The impact of e-commerce on the sustainable development: case of Ukraine, Poland, and Austria

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Abstract. The COVID-19 pandemic dramatically and irreversibly transformed global e-commerce trends. The process of internationalization has been slowed down considerably, the level of globalization impact has decreased, that, consequently, has led to a strong lag in the development of some countries. The aim of the study is to determine the nature of e-commerce socio and economic effects in Ukraine, Poland, and Austria. For analysis, a modern mathematical apparatus was used – the Cobb-Douglas model and the Markov chain methodology. The study shows a significant positive impact of e-commerce on employment and GDP in the three countries. Thus, with an increase in investment levels in e-commerce and ICT by 1%, employment in Ukraine will increase by 0.02%, in Poland – by 0.14%, and in Austria – by 0.17%. Similarly, Ukraine’s GDP may rise by 0.07%, Poland’s – by 0.2% and Austria’s – by 0.07%. Therefore, a stable flow of investment in e-commerce will provide countries with a faster way out of the crisis, create more jobs and opportunities for business development.

1. Introduction

As a result of the COVID-19 pandemic, the structure of retail trade has undergone significant changes. Issues related to the introduction of online services for trade in goods and services were raised, and effective management of e-commerce services became necessary. About 21% of European offline stores have been forced to close forever due to bankruptcy during quarantine [1]. The COVID-19 pandemic and strict quarantine restrictions have forced many governments to invest heavily in the development of e-commerce services. Of course, Ukraine needs to comply with the world level of regulation of the e-commerce market and cloud technologies to reach a qualitatively new level of development and implementation of advanced technologies.

According to global trends, in 2021 about a third of the population will be ready to buy online, and the share of online sales among global retailers will be 18% [2]. Thus, it is necessary to increase investment in the development of e-commerce technologies and increase its positive social and economic effects.
The potential of ICTs to advance the 2030 Agenda for Sustainable Development and achieve other internationally agreed development goals could accelerate progress across all 17 Sustainable Development Goals (SDGs). E-commerce has direct relevance to several of these goals (for example, to promote the empowerment of women as entrepreneurs and traders, to support productive activities, decent job creation, entrepreneurship, creativity and innovation, to increase the exports of developing countries, et.) [3].

2. Related works

E-commerce can be considered as a tool to promote productivity growth and improving innovation. Structural and technological changes generate the creation of better jobs (SDG 8 and 9). The E-commerce Index has increased 4 times since 2014 until 2021 (Figure 1).

![Global E-Commerce Index](image)

**Figure 1.** Global E-Commerce Index [4].

The topic of economic uncertainty's impact on national economic development has been studied in [5], in which based on GARCH model was studied the impact of stock market volatility and economic uncertainty on US real GDP. N. Fernandez, for example, in the study [6] of the economic impact of COVID-19 on the world economy considers the dynamics of GDP depending on the quarantine scenarios.

E-commerce as an additional sales channel is necessary for business. Back in 2019, before the COVID-19 pandemic and quarantine, an interesting study was conducted, the main purpose of which was to determine the effectiveness of the use of e-commerce systems for export [7]. Even before the pandemic, it was important for businesses to use e-commerce systems for profitability.

It is not enough for e-commerce companies to simply analyze the data to create high-precision forecasts, set up the most cost-effective logistics process and optimize costs. It is now important to use more advanced technologies such as data management, data engineering, data science and machine learning to work with data that is profitable [8]. It is important to collect and analyze all possible characteristics of your customer and use them in a comprehensive Data Science solution to increase sales and control them [9].

E-commerce promotes sustainable development in the fields of economic prosperity, poverty reduction, social development, international cooperation, etc. It provides people with decent work and increases economic growth in short and long-run [10].

The aim of the study is to define the nature of the e-commerce impact on national economies and SDG and to prove the efficiency of investments in e-commerce and ICT during COVID-19 crisis.
3. Current trends of e-commerce in Ukraine, Poland, and Austria

Global trends in the e-commerce market indicate an increase in its share and popularization among the population, which in turn leads to the need to create legislation that will qualitatively regulate the e-commerce market, as well as ensure the legality of transactions for the sale of goods and services [11]. The largest growth in the e-commerce market is expected in India due to cheap labor and significantly lower prices for technological equipment [12].

Comparing shares of e-commerce in the GDP of countries for the period from 2013 to 2020 on Figure 2, it can be mentioned that the ratio of this parameter changes dynamically with each passing year. Austria for many years had the largest share of online sales in GDP and since 2020 the share of online trade in the country was 22%, while Poland was second with a share of online sales of 14%. It should be noted that e-commerce in Ukraine began to develop later than its European neighbors, but the rapid growth of online sales in the country’s GDP indicates a high rate of expansion of e-commerce and its growing importance in the domestic market [13-15].

Prospects and forecasts for the development of e-commerce in the three study countries are quite broad. It is important to note that the introduction of advanced technologies and e-commerce will stimulate further innovative development of national economies. Based on this, it is necessary to create legislative programs to overcome barriers of entry into the e-commerce market, as well as the promotion among businesses of modern technologies for collecting and processing information for quality analysis and control of e-commerce services both at the individual level and at the states level.

![Figure 2. Shares of online trade in GDP in Ukraine, Poland, and Austria.](image)

In general, Ukraine has very favorable prospects for the development of e-commerce, but it is necessary to consider specific factors. These prospects will not be realized without overcoming certain problems: imperfection of the regulatory framework for electronic transactions, distrust of small and medium-sized businesses, low Internet penetration in rural areas, poorly developed electronic payment system and insufficient data security. Without solving these problems will be difficult to reach SDG 8 and 9.

4. Methodology

To determine the strategic directions of investment in the three countries, Kobe-Douglas models were built. We chose the country’s GDP as a dependent indicator of economic development, and the factors of the model were the volume of investments in the e-commerce industry and the level of employment in the field of e-commerce and information and communication technologies. The model is as follows:
\[
\text{GDP}_i = a \cdot b_1 I_{ij} \cdot b_2 E_{ij} \tag{1}
\]

where \( I_{ij} \) – the amount of investment in the country and in the industry \( j \), \( E_{ij} \) – employment in the country and in industry \( j \).

The Kobe-Douglas equation with a logarithm is a linear logarithmic regression model:

\[
\ln(\text{GDP}_j) = \ln(a) + b_1 \ln(I_{ij}) + b_2 \ln(E_{ij}). \tag{2}
\]

Thus, solving the linear regression equation, we obtain the coefficients of elasticity for each sector.

The model specification for social effects is the same and includes features such as wages overall and in ICT field. To define the flow process between personnel with different qualification levels the Markov Chain model is used [16].

The main purpose of this study is to examine the impact of ICT and e-commerce on the economic, social and environmental sectors of Ukraine, Poland and Austria in the context of the concept of sustainable development. The annual data of the World Bank for 2000-2020 are taken for analysis.

5. Results

5.1. E-commerce social effects

Most studies show a positive or neutral impact of ICT and e-commerce on employment, so there is a need for a detailed analysis, which directly depends on the nature of the development of information and communication technologies in Ukraine, Poland, and Austria.

The following indicators for Ukraine, Poland and Austria were selected for analysis using the Kobe-Douglas model: employment; average salary; the level of wages in the field of e-commerce and ICT; investments in e-commerce and ICT. Data for analysis are taken from 2011 to 2020 with annual dynamics from the resources of Eurostat, World Bank and Ukrstat [13-15]. Before proceeding to the simulation process, the data series and stationarity were tested using the ADF test and the hypothesis of no shifts was confirmed, which means that the selected data series can be used for regression analysis. The simulation results are given in Table 1.

Table 1. The impact of ICT and e-commerce on the employment rate in Ukraine, Poland and Austria.

| Country | Feature | Coefficient | p-value |
|---------|---------|-------------|---------|
| Ukraine | C       | 31.44       | 2.44e-03 |
|         | ln (Inv) | 0.02        | 3.74e-11 |
|         | ln (Wage) | 0.07        | 2.02e-09 |
|         | ln (WageICT) | 0.11     | 5.70e-07 |
|         | F-test   | 61.32       | 0.04    |
|         | R^2 adj  | 0.63        |         |
| Poland  | C       | 25.02       | 7.21e-05 |
|         | ln (Inv) | 0.12        | 4.05e-09 |
|         | ln (Wage) | 0.13        | 5.39e-07 |
|         | ln (WageICT) | 0.01   | 2.16e-08 |
|         | F-test   | 89.65       | 6.74e-11 |
|         | R^2 adj  | 0.86        |         |
| Austria | C       | 27.83       | 6.35e-18 |
|         | ln (Inv) | 0.10        | 0.06    |
|         | ln (Wage) | 0.16        | 0.01    |
|         | ln (WageICT) | 0.04   | 3.75e-09 |
|         | F-test   | 74.84       | 6.94e-11 |
|         | R^2 adj  | 0.91        |         |
The simulation results are significant because p-values of all coefficients are less than 0.05, and the hypotheses about autocorrelation (based on the Broisch-Godfrey test) and heteroskedasticity (based on the White test) are rejected for the models. For the model on the database of Ukraine, a lower coefficient of determination was obtained, which may indicate a lower correlation of indicators, as well as the presence of factors that are not included in the model but set the main dynamics of the employment target. For Ukraine all indicators are significant and have a positive impact on employment. Thus, an increase in investment in e-commerce and ICT by 1% brings an additional 0.02% employment growth.

Considering the general level of wages and salaries in the field of ICT, it is worth paying attention to greater elasticity with the wage in the field of e-commerce and ICT (0.07% and 0.12%, respectively). In general, the level of wages in the field of ICT is higher by about 52% and is growing faster, so the dependence is probably more significant. From this we can conclude that by stimulating the employment of highly qualified personnel in the field of ICT, the level of social development will grow faster than by stimulating the general employment of the population.

In Poland, there is a greater correlation between the level of employment and investment in e-commerce and ICT – with an increase in investment by 1%, employment is expected to grow by 0.13%. In Austria, the ratio is slightly lower at 0.11%. Interestingly, for Poland and Austria, the relationship between employment and the average wage is stronger than with wages in e-commerce and information and communication technologies. For comparison: with an increase in the average wage by 1%, employment increases by 0.14% in Poland and by 0.17% in Austria. With regard to the relationship between wages in the field of e-commerce and ICT, with an increase in wages by 1%, employment in Poland increases by 0.01%, and in Austria – by 0.04%. It is also important to note that the models of both Poland and Austria are more significant in terms of the coefficient of determination, which can probably be explained by more stable economic situation in the countries. Thus, the obtained models can be considered reliable and using them strategic recommendations for Ukraine can be built, considering it is at the initial stage of implementation of cloud technologies and e-commerce systems.

To conduct a comprehensive analysis, it is also necessary to assess the availability of flow processes between groups of workers in terms of skills in the field of ICT and e-commerce. This will allow assessing the level of readiness of Ukraine for the rapid development of e-commerce in the middle of the country at the expense of its own workforce. The simulation results for Poland on Figure 3 are similar and are indicators of a more stable situation in the e-commerce and ICT market than in Austria. In fact, 94% of highly qualified staff remain in their positions from year to year, while 97% of the total number of low-skilled staff in this field hold their position. This result indicates absence of flow processes, which may be since a significant proportion of the foreign population is employed in the field of ICT and e-commerce in Poland. Thus, the country keeps the market somewhat closed from the national population, while creating a high level of Internet penetration and raising public awareness of online technologies. Also, a significant role is played by the level of investment in the industry, which has been stable over the past 5 years, which has stabilized employment in this area and robotized much of the work.

Unfortunately, it is impossible for Ukraine to build such a model due to the lack of relevant data, but we can draw conclusions based on models for Austria and Poland. As a result of the simulation, it was concluded that in a country with a stable flow of investment in e-commerce and ICT, the employment rate is also stable and constantly growing for all qualification groups – low-educated and middle- and high-educated staff. While in Austria, a country that has only been investing in ICT since 2013, staff turnover is present. It is important to note that we do not consider the process of staff turnover between qualification levels a negative phenomenon, but stability is a sign of a mature stage of development of the industry.

Thus, the social status of Ukraine is sensitive to changes in the field of e-commerce, so it is necessary to build a comprehensive strategy for the development of e-commerce and ICT based on the experience of European countries, including Austria and Poland.
5.2. E-commerce economic effects

Our key goals for modeling the economic effects of e-commerce are: identify key sectors of the economy and model their impact on GDP growth; describe the impact of investment in key sectors of the economy and employment on GDP growth in Poland, Austria, and Ukraine.

The ADF test was used to test the stability of the regression models. The stationary nature of the selected series was confirmed by testing data from 2000-2020. Regression models were tested for autocorrelation using the Broysch-Godfrey test and for heteroskedasticity using the White test, but for all models the hypotheses autocorrelation and heteroskedasticity were rejected.

Table 2 shows the model of the impact of e-commerce and ICT on the GDP of selected countries.

The coefficients of elasticity for all selected countries are positive, which indicates the importance of the e-commerce industry for them. We consider this result to be quite expected, as ICT and e-commerce have started to develop relatively recently.

Table 2. The impact of ICT and e-commerce on the GDP in Ukraine, Poland, and Austria.

| Country | Feature | Coefficient | p-value |
|---------|---------|-------------|---------|
| Ukraine | ln (a)  | 23.56       | 1.43e-15 |
|         | ln (Inv)| 0.07        | 0.17    |
|         | ln (Emp)| 0.01        | 0.02    |
|         | F-test  | 4.78        | 0.02    |
|         | R^2 adj | 0.37        |         |
| Poland  | ln (a)  | 23.17       | 1.76e-17 |
|         | ln (Inv)| 0.18        | 1.65e-12 |
|         | ln (Emp)| 0.03        | 3.99e-03 |
|         | F-test  | 117.67      | 1.57e-16 |
|         | R^2 adj | 0.99        |         |
| Austria | ln (a)  | 24.56       | 4.39e-13 |
|         | ln (Inv)| 0.06        | 0.04    |
|         | ln (Emp)| 0.17        | 0.17    |
|         | F-test  | 46.02       | 8.72e-06 |
|         | R^2 adj | 0.89        |         |
Thus, the highest level of e-commerce impact on employment is modeled in Poland – 0.12% employment growth with 1% growth in investment in e-commerce and ICT. For Austria the figure is 0.1%, and for Ukraine 0.02%. Regarding the impact of e-commerce on GDP, with a 1% increase in investment in the industry, GDP in Poland grows by 0.18%, in Ukraine – by 0.07%, and in Austria – by 0.06%. Comparing the result of previous studies [17-23], it is important to note the similarity of conclusions that is a proof of significance of investment in e-commerce to overcome the crisis.

It is important to use advanced Data Science solutions at both the macroeconomic and enterprise levels to ensure sustainable positive socio-economic effects. The modern techniques that are used in e-commerce are described in previous studies on Data Science methods in marketing and e-commerce amid COVID-19 pandemic [24-29]. Among the important technologies should be the use of recommendation systems, tracking systems for transportation logistics and analysis of the effectiveness of marketing communications.

5.3. E-commerce environmental effects

E-commerce has also a significant impact on the environment and ecological policy. The most positive e-commerce impacts on the environment describe the following areas [30]:

1) transportation emissions. The use of e-commerce mechanisms in business models, especially in COVID-19 era, allows companies to operate without physical travel to the workplace. As transport is responsible for a significant number of harmful emissions and air pollution, reducing the organization’s dependence on transportation helps to reduce the carbon footprint;

2) paper waste. Paper waste is produced by most organizations around the world. However, digital information transmission helps to reduce the need for physical paper in business, which automatically minimize paper waste. Paperless business models are now becoming possible and in demand through e-commerce. Figure 4 demonstrates the direct correlation between The Waste Management index and E-commerce Index based on information of 17 countries;

3) digital storage. Digital transmission and digital production together can eliminate warehouses and create so-called on-demand production. Warehouses can be an environmental problem, as they accumulate a large number of trucks traveling to and from them, and can pollute the air, damage the quality of roads, create problems for traffic safety.

Figure 4. Correlation between Waste management and E-commerce indices

Source: compiled by authors based on [31, 32].
E-commerce industry could also pose some challenges for the environment [30]:
1) transportation emissions. Although, as noted above, e-commerce business models reduce emissions from consumers, vehicles still emit large amounts of pollutants;
2) packaging. All goods transported require packaging, so delivery via the Internet creates a significant cardboard trail of all materials used, which produces additional debris;
3) item returns. Customers are often dissatisfied with the goods they deliver (for example, the goods may be different than they look on the Internet), so they can be returned. The return of goods has a negative impact on the environment both through transport emissions and through packaging (increasing the number of trips, emissions, garbage).

6. Conclusion
In general, Ukraine has very favorable prospects for the development of e-commerce, but it is necessary to consider specific factors. These prospects will not be realized without overcoming certain problems, namely: imperfection of the regulatory framework for electronic transactions, distrust of small and medium-sized businesses, low Internet penetration in rural areas, poorly developed electronic payment system and insufficient data security.

Thus, with an increase in the level of investment in e-commerce and ICT by 1%, employment in Ukraine will increase by 0.02%, in Poland – by 0.14%, and in Austria – by 0.17%. Similarly, Ukraine’s GDP will grow by 0.07%, Poland’s by 0.2% and Austria’s by 0.07%. It is worth noting the significant elasticity of wages in the field of ICT and employment in Ukraine – 0.12%. For comparison: with a 1% increase in wages, employment in Poland increases by 0.01%, and in Austria – by 0.04%.

The future of sustainable e-commerce is as follows [30]:
1. Sustainable packaging. Businesses need to create innovative packaging solutions in the context of sustainable development and waste-free production.
2. Sustainable shipping. It is also important to find ways to reduce the effects of frequent transport (for example, consolidation of goods, which reduces the number of trips and the number of containers).
3. Supply chain integration. There are many industries that work in e-commerce, but they all can reduce waste through smart digital integration.
4. Decreased energy waste. For example, the transition to solar energy or the transfer of individual works to contractors can reduce transportation waste.

Indeed, it is important to attract highly qualified staff to move to a qualitatively new level of development of e-commerce services at the state level. This also requires an analysis of the effectiveness and implementation of the latest systems in e-commerce services at the enterprise level. The most important among such technologies are predicative modeling, clustering of consumers, personalization and customization of offerings, analysis of logistics, as well as a comprehensive analysis of the effectiveness of marketing strategies in e-commerce. The complex of the above-mentioned technologies will ensure not only SDG on micro, but also increase in the socio-economic progress on macro level.

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