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ASSESSING THE IMPACT OF MULTICHANNEL SALES INTEGRATION ON THE EFFICIENCY AND COMPETITIVENESS OF UKRAINIAN RETAIL IN THE CONTEXT OF DIGITAL COMMERCE

One of the most significant changes the business world is currently experiencing is the progressive development and adoption of digital commerce. Taking into account the rapid development of web and Internet technologies, e-commerce is increasing volumes on a global scale and is being formed as a separate branch of the economy. Every year from 30 % to 70 % businesses of all countries (regardless of their level of development) are moving to the online environment. This is especially true for business entities that carry out trading activities.

The object of the study is the process of integrating multichannel sales in retail trade in Ukraine, with a focus on its impact on the efficiency and competitiveness of enterprises in the market. The problem under consideration is to determine the most effective methods and strategies for implementing e-commerce in the Ukrainian economy, which is under the influence of martial law and other socio-economic factors.

The main results of the study show that the integration of online and offline sales channels significantly increases business productivity. It was found that the use of omnichannel platforms can significantly improve customer interaction and increase sales. In particular, the analysis showed that properly integrated sales channels can increase the efficiency of enterprises by 20–30 %.

These results can be explained by the high level of adaptability of Ukrainian companies to new technologies and their ability to quickly integrate digital platforms into their business processes. The study also confirmed that businesses that actively use omnichannel strategies achieve higher levels of efficiency and competitiveness.

In practice, these results can be applied to the real-life conditions of Ukrainian retailers. This is especially true for small and medium-sized enterprises seeking to increase their market presence through the introduction of modern technologies and the integration of various sales channels. Using the data obtained will allow companies to optimise their business models, develop effective marketing campaigns and improve customer interaction. The findings can also be applied to the analysis of omnichannel retailing and digital commerce in other countries at different stages of retail development. This study also provides practical recommendations that may be useful for international companies and academics interested in improving retail performance.

Keywords: e-commerce, omnichannel sales, channel integration, retail competitiveness, digital platforms, Ukrainian retail, business efficiency.

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1. Introduction

The modern development of information technology and digital platforms has a significant impact on all aspects of economic activity, including retail. E-commerce has become a driving force for business growth and expansion around the world, and this trend is particularly noticeable in European markets, where international trade and cooperation are developing most dynamically. One of the most important challenges facing Ukrainian retail in the context of digital transformation and socio-economic instability is the search for effective methods and strate-

gies for integrating omnichannel sales to ensure stable competitiveness in the market. This problem is particularly relevant in the context of martial law, which significantly affects the ability of enterprises to adapt their business models to new challenges. Despite significant progress in the implementation of digital technologies, there is still insufficient research on how Ukrainian retailers can best adapt their business models to the crisis and rapidly changing market. In Ukraine, which is actively integrating into global economic processes, e-commerce is also gaining popularity. According to the Ecommerce Foundation, in 2021, the total volume of e-commerce in the European Union reached

718 billion euros, representing a 13 % increase compared to 2020, when the volume was 633 billion euros. The forecast for 2022 indicates a continuation of this upward trend with an expected growth of 13 % and a turnover of 797 billion euros, although this growth will be modest [1]. This indicates the significant impact of digitalization on economic processes, including retail.

The scientific novelty of this study is that for the first time a comprehensive analysis of the impact of omnichannel sales integration on the efficiency and competitiveness of Ukrainian retailers in the digital commerce environment was carried out. In particular, new patterns in the use of omnichannel platforms have been identified, which allow not only to improve customer interaction but also to increase the efficiency of enterprises by 20–30 %. For the first time, a model of omnichannel sales integration adapted to the conditions of the Ukrainian market, which is under the influence of war and socio-economic challenges, is proposed. This model is based on a combination of online and offline sales channels and takes into account the specific behavior of Ukrainian consumers in times of crisis.

There is a significant amount of research in the scientific literature on e-commerce and omni-channel sales, including the effectiveness of various sales channels, the integration of online and offline platforms, and consumer behavior in an omni-channel environment. A significant contribution to the study of e-commerce development has been made by numerous scholars, for example, the authors of papers [2–8].

Filling the existing research gap through a comprehensive analysis of the specifics of e-commerce and multichannel sales in Ukrainian retail is *the aim of this study*. The scientific component involves developing of a strategy for integrating multichannel sales, taking into account the specifics of the Ukrainian market, identifying mechanisms of adapting existing e-commerce models to local conditions, and analyzing the impact of various factors on the efficiency of these models. The practical component is to develop recommendations for optimizing sales strategies for Ukrainian retailers, which will increase their competitiveness, increase sales and improve customer interaction through various sales channels.

The development of this model includes several stages. First, identification of the impact of different sales channels on consumer behavior, which allowed to create strategies aimed at maximizing customer experience. In particular, it was found that the effective integration of omnichannel platforms helps to increase customer loyalty and increase the frequency of purchases. Secondly, the study showed that Ukrainian companies, despite economic challenges, are highly adaptable to new technologies and quickly integrate digital platforms into their business processes.

2. Materials and Methods

The object of research is the process of integrating multichannel sales in retail trade in Ukraine, with a focus on its impact on the efficiency and competitiveness of enterprises in the market.

The theoretical methods used in the study include literature analysis, generalization, systematic approach and comparative analysis. Literature analysis involved the study of scientific papers on e-commerce and multichannel sales, which allowed identifying the main concepts and approaches in this area. The method of generalization was used to synthesize the data obtained in order to identify general trends

and patterns. The systemic approach allowed to consider the object of research as a system consisting of interrelated elements, such as online and offline sales channels. Comparative analysis provided an opportunity to compare different models of multichannel sales used in Ukraine and abroad to identify the most effective approaches.

Experimental research was conducted in the real-life conditions of Ukrainian retail companies. The sample of companies included small and medium-sized enterprises selling through various sales channels. The study covered the period from January 2014 to December 2023, and focused on analyzing the effectiveness of the integration of online and offline sales channels. The experimental conditions included both traditional retail outlets and modern online platforms.

3. Results and Discussion

An analysis of the scientific literature on the definition of the concept of "e-commerce" reveals the absence of a single generally accepted approach to its interpretation. This is explained by the diversity of views of representatives of different scientific schools that consider e-commerce from different perspectives. Given this, it is possible to group different approaches to understanding e-commerce, which allowed not only to better understand the essence of this phenomenon, but also to offer our own definition.

The definitions proposed by international organizations are also worthy of considerable attention and have been analyzed. The results of the analysis showed that e-commerce can be interpreted from different perspectives:

- as a socio-economic phenomenon that affects the economy and society [9];
- as special legal relations that include regulation of the rights and obligations of participants in electronic transactions [2];
- as entrepreneurial activity that covers all types of commercial activity carried out via the Internet [4]. E-commerce can also be viewed:
- as a means of doing business that uses digital technologies to manage business processes and interact with customers [10];
- as a set of transactions involving the purchase, sale and exchange of goods and services through digital platforms;
- as the process of using electronic information systems that facilitates automation and efficiency of operations [3]. E-commerce is interpreted:
- as a web-based trading concept that creates new market opportunities and business models;
- as a process of buying, selling or exchanging, covering all stages of trading operations; as a special case of e-business, including all types of business activities via the Internet [11];
- as a form of business transaction and business process carried out through digital channels [12];
- as a system of legal relations, including legal aspects of concluding transactions and fulfilling obligations in the digital environment [5].

Based on the analysis of various definitions of e-commerce provided by scholars and international organizations, it is possible to formulate our own definition: e-commerce is a business activity in the field of buying and selling goods and services using the Internet at all stages of business processes.

There are several key forms of e-commerce, each of which has its own characteristics. The main forms include

B2B (business-to-business), B2C (business-to-consumer) and C2C (consumer-to-consumer).

B2B (Business-to-Business) covers the interaction between contracting companies that use e-commerce tools to conclude transactions, form supply, procurement and sales systems. This sector is the dominant one in the e-business sector, accounting for about 85 % of its total turnover.

B2C (Business-to-Consumer) represents a model where products are sold directly from businesses to end consumers. This form of e-commerce focuses on retail, providing consumers with access to goods and services for personal use. It plays a key role in the retail sector, making it easier for customers to purchase goods and services.

C2C (Consumer-to-Consumer) is based on the interaction between individual consumers who buy, exchange or sell goods and services through e-commerce platforms. This model allows individuals to easily conduct commercial transactions with each other.

In addition to these basic forms, there are other categories of interaction, such as:

- *B2G (Business-to-Government)*, which involves interaction between business and government;
- *G2C (Government-to-Citizens)*, where government provides services to citizens;
- *G2G (Government-to-Government)*, which covers cooperation between government organizations;
- *B2P (Business-to-Partners)*, which refers to the relationship between a business and its partners;
- *B2E (Business-to-Employee)*, which involves interaction between a business and its employees [13].

In the international e-commerce market, the leading role is played by the B2C (Business-to-Consumer) model, which includes the sale of goods and services to end consumers [9]. However, the B2B (Business-to-Business) model, which involves commercial transactions between companies, is also rapidly gaining momentum. According to DHL Express, by 2025–2027, it will account for 80 % of all transactions, and 70 % of business-to-business interactions will take place online [13].

It is noted that business is gradually moving away from traditional B2B and B2C models, preferring the new D2C (Direct-to-Consumer) approach [14]. This model allows manufacturers to avoid intermediaries and communicate directly with customers, which allows brands to better understand their customers and control all stages of interaction – from the first contact to the final purchase.

Regardless of what models of e-commerce will develop in the future, this sector has already gained significant popularity around the world and will continue to grow. According to the Digital Commerce 360 consulting agency, more than 50 % of shoppers from Europe, Africa and the Americas are ready to make purchases on foreign online platforms [8].

E-commerce offers numerous advantages that make it an attractive option for businesses looking to expand their business. One of the main advantages is easier access to international markets, which allows companies to expand their operations abroad more quickly and efficiently. In addition, e-commerce simplifies the process of matching products to the market, which helps businesses better meet consumer needs.

Another important feature is the reduction of sales cycles in the B2B sector, which allows companies to close deals faster and increase sales. E-commerce makes it possible to rapidly expand internationally, as it lowers barriers

to entry into new markets. This means that even small companies can compete on a global scale.

The growth of international e-commerce is a steady trend that has been accelerated by the COVID-19 pandemic. Many businesses have switched to online sales, which has accelerated the development of this sector. Forecasts show that the global e-commerce market will continue to grow in the coming years, which confirms the profitability of this model for online retailers [8].

In 2020, the Ukrainian e-commerce market showed the highest growth rate among neighboring countries, reaching 41 %. The top three also included Poland with 37 % and the Czech Republic with 29 %. Analyzing annual e-commerce spending per person and the share of e-commerce in GDP, it is worth noting that in Ukraine this share is 2.6 %. For comparison, in the Czech Republic, this figure reaches 3.7 %, and in Latvia – only 1.1 % [1].

The low level of annual e-commerce spending in Ukraine can be explained by low per capita income and limited purchasing power. The highest e-commerce spending per person was recorded in the Czech Republic – 841 dollars per year. The total volume of the Ukrainian e-commerce market is still in its infancy, which promises rapid growth in the future. The retail market is also showing steady growth at 3.9 %.

The decline in the number of offline stores in Ukraine is fueling the development of online commerce. However, despite significant annual growth, Ukraine is still far from becoming an e-commerce leader. One of the important aspects for further development is to improve internet coverage, which in 2019 was only 67 %, which is below the average in Eastern Europe. The share of people making purchases online is only 21 %.

Ukraine's e-commerce market lags far behind other European countries in terms of volume. For example, it is 19 times smaller than the Polish market and almost 150 times smaller than the German market. The share of e-commerce in Ukraine's retail trade is only 3–4 %. Among the barriers to development are limited access to international payment systems such as PayPal and an insufficient number of POS terminals, which are three times less in Ukraine than in Poland [15].

In 2016–2019, the number of companies making online purchases increased by 42.3 %. However, the number of companies receiving orders for the sale of products online decreased by 2.5 %. In 2019, the share of products sold through websites or apps was 4.5 % of the total volume of products sold in Ukraine [2]. The main barriers to the rapid development of e-commerce in Ukraine are institutional, informational, financial, market, and logistical factors. The inefficient organization of logistics, e-procurement and auctions [2], as well as the impact of the Russian-Ukrainian war, are serious obstacles. In 2020, the e-commerce market in Ukraine was worth 4 billion dollars, with a projected annual growth of 15 %. The share of e-commerce in retail trade was 8.8 % in 2020. Electronics accounts for the largest share of e-commerce. Promising categories include clothing, furniture, toys, cosmetics, as well as medicines and food.

Factors driving the growth of e-commerce in Ukraine include:

- increasing internet penetration;
- growing number of smartphone users;
- COVID-19-related restrictions;
- growing confidence in digital payment systems;
- improved payment methods;

- expanding delivery geography and shorter delivery times;
- low delivery costs;
- growing individual consumption;
- increasing reliability of online stores;
- development of innovative technologies such as augmented and virtual reality [9].

With the beginning of a large-scale escalation of the Russian-Ukrainian war on 24 February 2022, Ukraine's integration into the European Union has gained new momentum. In the context of the European integration course, the Ukrainian e-commerce sector should quickly adapt to EU standards. The dynamic development of e-commerce in the European Union over the past decade has led to significant changes in the legislation governing this area. For example, starting from 1 July 2021, the EU introduced new rules for taxation of sales of goods and services via the Internet. All imported parcels are now subject to value added tax (VAT).

In Ukraine, in line with its European integration, the country adopted the E-Commerce Law in 2015, which transposed the 2000 EU Directive into Ukrainian law. However, the EU has introduced a number of other changes to e-commerce legislation that have yet to be reflected in the Ukrainian legal framework. For example, in the EU, online platforms must provide information on the criteria for selecting goods, their prices and price changes. Buyers have equal rights, regardless of the location of the seller or buyer, which eliminates geo-blocking and ensures free access to online shopping.

Ukraine currently lacks regulation of the supply of digital services, while the EU has such rules at the state level. In addition, in the EU, all sales of goods in online stores must be taxed in the country of destination using VAT if the cross-border B2C sale exceeds 10,000 EUR. To simplify the declaration of all cross-border B2C sales, the EU has a "One Stop Shop" system, which allows reporting through the tax portal of one member state.

In Ukraine, the legislation has not yet approached European standards in these matters, which creates problems for Ukrainian e-commerce businesses, which often operate in the shadows and are potentially risky for consumers [3].

If the necessary changes are made to align Ukrainian e-commerce with EU standards, Ukraine has the potential to significantly transform this sector by 2030. Given the impetus already received from the COVID-19 pandemic, Ukrainian e-commerce is showing record growth rates, outperforming most Eastern European countries. Therefore, the implementation of European norms and standards can significantly accelerate the development of this sector, ensuring further progress and integration into the international market.

The research findings confirm that e-commerce and multichannel sales have a significant impact on the development of the Ukrainian retail market. This is due to the high level of integration of information technology into business processes, which allows companies to interact with customers faster and more efficiently. The literature analysis revealed that e-commerce is becoming increasingly important for Ukrainian businesses due to the convenience and accessibility of digital platforms for consumers.

The results are somewhat different from those known from the literature, especially in the context of implementing multichannel sales. Known studies tend to focus on markets in developed countries where e-commerce infrastructure is

more developed. In the case of Ukraine, there is a specificity in the form of limited access to international payment systems and low purchasing power of the population, which affects the market growth rate. However, domestic companies demonstrate high adaptability and the ability to quickly integrate new technologies, which is a positive factor for further development.

The findings can be applied in practice to optimize the sales strategies of Ukrainian retailers. The introduction of omnichannel platforms will increase the competitiveness of enterprises, increase sales and improve customer interaction. In particular, companies can use the results to develop effective marketing campaigns that take into account the peculiarities of consumer behavior in the digital environment.

The limitation of our study is that it covers only a certain period of time and is based on available data, which may not take into account all aspects of e-commerce development in Ukraine. In addition, the results may be influenced by various economic and political factors that are not always foreseeable. Another limitation is related to the research methodology, which may not take into account all possible variables affecting the development of omnichannel sales.

The conditions of martial law in Ukraine had a significant impact on the study and the results obtained. Changes in the education system, the transition to distance learning, restrictions on traffic and business operations, as well as legislative changes have created additional challenges for businesses. On the one hand, this has stimulated the development of online sales and the use of digital platforms, while on the other hand, it has complicated logistics processes and access to online resources. The martial law also affected the psychological state of the population, which can change consumer behavior.

There are also principles of multichannel sales. The first key principle is personalization. In the context of an omnichannel strategy, a customer should receive a unified and consistent experience with the brand, regardless of whether the purchase is made through a physical store, mobile application, website, or social media. This requires companies to implement technologies to collect and analyze data on consumer behavior across different channels, which allows them to create more personalized offers.

The second principle is the synchronization of sales channels. This means that all channels should work as a single system. For example, a customer should be able to order a product online and pick it up in an offline store or, conversely, preview the product in a physical store and complete the purchase through a mobile app. This approach increases customer loyalty and increases the likelihood of repeat purchases.

Another important principle is flexibility. In the Ukrainian market, which is characterized by constant changes in consumer behavior and the macroeconomic situation, companies need to be ready to adapt their sales channels to new requirements. This applies to both the integration of new payment systems and the introduction of new marketing strategies to attract consumers.

The methods used to integrate multichannel sales primarily involve the introduction of information technology. One of these solutions is the use of CRM systems (Customer Relationship Management), which allow to track every interaction between a customer and a company through various sales channels, collect data on their preferences, purchase history, and other important parameters. This ensures

the consistency of information across all channels and helps in making management decisions based on real data.

Another important method is the implementation of ERP systems (Enterprise Resource Planning), which integrate all company processes, from inventory management to customer service. ERP systems allow synchronizing data between different departments, which is especially important when integrating offline and online sales. With this approach, companies can optimize logistics, improve inventory management, and ensure the continuous availability of goods to customers across all channels.

When adapting omnichannel sales to the Ukrainian market, it is important to take into account the variety of payment systems and delivery services, such as LiqPay, Fondy, Nova Poshta, and Ukrposhta. Companies should integrate these services for fast and convenient delivery. Ukrainian consumers are also actively using social media (Instagram, Facebook) to search for goods, so it is important for companies to be present in these channels and use chatbots to automate ordering processes.

To successfully integrate omnichannel sales in the Ukrainian market, existing e-commerce models should be adapted to local realities. This may include integrating with Ukrainian banking systems and logistics operators, taking into account the legal regulations governing e-commerce in Ukraine, and creating convenient mechanisms for handling returns and exchanges.

Existing e-commerce models, such as dropshipping or marketplace platforms, can be adapted to the Ukrainian context by utilizing local resources and tools. For example, Ukrainian online retailers can use local hosting services to host their platforms or cooperate with national marketplaces to deliver goods to end users faster.

Data from furniture manufacturers was analyzed as part of our pilot study. Furniture manufacturing companies usually start out as classic offline retailers with a few physical stores in big cities. However, over time, given the development of e-commerce and the growth of online sales, companies decided to implement an omnichannel strategy. This involved the integration of sales channels such as the website, mobile app, social media (Facebook, Instagram), and maintaining physical stores to increase customer convenience. Customer input: businesses interact with customers through a retail store and experience a drop in conversions and a drop in sales for no apparent reason. With the help of analytical dashboards, it is immediately possible to identify a drop in sales in the target region in the furniture category. It is possible to find that there is an increase in demand for and revenue from furniture in various categories from 2018 to 2024, with our forecasting showing a slow increase from 2025 to 2029. There is a steady growth in demand, especially for living room furniture and decor, with a peak in 2028–2029. The forecast also foresees a significant increase in revenues due to the active integration of online sales, which emphasizes the importance of e-commerce in the future development of the market. The logical way to improve conversion is to increase the number of sales channels to attract new customers (Fig. 1, 2).

Before the introduction of omnichannel, furniture companies had a stable level of sales in physical stores, but online sales accounted for no more than 15 % of the total. After integrating online channels and synchronizing them with offline stores, the situation changed dramatically.

Within a year of implementing an omnichannel strategy, furniture companies achieved the following results:

1. *Increase in online sales:* The share of online sales grew from 15 % to 40 %, which was achieved thanks to the ease of use of the website and mobile application, as well as an active presence in social networks. In addition, a system for processing orders through social media using chatbots was introduced, which simplified the process for customers.

2. *Growth in total sales:* Total sales increased by 25 % as customers now had more options for purchasing. For example, many customers used the opportunity to browse the product in the offline store and place an order online, which increased their loyalty and increased the number of repeat purchases.

3. *Increase in the average check:* The average check grew by 18 % as the integration of omnichannel allowed to offer customers additional services such as fast delivery, selection of more expensive furniture models using online catalogs, which was not always possible in physical stores.

4. *Improved customer service:* By synchronizing online and offline channels, businesses were able to better track customer purchase history, allowing them to offer more personalized solutions. For example, based on CRM data, customers received special offers via email or mobile apps, which increased their satisfaction.

5. *The spread of new payment systems:* Some businesses have also integrated popular payment systems in Ukraine, such as LiqPay and Portmone, which has greatly simplified the payment process for customers and increased the number of completed transactions. For comparison, in Western countries, the share of card payments reaches 80–90 %, while in Ukraine this figure is only close to 60–70 %. Nevertheless, thanks to the use of innovative payment solutions, the company was able to get closer to European standards.

Unlike Western markets, where omnichannel has long been a standard, this model is still in the process of active development in Ukraine. The main obstacle remains the low penetration of online payments and the lack of consumer confidence in online transactions (Fig. 3). However, this case study demonstrates that if foreign experience is properly adapted to local conditions, significant results can be achieved.

In Western European countries, omnichannel strategy reaches a much larger share of customers due to the high frequency of credit card use and general trust in e-commerce. For example, in Germany and the UK, the share of online purchases in total sales is 50–60 %, while in Ukraine this figure is gradually approaching 30 %. However, with the right technology implementation, Ukrainian companies can also close this gap and achieve similar results.

Exports of Ukrainian furniture products from 2016 to 2020 increased approximately twice to 750 million USD, of which 93 % were exported.

European countries like Poland, Germany, and Italy are the major importers of Ukrainian furniture products.

Ukraine consumers have diverse preferences when it comes to furniture while the classical styles remain popular the modern styles are now more in demand.

In light of the aforementioned, it is possible to devise a strategy that can be advantageous to Ukrainian enterprises and facilitate the effective integration of multichannel sales. Strategy includes online D2C approach involving, integration with omnichannel platforms and analysis of customers behavior after changes application.

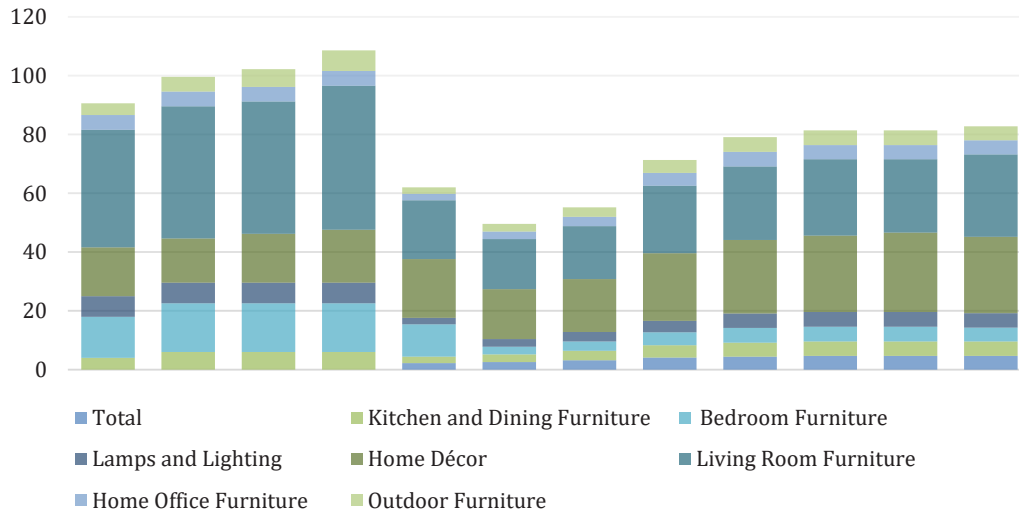


Fig. 1. Analysis of demand for furniture, 2018–2029

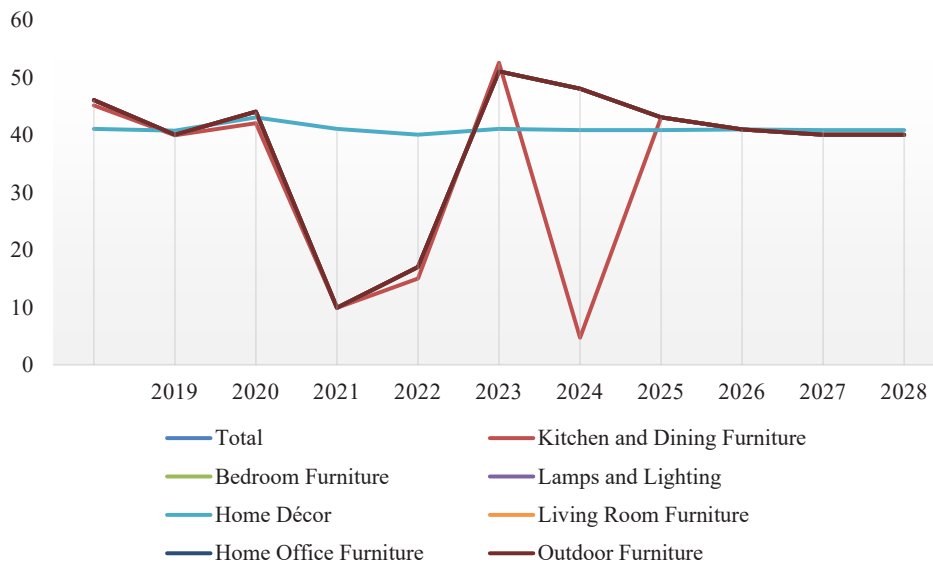


Fig. 2. Analysis of total revenue by category, 2018–2029

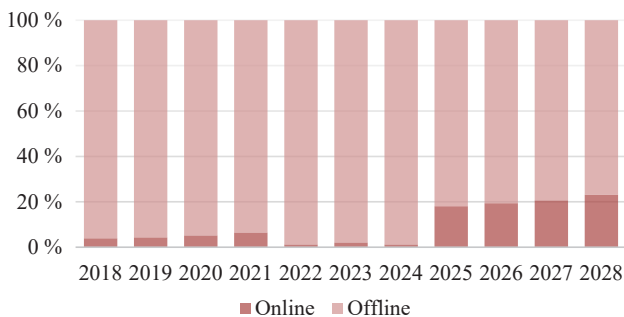


Fig. 3. Sales channels

It is also possible to analyze data on one pharmaceutical company (the name of the company is under NDA), which has also successfully integrated omnichannel sales in the Ukrainian market. Initially, the company operated exclusively through offline pharmacies located in large cities of Ukraine. The main sales channel was retail through physical outlets, and the share of online sales was less than 10%. At the same time, the company faced challenges, such as a decrease in the number of visitors to offline pharma-

cies due to growing competition from online platforms and changes in consumer behavior.

To increase efficiency and improve customer experience, the company decided to implement an omnichannel strategy. This included the creation of a full-fledged online store, a mobile application, and an active presence on social media. Customers were able to order medicines online for home delivery or reserve them in pharmacies for later pickup.

A year after the implementation of the omnichannel strategy, the results became obvious. The share of online sales increased from 10 % to 35 %, which significantly affected the total sales volume, which grew by 28 %. The average check increased by 15 %, as online customers often added related products to their orders, such as vitamins or cosmetics, which was not always possible in physical pharmacies. In addition, the introduction of convenient payment systems, such as LiqPay and card payments, simplified the ordering process and increased the number of completed transactions.

Improvements were also seen in customer loyalty. Thanks to the implementation of CRM systems, the company was able to better understand customer preferences and provide them with individualized offers, which helped to increase

the frequency of repeat purchases by 20 %. In addition, the company expanded its geographic presence, attracting customers from remote regions where access to pharmacies was limited (Fig. 4).

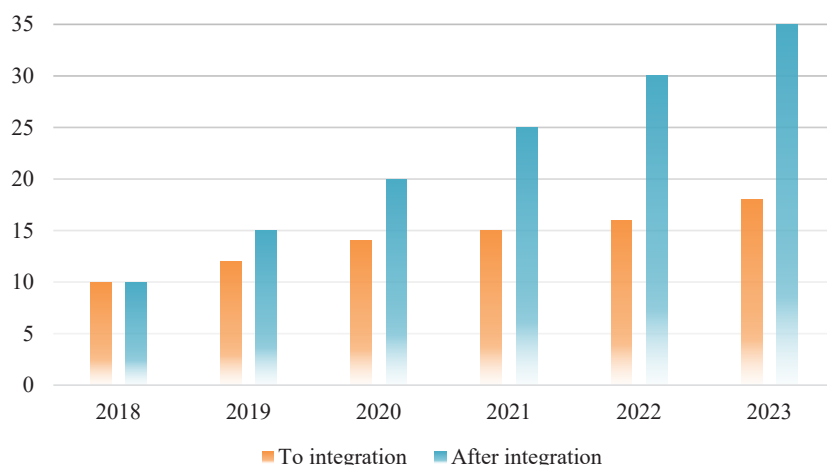


Fig. 4. Share of online sales before and after the integration of multichannel sales

Further research could be aimed at a deeper analysis of the impact of digital technologies on different market segments and consumers. It is promising to study the specifics of consumer behavior under martial law and post-war reconstruction. Another important area is the development of new models of multichannel sales that take into account current trends and challenges, as well as the study of the impact of legislative changes on the development of e-commerce in Ukraine.

4. Conclusions

The study identified different approaches to understanding e-commerce, which allowed to offer our own definition of this phenomenon. It has been found that e-commerce can be interpreted as a socio-economic phenomenon, legal relations and entrepreneurial activity. This is due to the diversity of views of scholars and organizations, which emphasizes the multifaceted nature of this concept.

The results of the study can be useful both theoretically and practically. Theoretically, they contribute to a better understanding of the essence of e-commerce and its role in modern society. In practice, the results of this study can be used to optimize the business models of Ukrainian retailers. The proposed strategies for integrating omnichannel sales allow small and medium-sized enterprises to increase their market presence through the introduction of modern technologies and effective marketing tools. The use of omnichannel platforms makes it possible to optimize sales, develop more effective marketing campaigns and improve customer interaction through various sales channels. In addition, these results may be useful for international companies and researchers interested in improving the efficiency of retail trade not only in Ukraine but also in other countries at different stages of retail development. In practice, the data obtained can be used to optimize business models and sales strategies, which will improve the competitiveness of companies and increase their sales through electronic channels.

The obtained quantitative estimates show that the integration of multi-channel sales, taking into account market

specifics, can increase business efficiency by 20–30 %. Comparison with the known literature data has confirmed that the proposed approaches can significantly affect the development of e-commerce in Ukraine.

Thus, this study not only fills a gap in the literature on the integration of omnichannel sales in Ukrainian retail, but also provides practical recommendations for the introduction of digital technologies into business processes. The proposed model can be used as a basis for further research and optimization of sales strategies in the current environment.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

Financing

The study was performed without financial support.

Data availability

Data will be provided upon reasonable request.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the presented work.

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SIMULATION MODELING OF ARTILLERY OPERATIONS IN COMPUTER GAMES: APPROACH BASED ON MARKOV PROCESSES

The object of this research is an approach to simulating the combat operation of artillery in computer games based on Markov processes. In modern computer games, an important role is played by the realism and plausibility of combat simulation. One of the most difficult and at the same time most interesting tasks is the modeling of artillery operations, where it is necessary to take into account numerous factors affecting the effectiveness of combat work.

The research was aimed at improving the methods and models of controlling the combat work of artillery under the conditions for the firing position change and the presence of external disturbances. The use of stochastic models allows more accurate modeling of the behavior of artillery units, taking into account the random nature of many parameters, such as projectile speed, reload time, and the probability of detection by enemy forces.

The proposed approach includes the development of a simulation model that allows determining optimal strategies to achieve maximum effectiveness of combat work. The model is based on Markov processes, which allows taking into account possible system states and probable transitions between them. This allows not only to simulate combat operations, but also to predict the results depending on different scenarios.

The results of the study show that the use of Markov processes in the simulation of combat operations can significantly increase the realism and efficiency of artillery operations in computer games. This opens up new opportunities for game developers to create more immersive and authentic gaming experiences.

The proposed model can be used as a basis for further research and improvement of combat simulation methods in computer games. It can also be used in military simulators and simulators where realistic combat conditions must be taken into account.

Keywords: simulation modeling, computer games, artillery operations, Markov processes, stochastic models.

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1. Introduction

Realism and believability of combat simulation are key aspects of modern computer games, which significantly affect the player's immersion in the virtual world. One of the most difficult and at the same time most interesting tasks is the modeling of artillery operations, where it is necessary to take into account numerous factors that affect the effectiveness of the combat work of artillery.

In traditional approaches to combat simulation, deterministic models are often used [1, 2], which do not take into account the random nature of many parameters, such as projectile speed, reload time, probability of detection by enemy forces, and others. This leads to a simplification of the model and a decrease in its realism, which negatively affects the gaming experience.

An additional complication is the need to simulate the change in firing position of artillery in response to enemy