between the number of patents and new job opportunities. The selection of appropriate variables is an important determinant in quantifying the impact of innovation on economic output. **Bartelsman et al. (2019)** confirm that broadband use predicts productivity better than product

innovation. **Baum et al. (2017)** draw attention to the need to consider sectoral heterogeneity when exploring the links between R&D, innovation, and productivity. **Baumann and Kritikos (2016)** also investigate the same relationships between variables, focusing on micro-companies. Their ambition was to determine the extent to which micro-companies differed from other companies in terms of their innovativeness. The link between R&D, innovation, and productivity is no different for micro-companies than for larger companies. Innovation can also predict a company's resilience. **Spescha and Woerter (2019)** confirm that companies with research and development -based innovations are more resistant to fluctuations in the economic cycle than non-innovative companies. Cooperation and regional specificities are important determinants of innovation development. Small and medium-sized enterprises (SMEs) in innovative regions use combinations of internal R&D, external cooperation, and non-research-related inputs. In less innovative regions, SMEs rely mainly on external resources and cooperate with other firms. Universities and research and technology organizations have also become important components of innovation systems in these processes (**Giannopoulou et al. 2019**).

Innovation and e-commerce have also sparked changes in the traditional thinking of *B2B* marketing. **Lin et al. (2020)** confirm this effect in their study, and further note that technological innovations in the digital space have brought about changes in marketing processes, especially in the *B2B* environment, where alignment with different stakeholders is essential.

In the digital economy of e-commerce, ethical leadership and trust are also important. Social trust in the country promotes the use of open *B2B* e-commerce but prevents the use of closed e-commerce. **Donbesuur et al. (2020)** point to the absence of an investigation into the impact of technological and organizational innovations on the performance of companies. According to them, technological and organizational innovations have a synergistic effect on international performance. Durakovic and Cosic compare the impact of innovation strategies on business performance in *B2B* and *B2C* companies in Bosnia. They argue that *B2C* companies are more knowledge-intensive and successful in business; and *B2B* employs a significantly higher number of workers, is labor-intensive, and does not have sufficient potential to be sustainable or attract workers from the global market. They have significantly lower wages and exports. Stabilizing the country thus requires priority investments in *B2C* companies where wages are higher.

According to Hoejmos et al. (2012), companies operating in *B2C* markets are also more involved in green supply chain management because of higher pressures from institutions as well as stakeholders. Building trust can be a powerful stimulator of the better use of green management in *B2B* markets. **Wright et al. (2019)** raise the question of the position of big data technology for innovation in *B2B* marketing. The online marketing environment is dynamic and requires permanent innovation. Thus, Wright et al. appeal to the necessity of linking innovation activities between *B2B* and *B2C* when *B2B* products and services of customers provide value to end (*B2C*) customers. This study highlights the impact of innovation on business-to-business relationships. Related to this is the growing importance of *B2B* and *B2C* communication and customer relations, which are influenced by the dynamic changes in the e-marketplace. This fact is confirmed by **Davidavicienė et al. (2017)**, who highlight the need to understand and implement innovative tools to communicate within *B2B* with *B2C* on social media channels. **Purchase et al. (2009)** point out that suppliers perceive different relationships between businesses (*B2B*) and the government (*B2G*) based on perceived value. This can also significantly affect suppliers' decision-making processes and disadvantage government procurement.

In an international environment, e-business is a more complex system, as shown by **Zhu et al. (2006)**, who explored how technology readiness, technological integration, company size, global scale, management barriers, intensity of competition, and the regulatory environment influence the assimilation of online business at the corporate level. A significant finding was that competition

positively influences initiation and acceptance but negatively affects routine. Excessive competition leads companies to pursue the latest technologies (Saunila et al., 2021). The regulatory environment plays a more important role in developing countries than in developed countries. Soto-Acosta et al. (2016) explore the motives behind e-business development in companies. They analyzed the intermediary effect of organizational innovations on the relationship between e-commerce and a company's performance. The results of the analyses showed that e-commerce development is based on technological and internal organizational resources rather than external pressures.

The studies presented herein convince us of the need to better explore the impact of e-commerce as well as innovations on the economic development of the countries. Scholars have thus far reflected on the investigation of separate platforms (*B2B*, *B2C*, *B2G*) and their relations to macroeconomic indicators to a minimal extent. There especially exists a strong imbalance in academic research between *B2B* and *B2C*.

3. Methodology

The main goal of this study was to quantify the relations in the trajectory of innovation activity of the countries, the outputs of *B2C*, *B2B*, and *B2G* e-commerce by the companies, and the economic development of EU member countries. Fig. 1 also shows these relationships.

The three research questions raised from the main objective of the study:

RQ 1. Is there a relationship between their innovative activity and the outcomes of e-commerce in EU countries?

RQ 2. Is there a relationship between e-commerce outcomes and economic development in EU countries?

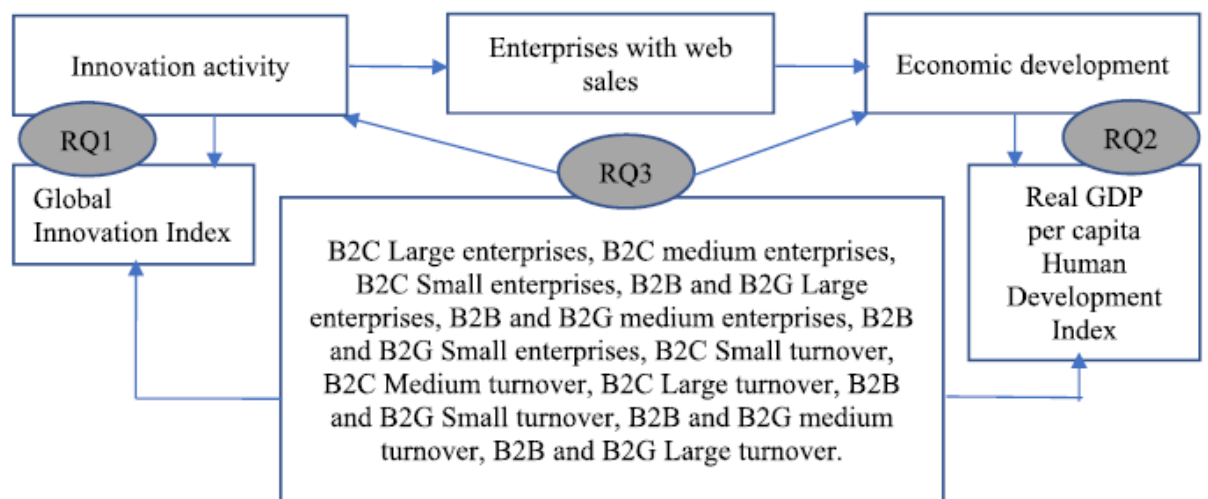


Fig. 1. Relations between the explored components and the research questions.

RQ 3. Are there differences in the outcomes of *B2C*, *B2B*, and *B2G* businesses among the countries explored regarding the observed companies with innovation and economic development?

The Global Innovation Index (*GII*) is the general indicator of innovation activities that considers a wide variety of innovation areas. These areas are related to and synergistically complement each other. This indicator was evaluated as the most suitable for the needs of the study goal. In the area of business outputs in e-commerce, sales characteristics and number of companies were selected. These characteristics are widely applied, and at the same time, they represent the attributes sufficiently general enough in order to cover the investigated relations. Economic development was captured by two complementary characteristics (human development index [*HDI*] and *GDP*); as long as *GDP* captures only the economic aspect, *HDI* captures economic development from a social point of view.

The analytical processes included data on an annual basis for the period from 2013 to 2021 for all EU member countries [$n = 27$ - Austria (AT), Belgium (BE), Bulgaria (BG), Croatia (HR), Cyprus (CY), Czechia (CZ), Denmark (DK), Estonia (EE), Finland (FI), France (FR), Germany (DE), Greece (EL), Hungary (HU), Ireland (IE), Italy (IT), Latvia (LV), Lithuania (LT), Luxembourg (LU), Malta (MT), Netherlands (NL), Poland (PL), Portugal (PT), Romania (RO), Slovakia (SK), Slovenia (SI), Spain (ES), Sweden (SE)].

Two groups of variables (indicators) were examined. The first group consisted of macroeconomic indicators and the second group of indicators demonstrated a level of e-commerce. *GII* values were obtained from the final reports of the World Intellectual Property Organization (**WIPO, 2022**), *HDI* from the **United Nations Development Program** (2022), and real *GDP* per capita from the Eurostat database (2022). The Internet business indicators were obtained from Eurostat databases—the share of businesses with e-commerce from the e-commerce sales database (**Eurostat, 2022a**) and the turnover share from the value of the ecommerce sales database (**Eurostat, 2022b**). **Table 1** summarizes the selected variables.

The analytical process was divided into three stages. As part of the first one, a descriptive analysis was carried out with the aim of identifying the fundamental characteristics of the selected indicators. Subsequently, a panel regression analysis was carried out to evaluate the relationships resulting from the main objective of the study. In the last stage, cluster analysis was carried out, the purpose of which was a more detailed representation of the relations among the countries in the discussed topic.

As part of the descriptive analysis, non-parametric difference tests (Kruskal-Wallis test) were performed to assess the differences among the individual countries and years. The panel regression analysis was implemented through a two-way approach as well as the individual models. The F test for the presence of the individual effects and the time effects (statistical significance of the structure defined by the countries and the individual years), the Hausman test (selection of the fixed-effects model as within approach or the random effects model), and the Breusch-Pagan test (evaluation of the constant characteristics of the residual variability - homoskedasticity). In the models where significant heteroskedasticity was identified, the Arellano estimation method was applied to the fixed-effects models and the White method for the random effects models. The input to the cluster analysis consisted of the standardized and averaged indicators (standardization from 0 to 1, where 1 represents the highest rating and the highest average value of the original variable). The number of clusters was estimated using the silhouette method. The cluster analysis was carried out through partitioning around medoids by applying Manhattan distances. The analytical processes were carried out in the *R* software environment [version 4.2.1 (**R Core Team, 2022**)] using the *R* studio application and the packages *plm*, *lmtest*, *sandwich*, *cluster*, and *factoextra*.

Table 1 Variables description.

Abbreviation	Whole name	Unit
B2C Large enterprises	Enterprises with web sales B2C Percentage of enterprises Large enterprises (250 employees and selfemployed persons or more), without financial sector	%
B2C medium enterprises	Enterprises with web sales B2C Percentage of enterprises Medium enterprises (50249 employees and selfemployed persons), without financial sector	%
B2C Small enterprises	Enterprises with web sales B2C Percentage of enterprises Small enterprises (1049 employees and selfemployed persons), without financial sector	%
B2B, B2G Large enterprises	Enterprises with web sales B2B and B2G Percentage of enterprises Large enterprises (250 employees and selfemployed persons or more), without financial sector	%
B2B, B2G medium enterprises	Enterprises with web sales B2B and B2G Percentage of enterprises Medium enterprises (50249 employees and selfemployed persons), without financial sector	%
B2B, B2G Small enterprises	Enterprises with web sales B2B and B2G Percentage of enterprises Small enterprises (1049 employees and selfemployed persons), without financial sector	%
B2C Small turnover	Enterprises turnover from web sales B2C Percentage of turnover Small enterprises (1049 employees and selfemployed persons), without financial sector	%
B2C Medium turnover	Enterprises turnover from web sales B2C Percentage of turnover Medium enterprises (50249 employees and selfemployed persons), without financial sector	%
B2C Large turnover	Enterprises turnover from web sales B2C Percentage of turnover SMEs (10249 employees and selfemployed persons), without financial sector	%
B2B, B2G Small turnover	Enterprises turnover from web sales B2B and B2G Percentage of turnover Small enterprises (1049 employees and selfemployed persons), without financial sector	%
B2B, B2G medium turnover	Enterprises turnover from web sales B2B and B2G Percentage of turnover Medium enterprises (50249 employees and selfemployed persons), without financial sector	%
B2B, B2G Large turnover	Enterprises turnover from web sales B2B and B2G Percentage of turnover SMEs (10249 employees and selfemployed persons), without financial sector	%
GDP	Real Gross Domestic Product percapita	EUR
GII	Global Innovation Index	Index 1–100
HDI	Human Development Index	Index 0–1

4. Results

In this section, the selected analytical procedures that lead to the fulfillment of the main objective are presented. In the first part, it is possible to find the outcomes of the descriptive analysis together with the outcomes of the difference tests of the selected characteristics among the countries, as well as between the individual years. This is followed by the application of panel regression analysis, and in the last section, a space is devoted to the results of the cluster analysis.

From the results of the descriptive analysis (**Table 2**), it is possible to identify the fundamental characteristics of the indicators that enter the subsequent analytical processes. The sales indicators show the ratio (in percentage) of the businesses with Internet sale to the Internet sales revenue. We find that the *B2C* outcomes compared with the *B2G* outcomes are not fundamentally different (for instance, mean *B2C* large enterprises - 19.59 ± 7.43 , *B2B*, *B2G* large enterprises - 19.08 ± 7.43), even though lower central tendency outputs were recorded in *B2G* than in *B2C*. By contrast, the turnover of companies with Internet sales exceeds the ratio of *B2G* companies. The last three columns show the outputs of the macroeconomic indicators. They represent an assessment of the differences between the individual countries and also between the individual years. Differences were also evaluated using the nonparametric Kruskal-Wallis test. When evaluating the differences between countries, we find that there is a significant difference in all indicators. A difference was also identified between the individual years. However, there was no significant difference between the individual years in the macroeconomic outputs (*GDP*, *GII*, and *HDI*). **Table 3** demonstrates the average values of the selected indicators in EU member countries. Higher values of the individual indicators are highlighted with more intense coloring. Ireland, Sweden, and Finland belong among the countries with a higher rate of e-commerce. Lower rates were identified in Bulgaria, Romania, and Luxembourg. The lower level of e-commerce could also be justified by economic development; however, Luxembourg is an obvious exception because of its specificity (a small but developed country). Based on the results of the selected macroeconomic indicators, Luxemburg and Nordic countries dominate the area of economic development, while lower values were recorded in Romania, Bulgaria, and Hungary.

Table 2 Descriptive analysis and difference testing.

Variable	Mean	Median	Std. Dev.	Min	Max	diff Year H (p value)	Diff Country H (p value)
B2C Large enterprises	19.59	19.00	7.46	6.00	41.00	16.81 (0.01)	173.19 (<0.001)
B2C medium enterprises	15.49	14.00	6.76	5.00	43.00	17.51 (0.008)	165.71 (<0.001)
B2C Small enterprises	12.20	12.00	4.60	4.00	28.00	22.14 (0.001)	146.87 (<0.001)
B2B, B2G Large enterprises	19.08	18.00	8.51	4.00	42.00	15.94 (0.014)	186.19 (<0.001)
B2B, B2G medium enterprises	14.37	14.00	5.87	3.00	32.00	11.28 (0.08)	193.98 (<0.001)
B2B, B2G Small enterprises	10.32	10.00	4.56	3.00	24.00	10.85 (0.093)	183.81 (<0.001)
B2C Small turnover	1.80	1.00	1.50	0.00	11.00	16.83 (0.01)	95.84 (<0.001)
B2C Medium turnover	2.05	2.00	1.45	0.00	8.00	18.88 (0.004)	122.13 (<0.001)
B2C Large turnover	2.59	2.00	2.06	0.00	16.00	13.9 (0.031)	125.19 (<0.001)
B2B, B2G Small turnover	2.23	2.00	1.37	0.00	7.00	10.09 (0.121)	137.55 (<0.001)
B2B, B2G medium turnover	3.50	3.00	2.14	0.00	15.00	15.08 (0.02)	120.74 (<0.001)
B2B, B2G Large turnover	3.70	3.00	2.58	0.00	22.00	11.69 (0.069)	137.3 (<0.001)
GDP	26,196	20,450	17,030	5390	84,750	2.23 (0.897)	237.72 (<0.001)
GII	48.77	48.34	7.29	35.60	63.82	0.41 (0.999)	231.92 (<0.001)
HDI	0.89	0.89	0.04	0.80	1.00	6.78 (0.341)	221.71 (<0.001)

In the next stage, attention was paid to the evaluation of the relationships between the innovative activity of individual countries and their outputs related to e-commerce, as well as to the evaluation of the relationship between e-commerce and the development of the economies. Attention was also paid to the assessment of the conditions of an application, as well as the selection of the individual methods for assessing the mentioned relationships. **Tables 4 to 6** present the outputs from the evaluation of the conditions related to the application of the panel regression analysis.

Table 4 presents the results of the evaluation of the conditions for the model with the independent variable, (*GII*) and the dependent variable in the form of the outputs of *B2C* and *B2G* e-commerce of the companies. The last column of the table demonstrates the most appropriate method for estimating the relationships by applying a panel regression analysis. For this relationship, a two-way effects model was applied in all cases (based on the results of the F test). If the Hausman test showed a significance level, the fixed-effects model was preferred. The only questionable relationship was one of the innovations with a *B2C* small turnover (test statistics = 3.79, p value = 0.052). In this case, the p value was very close to the statistical significance threshold, so we decided to apply the fixed-effects model. The Breusch-Pagan test demonstrated the significance of heteroscedasticity, in which robust models were applied in most cases.

Table 5 evaluates the conditions of the panel regression models. Based on the outputs of the F test year, it can be concluded that only the structure of countries is significant in the assumed relationships. Accordingly, individual effects models were selected, where the panel variable was created based on the structure of the countries. In most cases, the fixed-effects model is preferred. Significant heteroscedasticity was not observed in only three cases.

As in the previous case, the relationship of *B2C*, *B2B*, and *B2G* ecommerce outputs of companies with *HDI* will be estimated through individual effects models with the panel variable country. The Hausman test showed that half of the explored relationships were estimated by the random effects models and half by the fixed-effects models. Hetero-scedasticity is apparent in several cases where these relationships are estimated by applying robust methods.

Table 7 presents the main outputs of the relationship assessment. It is divided into three basic parts: (i) *GII* → Internet sales output, (ii) Internet sales output → *GDP*, and (iii) Internet sales output → *HDI*.

When we focus on the first part (*GII* → Internet sales output), it is obvious that most of the relationships are significant and have a positive effect.

Table 3 Descriptive analysis - arithmetic mean of the selected indicators in the classification of the individual countries.

ID	B2C Large enterprises	B2C medium enterprises	B2C Small enterprises	B2B, B2G Large enterprises	B2B, B2G medium enterprises	B2B, B2G Small enterprises	B2C Small turnover	B2C Medium turnover	B2C Large turnover	B2B, B2G Small turnover	B2B, B2G medium turnover	B2B, B2G Large turnover	GDP	GII	HDI
AT	18.56	16.44	13.67	21.44	15.00	10.44	1.56	1.33	1.56	1.11	1.44	2.22	36670.00	52.05	0.91
BE	25.56	17.33	16.44	32.11	19.67	15.00	1.67	1.71	4.71	3.43	6.71		34775.56	50.66	0.93
BG	9.00	9.11	7.00	8.11	6.33	5.22	0.44	0.44	0.56	0.67	0.89	2.22	6101.11	41.54	0.81
CY	28.78	26.11	9.11	18.33	16.44	5.67	1.22	2.67	1.78	0.67	3.11	0.44	23038.89	46.71	0.88
CZ	18.78	17.00	17.33	21.78	18.67	16.67	2.56	2.44	3.22	4.11	5.33	4.11	16995.56	49.53	0.89
DE	17.00	14.40	14.67	24.60	17.25	14.50	1.56	1.44	1.89	2.25	2.78	3.89	34785.56	57.26	0.94
DK	27.11	17.11	16.44	33.89	21.78	16.33	2.00	2.88	2.38	3.88	4.75	5.38	47190.00	58.04	0.94
EE	21.67	15.33	11.67	20.33	15.56	10.78	1.33	1.11	3.22	2.67	4.22	3.67	13570.00	50.70	0.89
EL	17.44	15.56	9.38	11.44	9.25	6.25	2.29	2.38	1.89	1.29	1.75	1.13	17043.33	38.50	0.88
ES	15.89	14.11	11.78	16.56	14.22	10.44	1.33	1.44	3.33	1.78	3.33	4.67	23456.67	48.14	0.91
FI	27.25	13.88	13.13	35.00	19.50	12.63							35851.11	59.27	0.93
FR	17.89	14.00	10.00	16.56	9.67	6.67	1.11	1.67	3.33	1.75	2.50	4.22	31921.11	53.79	0.90
HR	18.00	16.56	13.33	17.33	16.44	14.22	1.67	2.33	1.78	3.33	4.00	2.56	11682.22	39.51	0.85
HU	11.22	11.00	10.56	12.00	10.89	8.67	1.89	1.11	1.67	2.22	2.89	5.89	12031.11	43.05	0.84
IE	35.56	36.89	21.33	26.89	22.67	11.44	4.56	4.78	8.11	2.67	7.33	10.56	53196.67	56.43	0.93
IT	16.44	9.56	8.22	13.22	7.67	5.56	0.33	0.33	1.00	1.00	2.00	2.33	28214.44	46.45	0.89
LT	19.44	19.11	15.89	17.00	18.00	15.33	3.44	3.78	1.56	4.67	4.00	2.78	12764.44	41.03	0.87
LU	10.11	9.44	8.33	11.67	9.11	7.00	1.00	0.00		1.17	0.67		83301.11	54.87	0.92
LV	18.78	10.00	8.00	16.00	10.11	6.56	1.13	1.00	2.38	1.13	5.25	1.75	11522.22	43.56	0.86
MT	27.33	26.13	15.13	18.33	18.13	10.00	1.57	3.00	3.00	1.57	3.25	2.44	20621.11	49.62	0.90
NL	19.56	13.33	14.78	24.56	18.89	15.78	3.00	1.78	5.00	3.00	3.22	4.44	40210.00	60.79	0.90
PL	14.33	11.11	8.78	16.22	10.89	8.00	1.33	1.00	1.43	2.00	2.67	5.13	11833.33	40.66	0.87
PT	19.67	14.13	9.33	14.56	9.63	6.78	1.78	2.33	2.56	1.67	3.44	4.00	17288.89	45.32	0.86
RO	10.56	7.67	7.67	6.67	4.89	4.00	1.44	1.78	2.67	1.22	1.56	1.78	8252.22	37.73	0.83
SE	24.33	18.22	15.67	34.22	25.11	16.11	2.44	4.00	3.11	2.67	4.67	5.67	42921.11	62.86	0.94
SI	25.44	13.33	12.22	18.56	11.89	11.78	0.71	0.00	0.44	2.17	2.00	1.89	19202.22	45.99	0.91
SK	11.78	11.78	10.56	12.11	10.56	8.11	1.67	1.67	1.22	2.44	3.11	4.56	14858.89	41.90	0.85

Table 4 Evaluation of the model of the GII association with the outputs of *B2B*, *B2C*, and *B2G* enterprises.

independent variable: GII	F test - Country	F test - Year	Hausman - Robust	Breusch-Pagan Test	Model
B2C Large enterprises	24.13 (<0.001)	7.93 (<0.001)	50.45 (<0.001)	2.25 (0.134)	RE TW
B2C medium enterprises	46.21 (<0.001)	4.17 (<0.001)	47.56 (<0.001)	8.63 (0.003)	RE robust TW
B2C Small enterprises	14.91 (<0.001)	12.72 (<0.001)	76.71 (<0.001)	0.01 (0.93)	RE TW
B2B, B2G Large enterprises	18.85 (<0.001)	10.97 (<0.001)	71.04 (<0.001)	5.42 (0.02)	RE robust TW
B2B, B2G medium enterprises	21.94 (<0.001)	5.74 (<0.001)	41.53 (<0.001)	0.39 (0.531)	RE TW
B2B, B2G Small enterprises	23.79 (<0.001)	5.78 (<0.001)	51.79 (<0.001)	7.44 (0.006)	RE robust TW
B2C Small turnover	4 (<0.001)	4.03 (<0.001)	3.79 (0.052)	1.14 (0.285)	FE TW
B2C Medium turnover	10.26 (<0.001)	5.57 (<0.001)	15.44 (<0.001)	3.58 (0.058)	RE TW
B2C Large turnover	8.64 (<0.001)	4.44 (<0.001)	4.28 (0.038)	41.73 (<0.001)	RE robust TW
B2B, B2G Small turnover	11.27 (<0.001)	1.61 (0.125)	1.54 (0.214)	6.42 (0.011)	FE robust TW
B2B, B2G medium turnover	7.86 (<0.001)	1.95 (0.055)	3.04 (0.081)	5.61 (0.018)	FE robust TW
B2B, B2G Large turnover	13.7 (<0.001)	2.86 (0.005)	25.24 (<0.001)	5.72 (0.017)	RE robust TW

Note: RE - Random effect model, FE - Fixed (within) effect model, robust -heteroscedasticity treatment, TW - twoways effect model.

First, it is appropriate to compare the effects of *B2C*, *B2B*, and *B2G*. If we focus on the coefficient of determination for companies, there is a higher coefficient of determination for *B2B* and *B2G* than for *B2C* in the significant relationships. In the terms of turnover, the difference is more on the side of the *B2C* companies. It was also found that innovations (*GII*) did not have a significant impact on *B2C* medium companies, *B2B* and *B2G* small companies, *B2C* medium turnover, and *B2B* and *B2G* large turnover. Thus, the formula based on the size of the companies is very likely not to correctly explain the connection between innovations and Internet sales output. Among the analyzed relationships, one negative relationship was also demonstrated ($GII > B2B$ and $B2G$ medium turnover: $\beta = -0.007$, sig = 0.043), but this is a relationship at the threshold of acceptability with a low coefficient of determination, so it is definitely not an important result. The second part of the table focuses on the relationship between e-commerce and economic development presented by real gross domestic product

per capita (Internet sales output $\wedge$ GDP). Even in this case, most relationships appear to be statistically significant with a positive p coefficient. In this case, it cannot be said that there is an assumption of a certain principle based on the difference in the relationship between the size of the company or by focusing on the customer, that is, at the B2B, B2C, and B2G companies. A similar output is also shown in the last part of Table 6 when examining the effect of e-commerce on economic development presented by the Human Development Index (Internet sales output $\rightarrow$ *HDI*). In most observed cases, a significant positive relationship was evident. The following part of the analysis will be devoted to the assessment of the explored relations in the context of EU member countries more consistently.

The conclusions of the analytical processes are devoted to cluster analysis applications. The average data entered this analysis (the average for the countries was in the individual years) and successively standardized from 0 to 1, where 0 represents the lowest value, and 1 represents the highest value meaning the best value. The number of clusters is estimated using the silhouette method.

Fig. 2 expresses the association between the innovation potential of the country (represented by the average standardized *GII* rating) and the e-commerce outputs of the *B2B* companies (left) and the *B2B* with *B2G* companies (right). The mentioned clusters divide the countries with better evaluation outcomes and, apparently, those with worse ones. The countries located in the upper right corner represent a more positive evaluation of the studied fields; the lower left corner represents the countries that do not show a positive evaluation. Countries such as Sweden, the Netherlands, and Denmark, which are economically and socially more developed countries, dominate the area of the association relating the innovations and e-commerce of *B2C* companies. Bulgaria was placed in the two clusters, and can be considered as the country with the worst ranking of the association of the innovation and e-commerce of *B2C* enterprises. When relating the evaluation of the innovations and the *B2B* and *B2G* companies with e-commerce, the group of the countries consisting of Ireland, Finland, Denmark, and Sweden is significantly dominant. Countries such as Greece, Bulgaria, and Romania are among those with a more negative evaluation.

Fig. 3 visualises the association between the assessment of the economic development and the assessment of the outputs of the *B2C* Internet commerce as well as the *B2B* and *B2G* enterprises. In the case of the *B2C* business connections, the first cluster consists of the countries with a more positive rating. Ireland and Luxembourg deviate significantly from the other countries. Luxembourg acquires a very positive evaluation in the area of the economic development, but the evaluation of the outputs of the e-commerce is at the level of Bulgaria. On the contrary, Ireland shows the extremely high values of the *B2C* Internet business outputs that are demonstrated in its deviated position visible in **Fig. 3**. In this case, Bulgaria lags behind mostly and is followed by Romania. In the case of Bulgaria and Romania, there is also a clear lag in the field of relationship between the *B2B* and *B2G* companies with e-commerce and the assessment of the economic development.

Table 5 Evaluation of the model of the outputs of *B2B*, *B2C*, and *B2G* enterprises association with gross domestic product.

Dependent variable: GDP	F test - Country	F test - Year	Hausman - Robust	Breusch-Pagan Test	Model
B2C Large enterprises	509.77 (<0.001)	0.06 (1)	0.49 (0.482)	38.58 (<0.001)	FE robust IE
B2C medium enterprises	588.74 (<0.001)	0.07 (1)	0.11 (0.735)	14.53 (<0.001)	FE robust IE
B2C Small enterprises	594.18 (<0.001)	0.24 (0.984)	2.93 (0.087)	9.02 (0.003)	FE robust IE
B2B, B2G Large enterprises	425.2 (<0.001)	0.2 (0.991)	63.86 (<0.001)	25.41 (<0.001)	RE robust IE
B2B, B2G medium enterprises	502.06 (<0.001)	0.04 (1)	2.46 (0.117)	15.22 (<0.001)	FE robust IE
B2B, B2G Small enterprises	501.44 (<0.001)	0.06 (1)	0.46 (0.499)	4.52 (0.033)	FE robust IE
B2C Small turnover	343.97 (<0.001)	0.18 (0.993)	0.16 (0.687)	0.17 (0.68)	FE IE
B2C Medium turnover	363.9 (<0.001)	0.44 (0.896)	0 (0.975)	1.55 (0.213)	FE IE
B2C Large turnover	181.88 (<0.001)	0.3 (0.965)	2.68 (0.102)	4.58 (0.032)	FE robust IE
B2B, B2G Small turnover	345.84 (<0.001)	0.33 (0.956)	2.7 (0.1)	4.94 (0.026)	FE robust IE
B2B, B2G medium turnover	346.01 (<0.001)	0.4 (0.918)	0 (0.996)	0.82 (0.366)	FE IE
B2B, B2G Large turnover	206.19 (<0.001)	0.16 (0.996)	3.7 (0.054)	11.93 (<0.001)	FE robust IE

Note: RE - Random effect model, FE - Fixed (within) effect model, robust -heteroscedasticity treatment, IE - individual effect model.

Table 6 Evaluation of the model of the outputs of *B2B*, *B2C*, and *B2G* enterprises association with human development index.

Dependent variable: HDI	F test - Country	F test - Year	Hausman - Robust	Breusch-Pagan Test	Model
B2C Large enterprises	50.62 (<0.001)	0.81 (0.595)	22.66 (<0.001)	15.61 (<0.001)	FE robust IE
B2C medium enterprises	72.29 (<0.001)	0.54 (0.827)	0.77 (0.381)	10.87 (<0.001)	RE robust IE
B2C Small enterprises	62.75 (<0.001)	1.14 (0.337)	33.06 (<0.001)	5.09 (0.024)	FE robust IE
B2B, B2G Large enterprises	37.08 (<0.001)	1.27 (0.263)	44.33 (<0.001)	26.05 (<0.001)	FE robust IE
B2B, B2G medium enterprises	50.42 (<0.001)	0.46 (0.882)	18.03 (<0.001)	8.63 (0.003)	FE robust IE
B2B, B2G Small enterprises	60.13 (<0.001)	0.65 (0.737)	10.2 (0.001)	0.13 (0.72)	FE IE
B2C Small turnover	66.92 (<0.001)	0.46 (0.884)	0.81 (0.369)	1.73 (0.188)	RE IE
B2C Medium turnover	61.62 (<0.001)	0.56 (0.812)	0.54 (0.462)	4.07 (0.044)	RE robust IE
B2C Large turnover	60.89 (<0.001)	0.57 (0.804)	7.75 (0.005)	3.91 (0.048)	FE robust IE
B2B, B2G Small turnover	63.54 (<0.001)	0.6 (0.778)	1.1 (0.295)	1.91 (0.167)	RE IE
B2B, B2G medium turnover	56.96 (<0.001)	0.57 (0.8)	3.31 (0.069)	3.74 (0.053)	RE IE
B2B, B2G Large turnover	60.37 (<0.001)	0.54 (0.824)	2.29 (0.13)	0.06 (0.809)	RE IE

Note: RE - random effects model, FE - fixed (within) effects model, robust -heteroscedasticity treatment, IE - individual effects model.

Table 7 Panel regression analysis outcomes.

Model	Coef	GII -> web sales output		-	web sales output -> GDP		-	web sales output -> HDI	
		Coef (sig)	R ²		Coef (sig)	R ²		Coef (sig)	R ²
B2C Large enterprises	α	9.826 (<0.001)	0.157		–	0.189		–	0.11
	β	0.2 (<0.001)			266.748 (<0.001)			0.001 (<0.001)	
B2C medium enterprises	α	19.666 (<0.001)	0.054		–	0.273		0.868 (<0.001)	0.308
	β	–0.086 (0.420)			411.58 (0.018)			0.0014 (<0.001)	
B2C Small enterprises	α	6.942 (<0.001)	0.128		–	0.303		–	0.129
	β	0.108 (0.002)			433.94 (0.018)			0.0014 (<0.001)	
B2B, B2G Large enterprises	α	–6.596 (0.241)	0.431		21873.374 (<0.001)	0.123		–	0.13
	β	0.531 (<0.001)			223.964 (<0.001)			0.0011 (<0.001)	
B2B, B2G medium enterprises	α	0.468 (0.803)	0.317		–	0.207		–	0.101
	β	0.285 (<0.001)			393.25 (0.005)			0.0014 (<0.001)	
B2B, B2G Small enterprises	α	5.328 (0.143)	0.172		–	0.143		–	0.078
	β	0.103 (0.154)			378.21 (0.004)			0.0014 (<0.001)	
B2C Small turnover	α	–	0.042		–	0.003		0.885 (<0.001)	0.53
	β	0.194 (0.042)			–109.67 (0.45)			0.0018 (0.014)	
B2C Medium turnover	α	1.039 (0.507)	0.027		–	0.291		0.881 (<0.001)	0.747
	β	0.019 (0.556)			1366.29 (<0.001)			0.0038 (<0.001)	
B2C Large turnover	α	–4.039 (0.033)	0.163		–	0.013		–	0.013
	β	0.137 (<0.001)			206.9 (0.165)			0.001 (0.16)	
B2B, B2G Small turnover	α	–	0.014		–	0.005		0.885 (<0.001)	0.516
	β	0.086 (0.007)			–189.36 (0.761)			0.0018 (0.076)	
B2B, B2G medium turnover	α	–	0.003		–	0.247		0.884 (<0.001)	0.762
	β	–0.007 (0.043)			832.04 (<0.001)			0.0014 (0.025)	
B2B, B2G Large turnover	α	1.699 (0.514)	0.130		–	0.148		0.879 (<0.001)	0.376
	β	0.041 (0.466)			610.31 (<0.001)			0.0017 (0.003)	

5. Discussion

E-commerce is playing an increasingly important role in the digital economy of various business platforms. The global rate of e-commerce is increasing rapidly, which has implications for the digital economy and strongly shows itself in the microeconomic sphere. A systematic study of the impact of new *ICT* and innovation is essential for increasing and maintaining the competitiveness of firms. Not all innovations and technologies are connected with competitiveness and economic growth. Therefore, it is essential to understand the factors that increase the probability of the successful use of *ICT* and innovative activities and promote the economic development of the country.

The descriptive analysis shows that, on average, in EU member countries, approximately 19% of large companies, approximately 15% of medium-sized companies, and approximately 11% of small companies run business via the Internet. The analysis of the differences showed that there were significant differences between individual countries in the examined indicators. Between the individual years, the differences were more pronounced in e-commerce indicators. Macroeconomic characteristics did not show significant differences between individual years. This fact can also be related to the different levels of innovative development, changes in the business environment of the individual countries, legal and organizational aspects, government support for science and research, and so forth (Shu & Steinwender, 2019; Spescha & Woerter, 2019; Cai et al., 2022). As mentioned by Donbesuur et al. (2020), studies quantifying the impact of technological and organizational innovations on companies' economic outputs are absent. A detailed explanation of the influence of the investigated parameters on the microeconomic sphere is not possible without a systematic investigation of the innovations in relation to the national and international macro environments.

The outcomes of the descriptive analysis show that e-commerce outputs can be related to macroeconomic outputs representing the economic development of the countries. This is also indicated by the fact that countries with a higher level of economic development also show a higher level of e-commerce and vice versa. Ireland, Sweden, and Finland are among the countries with the highest rates of e-commerce, and Bulgaria and Romania are among the countries with the lowest rates. An exception is Luxembourg, which is considered an economically developed country but shows relatively low levels of e-commerce. The explanation in this case can be in the form of country size. Although Luxembourg is economically advanced, it is also considered a small country with a specific

economy. The authors of several research studies have also worked with this assumption, and their results confirm our findings (Anvari & Norouzi, 2016; Choi & Yi, 2018).

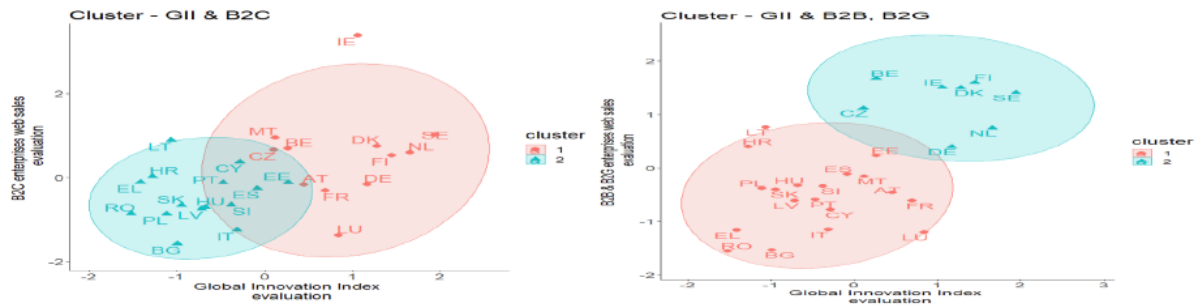


Fig. 2. Innovations (*GII*) and outcomes of e-commerce in the dimensions of *B2B*, *B2C*, and *B2G* companies.

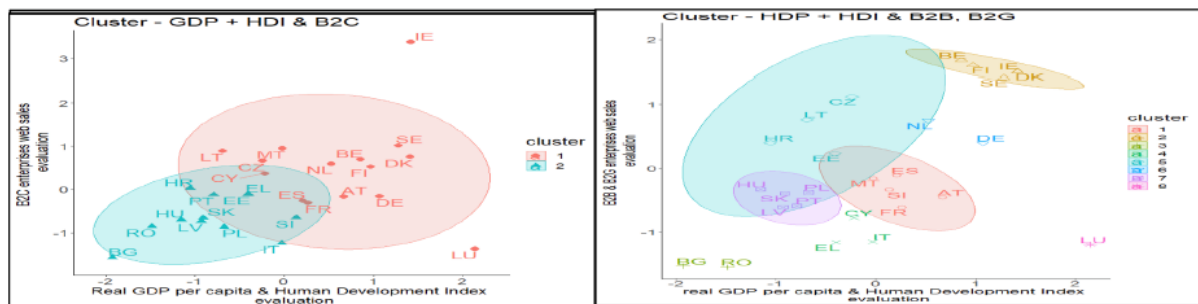


Fig. 3. Innovations (*HDI*) and outcomes of e-commerce in the dimensions of *B2B*, *B2C*, and *B2G* companies.

When evaluating the relationships between innovations and Internet sales output, significant positive relationships were evident in most cases, which can be interpreted as the fact that innovations influence ecommerce outputs to a certain extent. This fact is also confirmed by research studies by Kabango and Asa (2015), Akcali and Sismanoglu (2015), Escursell et al. (2021), Mohdhar and Shaalan (2021), and others.

In countries and years where higher rates of innovation are presented by the *GII*, higher rates of e-commerce outputs can also be expected. When comparing the relationships between the *B2C*, *B2B*, and *B2G* companies, closer relationships occurred in the fields of the *B2B* and *B2G* companies, as the lowest regression coefficients are reached just right by the relation created by this pair of e-commerce types. In the case of large enterprises, the regression coefficient stands at 0.531, while the small enterprises are lowered at 0.285, with medium enterprises somewhere in the middle at a level of 0.103. For the turnover models, other relations are partially seen. Small enterprises topped at 0.086, while large enterprises stood in the second position at a value of 0.041. The only negative and, hence, the lowest level, is reached by medium enterprises that peaked at -0.007 . Unusual differences between *B2C* and *B2G* companies did not appear in the sales of these companies.

The relationship between e-commerce and the outputs of economic development (*GDP*, *HDI*) can be perceived positively, as in these cases, the outputs of the panel regression analysis indicate that a majority of the relationships are significant. Thus, a higher rate of economic development is expected in countries with higher e-commerce output. In general, the results from the analysis of the relationships can be summarized in a way that countries with higher innovation activity show higher rates of e-commerce and, at the same time, countries with a higher rate of e-commerce show a higher rate of economic development. These findings are also supported by the results of studies by Anvari

and Norouzi (2016), Belazreg and Mtar (2020), Fernandez-Portillo et al. (2020), Xie et al. (2022), and others.

Cluster analysis indicated that more developed countries demonstrated a more positive evaluation than less developed ones. Countries such as Sweden, the Netherlands, and Denmark dominate the area of associating the innovations and e-commerce of *B2C* companies. Countries such as Bulgaria, Italy, Poland, and Romania did not receive positive evaluations. When linking the evaluation of the innovations and the *B2B* and *B2G* companies with the e-commerce, a group of the countries consisting of Ireland, Finland, Denmark, Sweden dominates clearly. Countries such as Greece, Bulgaria, and Romania belong to the group with more negative evaluations. The results are similar when linking the evaluation of e-commerce with the evaluation of economic development. Nordic countries show a positive evaluation, and countries such as Bulgaria and Romania are again evaluated negatively. An obvious deviation from other countries can be observed when linking the evaluation of economic development with the e-commerce outputs of *B2B* and *B2G* companies.

Several authors point to the differences in the effects of *B2C*, *B2B*, and *B2G* platforms on macroeconomic outcomes (e.g., **Duraković & Cosic, 2019; Baum et al. 2017; Baumann & Kritikos, 2016**), but a more detailed investigation of several determinants influencing the differences is needed. This also requires access to more deeply structured data, which is a problematic issue in the business sphere.

Countries with lower ratings should not be viewed as negative. It is more appropriate to view these countries as having high potential for development. According to the beta and sigma convergence, it can be considered that the countries with a lower level of development can be developed faster and in a less demanding way than the countries with a higher level of development.

To study the impact of innovation on a trading platform, it is essential to focus on research trajectories separately to study innovative product and service processes within *B2C*, *B2B*, and *B2G* e-commerce. This fact also results from the knowledge that the available research studies declare a significant fragmentation of research on service innovation within *B2B* and it is not clear to what extent *B2B* service innovation differs from *B2B* product innovation (**Qu et al. 2015; Saunila et al. 2021; Spescha & Woerter, 2019; Davidaviciene et al. 2017**). Service-oriented *B2B* companies are less sophisticated in innovation methods, have lower innovation expectations, prioritize incremental innovations, and are less explicit in managing innovation. Most *B2B* companies offer their customers hybrid products and services offerings.

According to **Biemans and Griffin (2018)**, *B2B* companies with a mixed-product strategy of 75/25 products/services or services/products are the most supportive of innovation. Almost half of *B2B* companies offer flows where neither products nor services are dominant, and further research is necessary according to the findings of these authors. It will become even more difficult to quantify the level at which innovations impact the hybrid products of the *B2B*, *B2C*, and *B2G* markets. (**Biemans & Griffin, 2018**).

In the future, qualitative research focused on determining how companies can develop integrated products and services will also be desirable. Our findings provide several recommendations for company managers. The dynamic development of the business environment and the impact of globalization processes will require improving the innovation efforts of companies by more explicitly focusing on innovation through a proactive innovation strategy as well as intensification of international competition, thus creating a culture that not only supports but also manages the innovation culture in the company.

As stated by Hanifah et al. (2019), innovation strategy and culture are the two main pillars of product and service innovation performance. More explicit management of innovation will have a positive effect on the innovation performance of companies and thus support their strategic competitive advantage (Audretsch & Belitski, 2023; Ivanová & Čepel, 2018; **Rauter et al. 2019**). Attention is also paid to the importance of quality screening methods applied to innovative projects in the initial stages of development (**Parida et al., 2017**). Companies should also have the support and effort to experiment with and develop active approaches for the innovation of their products and services (**Hauser et al. 2017**).

These facts represent a strong appeal for the search for and development of new concepts and tools to make these innovation processes in companies more efficient. This can have an impact on revealing new determinants of innovation development in *B2B*, *B2C*, *B2G*, and other markets, and thus, examine their impact on various macroeconomic indicators.

The study provides several outputs necessary for creators of innovative and economic policies, focusing on actively supporting the quality of the business environment and dealing with the creation of regional as well as national strategies, and for managers in companies operating on various market platforms. The results also support the construction of national and international benchmarking indicators necessary for the implementation of comparative analyses and the design of international databases.

6. Conclusion

Despite trying to create conceptual frameworks to analyze the relationships between technology, innovation, business efficiency, competitiveness, and economic development, the environment of trading platforms in relation to the development of e-commerce, innovation potential, and macroeconomic characteristics has not yet been sufficiently studied.

Our study reflects these facts in order to quantify the relationships between the innovation activity of countries, the results of *B2C*, *B2B*, and *B2G* e-commerce, and the economic development of EU countries, thus bringing new knowledge and opening other necessary research dimensions.

The results of these analyses yielded several interesting findings. Foremost, innovation is positively related to e-commerce output. This means that, when there are low innovation outputs, there are also low e-commerce outputs. A higher innovation rate can have a positive effect on e-commerce.

The main limitation of this study is the endogeneity problem. First, it is not possible to view the relationships presented herein from the perspective of causality. Second, the relationships are realized using a relatively homogeneous sample of countries with a relatively high stage of economic development. The generalization of the results for countries with a low level of development would be very bold at this stage of the research. Future research will aim to evaluate the relationship between business and the economic development of the countries, where emphasis will be placed on countries with a low level of development. We also plan to compare the relations between countries at higher and lower levels of economic and innovative development. It is also planned to include the environmental characteristics in this research and thus, to demonstrate the associations with newer research trends in the field of green and circular economies.

The results of the analyses confirm the relationship between e-commerce and economic development. The increase in the share of e-commerce also supports countries' higher economic development. The countries with the best ratings of e-commerce outputs, innovation, and economic development are

mainly Nordic, Belgium, Denmark, and other economically stable countries. Bulgaria and Romania received the lowest ratings.

The dynamics of *ICT* development, as well as the innovative activities of countries, have a significant impact on the development of ecommerce, which is also reflected in the economic development rate of countries. Policymakers should improve institutional quality, regulatory environments to optimize business processes in the international business environment, and support the creation of national databases essential for the development of benchmarking indicators in this area.

To ensure sustainable economic growth in the digital economy, policymakers need to pay constant attention to the development of integrated structures focused on innovation and economic development policies and systematically study and evaluate innovation parameters at both institutional and national levels.

Ethical approval:

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflict of interest:

Marinko Skare declares he has no conflict of interest. Beata Gavurova declares she has no conflict of interest. Martin Rigelsky declares he has no conflict of interest.

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