Current Issues in the Development of E-commerce Systems

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Abstract
The research delves into the intricacies of digital commerce and its intersection with digital marketing, underscores the transformative potential of data analytics in understanding consumer behavior and refining marketing strategies.
Furthermore, the authors investigate the contemporary trajectories of e-commerce, highlighting innovative digital tools. Based on empirical data, offers guidelines for vendors to optimize product recommendations, underscoring the significance of such personalization in a vast online marketplace. In paper also study the elucidates the comprehensive features of digital commerce platforms and identifies prevailing trends, including personalization, data analytics, and the emphasis on corporate social responsibility.

Keywords [1]
E-commerce, digital marketing, consumer behavior, product recommendations, consumer expectations

1. Introduction

Let's note that digital commerce is gaining traction. The scale of electronic trade, as a form of electronic commerce, has significantly increased in recent years, especially in connection with the pandemic and global conflict situations, and such a trend will continue. This growth will be accompanied by e-commerce trends and digital developments that require a focus on consumer expectations. If we compare digital and electronic commerce, electronic commerce is a subset of digital commerce. Electronic commerce is commerce in electronic form, encompassing electronic transactions, the exchange of goods and services through electronic means of communication.

According to the Law of Ukraine "On Electronic Commerce" [1], electronic commerce refers to relations aimed at making a profit that arises during the commission of legal acts related to the acquisition, change, or termination of civil rights and obligations, carried out remotely using information and communication systems. As a result, participants in such relations acquire property rights and obligations. It should be noted that electronic commerce is the act of selling goods on the global Internet network when the transaction is made on a website.

Digital commerce is the process of buying things online without human intervention. The distinction is that the working processes of digital commerce are fully automated, starting from digital marketing and sales and ending with product delivery – logistics and automated after-sales service.

The concept of "digital commerce" covers everything that ensures the customer's journey when he buys a product, that is, search engine optimization and targeted advertising, convenient payment technologies for the customer, fast and reliable delivery, online assistants and augmented reality, blockchain, and other digital technologies during the purchase of goods or services.

Augmented and virtual reality is becoming more common, especially in the e-commerce industry. This simplifies the buying process for customers, eliminating many misunderstandings. There are examples of digital commerce that use augmented reality technology to make their products and the purchase process interactive, including Apple. Expansions of virtual reality and augmented reality can

change the way people perceive and buy goods in online stores. They will allow consumers to virtually "try on" clothing, shoes, or accessories before buying, as well as electronic interactions. With connected devices that collect data and send it to the cloud, e-commerce can become more personalized. For example, IoT refrigerators can automatically order products when they run out, and smart advertising can more accurately target consumers.

2. Trends in digital commerce: analysis of recent research and innovations

Digital commerce encompasses digital marketing, which allows companies to effectively attract and retain customers using digital channels such as social networks, websites, emails, and more. A well-known solution is the Customer Data Platform (CDP), designed for marketing. This platform allows companies to gather and unify client data from various sources to understand the expectations of each consumer. This customer data platform aids in addressing each query in real-time, significantly enriching the customer experience and boosting brand loyalty.

Let's enumerate the primary benefits that companies can reap from leveraging digital commerce:

- Presence in the global internet network to cater to the needs of digital consumers. They can engage with brands anytime and anywhere. With online services, customer satisfaction and thus e-sales are enhanced;
- Reduction in marketing and customer acquisition costs.

At the core of digital commerce are data and analytics, which allow a deeper understanding of consumer behavior patterns and people's preferences, and adapt marketing efforts to target specific audiences. Personalization increases the chances of successful communication, leading to cost reduction. As a result, businesses of all scales can promote effective marketing initiatives, opening new horizons for small and medium-sized businesses. At the same time, they can provide personalized communication with the audience, elevate user satisfaction levels, and have a higher likelihood of executing successful marketing campaigns.

A digital commerce platform is a software solution offering clients an interactive experience during the purchase of goods or services, allowing consumers to establish electronic relations with the brand using e-commerce recommendation systems.

Thus, solutions for digital commerce can encompass all components of e-commerce, alongside other crucial capabilities to ensure an improved customer experience.

These include advertising campaigns and content for omnichannel marketing, customizable dashboards, advanced analytics, UX-mapping and customer journey organization, product descriptions tailored for interconnection across various categories, supply chain management, and more.

Let's now highlight the key trends in digital commerce:

- Personalization and segmentation.
- Customer Data Analytics.
- Technological Innovations.
- Cybersecurity.
- Increasing data volume.
- Logistics and delivery.
- Legislative restrictions and regulation.
- Consumer expectations.
- Social responsibility.

2.1. Personalization and segmentation

Using a digital approach is crucial as it involves a tailored digital strategy, the potential, and e-interaction that a client expects from a brand.

In an environment of increasing digital influence, it's vital to continuously enhance brand recognition across all platforms. Thanks to multichannel content and e-commerce, businesses can seamlessly transition from one channel to another. Omnichannel strategies help convey the necessary message to clients at the right time. Through omnichannel marketing, a consistent experience for clients can be maintained regardless of whether they engage through an app, social media, or in person.

Personalization and segmentation involve leveraging user data, simplifying the shopping experience for individuals. Personalization provides both anonymous and registered clients with a vastly superior user experience through tailored messages, on-site recommendations, and real-time data usage. With these capabilities, a customer's journey with a specific brand becomes more engaging at every interaction stage. AI-based personalization aids in understanding client expectations and crafting a data-driven digital marketing strategy to enhance sales in digital markets.

2.2. Customer data analytics

Using customer data analytics provides a deep understanding of user expectations and behaviors [2]. Making informed decisions based on client data makes every interaction with the e-platform more appealing to consumers, encouraging them to make purchases again. Analytics are often used to measure progress with the aim of identifying opportunities for improvement. By determining KPIs that inform about the behavior of each site visitor, data can be obtained about the total number of user visits, client visits before purchase, types of channels consumers' use, the time visitors spend on the site, and product categories they are interested in. This forms the foundational information for refining the digital marketing strategy. Data analysis should be applied to every client to understand their priorities and preferences. This is a way to offer added value for B2B and B2C clients. Data analytics helps marketplaces offer each client a corporate-level experience, precisely tailoring services.

E-commerce systems have faced a large volume of data that needs processing and analysis. Effective data management and its analytics are essential tasks.

In the modern era of digital transformation, the volume of data collected and analyzed by e-commerce companies is continuously growing. Leveraging this information can provide businesses with significant insights and strategic advantages. Leading companies actively use big data analysis to better understand their clients, optimize operational efficiency, and increase profitability. Analysis can assist in identifying purchasing patterns, demand for products, and the level of consumer satisfaction.

Rapidly evolving artificial intelligence and machine learning technologies can facilitate the automation of big data analysis processes, trend forecasting, and the refinement of decision-making processes. Moreover, companies can use this data to craft more personalized and effective marketing strategies, targeting specific audience segments or even individual consumers.

However, with the growth in data volume comes an increased responsibility for companies to maintain the confidentiality and security of this data. This heightens the importance of issues concerning the protection of customers' personal data. For instance, a study by McKinsey & Company examines how companies can harness big data for competitive advantages [3]. Regarding data security issues, one can explore the latest strategies and data protection technologies in [4-5].

Digital commerce can be enhanced through analytics based on artificial intelligence, machine learning, automated selection, and methods of intelligent action. Artificial intelligence programs can be integrated into commercial solutions to optimize the site, product recommendations, and personalized user experience. For e-commerce solutions that do not scale with the business, headless eCommerce is appropriate. In this case, the frontend and backend of the site are separated. An API is used for communication between them. Small trade companies can improve the presentation level with constant updates, while the backend level evolves independently. This does not cause any downtime, keeping the website content consistently accessible to all clients. Today, every customer intends to pay for goods and services in a way that is convenient for them, using various payment instruments. Offering diverse and flexible electronic payment systems is an important trend. The most popular payment systems worldwide are PayPal, Stripe, Square, Apple Pay, Google Pay, Amazon Pay, Alipay, and Klarna.

For instance, QR code payments are becoming prevalent. It's a known fact that 50 percent of website traffic comes from mobile devices. Therefore, the adoption of e-commerce mobile apps is a trend that necessitates website optimization for mobile devices. Today, e-commerce systems face a range of problems and challenges that continuously change in line with technological advancements and shifts in consumer habits. Let's enumerate the most pressing issues e-commerce systems encounter:

First and foremost, the increasing competition in e-commerce requires companies to continuously evolve and strive to stand out from the rest. This escalating competition in online trading arises from several key factors and significantly affects companies operating within a specific market segment. The main aspects of the growing competition in e-commerce encompass the following areas.

Primarily, there's the increase in the number of participants. E-commerce attracts more and more companies and enterprises as digital technologies become increasingly accessible. This leads to a growth in competitors in the digital market, forcing companies to find ways to distinguish themselves and be unique. Another significant factor is the expanding array of products and services available to consumers. Thanks to the global internet network, consumers have access to a broad spectrum of goods and services from around the world. This makes them more discerning and prone to comparing prices and quality in real-time, pushing companies to primarily focus on enhancing their competitiveness.

Consumers expect fast delivery, convenient customer service, quality products, and low prices. This necessitates companies to continually elevate service standards and innovate.

The rise in technological competitiveness is an undeniable fact. Companies possessing advanced technologies and data analysis capabilities have an edge in the competitive landscape. Technological advancement offers the ability to automate processes and enhance convenience for consumers.

Companies must continuously refine their products and services, develop new offerings, and introduce innovations [6] to captivate consumer attention and keep them satisfied. In this context, e-commerce companies must be prepared for constant change and improvement, create unique propositions, focus on the quality of service and interaction with customers, and utilize innovative technologies to increase efficiency and competitiveness in the e-commerce market.

2.3. Technological innovations

Technological Innovations: Consumers quickly adopt new technologies such as artificial intelligence, virtual reality, and blockchain. E-commerce must explore and implement these innovations to enhance the user experience. Technological innovations play a pivotal role in the world of e-commerce. Consumers, especially the younger generation, quickly adapt to innovations, pushing companies to stay current by integrating new technologies into their business models. Below is a Table 1 showcasing tools and innovations that have already been implemented in e-commerce or have the potential to become a part of this sector in the future.

Table 1
Tools and innovations in e-commerce

Technology	Description	Usage Examples
Artificial Intelligence	Helps in personalizing shopping, enhances recommendation systems, and serves customers through chatbots.	Personalized recommendations on platforms like Amazon.
Virtual Reality	Offers a more immersive shopping experience, allowing customers to "try on" or "view" products in a virtual space.	Virtual fitting rooms on platforms like ASOS.
Blockchain	Ensures transparency and security of transactions.	Cryptocurrency payments on platforms like Shopify.
Internet of Things (IoT)	Facilitates innovative solutions for customer service and purchase tracking.	Cashier-less stores like "Amazon Go".
Big Data	Analyzes large amounts of data for predicting consumer needs and optimizing marketing strategies.	Predicting purchases and consumer behavior on platforms like Alibaba.
Cloud Technologies	Allows quick scaling of operations, cost optimization, and efficiency improvement.	Cloud solutions for businesses from Google Cloud and AWS.
3D Printing	Creates user-specific goods or speeds up the manufacturing process.	Online stores offering products made via 3D printing.
Augmented Reality	Allows customers to "see" how products will look in their home before purchase.	Home design apps from companies like IKEA.

Each of these technologies, listed in the Table 1, can significantly influence the consumer experience in e-commerce, offering new and innovative ways to interact with products and brands.

2.4. Cybersecurity

In the development of electronic and digital commerce, cybersecurity is of paramount importance. Along with the benefits that companies and their clients can obtain from using digital commerce, there is a potential for threats of various natures to their cybersecurity. Ignoring these threats, which will be discussed below, can cause significant harm to all stakeholders – from reputational losses to financial ones:

1.   As mentioned, full online customer service without involving a human salesperson greatly enhances the convenience of communicating with brands anywhere and at any time. However, such a service approach requires a higher level of user expertise and does not always satisfy the customer's needs fully. For instance, the Ministry of Digital Transformation of Ukraine conducted a sociological study titled "Digital Literacy of the Ukrainian Population", according to which 53% of Ukrainians lack basic digital skills, and another 15.1% of people aged 60-70 do not possess any digital skills at all [7]. Considering this, it is essential to maintain the possibility for all categories of people to make online purchases in a manner convenient for them, not limiting their right to shop on the global internet network with the assistance of a sales consultant.

2.   As previously asserted, at the core of digital commerce are data and analytics, which allow for a better understanding of consumer behavior patterns and preferences. They enable companies to tailor their marketing efforts towards target audiences, and personalization increases the chances of successful communication, leading to reduced costs. However, companies must remember the customer's right to anonymity, the right to prohibit surveillance and/or monitoring, including through "cookies", HTTP headers, HTML5, web beacons, or other technologies, and the right to be forgotten. The use of continuous tracking technologies is touted by various app developers as a means to enhance the online user experience by remembering preferences and prior views. Still, it remains uncertain how else this information might be used. Specifically, in the imposition of contextual advertising or converting an individual from a subject to an object of research unbeknownst to them. Cybersecurity experts label such technology as "depersonalization", the essence of which lies in computations pushing the user out of the relationship, either partially or fully. Already, there are programs that act on behalf of the individual, for instance, setting priorities based on previously tracked preferences or receiving contextual ads about product sales based on past behavior. This gives individuals a seeming "choice without choice". Despite the benefits offered by these technologies, there will always be a risk that some software components may exhibit unpredictable characteristics, either due to external interference, misuse, or that certain elements might contain bugs, leading to unforeseen consequences. Therefore, it's crucial for a customer to be preemptively informed by the e-commerce or digital commerce website owner about the use of specific "cookies", artificial intelligence for learning, and that human actions might be tracked and used later with certain intent. Thus, providing the option to decline tracking technologies if the client wishes so. In turn, clients should also be granted the right to easy and unhindered account deletion or the use of an anonymous profile. If anonymizing an agreement or personal profile isn't feasible, a prudent advice would be for clients to use a separate profile and phone number solely for online purchases.

3.   A characteristic of digital commerce is its ability to offer convenient payment options for customers. However, the security of payments during online transactions for goods and services remains the top priority. This is evidenced by relevant statistics, which show that since the beginning of the full-scale invasion in Ukraine, there has been an increase in cybercriminal activity. Over 11% of Ukrainians have fallen victim to fraudsters since the start of the full-scale invasion. Most often, Ukrainians were deceived during online purchases or sales [8].

It's essential to remember that there is no method with a 100% guarantee to protect a customer from cyber threats and fraud. However, there are guidelines that, when followed, can minimize the aforementioned risks of being deceived. The process of ensuring cybersecurity is not solely the responsibility of one party – be it the company, government body, or the customer. Cybersecurity requires a comprehensive approach and the implementation of appropriate preventive measures by every responsible entity. Universal guidelines include:

1.   Enhancing the protection level of accounts (profiles) and personal financial accounts by applying two- or three-factor authentication or identification. While these actions might require additional time for inputting passwords or extra codes for identity verification, they can protect funds from criminals.

2.   Maintaining personal anonymity. Provide as little extraneous information about yourself as possible. Criminals might exploit personal information on social media and carelessly left personal data to impersonate a specific individual during checks.

3.   Ignoring calls from unknown numbers. It's better not to answer calls from unfamiliar numbers and to check them in the relevant databases for affiliation with fraudulent activities. If it's determined that the number is associated with criminal activity, it should be immediately blocked and/or reported to the competent law enforcement agencies.

2.5.   Mobile interface optimization

With the rise in the use of mobile devices for online shopping, it's crucial to have an optimized interface for mobile apps and websites.

An essential aspect of e-commerce system development is mobile interface optimization. From the fundamentals of responsive design to the implementation of technological innovations, developers are continually seeking ways to enhance the user experience. Table 2 presents several directions and examples of optimization.

Table 2

Directions for mobile interface optimization

Area of Optimization	Application		
Loading speed	Load time optimization		
	Optimizing images		
Intuitive navigation	Deep linking		
	Interactive elements		
Personalization of user experience	Adaptive design		
	AI and machine learning (recommendation systems)		

Let's consider the primary applications highlighted in Table 1. A study published by Google in 2018 [9] highlighted that 53% of mobile device users abandon a website if its loading takes more than 3 seconds. Such research emphasizes the importance of optimizing load time, and companies like Google offer tools to analyze site speed, assisting website owners in enhancing the overall user experience. Image optimization also affects loading speed, as explored in the study [10] which examines image optimization methods for improving mobile website loading speeds. The authors developed an automated system for image optimization that significantly enhances loading time without compromising image quality. In another study [11], Deep Linking was identified as an effective way to boost user engagement by providing seamless transitions between different apps or platforms [12]. The authors suggest it can be a tool for increasing conversion rates in mobile commerce. Another research [13] indicates that interactive elements can enhance user satisfaction and improve the user experience. The author discusses mobile interface design and its impact on user satisfaction, noting that interactivity is a key factor in user engagement. Responsive design also greatly impacts the evolution of e-commerce systems. In [14-15], various approaches to responsive design that aid in creating more personalized user experiences are discussed, revealing the importance of responsive design in developing interfaces that automatically adjust based on various adaptation criteria, thereby enhancing user experience.

Furthermore, AI and machine learning have a significant impact on e-commerce systems: modern research emphasizes their significance in creating personalized recommendations for users in e-commerce contexts, showing that intelligent recommendation systems can significantly boost the efficiency of marketing strategies, facilitating sales growth and customer satisfaction [16].

2.6. Increasing data volume

E-commerce systems have faced a vast amount of data that needs to be processed and analyzed. Effective data management and analytics are crucial tasks.

In today's era of digital transformation, the volume of data collected and analyzed by companies in the e-commerce sector is continually growing. Utilizing this information can provide businesses with valuable insights and strategic advantages. Leading companies actively use big data analysis to better understand their customers, optimize operational efficiency, and boost profitability. Analysis can assist in identifying purchasing patterns, product demand, and customer satisfaction levels.

Rapidly evolving artificial intelligence and machine learning technologies can aid in automating the big data analysis process, predicting trends, and enhancing decision-making processes. Additionally, companies can leverage this data to create more personalized and effective marketing strategies targeted at specific audience segments or even individual consumers.

However, with the increase in data volume, companies' responsibility for preserving the confidentiality and security of this data also significantly grows. This accentuates issues concerning the protection of clients' personal data. For example, a study by McKinsey & Company analyzes how companies can use big data to gain competitive advantages [3]. Regarding data security issues, one can explore the latest strategies and data protection technologies in [5].

2.7. Logistics and delivery

An efficient logistics and delivery system is key to satisfying customers and retaining their trust. Challenges in this area include high costs, delays, and issues with lost goods.

In the context of e-commerce, logistics and delivery play a crucial role in ensuring effective and timely distribution of goods to consumers. Let's consider several important aspects of this process:

- Automation of logistical processes through the application of artificial intelligence and machine learning technologies, which allows for the automation of many aspects of the logistical processes, leading to reduced errors and increased productivity.

- Inventory management systems can assist in predicting demand, optimizing stock levels, and reducing costs.

- Drones and robotic delivery can significantly speed up the delivery process, bypass road congestions, and ensure timely delivery. Additionally, companies can focus on reducing the environmental impact of their logistic operations through the implementation of "green" initiatives, such as using electric vehicles for delivery.

- Supply chain security, which e-commerce companies should guarantee by using modern technologies for monitoring and management at all stages of the logistics process.

- Customer-centric services, such as swift product returns and flexible delivery options, contribute to enhancing the e-commerce customer experience.

2.8. Legislative restrictions and regulation

Regulation in e-commerce is vital for creating fair and conscientious markets, protecting consumer rights, and ensuring the stability and safety of this sector. It is crucial that the legislation is modern and takes into account the rapid development of technology and changes in e-commerce relationships.

Legislative restrictions and regulations for e-commerce vary depending on the country and region. However, there are general trends and typical rules that apply in many parts of the world. Laws determine the legal status of electronic transactions and also establish accountability for violations. This is important for building trust among buyers and sellers. The most significant is the data protection law. Many countries have laws that govern the collection and processing of personal data of customers and users in online stores. For example, the General Data Protection Regulation (GDPR) in the European Union sets obligations regarding the collection and processing of personal data.

Digital signatures and cryptographic protection are also important. Laws may require the use of electronic signatures to validate deals and transactions in e-commerce. Additionally, protection against cybercrime and mandatory data encryption is often regulated.

The Ukrainian Law 'On Electronic Trust Services" [17] defines the legal and organizational principles of providing electronic trust services, including cross-border ones, the rights and obligations of subjects of legal relations in the field of electronic trust services, the procedure for state supervision (control) over compliance with legislation in the field of electronic trust services, and also the legal and organizational principles of electronic identification.

Another significant law is the Ukrainian "Consumer Rights Protection Law", which regulates relations between consumers of goods, works, and services and manufacturers and sellers of goods, contractors of works, and service providers of various forms of ownership. It establishes consumer rights, as well as defines the mechanism for their protection and the basics of implementing state policy in the field of consumer rights protection. The legislation governs the rights and obligations of consumers in e-commerce, including rules on product returns, data confidentiality, and other aspects essential for the protection of consumer rights.

Legislation should be flexible and adapted to new technologies, such as artificial intelligence, blockchain, virtual reality, and IoT. Taxation regulation of e-commerce can significantly differ in various countries. The law may include rules on the mandatory collection of taxes on electronic transactions and methods for their calculation. Antitrust laws might restrict unfair practices in e-commerce, such as monopolistic behavior or abuse of market position. Taxation issues in e-commerce can be complex due to the global nature of this business. Legislation determines tax rates, obligations regarding tax collection, and other tax-related aspects.

The aforementioned regulations can significantly impact how businesses conduct e-commerce, so it's crucial to understand each country's legislation thoroughly and comply with it when developing and managing an online business.

2.9. Consumer expectations

Consumer expectations reflect the needs and aspirations that consumers have regarding products or services in e-commerce. Figure 1 depicts several key elements of consumer expectations.

When considering "consumer expectations" in the context of e-commerce (Figure 1), it's important to highlight specific examples from well-known market players, such as Amazon, to illustrate effective strategies they use to meet consumer expectations. Amazon, for instance, uses sophisticated algorithms and data to provide personalized product recommendations to its users, taking into account their purchase history and browsing behavior.

One of the features of the "Amazon Prime" service is fast delivery, which often occurs on the same or the next day, responding to the consumer desire to receive products as quickly as possible. Moreover, Amazon offers seamless integration between its mobile apps, website, and physical stores, such as Amazon Go, providing a consistent user experience across different platforms.

A significant aspect of their strategy also includes a comprehensive customer review platform where consumers can share their experiences and product ratings, which assists other customers in making informed decisions. From a social responsibility perspective, Amazon aims to reduce its carbon footprint through initiatives like the "Climate Pledge", with a goal of achieving net-zero carbon emissions by 2040 [18]. Finally, the company offers flexible return policies, allowing customers to easily return products if they don't meet their expectations. These practices demonstrate how Amazon continually adapts to meet changing consumer expectations in the e-commerce sector.
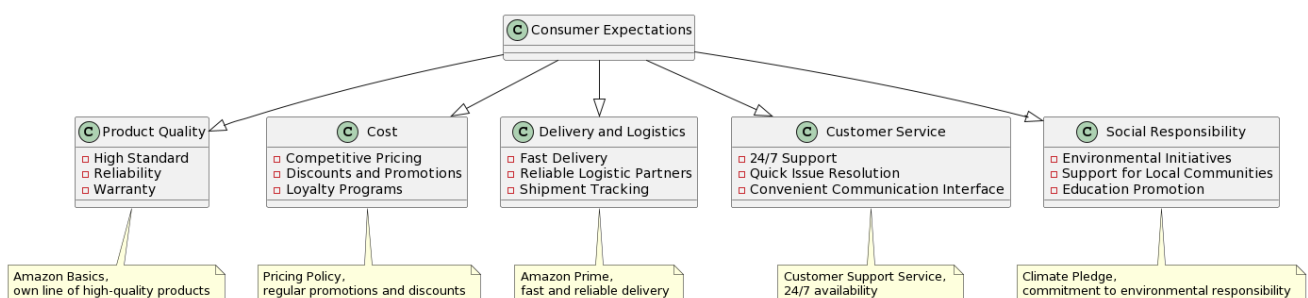

Figure 1: Key elements of consumer expectations

2.10. Social responsibility

Social responsibility in e-commerce is becoming an important tool for strengthening consumer trust and shaping a positive company image. Within this context, aspects such as environmental initiatives, support for local communities, charitable efforts, educational programs, and ensuring fair working conditions can be considered. Modern companies, for example, like Amazon with its "Climate Pledge" initiative, focus on environmental initiatives by introducing eco-friendly packaging materials, minimizing waste, and reducing their carbon footprint.

Additionally, some e-commerce platforms promote local production and support local brands, contributing to the development of the local economy. At the same time, they might engage customers in charitable actions, offering the possibility to allocate a portion of the purchase price to charitable causes. Educational programs also become part of the social responsibility strategy, aimed at increasing consumer awareness about important social issues. And, lastly, ensuring decent working conditions and equal opportunities for all employees is a crucial component of a company's social responsibility in the e-commerce sector.

The highlighted issues require continuous study and adaptation from companies operating in the e-commerce sector, as well as collaboration with experts from various fields to find optimal solutions.

3. Research methods and modeling

The authors of the research aim to identify the directions of development in e-commerce systems, the latest informational and digital technologies that contribute to this development, and based on the experimental data of a trading company, determine recommendations for sellers regarding the purchase of products for clients based on their previous purchase history. In modern e-commerce, one of the key challenges is providing effective and accurate product recommendations for clients. Product recommendations can significantly enhance customer satisfaction, brand loyalty, and ultimately, the company's overall sales and profits. This is especially relevant in today's world, where online stores offer a vast range of products, making it challenging for buyers to make a choice.

Therefore, recommending products to clients based on their previous purchase history is an actual task.

3.1. Problem statement

The data for developing the model was provided by the e-commerce website. Using this data, it was necessary to construct a model analyzing the influence of a client's history on their choice, that is, their purchase. The following indicators were identified for the modeling:

x_1 – InvoiceNo (invoice number). Nominal, a 6-digit integral number uniquely assigned to each transaction.

x_2 – StockCode. Product (item) code. Nominal, a 5-digit integral number uniquely assigned to each distinct product.

x_3 – Quantity. The quantities of each product (item) per transaction. Numeric.

x_4 – InvoiceDate. Invice date and time. Numeric, the day and time when each transaction was generated.

x_5 – UnitPrice. Unit price. Numeric, Product price per unit in sterling.

x_6 – Country name. Nominal, the name of the country where each customer resides.

Output variable: y – product. Product (item) name. Nominal

The total data sample contained 10,000 measurement points and was divided into two parts: 2/3 – training subsample A, the second (1/3 – every third row) – testing subsample B.

3.2. Modeling

Modeling was carried out in several stages:

Stage 1. Data preparation.

E-commerce data often contain transactional information, including details about products, prices, purchase times, buyer locations, and product names. We used a dataset that contained such information and underwent several data processing steps to prepare it for analysis and modeling: Each product description was encoded using the numbers corresponding to the first letters of every word in the title. For example, "WHITE HANGING HEART" was transformed into "2388": "W" (WHITE) is the 23rd letter of the alphabet, "H" (HANGING) is the 8th, and "H" (HEART) is also the 8th.

The variable x_4 was split into two variables: x_{4_1} and x_{4_2}.

x_{4_1} (PurchaseTime): The purchase time was extracted from InvoiceDate and reformatted without colons. For example, "12:49" became "1249".

x_{4_2} (PurchaseSeason): The purchase date was extracted from InvoiceDate and reformatted as mmyyyy. For example, "12/1/2010" became "122010".

This division helped us highlight the following features:

• Purchase Time: Understanding customers' temporal preferences can determine when the majority of customers are actively purchasing. This allows stores to adapt their marketing campaigns, offers, and product recommendations to maximize sales. Moreover, different customer groups may prefer shopping at different times. For instance, some customers might shop in the morning, while others in the evening. This information can be used to personalize the timing of product recommendation dispatches.

• Purchase Season: Analyzing the purchase season can identify seasonal trends and patterns in consumer behavior. This can aid in inventory planning, marketing campaigns, and the offering of seasonal discounts and promotions. Segmenting customers based on the purchase season can help in creating specialized marketing campaigns and product recommendations for each group. Furthermore, information about the purchase season can be used for personalized offers and recommendations, considering the individual preferences of customers during different times of the year.

The variable x_6 - country name. Countries were encoded using their telephone codes. For example, "United Kingdom" became "44".

Consequently, after the first stage, the number of input variables became 7: x_1, x_2, x_3, x_{4_1}, x_{4_2}, x_5, x_6.

Stage 2. Model Identification.

The sample contains m=7 arguments and n=10,000, which is divided into two parts: $n_A = 1/3\ n$, $n_B = 2/3\ n$.

To find the model, we will use a polynomial neural network with active neurons: GIA GMDH, the structure of which is detailed in [19]. GIA GMDH represents a set of iterative and iterative-combinatorial algorithms, defined by the components of the vector of three index sets: DM (Dialogue Mode), IC (Iterative-Combinatorial), MR (Multilayered-Relaxative). It identifies the optimal model by combining the values of the index sets.

$$y_l^{(r+1)} = f_{opt}(y_i^r, x_j) \tag{1}$$

$$f(u,v) = a_0 d_1 + a_1 d_2 u + a_2 d_3 v + a_3 d_4 uv + a_4 d_5 u^2 + a_5 d_6 v^2 \tag{2}$$

$$d_k = \{0, 1\},\ d_{opt} = \arg\min_{l=1,q} CR_l,\ q = 2^p - 1,\ f_{opt}(u,v) = f(u,v,d_{opt})$$

The activation of neurons occurs due to the optimization of partial descriptions of the obtained general model within each neuron. The combinatorial optimization implies that on each row, models are considered, for instance, of the following form (for a linear partial description):

$$f(y_i^r, y_j^r) = a_0 d_1 + a_1 d_2 y_i^{r-1} + a_2 d_3 y_j^{r-1} \tag{3}$$

where $d_k, k=1,2,3$ are the elements of the binary structural vector d, which take values of 1 or 0 (indicating the inclusion or exclusion of the respective argument), (2). The sorting scheme then looks like this:

$$100 \rightarrow f_1 = a_0 \qquad\qquad\qquad CR_1$$
$$010 \rightarrow f_2 = \quad\; a_1\, y_i^{r-1} \qquad\qquad CR_2$$
$$001 \rightarrow f_3 = \qquad\qquad a_1\, y_j^{r-1} \quad CR_3$$
$$110 \rightarrow f_4 = a_0 + a_1\, y_i^{r-1} \qquad\qquad CR_4$$
$$101 \rightarrow f_5 = a_0 + \qquad + a_1\, y_j^{r-1} \quad CR_5$$
$$011 \rightarrow f_6 = \quad\; a_1\, y_i^{r-1} + a_2\, y_j^{r-1} \quad CR_6$$
$$111 \rightarrow f_7 = a_0 + a_1\, y_i^{r-1} + a_2\, y_j^{r-1} \quad CR_7$$

$$\left. \right\} \underset{\min}{\Rightarrow} f_{opt} \qquad (4)$$

The best variant is chosen based on the minimum criterion CR, meaning the complexity of the partial model is optimized (1). The final model included two neurons: N_{70} and N_{123}:

$$\hat{Y} = -1.94006E + 6 + 2.0676 N_{70} - 2.14424E - 07 N_{70} N_{123} - 3.16451E - 07 N_{70}^2 + 1.2076 N_{123}$$

Each of these neurons was obtained in the final hidden layer as a pairwise combination of neurons from previous layers using combinatorial optimization (3).

$$N_{70} = 555143 - 14872 x_3 + 45941.4 x_{4\_2} x_5 + 8098.68 x_3^2 + 453082 x_5$$

$$N_{123} = 2.16482E + 09 - 5.23382E + 07 x_1 + 37321.1 x_1 x_6 + 316455 x_1^2 - 3.00372E + 06 x_6$$

Stage 3. Verification of the model's accuracy.

The selection criterion - is a regularity criterion, which is calculated for a given model complexity:

$$AR_B(s) = AR_{B|A}(s) = \left\| y_B - \hat{y}_{B|A}(s) \right\|^2 = \left\| y_B - X_{Bs} \hat{\theta}_{As} \right\|^2, \qquad (5)$$

$AR=0.37563$.

The accuracy of the built model was calculated according to formula (6):

$$R^2 = \frac{\sum_{i=1}^{n} \left(\hat{y}_i - \bar{y} \right)^2}{\sum_{i=1}^{n} \left(y_i - \bar{y} \right)^2} \, 100\%, \qquad (6)$$

where $\bar{y}$ – is the mean value, $\hat{y}_i$ – the model output, $R^2=82\%$. Since we have pre-encoded the products, the error does not give us an exact result y, but it only changes the last digits in the code, which allows us to relate the product to the identified samples (in this experiment, 10 different products were highlighted).

As can be seen from the obtained model, out of all 7 indicators, only 5 have a significant impact on the chosen product: : x_1, x_3, x_{4_2}, x_5, x_6. These indicators should be considered informative for this task. However, for a more accurate model, the influence of other factors that may affect the overall result should be investigated.

4. Conclusions

In our research aim to identify the directions of development in e-commerce systems, the latest informational and digital technologies that contribute to this development, and based on the experimental data of a trading company, determine recommendations for sellers regarding the purchase of products for clients based on their previous purchase history. In the initial stages of the research, the focus was on preparing data, which included organizing samples with seven arguments and partitioning them into subsets for analysis. The model identification process utilized a polynomial neural network with iterative and combinatorial algorithms to determine an optimal model. The complexity of the model was refined based on specific criteria, ultimately incorporating neurons that came from pairwise combinations in preceding layers. Through this intricate method, specific influential factors on product selection were identified.

Transitioning from the technicalities of model development, the broader picture of the study touches upon the digital transformation influencing every sphere of human interaction, especially e-commerce.

The integration of AI and machine learning not only refines the personalization of offers but also streamlines business operations. This digital evolution, while promising greater connectivity and efficiency, also brings forth challenges in international regulations, logistics, and data security. Technologies like blockchain and other digital payment methods could address some of these challenges, offering both reliability and efficiency.

In conclusion, as the world leans more into digital commerce and virtual interactions, the necessity for robust, data-driven models becomes evident. By understanding and leveraging data in sophisticated ways, businesses can stay at the forefront of the industry, offering innovative solutions, personalized experiences, and ensuring operational efficiency in a rapidly changing digital landscape.

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