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## Article

# The development of the e-commerce market in Poland in the conditions of intensification of migration processes

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## The Development of the E-Commerce Market in Poland in the Conditions of Intensification of Migration Processes

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**Abstract:** The impact of the war in Ukraine and migration has affected the e-commerce markets of the recipient countries, presenting both opportunities, in the form of an increased consumer base, and challenges, such as the lack of a clear development vision. This paper aims to investigate the influence of migration processes on the development of e-commerce in Poland and examine the feasibility of using forecasting methods by e-commerce companies under these conditions for future activity planning. To fulfill the research objective, the following tasks were addressed: investigating the current state of e-commerce development influenced by migration processes; exploring modern migration processes and their impact on global economies; assessing the impact of migration from Ukraine on the Polish market; and analyzing a Polish online store to develop a model for forecasting data and planning activities under the influence of migration processes. To achieve this goal, three models were constructed: a multiple regression model to assess the level of migration processes' influence on e-commerce; a neural network to forecast sales for a Polish e-commerce store; and cluster analysis to identify clusters of goods most affected by migration processes. The study analyzed the nuances of modern migration processes and assessed the reverse effect of migration as a driver of e-commerce development. Migration stimulates e-commerce by altering consumer behavior and logistics routes, increasing exports and imports, and fostering the spread of digital entrepreneurship. Using data from a Polish online store, the study modeled the impact of market changes on the company's operations and identified the most significant factors. Thus, the analysis explored the impact of migration on e-business in Poland through constructed models. Regression analysis revealed that migration processes have contributed to the development of the Polish online store's sales, thanks to the increase in migrant consumers and rising price levels. A neural network was developed with machine learning, incorporating macroeconomic and demographic factors into its forecasting typology. Cluster analysis was employed to examine the online store's assortment, identifying clusters by sales volume and migrants' influence. The analysis determined that, following the onset of the migration movement, categories experiencing a surge in demand from refugees, such as baby food products, appliances, telephones, furniture, and communication devices, saw the most significant growth.

**Keywords:** e-commerce; migration; forecasting; modeling; machine learning; big data; Data Science: regression analysis; clustering; neural network.

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**1. Introduction.** Given the prevailing instability of the economy and the turbulence of socio-political phenomena, every day business faces a variety of challenges that require effective management solutions. The war in Ukraine affected every country and every company by changing the macro- and microeconomic climate, and the incredible scale of the migration movements of Ukrainians caused general inflation, oversaturation of the labor market, and an increase in consumer and housing prices in the host countries. Despite the increased variability in the economic environment, e-commerce as part of the retail market continues to develop under the influence of global digitalization, the development of the latest technologies, and innovations. As expected, the impact of the war in Ukraine and migration affected the electronic business market (e-commerce) of the recipient countries, causing both opportunities in the form of an increase in the share of consumers, and challenges in the form of a lack of a clear vision of the development of further activities.

The question of how to achieve flexibility under crisis conditions and what to focus on when making management decisions regarding the sale of goods and services remains relevant for e-commerce. The study of the influence of migration processes on various aspects of e-commerce development can create a basis for making data-based decisions and form an innovative approach to managing enterprises in the e-commerce market. Forecasting data in such conditions is an extremely complex and uncertain process, but the availability of a large amount of multifaceted data on the nature of online purchasing behaviour enables e-entrepreneurs to research the consumer and dynamically adapt to all changing trends using predictive analytics of big data. The purpose of the work is to investigate the influence of migration processes on the development of e-commerce in Poland and to study the possibility of using forecasting methods by e-commerce companies under the conditions of the influence of migration processes for further planning of activities.

The research will address the lack of comprehensive studies examining the impact of migration processes on e-commerce development in Poland. Current literature not sufficiently explore the potential of forecasting methods for e-commerce companies in the context of migration dynamics. The paper will contribute to the existing body of knowledge by offering insights into the relationship between migration and e-commerce, particularly focusing on Poland. It offers novel perspectives on the utilization of forecasting methods by e-commerce companies in conditions of challenges posed by migration processes.

The paper will follow a structured format, beginning with a literature review, methodology, empirical analysis and modelling, and discussion to present a comprehensive analysis of the research topic, concluding with recommendations for future research. Case studies for Poland market will be incorporated to provide practical insights into the application of forecasting methods in the e-commerce industry amidst migration trends.

**2. Literature Review.** In the innovation society the boundaries between cities, suburbs and the countryside should be overcome (Gumzej, 2021) which will lead to a growth of e-commerce market. Transformational changes in e-business under the influence of the development of digitalization and intensified migration processes were studied by different foreign scientists. Singh et al. (2018) analyses the role and value of e-commerce in the global economy. Bosma et al. (2020) considered the development of digital entrepreneurship as one of the most frequent forms of business conduct by migrants. The main goal of the paper by Zatonatska et al. (2023) is to predict the e-commerce market in Ukraine and the European Union in the context of migration processes. Lin (2019) explores the influence of e-commerce and migration on urbanism in China. Huang et al. (2022) try to understand the influencing factors for returning residents to carry out rural e-commerce using the PLS-SEM method and SmartPLS 3.0 software. The research by Deng et al. (2023) presents structural equation modelling and the implementation of the method of bootstrapping analysis to investigate the influence of consumers' characteristics on their impulsive purchase in e-commerce.

An overview of various forecasting methods and their use in online and offline business are actual topic for foreign researchers. Yevmishkina (2016) shows that forecasting is a main procedure of strategic planning. Polat (2007) explores the potential application of forecasting as an effective tool for managerial decision-making for a value-chain management. The paper by Petropoulos et al. (2022) provides an overview of a wide range of different models, methods, and approaches for forecasting. Tang et al. (2022) investigate the role and value of big data in forecasting. O'Trakoun (2022) tries to explore which forecasting and modelling approaches were most resilient during the pandemic shock. According to a study by the International Monetary Fund (Englery et al., 2020), migration processes have a direct impact on the macroeconomic factors of host countries with developed economies. Accordingly, within 5 years after the migration shock (the beginning of an intensive influx of migrants), the growth of such macroeconomic indicators as income, employment rate, labor/production productivity, and the size of capital increased by an average of 1%.

It is worth noting that the influence of migration on the development of e-commerce is a rather rare topic for scientific research, however, in some works, the areas of e-business that are affected by migration processes are noted. So, the positive impact of immigration on labor productivity in recipient countries is also supported by the relationship between the local labor force and immigrant workers (Shekhar et al., 2016). When immigrants dominate the existing labor market and fill all the demand for scarce jobs, this encourages natives to move into new professions, which in many cases require educational, linguistic, and communication skills with a localized specificity that are not available to migrants. Thus, it increases their qualifications, and wages and, accordingly, stimulates the economy of the countries. Also important is remittances, which are the main form of income for many migrant families from developing countries and are one of the only sources of income and financial security for their members, accounting for more than 10% of their GDP. In 2021, the volume of remittances to such countries reached a record-high level of 589 billion US dollars and exceeded the amount of foreign direct investment (FDI) to these countries (Czaika & Reinprecht, 2020). The interaction of all these factors affects the public perception of migration and the policy chosen by the government, which usually depends on the distribution of gains or losses between different business sectors and socio-economic groups of the population (Koczan et al. 2021). Climate change and the natural disasters caused by it are some of the next challenges that prompt humanity to migrate in our time. A combination of physical, social, economic, and environmental threats can undermine food, water, and economic security even more than political and military conflicts. According to a report from the Internal Migration Monitoring Center (IDMC, 2021), in 2020, 30.7 mln migrants occurred precisely because of natural disasters in 145 countries and territories. Solving this problem in the future will require the involvement of the leadership and governments of countries in order not only to provide assistance to the affected population but also for the further prevention of natural disasters. The foreign influence framework brings together a powerful combination of tools, including development finance and humanitarian aid, technical expertise, capacity building, and partnerships to address climate change and migration (Government of the United States of America, 2021).

Digital technologies are the decisive factor in changing migration processes today. Online access to information gives humanity the opportunity to get all the necessary data for planning migration and moving to other countries. The use of applications for sharing information linked to locally placed groups of migrants has a negative impact, as it raises concerns about the promotion of illegal migration, human trafficking, etc. There are special apps and forums on social networks to help integrate in new countries, as well as keep in touch with relatives and make money transfers through mobile banking. Machine learning technologies are also relevant, with the help of which special chat-bots have been created to provide psychological assistance to migrants and help in the bureaucratic processes of document preparation (IOM, 2022). In the context of all statistical data and scientific research, we can conclude that the increase in the dynamics of modern migration processes, caused primarily by the exacerbation of political conflicts, the unstable economic situation in countries with underdeveloped economies, environmental problems, and other socio-economic factors, will be enhanced by the expansion of globalization and digitalization of the world. Migration policies and regulations by states are important to reduce fraud and the negative impact of misinformation, as well as to eliminate the global digital divide. With the rapid development of the global world economy, the emergence of a large number of players in local and regional markets, as well as the prevailing instability due to political, economic, and military conflicts, companies require a high speed of response. The main task of managing the activities of every company is management decisions, and it is high-quality and effective decision-making taking into account trends and information analysis that help companies to act and develop. It is very important for management to have up-to-date, true, and real data, as the quality of management decisions depends on them. One of the functional processes that help predict economic events and changes at the macro and micro levels is forecasting based on the maximum use of data.

The use of data analysis to assess the development and impact of migration processes has found feedback in many areas, such as the classification of immigrant applications for work visas using machine learning (Vegesana, 2018), the use of artificial intelligence to display migration patterns in real-time and predict their future trends (Comeau, 2019), analysis of the impact of migration on the forecasting of budget expenditures on health care (Zatonatska et al., 2022), use of big data to automate control of migration services at airports and checkpoints during COVID-19 (Ramzi, 2022). Despite the significant achievements of scientists, the issues of studying the impact of migration on the development trends of the e-commerce market remain unresolved, which requires further study of this economic issue for development of recommendation and practical approaches for effective business management.

**3. Methodology and research methods.** According to the purpose of the research, the following tasks were identified, solving of which involve using a number of general and special methods:

- to investigate the current state of e-commerce development under the influence of digitalization and migration processes;
- to investigate modern migration processes and their impact on world economies;
- assess the impact of migration processes from Ukraine on the Polish market;
- investigate the case of a real Polish online store and develop a model for forecasting data and planning its activities under the influence of migration processes.

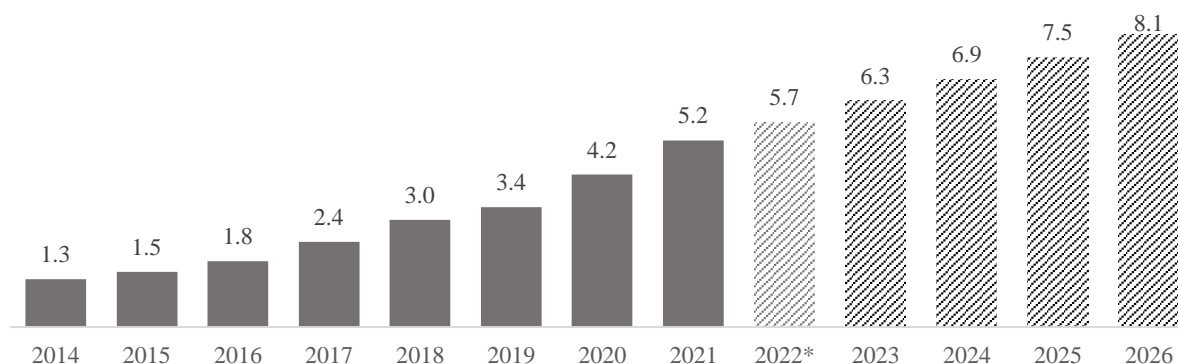
These tasks determine the core stages of the investigation and the structure of the paper. During the research, methods of induction and deduction, historical method, quantitative and qualitative analysis, comparative analysis, and statistical analysis were used. Forecasting methods, econometric methods, regression, and cluster analysis were used during modeling. The general research was carried out with the use of systematic analysis for the formation of the research concept and the formation of conclusions. The main hypothesis of the investigation is that migration leads to significant changes in the development of e-commerce, and influences the trends, structure, and consumer behavior. To review multifaceted statistical information, data from Statista (Retail e-commerce sales worldwide from 2014 to 2026, Number of Ukrainian refugees in Poland 2022-2023), IMF (Latest Global Growth Forecasts Show Challenges Facing Economies, The macroeconomic effects of global migration, The Refugee Surge in Europe: Economic Challenges), UN International Organization for Migration (World Migration Report 2022), as well as different reports from leading consulting companies McKinsey (A real-world edge to forecasting), PWC (Development prospects for the e-commerce market in Poland in 2018–2027), Nielsen (Technology adoption is driving an e-commerce boom, with huge implications for CPG ) were used. These data and internal database of one of the Poland e-commerce companies were a basis for the research and implementation of different models. To achieve the goal three models were built:

- multiple regression – to assess the level of influence of migration processes on e-commerce;
- neural network – to forecast sales of an e-commerce store in Poland;
- cluster analysis – to identify clusters of goods that were most affected by migration processes.

Multiple regression is relevant for assessing the level of influence of migration processes on e-commerce as this method allows analysing the relationship between multiple independent variables (such as migration patterns) and a dependent variable (e-commerce performance metrics). The main advantage is that multiple regression provides numerical coefficients that indicate the strength and direction of the relationship between migration processes and e-commerce performance. The results of multiple regression are relatively easy to interpret, making it suitable for stakeholders to understand the impact of migration processes on e-commerce and make a data-based management decision for more effective reaction on market changes. Neural networks are suitable for forecasting sales of an e-commerce store due to their capability to capture complex patterns and nonlinear relationships in data. The main advantages is that neural networks can capture intricate patterns and relationships in data that may not be captured by traditional linear methods like regression. Neural networks can adapt to changing patterns in sales data, making them suitable for forecasting in dynamic e-commerce environments. Cluster analysis is relevant for identifying clusters of goods that were most affected by migration processes. It helps in segmenting products based on their response to migration patterns and make management decision about focus product's categories, which are relevant for changed target audience. Cluster analysis groups together products that exhibit similar behaviours in response to migration processes, allowing for targeted strategies for each cluster. By identifying clusters of goods most affected by migration, businesses can gain insights into which product categories are most vulnerable or resilient. Such opportunities make it possible to provide a basis for decision-making, such as reallocating resources or adjusting marketing strategies based on the characteristics of different product clusters. This help to switch for innovative marketing strategy of the e-commerce company.

**4. Results.** With the development of the information technology revolution, the digital economy has emerged as a new and progressive form of doing business. Constant global and local crises, political and military conflicts, as well as the COVID-19 pandemic prove the need for progress and new ways of conducting commerce. Digitization of economic services is a necessary measure that allows the economy not only to function but also to develop rapidly around the world (Pan et al., 2021). E-commerce is a major part of the digital economy. The development and growth of e-commerce over the past few years have occurred precisely thanks to the extensive use of digital devices and systems by humanity, and the COVID-19 pandemic has

given a decisive impetus to the revolution of this form of doing business. As access to and use of the Internet continues to grow rapidly worldwide, and the number of Internet users worldwide exceeds 5 bln, the number of consumers making online purchases continues to increase. Accordingly, the e-commerce market is also growing. Statista (2023b) estimates that in 2022, global e-commerce retail sales will exceed \$5.7 trln. According to forecasts, by the end of 2026, the size of the global e-commerce market will reach 8.1 trln US dollars, which is almost 2 times more than in 2020 with COVID-19 (Fig. 1).



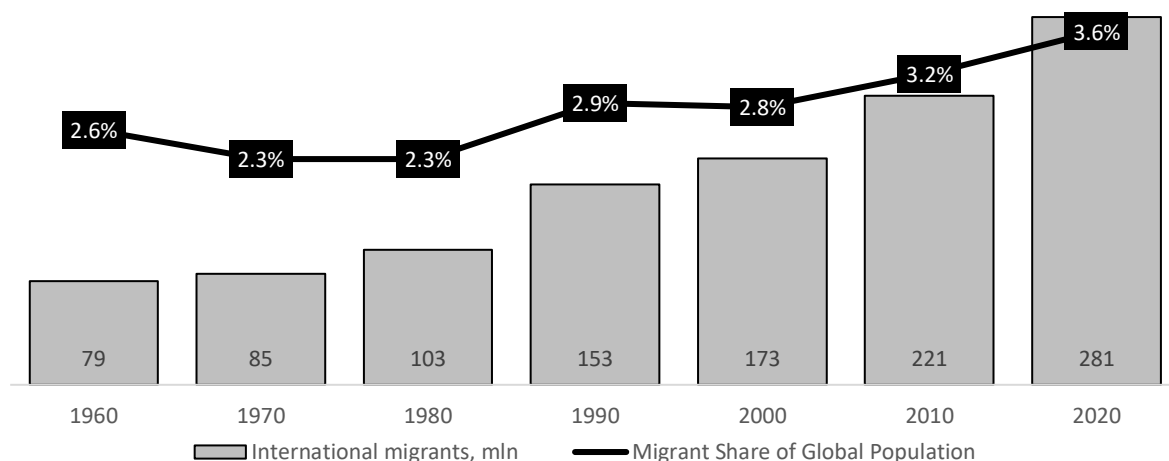
**Figure 1.** Global e-commerce retail sales from 2014 to 2026, bln USD

Sources: developed by the authors based on data from Statista (2023b).

As e-commerce develops, the volumes of accumulated data grow in parallel. Digital data is the most important factor in decision-making, production processes, transactions, and relationship management in e-commerce. Today, the use of big data analysis, the use of Data Science models and artificial intelligence, storage and manipulation of data using cloud technologies, etc., are very relevant in the field of electronic business. With its great operational and strategic potential, especially in generating business value, big data has the potential to transform the entire business model and to switch on innovation management. For e-commerce companies, this change affects their core functional business model components: marketing, pricing, supply chain, management, etc. (Kemp, 2023).

#### 4.1. Peculiarities of modern global migration processes

According to the Gallup World Poll, more than 750 mln adults would like to migrate if they had the opportunity (Esipova et al., 2018). Accordingly, worldwide, on average, one in eight people have the desire to migrate for economic, professional, political, or social opportunities. Of course, this number could be higher, because, for example, there are a large number of Ukrainians living in the East of Ukraine who currently refuse to leave their homes, despite the constant threat to their lives and continuous hostilities. On the other hand, it should be understood that only a small part of those in need of migration are actually able to implement it and ensure a full life abroad. Czaika & Reinprecht (2020) single out the following modern causes (factors) of migration: demographic (family changes, marriage, family reunification); economic (business affairs, job search, search for better economic conditions and living standards); security (migration due to military conflicts and war, repression and change of power); external environment (climate changes and natural disasters); human development (education, skills acquisition, practice abroad); individual (personal goals and migration experience, constant traveling rhythm); political and institutional (insurance conditions, services and availability of food, migration policy, political rights); socio-cultural (networking and migration societies, cultural exchange, gender relations); supranational (globalization, improvement of international relations and geopolitical transformation). According to the UN International Organization for Migration (IOM, 2022), in 2020 the number of international migrants increased to 281 mln people, or 3.6% of people in the world lived outside their home country. This share has grown at an exponential rate over the past 30 years and continues to grow, which will contribute to the growth of globalization and the blurring of borders between countries and cultures (Fig. 2). As of 2020, Europe and Asia, with 86.7 and 85.6 mln people respectively, are among the world regions that receive the most migrants and immigrants. Interestingly, Oceania (21.4% of immigrants among the population of the countries of the region) and North America (15.7%) are leading in terms of percentage; in Europe, this share is 11.6%. The situation among the countries of the Middle East is special, in this indicator the OAE is leading with a share of immigrants of 93.9% (IOM, 2022).



**Figure 2.** Number and share of global migrants in the world, 1960-2020

Sources: developed by the authors based on data from IOM (2022).

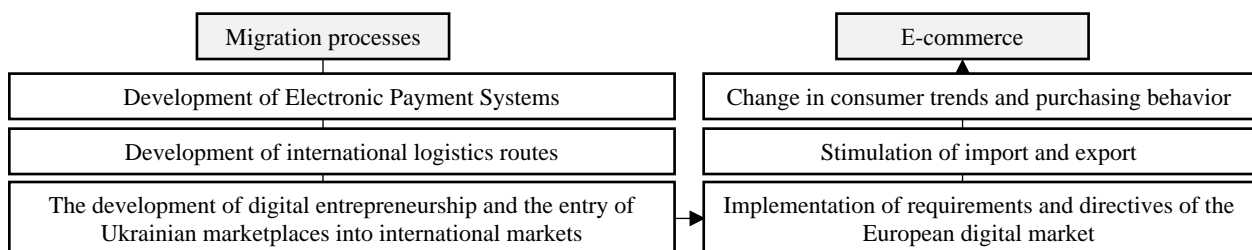
The USA (50.6 mln people), Germany (15.8 mln people), and Saudi Arabia (13.5 mln people) are leading the countries with the largest number of international migrants. India has the largest number of expatriates in the world, namely 17.9 mln people, but they are most concentrated in the UAE (3.5 mln), the United States (2.7 mln) and Saudi Arabia (2.5 mln). After India, as of 2020, Mexico (11.2 mln people) and Russia (10.8 mln people) are leading in the number of emigrants (IOM, 2022). In total, the number of displaced persons as of the end of 2021 has increased to 89.3 mln people, which is 1.1% of the world's population. Among them, 30.3% (or 27.1 mln) are refugees who were forced to leave their homes due to military conflicts. As of May 2022, the total number of refugees reached the mark of 100 mln people, which means that the increase in their number by 10.7 million people was mainly caused by the war in Ukraine (UNHCR, 2022). The crisis of immigrants from Ukraine is called the second largest after World War II (Operational data portal, 2023). From February 24, 2022, to April 4, 2023, 8.1 mln Ukrainians were registered as refugees, of which 5 mln people received the status of temporary protection and the possibility of legal residence in their respective countries with state support and social assistance. The largest number of Ukrainian refugees is registered in Poland (1.6 mln people), the Czech Republic (504 thsd people), and Slovakia (113 thsd people) (Ukraine Refugee Situation, 2023). International migration is perceived as both a challenge and an opportunity for host countries. In the short term, immigration is usually a threat to local labor markets, with potential effects on wages and competitive displacement of the local workforce, including the fact that the arrival of a new population can cause an increase in short-term fiscal costs. On the other hand, if we look at the medium and long term, immigrants can contribute to the growth of production, create new opportunities for local companies, exchange experience and skills with native inhabitants, generate new ideas, stimulate international trade, and contribute to the long-term budget balance, evenly complementing the age distribution of developed countries. For example, for the period 2006-2016, migrants accounted for 47% of labor force growth in the US and 70% in Europe, respectively (Kaczmarek & Ono, 2022).

#### 4.2. The impact of migration on the transformational changes of the e-commerce market

Population migration is perceived as a multifaceted process, which, as mentioned above, has a positive and negative impact on economic development and its disproportion. Population migration, trade activity, and investments are considered as key economic factors in international economic relations. Despite the versatility of these processes and their absolute separation in legislative regulation, they are closely related at the micro-economic level. Population migration has a cognitive impact on commerce in terms of trade (import and export), increased remittances, labor market, technology transfer, new knowledge, innovations, and information for both countries of origin and recipient countries (Cottier & Shingal, 2021). An increase in the working population and consumers stimulates the development of the entire economic structure. The electronic market of goods and services also undergoes changes under the influence of migration processes, changing and adapting to the needs of the migrating society. Migration is driving changes in the e-commerce market both in terms of consumer behavior and the operation of e-commerce platforms. Changing demographic characteristics of consumers is one of the key factors in consumption. As noted in the report of the World Bank (Global Migration Group, 2017), new buying habits, and increased demand for "nostalgic"

products that were in demand in the native country, significantly changed the market and stimulated imports into the offline and online markets. At the same time, the demand for information search and familiarization with the assortment through electronic platforms is growing, in turn increasing the traffic and attendance of e-commerce platforms (Global Migration Group, 2017). The creation of various interaction mechanisms and the need for international transactions contribute to the development of efficient and cost-effective cross-border payment services. The relationship between retail payment systems is relevant, allowing consumers to interact directly at the cross-border level with the help of connected payment infrastructures, reducing dependence on traditional banking intermediaries and speeding up the purchase process. Increasing the interoperability of different payment systems can help make cross-border payments cheaper and faster for migrant end-users (Committee on Payments and Market Infrastructures, 2022). Among them, a variety of possible payment methods can be characteristic. Since each e-market within different states has its own popular payment methods, it is important for the host country to adapt to alternative payment methods in order to satisfy a new segment of consumers. Migration processes can stimulate the development of international logistics routes and delivery systems. Not always available offers of goods in the recipient country can satisfy the immigrant segment of the target audience, which will encourage them to order already existing verified offers from their home countries and arrange international delivery. Such a trend is currently observed in the Ukrainian market when brands try to adapt to the migration of Ukrainians and offer international delivery. For example, the Nova Post's entry into the Polish market can stimulate Ukrainian offline and online business at the international level, ensuring the delivery of domestic goods to the Ukrainian target audience abroad. In addition, in April 2022, the company launched the "Things from home abroad" service, which was quite relevant for refugees who quickly left their homes without preparation, fleeing attacks from Russia (Molodan, 2023). In the digital era, special attention is paid to digital entrepreneurship, the development of which has reached a considerable scale and is considered as a new type in the field of immigrant entrepreneurship in parallel with the growth of international migration, globalization processes, and the development of international trade (Elia et al., 2019; Portes et al., 2002). This area is of particular importance for migrants in creating new businesses and improving the efficiency and competitiveness of already existing enterprises in foreign markets. In particular, cross-border e-commerce platforms act as a bridge between the entrepreneurial ecosystems of host and home countries and stimulate transnational entrepreneurship (Duan et al., 2020).

In general, transnational entrepreneurs are "social entities that use networks and information in order to find business opportunities or support business in dual social fields, which prompts them to use different strategies and methods of promoting their entrepreneurial activities" (Portes et al., 2002). All their activities are characterized by the presence of capital investments and strategic initiatives regarding the implementation of economic and commercial operations in a foreign space with the involvement of immigrants. The use and implementation of activities with the help of digital technologies and in particular e-commerce defines them as transnational digital entrepreneurs. Transnational digital entrepreneurship in the space of electronic commerce is of great importance both for migrants and for countries participating in the migration process in terms of socio-economic development. For example, according to the report of the Global Entrepreneurship Monitor (Bosma et al., 2020), during 2017-2018 in the UK, immigrants were twice as likely to participate in the creation of venture enterprises than local residents. Accordingly, summarizing the connection between migration and e-commerce, the following influencing factors can be identified (Fig. 3).



**Figure 3.** The main factors of influence of migration processes on the development of e-commerce  
Sources: developed by the authors.

Thus, migration processes have more positive than negative factors influencing the development of e-commerce. Businesses that can adapt to the changing needs and preferences of migrant consumers will have new opportunities to expand sales and increase their customer base, otherwise, they will face difficulties in

competing in an increasingly diverse market. The migration processes caused by the military invasion of Ukraine are among the largest in recent human history. The challenges caused by them for European society and economy are colossal, because not only the macroeconomic climate has changed, but changes have also taken place at the consumer level, which requires a quick response both at the level of the country's government and at the level of business in general. Poland, being a conditional transit point to Europe from the side of Ukraine, took the biggest blow of migration movements, which definitely affected its demographic, social, and economic characteristics. Almost 1.6 mln Ukrainians received protection from Poland in 2023 and given the continued hostilities and continued attacks from Russia, this figure will grow (Operational data portal, 2023). According to a study by the National Bank of Ukraine with reference to IMF data and a survey of UN specialists (Tucha et al., 2022), Ukrainian refugees, under the condition of a similar rhythm of immigration, will stimulate the growth of the production of goods and services on the territory of Poland, as well as Estonia and the Czech Republic in the range of 2.2-2.3 by 2026 % until the end of 2026. It is expected that migration processes also cause short-term growth of the Polish retail market during the spring of 2022, with the situation stabilizing starting from June (Fig. 4). Among the negative consequences for the Polish market, the NBU cites an average 18% increase in inflation rates and a 20% increase in real estate prices.



**Figure 4.** Retail market turnover of Poland and Estonia, seasonally adjusted data with base period 2016=100  
Sources: developed by the authors based on NBU (2022).

The Polish e-commerce market is characterized by high volatility and a level of uncertainty due to the COVID-19 pandemic. Galloping inflation and the consequences of Russian aggression against Ukraine also create tension in the market and complicate the process of planning activities. A fundamental study on the development of e-commerce in Poland for the next 5 years in the context of the war in Ukraine was made by the consulting company PWC (2023). According to them, the growth of e-commerce market sales in the coming years will be mainly due to inflation, which will cause a decrease in the level of demand. But among the positive factors that will stimulate growth, the increase in the number of consumers due to almost 2 mln refugees from Ukraine stands out. Among them, it emphasizes the return to the long-term trend of increasing the use of electronic platforms due to the "digital" generation and increasing the share of tech-savvy users. Accordingly, the Polish market continues to be saturated with new players, which intensifies the struggle and requires an increase in competitiveness. Overall, Poland's electronic market is the 21<sup>st</sup> largest in the world with an expected revenue of \$16.6 bln in 2023 and growth rates of 10.7% in the next 5 years. The largest electronic markets include fashion (30.9%), body care products (18.1%), and furniture and home appliances (17.4%) (EcommerceDB, 2022). PWC also emphasizes the category "fashion and clothing" as a positive driver of e-business, justifying this by the influx of a group of Ukrainian consumers, which will accordingly increase the sales of the category, change consumer preferences and trends in the Polish market, improve the experience of working with users and the level of service in general (PWC, 2023). According to all the above factors, e-commerce in Poland will grow. An important business task in the context of this situation is to study the degree of influence and quick response to the turbulence of the economic situation of the Polish market, as well as to increase competitive advantages against the background of the gradual transition of offline representatives to the Internet environment, in which the methods of data analysis and their forecasting are relevant to use. One of the strategies identified by consulting to deal with uncertainty and dynamic market change is the implementation of data analysis. This includes the development of centers for analytics and work with data; demand forecasting using big data; development of an experimental innovative approach to new business models using data analytics; introduction of new business KPIs focused on reflecting consumer

behavior and demand with the help of technologies (PWC, 2023). Forecasting methods of data analysis are relevant for implementation from the point of view of being able to determine how product sales will develop with the help of data on consumer behavior on the Internet and auxiliary statistical indicators. Since migration processes affect the entire economy of Poland in general, it is expedient for e-companies to supplement forecast modeling with research on the impact of macroeconomic market indicators, such as the level of consumer prices, including migration data. In this context, regression analysis, machine learning methods for better reading of trends and forecasting of results, application of cluster analysis in order to investigate the change in the category assortment and understand how consumer trends and sales by segment have changed can be effective. Research on price development and dynamic pricing using forecasting is also useful in the Polish context. Accordingly, taking into account the need for the Polish market to respond to changes in the country's economic and demographic situation, forecasting using modern data analysis methods is an effective tool for planning future activities in a dynamic environment and increasing competitive advantages via development of an effective marketing strategy. Further, in order to study the influence of changes in the market situation in Poland on the activity of a local online store, the authors proposed modeling using leading forecasting methods.

#### *4.3 Impact of migration on the development of e-commerce sales of enterprises in Poland*

Considering the migration processes that were caused by the military invasion of Ukraine, significant changes took place at the macro- and micro-levels of the Polish market. In order to investigate the impact of migration processes on the development of an e-commerce company in Poland, the authors conducted a modeling based on the data of a Polish online store and marketplace that sells various categories of goods on its own online platform. In the research, three models were built:

- regression analysis using multiple regression - to assess the level of influence of migration processes;
- analysis using a neural network for the purpose of forecasting sales of an electronic store;
- cluster analysis - with the aim of identifying clusters of goods that were most affected by migration processes.

To begin with, it is appropriate to investigate the impact of migration and the main macro-indicators of the Polish economy on the change in e-commerce sales. The data used in the construction of the regression model represent monthly information on orders for online store products by category for the period 2019-2022 and contain the following parameters: date of order, country, region, sub-region, product ID, category, subcategory, sale amount, amount and size of discount. Among the macroeconomic indicators, the authors chose Poland's GDP as an indicator of changes in the country's goods and services market; consumer price index as a representative measure of inflation; price index of product categories, including furniture and household goods; as well as the number of refugees who arrived in Poland from all countries (including Ukraine) for 2019-2022 as an indicator of migration. Since the level of migration and all indicators are expected to change significantly after February 2022, for a more thorough review of the impact, the author built two regression models for two periods - pre-war for 2019-2021 and in general for 2019-2022 - and conducted a comparative analysis of them. According to the specifics of building a regression model, the dependent variable  $Y$  is the company's sales (*sales*) and the independent variables are:

- GDP – Poland's GDP in billions of dollars based on data from Statistics Poland (2023);
- CPI – nominal index of consumer prices with the base period of 1998 in order to reflect the impact of the dynamics of price change based on data from Statistics Poland (2023);
- PIC (Price index of category) - price index for the category of these goods (Statistics Poland, 2023);
- Refugee – the number of refugees who applied for protection in Poland based on data from Statista (2023a) and Serwis Rzeczypospolitej Polskiej (2022).

Data for all indicators are monthly for the period from 2019 to 2022. All simulations will be performed using the R programming language in the RStudio programming environment. The results of multiple regression for the periods 2019-2021 and 2019-2022 are presented in Table 1 and Table 2, respectively.

For effective and correct modeling, the authors checked the data for the presence of autocorrelation, heteroscedasticity, and normality of the distribution of residuals, otherwise, if all these characteristics are present, the determination of the parameter coefficients by the model is incorrect. The test results for the first model: the model lacks heteroscedasticity (according to the Glaser method, the coefficient of determination is small ( $R^2 = 0.1633$ ), the model is not adequate, which indicates the absence of heteroscedasticity), there is no autocorrelation (according to the Durbin-Watson criteria  $dw$  statistic = 2.190885,  $p$ -value = 0.866 and it is greater than 0.05, therefore the hypothesis of the presence of autocorrelation is rejected), and the residuals

have a normal distribution (according to the Shapiro-Wilk test, the normality of the distribution of the residuals of the first model was obtained, since p-value = 0.9627, which is also greater than 0.05).

**Table 1.** Regression model results based on data for 2019-2021

<b>Residuals:</b>				
<b>Min</b>	<b>1Q</b>	<b>Median</b>	<b>3Q</b>	<b>Max</b>
<b>-37038</b>	-8850	1413	11639	31811
<b>Coefficients</b>	Estimate	Std. Error	t value	Pr(> t )
<b>(Intercept)</b>	-6.29005	2.60005	-2.419	0.021623
<b>GDP</b>	1.52603	3.73002	4.090	0.000284
<b>CPI</b>	-7.41402	8.89002	-0.834	0.410698
<b>PIC</b>	7.19903	3.77603	1.906	0.0655913
<b>Refugee</b>	-4.73601	8.47200	-0.056	0.955775
Residual standard error	16100 on 31 degrees of freedom			
Multiple R-squared:	0.5787	Adjusted R-squared:	0.5244	
F-statistic:	10.65 on 4 and 31 DF	p-value:	1.512e-05	

Sources: developed by the authors.

**Table 2.** Regression model results based on data for 2019-2022

<b>Residuals:</b>				
<b>Min</b>	<b>1Q</b>	<b>Median</b>	<b>3Q</b>	<b>Max</b>
<b>-37306</b>	-10214	860	11474	31869
<b>Coefficients</b>	Estimate	Std. Error	t value	Pr(> t )
<b>(Intercept)</b>	-4.10105	1.225e+05	-3.347	0.00171
<b>GDP</b>	1.40703	3.032e+02	4.643	3.23e-05
<b>CPI</b>	-4.53302	4.360e+02	-1.040	0.30436
<b>PIC</b>	4.57003	1.910e+03	2.392	0.02118
<b>Refugee</b>	3.1203	5.529e-02	0.094	0.03562
Residual standard error	15980 on 43 degrees of freedom			
Multiple R-squared:	0.6319	Adjusted R-squared:	0.5977	
F-statistic:	18.46 on 4 and 43 DF	p-value:	6.783e-09	

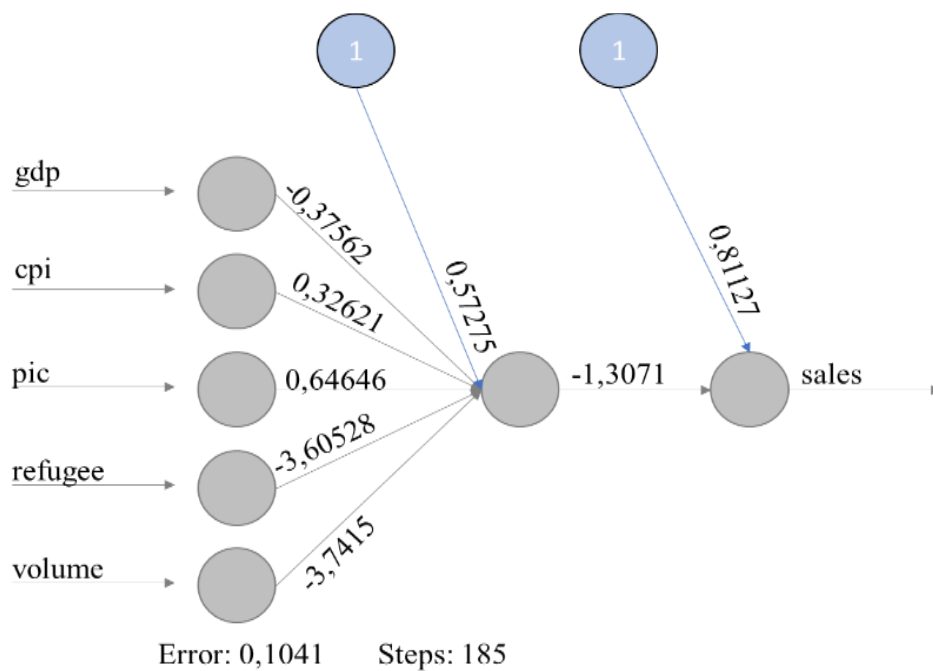
Sources: developed by the authors.

Similar checks were carried out for the second model for the period 2019-2022. According to all tests conducted, heteroskedasticity and autocorrelation are absent in model 2 (according to the Glaser method, the coefficient of determination is small ( $R^2 = 0.1273$ ), the model is not adequate, and according to the Durbin-Watson criteria dw statistic = 2.181544, p-value = 0.736) and the residuals are normally distributed (p-value = 0.8722). Therefore, the indicators of the obtained regression models are reliable. Comparing the results of the two models, we see that the coefficient of determination is higher in the second model, from which we can conclude about the higher degree of influence of migration processes and the economic situation in the country on the development of the company's e-commerce sales. It is also worth noting the level of influence of the migration indicator, which is higher in the second model and indicates the dependence of sales growth in 2022 due to the increase in the number of refugees and, accordingly, consumers. Considering the t-statistics, in the first model, the p-value indicated the insignificance of the predictor, in contrast to the second model, where the predictor was significant. Analyzing the correlation between sales and macroeconomic indicators, one can pay attention to the degree of influence of the price index of the category, which reflects the trend of growth in sales of these goods across the entire market. Instead, the general consumer price index was more significant in the second model. So, the regression analysis indicated the direct influence of migration processes on the change in sales of the e-commerce company, including some dependence between the macroeconomic indicators of the country's market. Accordingly, we see that the change in the economic situation stimulated sales, but at the expense of the influence of the price increase. Accordingly, in the further planning of the company and marketing decision making, these factors should be taken into account and the price policy should be reviewed. The introduction of profitable offers against the background of competitors will help increase the interest of users in purchasing goods on this Internet platform. Among other things, identifying this dependence will help the company in the process of forecasting demand and financial performance, respectively. It is appropriate for this company to build a forecasting model that can take into account all the listed trends in sales development according to the available factors.

#### 4.4. Construction of a neural network for data prediction of a Polish online store

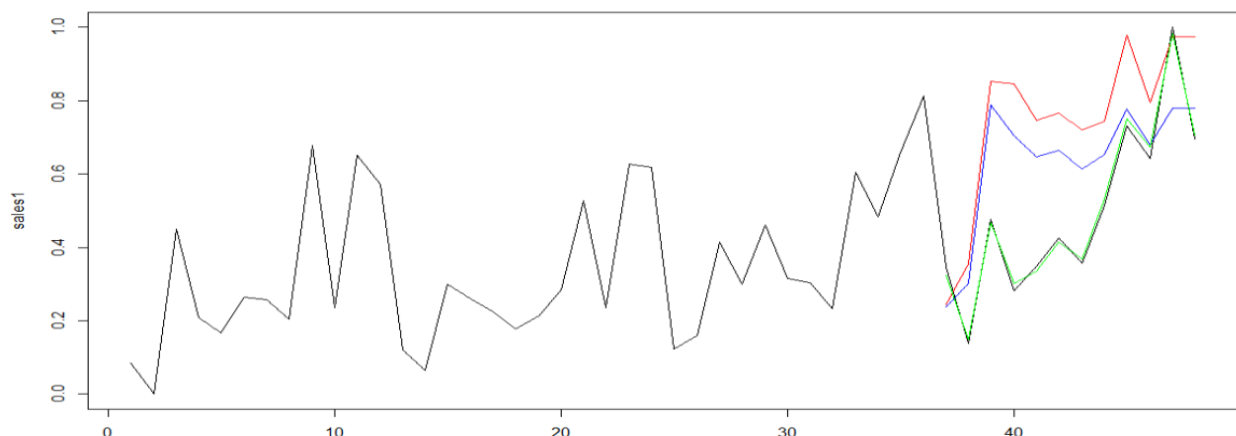
To further plan business activities, it is extremely important for Polish companies to understand exactly how e-retail will develop under the influence of migration processes. To investigate this issue, the authors built a neural network for forecasting the electronic sales of the company in question under the influence of macroeconomic factors that characterize changes in the Polish economy under the influence of migration processes and the collected big data of the enterprise. The data used in the previous model were used for the analysis. Also, as an additional parameter, an indicator of sales volumes for the month (sales and volume) was added, which characterizes the demand for the company's goods. Accordingly, after data preparation by normalization, a database ready for modeling was obtained. To carry out preliminary training of the model and check its results, the database was divided into training and test sets with a percentage ratio of 75% and 25%, respectively.

First, a neural network with one hidden node was built (Fig. 5), and a correlation test was carried out between the actual and predicted data, which was 0.6413614.



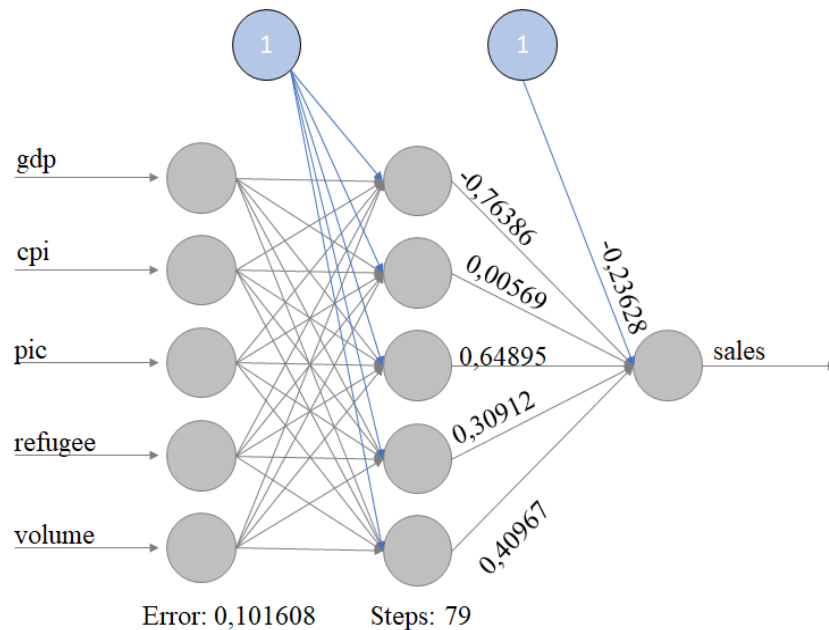
**Figure 5.** A neural network with one hidden node  
Sources: developed by the authors.

The findings show that the correlation coefficient is quite high, which is also indicated by the visualization of the forecast (red line in Fig. 6).



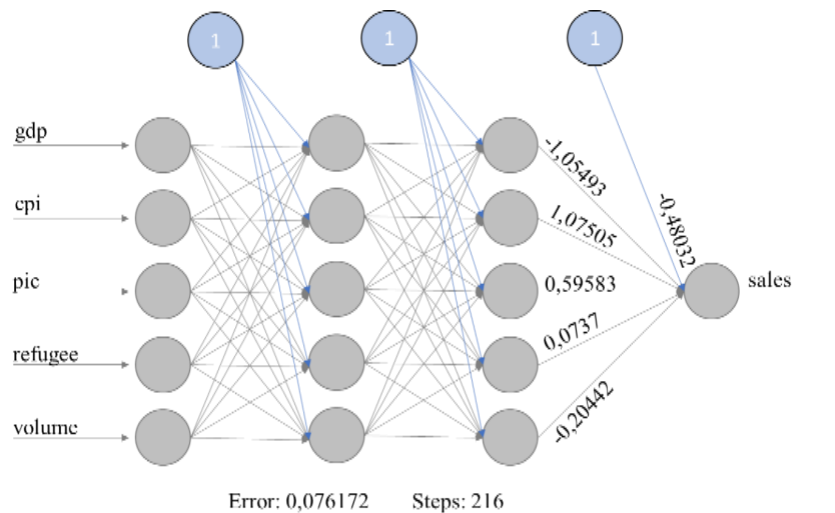
**Figure 6.** An image of the predicted and actual values of a neural network with 1 hidden node (red line), 1 hidden layer with 5 nodes (green line), and two hidden layers (green line)  
Sources: developed by authors.

In order to increase the accuracy of the model, the number of neural network layers was increased to one with 5 nodes (Fig. 7).



**Figure 7.** A neural network with one hidden layer with 5 nodes  
Sources: developed by authors.

The modeling error decreased a little, including the correlation coefficient increased to 0.843 (Fig. 6). In order to increase the efficiency of the model, the number of hidden layers of the neural network was increased to two (Fig. 8).



**Figure 8.** A neural network with 2 hidden layers  
Sources: developed by authors.

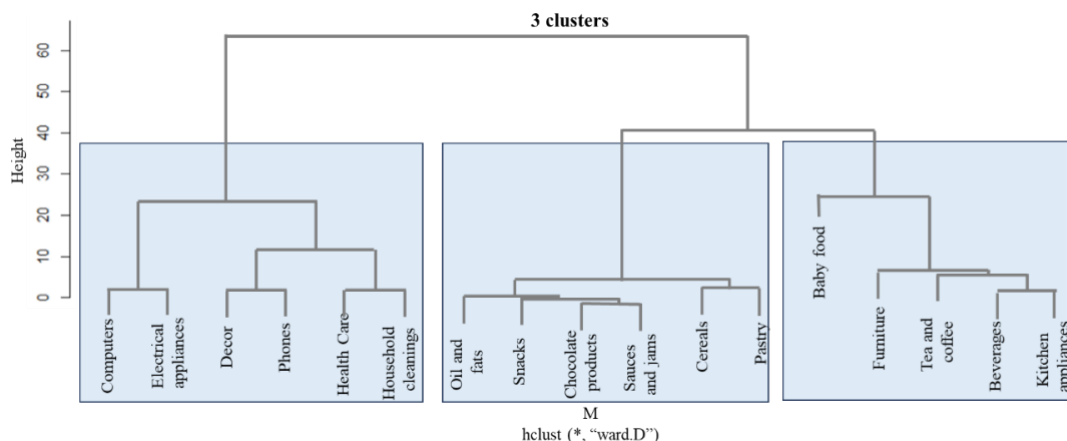
The results of the correlation analysis between the predicted and real data of the neural network with two hidden layers: the correlation increased to 0.997 (Fig. 6). Let's return the initial scale to the data and check the degree of correlation between them, which remains at the level of 0.997. Accordingly, the constructed neural network with a high degree of accuracy enables the Polish e-shop company to forecast sales, taking into account the influence of macroeconomic indicators of the Polish market, as well as taking into account its own past sales and demand for its products. The advantage of this model is the wide-scale use and multi-flexible selection of input parameters that can be used for analysis, taking into account the task and the investigated phenomenon in the context of migration processes. The recommendation for this online store is to supplement this model with

data from online store traffic and site visit indicators, which will reinforce the significance of the results and more accurately help plan the development of future sales.

**4.5. Using cluster analysis to forecast the product range of an e-commerce sales company.** In order to understand exactly how migration processes affect sales in terms of assortment, it is advisable to cluster sales by highlighting the main clusters of category groups of the online store and looking at how their composition changed after the beginning of the migration movements of Ukrainians to Poland. Databases for modeling are a sample of 17 site categories with sales information for the periods 2019-2021 and 2022. Two databases were created to compare the development of the formed clusters before and during the war. The databases contain the following indicators:

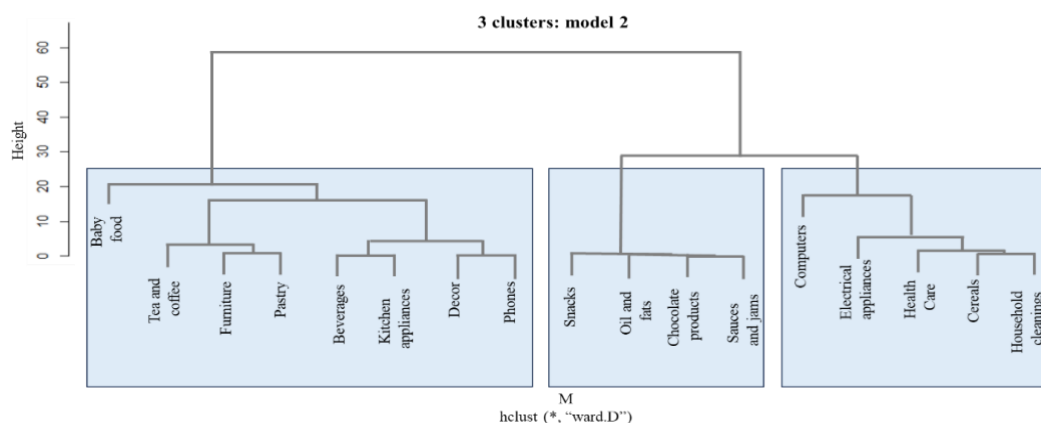
- $X_1$  – names of categories that will be divided into clusters;
- $X_2$  – amount of sales for the considered period;
- $X_3$  – demand for the category in the form of realized sales volumes;
- $X_4$  – average discount by category;
- $X_5$  – price per product unit;
- $X_6$  – the factor of the buyer's female gender.

Since the main part of Ukrainians who crossed the border with Poland after the start of the military invasion are mainly women and children, it is interesting to investigate how much the number of female buyers has changed between the base (2019-2021) and the current (2022) period. The Ward method was used for data aggregation, and the squared Euclidean distance was calculated in the R-Studio software environment, as provided by this method. After implementing a hierarchical cluster analysis using the Ward method and obtaining a preliminary dendrogram, the author's expert assessment identified 3 clusters of the  $k = 3$  model (Fig. 9).



**Figure 9.** Dendrogram of the Ward method cluster analysis based on data for the period 2019-2021  
Sources: developed by authors.

Similar manipulations with the data were carried out with the data for 2022 (Fig. 10).



**Figure 10.** Dendrogram of the Ward method cluster analysis based on data for the period 2022  
Sources: developed by authors.

Accordingly, after analyzing the clusters of each model, the authors selected the cluster with the largest sales (cluster 1), average (cluster 2), and smallest (cluster 3). Comparing the two models, we can see how the composition of the clusters has changed, which indicates a change in consumer preferences and a redistribution of sales in the company's category groups during 2022. For comparison, we will present the results of belonging to the cluster in tabular form (Table 3) and also derive the main statistical indicators of the clusters for a better comparison (Tables 4-5).

**Table 3.** Belonging of product categories to model clusters

Category name	Model 1 (2019-2021)	Model 2 (2022)	Category name	Model 1 (2019-2021)	Model 2 (2022)
Baby food	2	1	Household cleanings	1	2
Beverages	2	1	Kitchen appliances	2	1
Cereals	3	2	Oil and fats	3	3
Chocolate products	3	3	Pastry	3	1
Computers	1	2	Phones	1	1
Decor	1	1	Sauces and jams	3	3
Electronic appliances	1	2	Snacks	3	3
Furniture	2	1	Tea and coffee	2	1
Health care	1	2			

Sources: developed by the authors based on the company's data and open-source data.

**Table 4.** Statistical indicators of clusters of model 1 (2019-2021)

Variable	1			2			3		
	mean	min	max	mean	min	max	mean	min	max
Female	86	10	201	254	185	369	84	44	166
Sales	158 341	86 279	238 695	106 851	52 963	159 019	24 808	2 279	70 675
Quantity	1 001	166	2 305	2 880	1 964	4 083	990	475	1 979
Discount	23%	20%	30%	16%	10%	40%	12%	10%	20%
Price	247.0	102.0	506.0	41.2	15.4	71.2	28.8	3.3	70.1
Categories	Computers, Decor, Electronic appliances, Healthcare, Household cleanings, Phones			Babu food, Beverages, Furniture, Kitchen appliances, Tea and Coffee			Cereals, Chocolate products, Oil and fats, Pastry, Sauces and jams, Snacks		
Number of categories	6			5			6		

Sources: developed by the authors based on the company's data and open-source data.

The product categories such as baby food, beverages, furniture, kitchen appliances, baking supplies, tea, and coffee have moved from the cluster with medium and small sales to the largest cluster; sales of cereals also increased. On the other hand, the composition of the cluster with the lowest sales has hardly changed.

**Table 5.** Statistical indicators of clusters of model 2 (2022)

Variable	1			2			3		
	mean	min	max	mean	min	max	mean	min	max
Female	118	86	169	29	6	56	27	18	49
Sales	53 499	8 181	94 490	44 328	28 601	59 899	4 828	746	11 710
Quantity	1 136	639	1 891	278	68	592	260	172	435
Discount	12%	7%	37%	23%	16%	31%	7%	6%	8%
Price	55.2	8.2	135.0	314.0	58.2	815.0	23.6	3.4	67.5
Categories	Baby food, Beverages, Decor, Furniture, Kitchen appliances, Pastry, Phones, Tea and coffee			Cereals, Computers, Electronic appliances, Health care, Household cleanings			Chocolate products, Oil and fats, Sauces and jams, Snacks		
Number of categories	8			5			4		

Sources: developed by the authors based on the company's data and open-source data.

Considering the results in model 1, the majority of women bought products of cluster 2 in the online store. Instead, in 2022, the largest number of women drove the sales of the first cluster with almost the same assortment, but phones and decor were also added to them. So, taking into account that since the main part of

migrants from Ukraine are women and children, this affected the development of the main necessary categories of goods for refugees - baby food, telephones and equipment for setting up communications; decor, furniture, and kitchen equipment - for furnishing new homes. According to all these trends, the company can predict the development of categories, stimulating the demand for the realization of sales through discounts and profitable offers as the main marketing solutions.

**5. Discussion.** The growth of e-commerce is characterized by a high speed of development under the influence of digitalization and an increase in the share of the technologically savvy global population. Despite various modern challenges, mainly represented by the war in Ukraine, migration processes, global inflation, and the post-effect of the COVID-19 pandemic crisis, the e-commerce market continues to develop and represents the aspiration of businesses to change to meet the needs of humanity. The peculiarities of modern migration processes were analyzed, taking into account the influence of globalization. Accordingly, the reverse effect of migration as a driver of e-commerce development was also assessed. The main influencing factors are the development of logistics routes, stimulation of international trade, digital entrepreneurship, change in consumer behavior, and others. Migration processes are one of the less visible, but important factors in the development of the economy, as shown by the situation with Ukrainian refugees and the impact of migration on the economic environment of Europe and Poland in particular. Despite short-term shocks, migration stimulates e-commerce through the development of consumer behavior, and logistics routes, increasing the level of exports and imports, and the spread of digital business. All these changes have affected the Polish e-commerce market, which has become a considerable challenge for economic entities and requires the optimization of activity planning processes. On the basis of the data from a real Polish online store, modeling was carried out based on macroeconomic and migration indicators to investigate the impact of changes in the market situation on the company's activities and to identify the factors that had the greatest impact on it. The impact of migration processes on the e-commerce market of Poland, as the main host country of Ukrainian migrants, was investigated and the necessity of using forecasting methods for business planning and quick response to changes in the country's market was proven. This article is a continuation of our previous study (Zatonatska, 2023), and is also a significant addition to the studies of other scientists presented in the Literature Review block, in particular Englery et al. (2020), Koczan et al. (2021) and others. The main value of the study for the scientific community is to outline the improvement of the current understanding of how migration affects e-commerce, with a special emphasis on the Polish context. The article presents an innovative point of view regarding the application of forecasting methods by e-commerce enterprises for the purpose of forming a marketing strategy and making data-based decisions.

**6. Conclusions.** Thus, based on the results of the analysis, the impact of migration on e-business in Poland was investigated with the help of constructed models. With the help of regression analysis, it was established that migration processes contributed to the development of sales of the Polish online store due to the increase in migrant consumers and the increase in price levels. With the help of machine learning, a neural network was built, the typology of which takes into account the influence of macroeconomic and demographic factors during forecasting. The efficiency of the model is high, considering the testing of the model, which will help the company to make predictions with high accuracy in the future. Using cluster analysis, the assortment of the online store was studied and clusters were identified according to the amount of sales and the influence of migrants. It was established that after the start of the migration movement, the categories characterized by galloping demand from the refugees, including baby food products, appliances and telephones, furniture, and means of communication, have grown the most. The female share of buyers, as a representative indicator of changes in demographic indicators of the market due to migration, positively stimulated the growth of these categories, as they helped to settle in the country. During the period of post-war recovery, the situation regarding social and economic development will be quite difficult. Additional waves of migration are expected, which will require enterprises to adapt and respond quickly. The intensive implementation of big data technologies and analytical centers, whose activities will allow to realize forecasting on a dynamic level and achieve stability in conditions of uncertainty, is relevant. To date, despite all the challenges, the business has shown good results in the conditions of unpredictable economic changes, and data analysis technologies will only contribute to increasing competitiveness and sustainability. So, as areas of future research, it is relevant to focus on the implementation of data analysis on each stage of e-commerce functioning. The findings suggest that migration positively impacts e-business in Poland, particularly in certain product categories. Policymakers could consider crafting integration policies that facilitate migrants' access to online shopping platforms and support their settlement, thereby boosting consumer demand and economic growth. As well as, with anticipated waves of migration, policymakers may need to devise strategies to help businesses

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quickly adapt to changing consumer demographics and preferences. This could involve providing support for businesses to diversify their product offerings or adjust marketing strategies to cater to migrant populations. The recommendation to intensively implement big data technologies and analytical centers implies a need for support or incentives for businesses to invest in these capabilities. This could include funding for training programs or subsidies for technology adoption to enhance forecasting accuracy and competitiveness.

The study focuses on the impact of migration on e-business in Poland, limiting the generalizability of findings to other contexts in other countries. Future research should explore how migration influences e-commerce in diverse socio-economic and cultural settings. As well as the study does not capture the long-term effects of migration on e-business, particularly as migration patterns and economic conditions evolve over time. Longitudinal studies could provide deeper insights into the sustained impact of migration on e-commerce.

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**Data Availability Statement:** For the purpose of reviewing multifaceted statistical information, data from Statista (Retail e-commerce sales worldwide from 2014 to 2026, Number of Ukrainian refugees in Poland 2022-2023), IMF (Latest Global Growth Forecasts Show Challenges Facing Economies, The macroeconomic effects of global migration, The Refugee Surge in Europe: Economic Challenges), UN International Organization for Migration (World Migration Report 2022), as well as different reports from leading consulting companies McKinsey (A real-world edge to forecasting), PWC (Development prospects for the e-commerce market in Poland in 2018–2027), Nielsen (Technology adoption is driving an e-commerce boom, with huge implications for CPG ) were used.

**Informed Consent Statement:** Not applicable.

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#### **Розвиток ринку е-комерції у Польщі в умовах активізації міграційних процесів**

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Наслідки війни в Україні та міграція вплинули на ринок електронної комерції країн-реципієнтів, спричинивши як можливості у вигляді збільшення частки споживачів, так і виклики у вигляді відсутності чіткого бачення

розвитку. Метою роботи є дослідження впливу міграційних процесів на розвиток електронної торгівлі в Польщі та вивчення можливості використання методів прогнозування компаніями електронної торгівлі в умовах впливу міграційних процесів для подальшого планування діяльності. Відповідно до мети дослідження вирішувалися наступні завдання: дослідити сучасний стан розвитку електронної комерції під впливом міграційних процесів; дослідити сучасні міграційні процеси та їх вплив на світову економіку; оцінити вплив міграційних процесів з України на польський ринок; дослідити кейс польського інтернет-магазину та розробити модель прогнозування даних та планування його діяльності під впливом міграційних процесів. Для досягнення мети було побудовано 3 моделі: множинної регресії – для оцінки рівня впливу міграційних процесів на електронну комерцію; нейронна мережа для прогнозування продажів магазину електронної комерції в Польщі; кластерний аналіз – для виявлення кластерів товарів, які найбільше постраждали від міграційних процесів. Проаналізовано особливості сучасних міграційних процесів, а також оцінено зворотний вплив міграції як драйвера розвитку електронної комерції. Міграція стимулює електронну комерцію через зміну поведінки споживачів і шляхів логістики, підвищення рівня експорту та імпорту та поширення цифрового підприємництва. На основі даних польського інтернет-магазину було проведено моделювання на основі макроекономічних та міграційних показників, щоб дослідити вплив змін ринкової ситуації на діяльність компанії та визначити чинники, які мали на неї найбільший вплив. Таким чином, за результатами аналізу за допомогою побудованих моделей було досліджено вплив міграції на електронний бізнес у Польщі. Регресійний аналіз встановив, що міграційні процеси сприяли розвитку продажів польського інтернет-магазину через збільшення споживачів-мігрантів та підвищення рівня цін. За допомогою машинного навчання була побудована нейронна мережа, типологія якої враховує вплив макроекономічних і демографічних чинників під час прогнозування. За допомогою кластерного аналізу досліджено асортимент інтернет-магазину та виділено кластери за обсягом продажів та впливом мігрантів. Встановлено, що після початку міграційного руху найбільше зросли категорії, які характеризуються галопуючим попитом з боку біженців, зокрема на продукти дитячого харчування, побутову техніку та телефони, меблі, засоби зв'язку.

**Ключові слова:** електронна комерція; міграція; прогнозування; моделювання; машинне навчання; великі дані; Data Science; регресійний аналіз; кластеризація; нейронна мережа.