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INNOVATIVE MODEL FOR THE DEVELOPMENT OF E-COMMERCE IN FOODSTUFFS IN UKRAINE

Introduction. *In the context of contemporary challenges — particularly the wartime period, which has disrupted logistics chains, reduced purchasing power, and significantly altered consumer behavior — the development of e-commerce in food products has become increasingly important. This sales channel is emerging as a critical mechanism for ensuring food accessibility and market resilience, as it compensates for the limitations of traditional retail networks and facilitates adaptation to rapidly changing conditions.*

Problem Statement. *The lack of integrated models for forecasting and managing the market complicates strategic decision-making and limits the scalability of the sector.*

Purpose. *To develop an innovative model for the advancement of e-commerce in food products in Ukraine, given technological, economic, and social factors.*

Materials and Methods. *The empirical basis of the study comprises statistical data from the international platform Statista, covering the period 2018—2024, with forecast estimates for 2025—2029. The research methodology includes a comprehensive approach based on systems analysis, dialectical and historical methods, theoretical generalization, economic-mathematical modeling, and scenario analysis.*

Results. *The proposed economic mathematical model has enabled a quantitative assessment of the dynamics of e-commerce in food products in Ukraine, identified key growth drivers (including consumer trust, infrastructure readiness, and average consumer expenditure), and substantiated alternative scenarios for market development.*

Conclusions. *The proposed models and analytical findings can be applied in the formulation of public policy, the development of business strategies, and the design of support measures aimed at strengthening the role of e-commerce in Ukraine's food sector.*

Keywords: e-commerce, food sector of the economy, innovative approach, descriptive conceptual model, development scenarios, consumer behavior, digital distribution channel, digital transformation, digital marketing, sustainable development.

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Under conditions of rapid digitalization of the economy and the growing demand for online grocery purchases, the development of innovative approaches to food e-commerce in Ukraine is becoming increasingly important. This sector is emerging as a critical instrument for ensuring food security, accessibility, and product quality, while simultaneously requiring adaptation to new technological, social, and economic challenges. The novelty of this study lies in the development of integrated conceptual and economic–mathematical models that formalize the complex interrelationships among key market parameters and enable forecasting of market development under conditions of external shocks and internal transformations.

A review of the scholarly literature on e-commerce in general [1—11], and in the agri-food sector in particular [12—16], indicates that most studies focus on isolated aspects, such as technological innovation, logistics solutions, or consumer behavior. At the same time, insufficient attention is given to comprehensive models that integrate both quantitative and qualitative factors shaping market development in Ukraine, taking into account its specific economic and social conditions. This gap underscores the need for innovative approaches that combine systems analysis, quantitative forecasting, and sensitivity to the structural features of the local market.

The analysis of the cited sources [1—16] makes it possible to distinguish several theoretical strands that define the contemporary research landscape of food e-commerce:

- Technological approach — emphasizing digital platforms, recommendation algorithms, inventory management systems, and integration with ERP/WMS solutions. The literature suggests that technological innovation acts as a catalyst for efficiency; however, it does not, in isolation, resolve persistent challenges related to logistics and consumer trust [7, 10, 15, 16].
- Logistics approach — focusing on last-mile delivery, cold chain management, route optimization, and multi-warehouse infrastructure. For food products, logistics is a decisive factor due to sensitivity to temperature conditions and shelf life constraints [1, 2, 4, 12, 13].
- Behavioral/marketing approach — examining determinants of consumer trust, willingness to pay for delivery, and perceptions of online product quality, as well as the role of digital marketing in shaping habitual online grocery purchasing behavior [3, 9, 14].
- Institutional and economic approach — focusing on the influence of the regulatory environment, tax incentives, food safety standards, and the role of large marketplaces and institutions in shaping the "rules of the game" [5, 11, 12].
- Systemic (integrated) approach — combining the aforementioned strands into a unified interaction model encompassing platforms, suppliers, logistics, consumers, and regulators. It is at this level that issues of coordination, scalability, and resilience are most effectively addressed [4, 6, 8, 10].

Over the past five years, several hundred international publications indexed in Scopus and Web of Science have addressed food e-commerce. Leading contributions originate from diverse regions, with particularly strong representation from Asia (notably Indonesia) [17] and Europe (e.g., France) [18]. For instance, J. Guo et al. represent a Chinese research group examining the impact of COVID-19 on online agricultural product sales [19], while T. A. Monoarfa et al. provide an extensive bibliometric analysis of food e-commerce research in the Indonesian context [17]. Some studies reflect international collaboration, such as the Canadian–Ukrainian research by V. Galushko and A. Riabchyk [20]. Overall, the body of scholarship includes contributions from researchers based in China, East and Southeast Asia, Europe, and North America.

Several key thematic directions can be identified within this literature: consumer behavior studies; big data analytics and pandemic-related effects; econometric analyses; machine learning and optimization methods; as well as bibliometric and review studies.

Consumer behavior research focuses on preferences and motivations underlying online food

purchases. These studies typically employ surveys and in-depth interviews followed by thematic analysis. For example, O. Droulers and S. Lacoste-Badie identify key determinants influencing product choice, including a more limited selection of fresh foods, a tendency to purchase familiar products, and time-saving considerations [18]. Such qualitative research highlights shifts in dietary patterns and consumer health associated with the increasing use of online platforms.

Big data analytics and pandemic-related effects are typically examined using large-scale representative surveys and statistical modeling. For example, V. Galushko and A. Riabchyk surveyed more than 600 respondents in Canada in 2024 and analyzed the data using logistic regression. Their findings indicate that 72% of respondents changed their habits due to COVID-19, while 63% intend to maintain the new online purchasing mode [20]. Key determinants of the adoption of online grocery purchasing include perceived health risks, pre-existing consumption habits, demographic characteristics, and technological capabilities. Similar approaches — panel data analysis and logistic modeling — are widely employed in related studies.

Econometric research relies on transactional data from e-commerce platforms and online stores. For instance, J. Guo et al. applied a difference-in-differences (DiD) methodology to a dataset comprising 164,002 Chinese online grocery stores. Their results demonstrate a significant increase in online sales following the onset of the pandemic, particularly among smaller retailers and for essential goods [19]. These findings highlight both the resilience of supply chains and the critical role of small-scale suppliers.

Machine learning and optimization methods are increasingly used to analyze and optimize e-commerce processes. For example, Yang et al. employ deep neural networks and data mining techniques to enhance marketing strategies in online agricultural sales [21]. Such tools enable the modeling of large-scale transaction data and consumer behavior patterns, thereby improving demand forecasting and personalization.

Bibliometric and review studies provide systematic syntheses of the field and map its intellectual structure. Monoarfa et al. apply PRISMA methodology and VOSviewer tools to conduct a bibliometric analysis of the literature for the period 2012—2022, identifying core themes such as consumer segmentation, behavior, and purchase intentions [17]. Altarturi et al. combine bibliometric and content analysis to examine innovation in agri-food e-commerce, outlining key challenges and influential directions, including logistics, standardization, traceability, and the implementation of Internet of Things (IoT) and blockchain technologies [22]. In a similar vein, the meta-analysis by O. Tyrväinen and H. Karjaluoto synthesizes findings from 50 studies (covering more than 20,000 respondents) on online foodstuff retail before and during the pandemic, identifying the principal determinants of purchase intentions [23].

Although the number of studies specifically focused on Ukraine remains limited, international findings are largely transferable. First, the domestic food retail market — and e-commerce in particular — continues to expand despite the constraints imposed by the ongoing wartime crisis [29]. This suggests that Ukrainian consumers, similarly to those in other countries, are actively adopting online purchasing practices, implying comparable trends: increasing preference for online channels and growing demand for safe and convenient services. Second, the focus on food products introduces sector-specific considerations. For instance, O. Droulers and S. Lacoste-Badie show that online consumers often perceive a "more limited selection of fresh products" [18]. In the Ukrainian context, this implies that retailers should incentivize online sales of fresh produce (e.g., through flexible delivery conditions and enhanced quality communication). At the same time, the study by J. Guo et al. demonstrates that small online retailers significantly strengthened their role in food supply during the crisis [19]. Given Ukraine's substantial base of local producers and farmers, there is strong potential to expand their digital channels and support the development of food markets in online formats.

From the perspective of consumer experience, Ukrainian buyers are likely to share value orientations identified in other countries, with convenience, safety, and time efficiency acting as the primary drivers of e-commerce adoption. Increasing trust — consistent with the well-established Technology Acceptance Model (TAM) — and reducing perceived risk remain key priorities. For example, mobile applications and digital payment services (e.g., Monobank, Privat24) should prioritize user-friendly interfaces and seamless transaction processes. In addition, cultural specificities must be taken into account: Ukrainian consumers tend to value product freshness and local origin, implying that platforms should adapt their assortment and service models accordingly.

Logistics constitutes another critical factor. As demonstrated in prior research (including studies employing Internet of Things and blockchain technologies) [22], delivery organization and product traceability are essential for the effective functioning of food e-commerce. Under wartime conditions in Ukraine, these challenges are further intensified; however, international experience — particularly the success of micro-distribution networks and digital logistics solutions during crises — can inform the development of resilient logistics models, such as decentralized hubs and community-based bulk purchasing systems.

International research consistently indicates that food e-commerce is a rapidly expanding field characterized by a wide range of methodological approaches, from qualitative interviews to advanced machine learning techniques. These findings should be carefully considered in Ukraine when shaping both business strategies and public policy support. In particular, emphasis should be placed on convenience, the availability and diversity of fresh products, and the safety and reliability of online channels for consumers.

Thus, based on a synthesis of contemporary research, several key theoretical conclusions regarding the development of food e-commerce in Ukraine can be formulated. First, innovation in the food e-commerce sector should be conceptualized as a systemic category in which technological solutions become effective only in interaction with logistics mechanisms and socio-organizational

Table 1. **Systematization of Barriers Hindering the Effective Development of Food e-Commerce in Ukraine**

Barrier	Category	Cause Description	Consequences	Recommended Measures
Delivery of perishable goods	Logistic	High transportation costs; lack of developed cold-chain systems	Limits on assortment and delivery geography; risk of quality loss	Investment in cold logistics; public-private partnerships
Digital infrastructure	Technological	Poor internet quality in regions; difficulties integrating platforms and warehouse systems	Reduced service speed; limited business scalability	Development of broadband internet; standardization of IT solutions
Regulatory restrictions	Regulatory	Complexity in complying with sanitary standards; absence of specialized legislation for online food sales	Legal uncertainty; additional certification costs	Development of clear regulations for online food trade
High investment costs	Financial	Significant expenses for building logistics, IT solutions, and quality control systems	Lower market attractiveness for new entrants; low initial profitability	Tax incentives; startup support; grant programs
Consumer distrust	Consumer	Habit of buying food offline; concerns about quality and safety of online food	Slows demand growth and formation of a stable market	Trust-building campaigns, certification, return guarantees

Source: prepared by the author.

measures. Second, the capacity of e-commerce to ensure food accessibility and market stability under crisis conditions (e.g., military disruptions and supply chain breakdowns) largely depends on the adaptability of the underlying model and the application of scenario analysis to evaluate alternative development trajectories. Third, the role of institutional coordination is critical, including the establishment of regulatory standards, infrastructure development, and the promotion of efficient cold chain systems — areas that remain insufficiently addressed in many narrowly focused studies. Overall, the integration of these components forms a comprehensive, scientifically grounded approach to the strategic development of food e-commerce.

Based on the identified theoretical approaches, the principal barriers to the development of food e-commerce have been systematized (Table 1). The table provides a generalized overview of key constraints across major categories, including logistics, technology, regulatory environment, financial factors, and consumer-related aspects.

The research problem is focused on identifying the key drivers of digital transformation in the food e-commerce segment and assessing the impact of innovative technologies and logistics solutions on market efficiency. The distinctiveness of the approach lies in combining a descriptive model, which systematically captures the structure and stages of market development, with a quantitative economic–mathematical model that enables measurement and scenario-based analysis. This integrated framework makes it possible not only to explain the nature of digital transformation but also to develop practical recommendations for businesses and regulators.

The aim of the study is to develop an innovative model for the development of food e-commerce in Ukraine that accounts for a comprehensive set of influencing factors, including technological infrastructure, consumer trust, logistics costs, and broader socio-economic conditions. The application of this novel approach allows for effective forecasting of market dynamics, identification of potential risks and opportunities, and the formulation of strategic development scenarios aligned with the challenges and prospects of the digital economy.

In conditions of instability driven by both internal and external factors, the study of innovative mechanisms and models for food e-commerce development is of particular importance for ensuring the resilience of Ukraine's food market. The implementation of the proposed models is expected to enhance sectoral competitiveness, improve service quality, and facilitate the integration of the Ukrainian market into global digital trends.

E-commerce today represents one of the key drivers of transformation in the global economy, providing rapid and convenient access to goods and services through digital platforms. It plays a significant role in increasing the efficiency of market processes, reducing transaction costs, and expanding the geographic reach of firms of various sizes [24]. In the context of the food industry, e-commerce is especially important, as it enables adaptation to evolving consumer behavior, supports the timely delivery of perishable goods, and enhances service quality. The growing popularity of online purchasing stimulates the development of innovative logistics solutions and accelerates the digitalization of traditional supply chains, thereby strengthening food security and overall economic stability.

First, it is advisable to analyze macro-structural changes in the distribution of sales channels for food products globally and in Ukraine, with particular attention to the balance between online and offline retail. This indicator makes it possible to assess the level of e-commerce penetration in the food sector and to trace broader trends in the digitalization of consumer demand (Fig. 1).

The analysis of the dynamics of online and offline food retail shares globally and in Ukraine for the period 2018—2029 indicates a steady expansion of the global e-commerce segment, increasing from 2.8% in 2018 to a projected 9.9% in 2029, reflecting the ongoing digital transformation of consumer practices [26, 28]. In contrast, Ukraine — despite positive growth trends up to 2021 — experienced a significant decline in the share of online food sales in 2022, falling to 0.3%. This contrac-

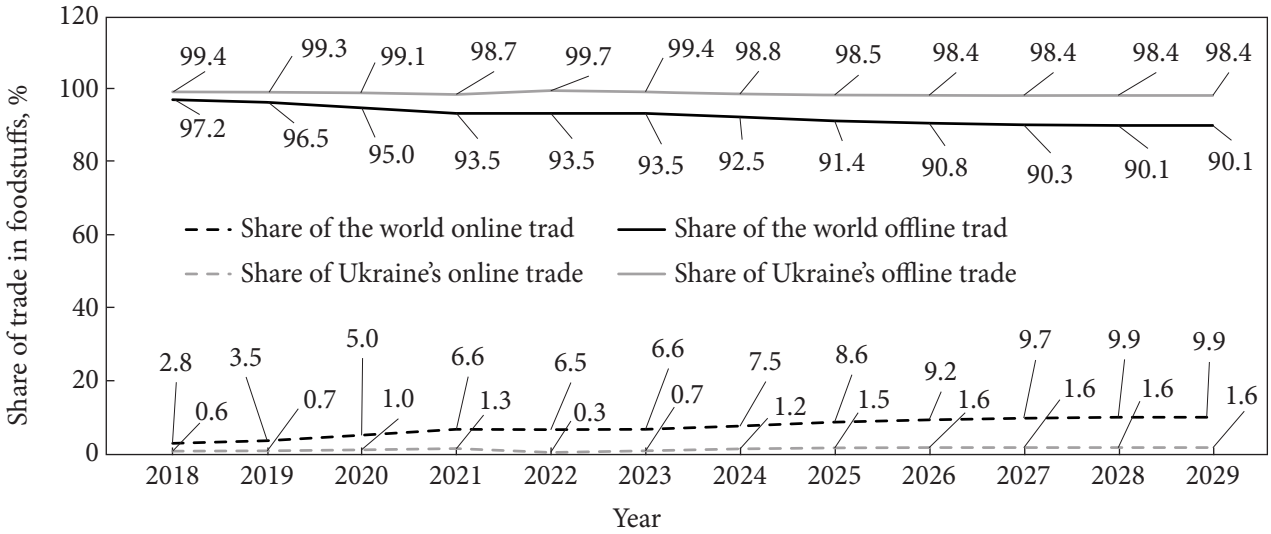

Fig. 1. Share of global and Ukrainian online and offline food retail, %. Data for 2025—2029 are forecast data
Source: calculated and compiled by the author based on [25—28].

tion was driven by severe security and logistics disruptions associated with the full-scale war.

Subsequently, a gradual recovery of e-commerce activity is observed, with projected stabilization at approximately 1.6% during 2026—2029 [26]. This trajectory contrasts with global trends and points to a structural lag in Ukraine's digital food distribution sector, highlighting the need for targeted policy measures and business strategies to support e-commerce development. Nevertheless, despite relatively low baseline levels, the Ukrainian market demonstrates substantial potential for digital expansion, particularly in the post-crisis period [29].

Figure 2 presents the comparative dynamics of food e-commerce in Ukraine for 2018—2029 against several leading product categories. In 2021, online food sales reached USD 753.9 million; however, in 2022, the market experienced a sharp decline of 82.5% due to military disruptions and logistics instability. Beginning in 2023, the market shows a steady recovery trajectory, with projections indicating growth to USD 1.53 billion by 2029 — more than double the pre-crisis level [30].

The data also reveal an increasing share of the food category within total e-commerce turnover, suggesting ongoing adaptation of business models to evolving consumer demand and the progressive development of delivery infrastructure. Compared to categories such as electronics, apparel, and cosmetics, food products demonstrate the highest recovery rates in the post-crisis period.

To gain a deeper understanding of the internal structure of growth in Ukraine's food e-commerce market, it is useful to analyze the dynamics of its key indicators — total sales, average consumer expenditure, number of users, and compound annual growth rates (CAGR). Comparing these metrics with global trends allows for a more precise assessment of the national market's position in the global context and helps identify directions for its further development.

The growth of the food e-commerce market represents a central trend in the global digital transformation of consumer behavior. Studying this process is particularly relevant in regions with high growth potential, such as Ukraine. Applying the CAGR metric enables the identification of consistent trends across the main components of the market: total sales, average expenditure per consumer, and user base (Table 2).

Between 2018 and 2021, Ukraine experienced rapid growth in food e-commerce, with market

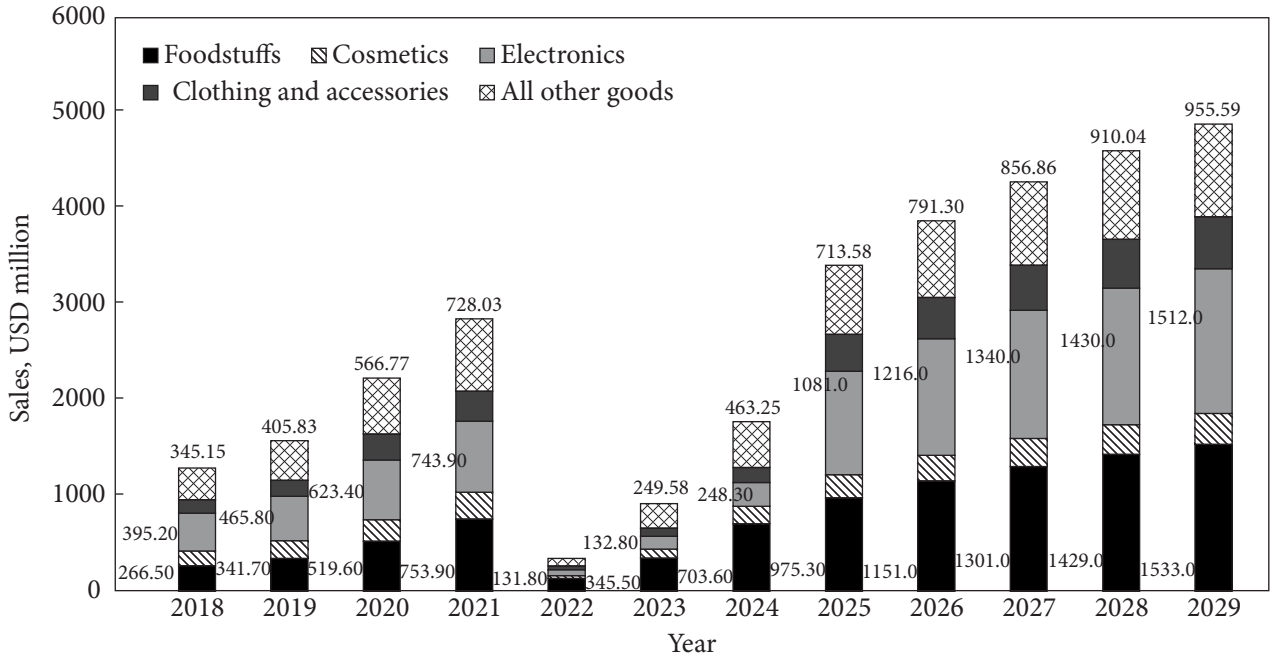

Fig. 2. Dynamics of online sales by consumer product categories in Ukraine, 2018—2029, USD million. Data for 2025—2029 are forecast data
Source: calculated and compiled by the author based on [30].

size increasing from USD 266.54 million in 2018 to USD 753.89 million in 2021, representing a 183% increase. However, in 2022, the market contracted sharply to USD 131.79 million (–82.52%) due to the onset of the full-scale war and the associated economic crisis. Subsequently, the market demonstrated a strong recovery: growth reached 162.18% in 2023 and 103.61% in 2024, reflecting the high adaptability and resilience of e-commerce under transformational conditions. According to Statista forecasts, growth rates are projected to gradually decline during 2025—2029, reaching 7.26% by 2029, which is characteristic of market stabilization and saturation phases [26]. The compound annual growth rate (CAGR) for Ukraine's market size is 17.56% for 2018—2024 and 11.96% for 2025—2029.

Globally, the food e-commerce market exhibits more stable growth, rising from USD 179.68 billion in 2018 to USD 1,226.40 billion in 2029. The highest growth rates occurred in 2020—2021 (up to 50.09%), followed by a gradual slowdown [28]. The CAGR for global market size is 24.84% for 2018—2024 and 10.09% for 2025—2029.

Ukraine's market is characterized by high volatility in annual growth rates, reflecting sensitivity to external shocks (e.g., 2022) and phases of rapid post-crisis recovery. In contrast, the global market shows smoother, more predictable growth patterns typical of mature markets. The projected reduction in volatility in Ukraine suggests a transition toward a stage of stable development.

Average revenue per consumer in Ukraine increased from USD 86.49 in 2018 to USD 135.90 in 2024 (CAGR 7.82%) and is forecast to reach USD 254.20 by 2029 (CAGR 9.72% for 2025—2029). The 2022 drop to USD 29.84 (–82.78%) reflects a sharp decline in purchasing power and overall online consumption. Subsequently, recovery is underway [26]. Globally, the average revenue per consumer rose from USD 243.00 in 2018 to USD 401.90 in 2024 (CAGR 8.75%) and is projected to reach USD 506.30 by 2029 (CAGR 3.01%) [28]. Compared to Ukraine, the global dynamics are less

volatile, indicating more stable and sustainable consumption patterns.

The number of online food consumers in Ukraine increased from 3.08 million in 2018 to 5.18 million in 2024 (CAGR 17.56%) and is projected to reach 6.03 million by 2029 (CAGR 2.05%). While absolute figures remain relatively modest, the intensity of growth in the initial period indicates the rapid formation of a digital consumer base. Globally, the number of online food consumers rose from 739.42 million in 2018 to 1,692.16 million in 2024 (CAGR 14.80%) and is expected to reach 2,422.28 million by 2029 (CAGR 6.87%) [26], reflecting the sustained global expansion of digital sales channels in the food retail sector.

Within the study of digital consumption transformation, it is important to analyze not only the total number of e-commerce consumers but also their distribution across food and non-food segments. In 2024, the share of online food consumers in Ukraine accounted for 63.4% of all online shoppers [26], demonstrating the growing significance of the food segment within the broader e-commerce landscape. For comparison, this share was 68% globally in 2024, albeit with substantially higher absolute numbers (1.7 billion users) [28]. A notab-

Table 2. **Food e-Commerce Market Size, Average Revenue per Consumer, and User Base: Ukraine and the World, 2018—2029**

Index	Year					
	2018	2020	2022	2024	2025	2029
Ukraine						
Electronic Trade in Foodstuffs, USD mln	266.54	519.56	131.79	703.55	975.23	1532.65
Growth Rate, %	—	52.03	–82.52	103.61	38.62	7.26
Average Revenue per Consumer from Online Food Trade, USD	86.49	123.80	29.84	135.90	175.40	254.20
Growth Rate, %	—	31.95	–82.78	90.39	29.07	6.36
Number of Consumers, mln	3.08	4.20	4.42	5.18	5.56	6.03
Ukraine's Share of Global Market	0.15	0.15	0.03	0.10	0.12	0.12
Narket CAGR, %	17.56				11.96	
CAGR of Average Revenue per Consumer, %	7.82				9.72	
CAGR of Number of Consumers, %	9.05				2.05	
World						
Electronic Trade in Foodstuffs, USD mln	179.68	342.48	509.76	680.08	834.99	1226.40
Growth Rate, %	—	50.09	5.95	22.88	22.78	5.66
Average Revenue per Consumer from Online Food Trade, USD	243.00	329.20	369.00	401.90	449.70	506.30
Growth Rate, %	—	27.50	–7.38	12.45	11.89	0.42
Number of Consumers, mln	739.42	1040.34	1381.46	1692.16	1856.77	2422.28
Ukraine's Share of Global Market	179.68	342.48	509.76	680.08	834.99	1226.40
Narket CAGR, %	24.84	10.09	24.84	10.09	24.84	10.09
CAGR of Average Revenue per Consumer, %	8.75	3.01	8.75	3.01	8.75	3.01
CAGR of Number of Consumers, %	14.80	6.87	14.80	6.87	14.80	6.87

Notes: Data for 2025—2029 are forecast data.
Source: calculated by the author based on [26, 28].

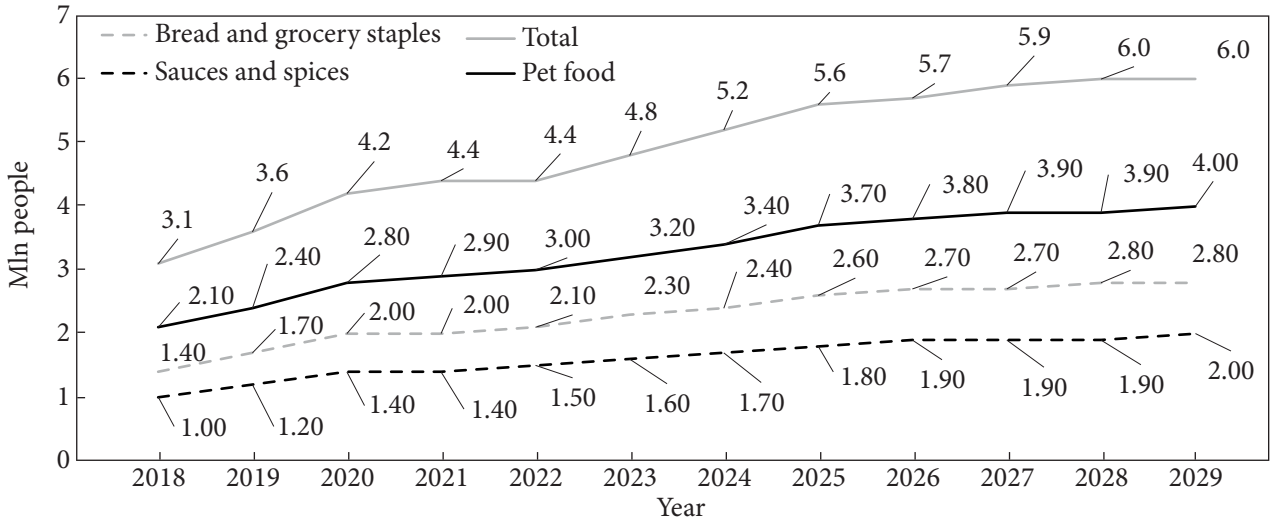

Fig. 3. Dynamics of online food e-commerce users in Ukraine by the three leading categories, 2018—2029, million users. Data for 2025—2029 are forecast data
Source: calculated and compiled by the author based on [26].

le feature of the Ukrainian market is the high concentration of demand within specific categories.

Analysis of user dynamics in Ukrainian food e-commerce by product category from 2018—2029 highlights key development directions. The clear leader in user numbers is the pet food segment, which grew from 2.1 million in 2018 to a projected 4.0 million in 2029, reflecting consistently high consumer engagement in a category with regular demand. The second-largest category is bread and cereals, rising from 1.4 million to 2.8 million users, confirming stable interest in basic food staples via digital channels. The third most popular segment is sauces and spices, increasing from 1.0 million to 2.0 million users, illustrating a trend toward expanding assortments and personalized taste preferences. Other categories remain less widely adopted, indicating opportunities for more active integration into e-commerce [26].

Overall, the trend reflects a gradual shift in consumer behavior toward regular online purchasing, even for products traditionally considered "offline." A strategic recommendation is the continued adaptation of digital channels to the characteristics of each product category, taking into account logistics requirements and consumer expectations (Fig. 3).

Ukraine's share of the global food e-commerce market remained stable at 0.15—0.16% between 2018 and 2021 but fell sharply to 0.03% in 2022, reflecting the direct impact of the national crisis. By 2024, the share recovered to 0.10%, with projections indicating stabilization at around 0.12% through 2029 [26]. This trend demonstrates the gradual recovery of Ukraine's competitive position in the global market.

Analysis of profitability rates and e-commerce penetration levels from 2018 to 2029 indicates a progressive strengthening of e-commerce both in Ukraine and globally (Table 3).

In Ukraine's online food retail sector, profitability has shown steady growth, rising from 3.9% in 2018 to a projected 6.0% in 2029 [26], surpassing the average profitability of e-commerce overall (4.9% in 2029) [30]. This trend suggests improvements in business model efficiency, reductions in operational costs, and growing consumer trust in digital food supply channels. Globally, the food e-commerce segment exhibits even faster profitability growth — from 5.7% in 2018 to 13.5% in 2029 [28] — nearly double that of overall food retail (9.0%) [30]. This underscores the global trend toward the commercialization of online food deli-

very, where economies of scale, logistics automation, and the development of fulfillment infrastructure contribute to higher margins.

At the same time, e-commerce penetration continues to rise. In Ukraine, the share of consumers shopping online increased from 21.2% in 2018 to 26.0% in 2029 [30]. For food e-commerce specifically, penetration rose from 11.1% in 2018 to 16.0% in 2029 [26], indicating slower but steady growth. In contrast, the global market shows more dynamic expansion: overall e-commerce penetration reaches 49.1% in 2029 [30], while the food segment achieves 33.1% [28]. This gap between Ukraine and global digitalization levels highlights both the potential for domestic market scaling and the need for investment in infrastructure, platforms, and digital literacy. The food segment appears particularly promising, demonstrating not only faster profitability growth but also the formation of a stable consumer base.

Table 3. **Profitability and e-Commerce Penetration Rates, Overall and for the Food Segment, in Ukraine and Globally, 2018—2029 (%)**

Index	Year					
	2018	2020	2022	2024	2025	2029
Ukraine						
Profit margin (% of market revenue)	3.1	2.6	4.1	4.4	4.0	4.9
Overall e-commerce						
E-commerce in foodstuffs	3.9	3.3	4.1	5.2	5.2	6.0
Penetration rate (%)	21.2	20.7	20.8	22.1	22.9	26.0
Overall e-commerce						
E-commerce in foodstuffs	11.1	12.7	13.0	13.9	14.6	16.0
World						
Profit margin (% of market revenue)	5.7	5.0	6.5	7.2	7.4	9.0
Overall e-commerce						
E-commerce in foodstuffs	5.7	5.3	7.6	9.7	10.3	13.5
Penetration rate (%)	32.2	35.7	39.3	40.6	42.4	49.1
Overall e-commerce						
E-commerce in foodstuffs	19.3	22.6	25.8	27.0	28.4	33.1

Notes: Data for 2025—2029 are forecast data.
Source: compiled by the author based on [26, 28, 30].

The analysis confirms that Ukraine's share of online food retail remains lower than global trends, due to several factors: underdeveloped infrastructure, limited trust in e-commerce, gaps in delivery coverage, lower digital literacy among older generations, cultural preferences (such as shopping at local markets), and the impact of war and instability.

In prior research [29], the author developed and tested a classification system for food product categories designed to simplify consumer perception and align with the layout logic of most retail stores. This classification was successfully applied to analyze global and Ukrainian food retail trends from 2018 to 2029. It was found that grouping products into generalized categories enables more effective tracking of consumer trends, demand shifts, and external market influences. In the present study, this classification has been adapted for analyzing online food retail to ensure comparability, highlight similarities and differences between online and offline sales structures, and provide deeper insights into consumer behavior transformation under digitalization (Fig. 4).

An analysis of the dynamics of online foodstuff retail in Ukraine from 2018 to 2029 indicates a gradual expansion of this segment and its increasing significance within the overall consumer market.

Fruits and vegetables remain one of the leading categories in traditional retail: offline sales reached USD 12.83 billion in 2021, with projected growth to USD 21.33 billion by 2029 (+66%) [25]. The share of this category in online sales is growing at a faster pace: over 2023—2029, the cumulative growth of online sales of fruits and vegetables is expected to exceed 122% [26]. This trend is driven by the expansion of delivery services, automation of order processing, and growing consumer trust in the quality of perishable products through online channels.

Meat and fish hold the second position in traditional retail, consistently accounting for over 25%

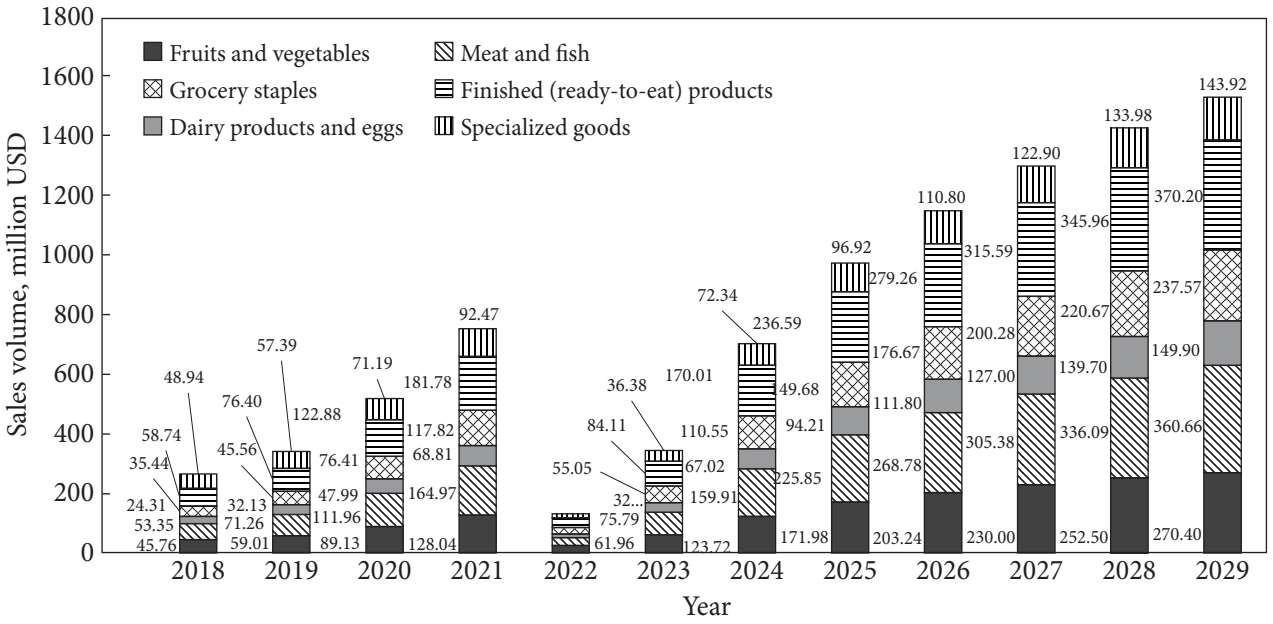

Fig. 4. Dynamics of online foodstuff retail in Ukraine, million USD. Data for 2025—2029 are forecasted data
Source: calculated and plotted by the author based on [26].

of total turnover. Projected growth for 2023—2029 is 84% [25]. In the e-commerce segment, this category is rapidly recovering following the sharp decline in 2022 due to disruptions in the cold chain; growth resumes from 2023 onwards thanks to the integration of refrigerated containers and expanded partner delivery networks [26].

Dairy products and eggs traditionally represent a significant share of offline sales but show more moderate growth in the online sector. Offline sales are expected to increase from USD 7.16 billion in 2022 to USD 15.00 billion in 2029 (+109.5%) [25], whereas online sales are constrained by the need for additional infrastructure solutions (cold chain management, expiry date control, return guarantees), which slows the pace of digital adoption.

Grocery staples (grains, oils, sauces, spices) demonstrate the greatest potential for scaling in online retail due to their long shelf life and low logistical risks. While their share in e-commerce was small in 2022, stable growth is expected in 2024—2025, with projected annual increases exceeding 10% [26]. In traditional retail, this category is also growing moderately, from USD 7.28 billion in 2022 to USD 14.87 billion in 2029 (+104%) [25].

Ready-to-eat products are experiencing stable demand in both offline and online retail formats, driven by urbanization and faster-paced lifestyles. In e-commerce, this category is actively expanding due to the growth of meal kits with recipes, lunch deliveries, and culinary services. In traditional retail, sales are projected to rise from USD 6.73 billion in 2022 to USD 13.10 billion in 2029, representing an increase of +94.7% [25].

Specialized products (e.g., baby food, pet food), while representing a smaller share of the overall market, show the highest rates of digital adoption. Their online segment grows faster than the general market due to frequent consumption patterns and the convenience of automatic repeat orders. In offline channels, growth is more moderate, projected at +47.5% for 2023—2029 [25].

Overall, e-commerce in the Ukrainian grocery sector is forecasted to reach USD 1.53 billion by 2029, while the total retail market is expected to reach USD 94.88 billion. The share of online sales

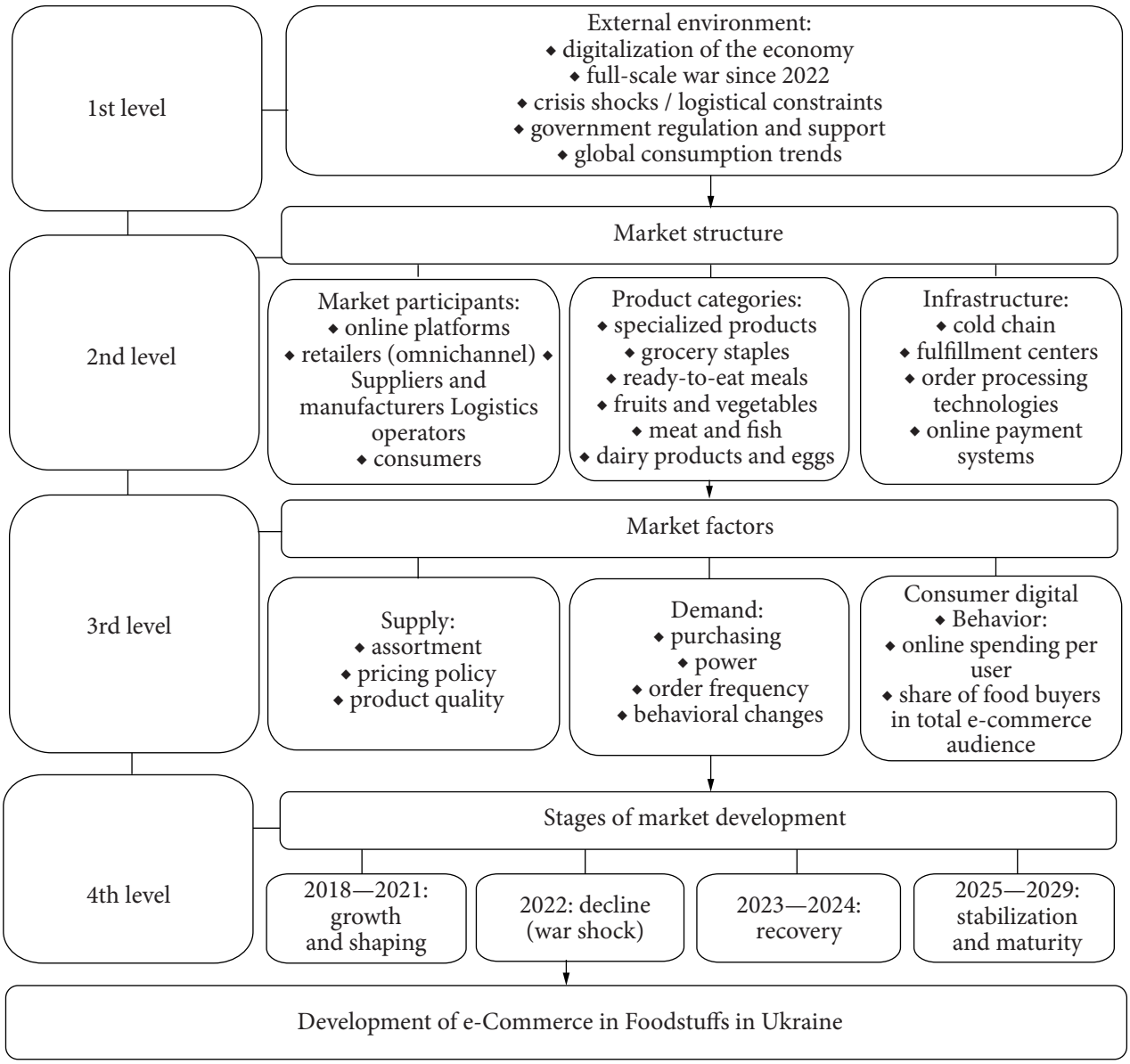

Fig. 5. Descriptive conceptual model of the development of retail e-commerce in foodstuffs in Ukraine (2018—2029)
Source: prepared by the author.

varies across product groups, ranging from 1—2% in perishable categories to 5—7% in staples and specialized products. This trend reflects the emergence of new consumer behavior that combines traditional choices with the convenience of digital channels.

The development of online foodstuff retail in Ukraine requires a comprehensive approach that considers market characteristics, consumer behavior, and logistical challenges. Factors supporting growth in this segment include: the development of logistics infrastructure, consumer education and trust-building, integration of technology, launch of local initiatives, strategic pricing and promotions, implementation of omnichannel so-

lutions, government support and regulation, and marketing personalization.

Based on this comprehensive analysis of Ukraine's online grocery market, it is appropriate to construct a **descriptive conceptual model** reflecting the key structural elements and market dynamics. This model will serve as the foundation for building an **economic-mathematical model** (Fig. 5).

The descriptive conceptual model of the development of online foodstuff retail in Ukraine (2018—2029) proposes a comprehensive approach to analyzing and forecasting market development by integrating key factors that influence its functioning. The model includes the following components:

- Technological infrastructure — encompasses the development of online platforms, logistics services, digital sales channels, and IT solutions for supply chain management.
- Consumer behavior — examines demand dynamics, behavioral patterns of online shoppers, trust levels in e-commerce, and the impact of socio-economic factors.
- Logistical and financial indicators — considers delivery costs, inventory optimization, payment systems, and discount policies.
- Regulatory and economic environment — includes legislation, tax policies, priority areas for food sector development, and state initiatives supporting e-commerce.
- Socio-economic factors — accounts for income levels, regional differences, demographic trends, and the influence of pandemics or crises on the market.

Key principles of the model:

- Integration of quantitative and qualitative data to forecast market trends.
- Consideration of the interconnections between technological, behavioral, logistical, and regulatory factors.
- Formation of market development scenarios under varying external conditions.

Novelty and innovation:

- The model combines descriptive and predictive approaches, allowing not only a depiction of the current market state but also an assessment of potential development scenarios.

Table 4. **Impact of Implemented Measures on the Key Parameters of the Online Foodstuff Retail Model**

Barrier	Current State	Measures	Expected State	Key Model Variables
Perishable Goods Delivery	High losses, limited assortment, narrow delivery area	Investments in cold-chain logistics, public-private partnerships	Reduced losses, expanded assortment and delivery coverage	$V(t)$, $A(t)$
Digital Infrastructure	Unstable internet, low platform integration	Expansion of broadband internet, IT standardization	Increased service speed, higher capacity	$S(t)$, $N(t)$
Regulatory Constraints	Difficulty complying with sanitary norms, legal uncertainty	Development of clear rules for online food trade	Lower certification costs, stabilized business processes	$D(t)$, $S(t)$
High Investment Costs	Low profitability, high financial barriers	Tax incentives, grant programs, startup support	Increased market attractiveness for new entrants	$I(t)$
Consumer Distrust	Low demand for online sales, low loyalty	Trust-building campaigns, certification, return guarantees	Increased demand and loyalty, formation of a stable market	$D(t)$

Sourse: prepared by the author.

- For the first time in Ukrainian research, technological, behavioral, and economic indicators are integrated into a single conceptual framework.
- It enables the formulation of strategic recommendations for both business and government regarding the development of online foodstuff retail, with attention to sustainable growth and innovative practices.

Based on identified barriers and the structural elements of the descriptive model, it is appropriate to identify key variables affected by specific interventions. Table 4 demonstrates how implementing the recommended measures can alter system states and adjust the main parameters of the economic-mathematical model of online foodstuff retail ($V(t)$, $N(t)$, $A(t)$, $S(t)$, $I(t)$, $D(t)$). Presenting the data in a "before/after" format clearly illustrates which barriers have the greatest impact on particular variables and where strategic measures can deliver the maximum effect on market development.

The table presents the key barriers to the development of online foodstuff retail and the expected effects of implementing corresponding measures. To link with the economic-mathematical model, the main variables are defined as follows:

- $V(t)$ is the market online foodstuff retail in year t;
- $A(t)$ is the average expenditure per consumer;
- $N(t)$ is the number of online consumers;
- $S(t)$ is the shock coefficient / impact of crisis and recovery factors;
- $I(t)$ is the infrastructure readiness and market attractiveness for new participants;
- $D(t)$ is the consumer trust in online purchases.

Based on the established descriptive conceptual model, which reflects key factors, actors, and development stages in the online foodstuff retail system in Ukraine, it is appropriate to proceed to the construction of an economic-mathematical model. This approach allows the formalization of interactions between the system's main parameters, quantitative assessment of the impact of individual factors on market dynamics, and forecasting of its further development.

The economic-mathematical model is based on identified relationships between sales, the number of consumers, average consumer expenditure, and external operating conditions, providing an analytical basis for management and strategic decision-making.

From the descriptive model, the primary variable $V(t)$ — the online foodstuff retail in Ukraine, measured in million USD per year t — is determined.

The basic equation of market size dynamics:

$$V(t) = N(t) \cdot A(t), \quad (1)$$

where: $V(t)$ is the market online foodstuff retail in year t; $N(t)$ is the number of online grocery consumers in year t; $A(t)$ is the average expenditure per consumer in year t.

The dynamics of consumer numbers are as follows:

$$N(t) = N_0 \cdot (1 + g_N)^{t-t_0}, \quad (2)$$

where: N_0 is the initial number of consumers in the base year (e.g., 2024); g_N is the average consumer annual growth rate (CAGR); t_0 is the base year.

The dynamics of average expenditure are as follows:

$$A(t) = A_0 \cdot (1 + g_A)^{t-t_0}, \quad (3)$$

where: A_0 is the average expenditure per consumer in the base year; g_A is CAGR of average expenditure CAGR.

Accounting for External Shocks:

In years of crisis (2022) or periods of rapid recovery (2023—2024), a shock coefficient $S(t)$ is introduced:

$$V(t) = N(t) \cdot A(t) \cdot S(t), \quad (4)$$

where $S(t) < 1$ is for the crisis year; $S(t) > 1$ — for the recovery period.

The shock coefficient S(t) proposed in this study, as a variable adjusting the baseline model, aligns with approaches applied in [1, 13], where military actions are considered a factor that can either stimulate or constrain digital distribution channels depending on logistical capabilities and infrastructure access.

The scenario-based approach includes optimistic and pessimistic scenarios:

Optimistic Scenario:

- g_N and g_A are higher than baseline forecasts (e.g., active digital adoption by the population, income growth, successful marketing campaigns).
- $S(t)$ is stable or improving: no new crises, improved delivery infrastructure, state support.
- Outcome: rapid growth of e-commerce, outpacing global trends.

Baseline Scenario:

- Based on forecast data (g_N, g_A, and $S(t)$ taken from Statista).
- Considered the most likely scenario if current trends and risk levels persist.
- Outcome: gradual growth, market stabilization by 2029, moderate integration of the food segment into e-commerce.

Pessimistic Scenario:

- g_N and g_A are declining due to decreased purchasing power, population outflow, and digital inequality.
- $S(t)$ reflects new or prolonged shocks (logistical complications, cyberattacks, connectivity outages, decreased trust in services, etc.).
- Outcome: slowed growth or stagnation of e-commerce, persistence of offline dominance in consumption.

For clarity, the results of the scenario-based approach are presented in Table 5.

The scenario-based approach enables the following:

- Compare alternative trajectories of market development;
- Assess the model's sensitivity to key parameters;
- Prepare stakeholders for potential challenges and opportunities;
- Justify political or business decisions under different scenarios.

For instance, according to research presented in [4], logistical innovations reduced delivery time from 5.8 to 2.6 days, which aligns with the author's conclusion regarding the impact of $S(t)$.

It is also possible to consider the influence of other factors:

$$V(t) = f\left(N(t), A(t), I(t), D(t), C_1(t), C_2(t)\right), \quad (5)$$

where: $I(t)$is the infrastructure readiness; $D(t)$ is the consumer trust; $C_1(t)$ is the logistics cost; $C_2(t)$ is the penetration coefficient.

These variables can be indexed and normalized within the [0; 1] interval for inclusion in a multifactor model.

The extended model for the development of e-commerce in the food sector represents a logical continuation of the basic economic-mathematical model. Its purpose is to account for the multidimensional nature of the market, where sales $V(t)$ are influenced not only by the number of consumers $N(t)$ and average expenditure $A(t)$ but also

Table 5. **Key Scenarios for the Development of Food e-Commerce in Ukraine (2018—2029)**

Scenario	Key Factors	Projected Sales Dynamics	Risks	Strategic Recommendations
Baseline	Current technologies, stable demand	Moderate growth of 5—7% annually	Competition, currency fluctuations	Support existing online platforms, moderate assortment expansion
Optimistic	Innovative platforms, high level of consumer trust	High growth of 10—15% annually	Technological failures, logistics disruptions	Investments in digital infrastructure, active marketing, expansion of regional presence
Pessimistic	Economic and social constraints	Low growth of 1—2% annually	Crises, declining demand	Cost optimization, development of delivery channels, risk reduction through diversification

Source: prepared by the author.

by qualitative factors reflecting infrastructure status, consumer trust, and logistics.

- **Infrastructure Readiness Index** $I(t)$: reflects the availability of logistics hubs, fulfillment centers, and service coverage.
- **Consumer Trust Index** $D(t)$: represents the level of consumer confidence in online sellers, brands, and rights protection.
- **Penetration and Logistics Cost Coefficients** $C(t)$: synthesize service accessibility, average delivery costs, and channel flexibility.

The inclusion of parameters such as infrastructure readiness, logistics costs, and consumer trust is supported by studies [1, 2], which emphasize the dependence of e-commerce efficiency on logistics services, digital literacy, and government support.

The results align with previous research [12]; however, the proposed model is innovative due to its multifactor approach, scenario-based adaptability, and ability to quantitatively forecast market dynamics under uncertainty.

Calculations based on statistical data (dynamics of $V(t)$, $N(t)$, $A(t)$, and $S(t)$) demonstrate that the proposed economic-mathematical model can accurately reproduce real trends in food e-commerce development. Using the core model parameters — market size $V(t)$, number of online consumers $N(t)$, average consumer expenditure $A(t)$, and the shock coefficient $S(t)$ — allows for a quantitative assessment of the impact of various factors (logistics, digital infrastructure, consumer trust, regulatory constraints) on market dynamics.

The model demonstrates high adaptability: it can be applied to assess development scenarios (baseline, optimistic, pessimistic) and to forecast sales in both the short and long term. Its practical applications include: formulating strategic recommendations for businesses and government regarding the development of e-commerce; evaluating the effectiveness of infrastructure and marketing measures; and analyzing market sensitivity to external shocks (military conflicts, logistical constraints, income declines).

Among the advantages of the model are the integration of quantitative and qualitative factors, adaptability to different scenarios, and the ability to forecast market dynamics under uncertainty. The main limitations are the need for regular updates of statistical data and the precision in estimating the influence coefficients of additional factors ($I(t)$, $D(t)$, $C_1(t)$, $C_2(t)$). Nevertheless, the proposed model serves as a versatile tool for strategic planning and research on the development of food e-commerce in Ukraine.

The application of innovative descriptive and economic-mathematical models in the study of food e-commerce in Ukraine provides a comprehensive understanding of both the structural-functional characteristics of the market and its quantitative dynamics. The descriptive model allows the identification of the system's core elements — actors, infrastructure components, external and internal influencing factors — and establishes stages of development. In turn, the economic-mathematical model provides a framework to formalize the interrelationships among these elements, quantify changes in key indicators (sales, average expenditure, number of consumers, etc.), and forecast future trends. The complementary use of both approaches enables not only a deeper understanding of the nature of digital transformation in the consumer market but also the formulation of strategic scenarios for its development under structural changes, external shocks, and the growing role of digital channels in food distribution.

Between 2018 and 2029, Ukraine's food e-commerce market demonstrates high dynamism, with a gradual increase in the share of online sales within the overall retail structure. In 2018, the food e-commerce amounted to only USD 266.5 million, approximately 0.6% of the total retail market for food products (USD 43.32 billion). By 2024, this share reached 1.2% (USD 703.6 million out of USD 59.24 billion), and by 2029, it is forecasted to exceed 1.6% (USD 1.53 billion out of USD 94.88 billion).

The most significant decline in food e-commerce in Ukraine occurred in 2022, with sales falling to USD 131.8 million (an 82.5% decrease compared to 2021), which was proportionally deeper

than the overall decline in offline retail (–20.7%). This indicates the critical vulnerability of digital sales channels to external shocks in the absence of established logistics and infrastructure. However, in 2023—2024, e-commerce demonstrated rapid recovery: growth in 2023 reached 162.3%, while the overall market grew by only 14.9%. In subsequent years, the online sector develops faster than traditional retail, confirming the active digitalization of the consumer market.

By 2029, e-commerce is expected to account for 1.62% of total food sales. Although this remains relatively low, it reflects the gradual integration of digital channels into the food sector, which has traditionally had limited online sales due to product-specific factors (shelf life, transportation, and consumer habits).

The study proposes a descriptive model that visualizes the logic of market functioning and development. The developed economic-mathematical model enables the quantitative assessment of Ukraine's food e-commerce market in the medium and long term. This model is suitable for scenario analysis, forecasting, and comparison with offline retail or global trends.

Ukraine's food e-commerce market demonstrates high dynamism, adaptability to crisis conditions, and potential for sustainable development. The main growth driver after 2022 is the increase in average revenue per user, indicating strengthened consumer loyalty and a growing share of regular buyers. In contrast, the global market exhibits steadier growth with lower volatility, driven by simultaneous increases in the number of users and gradual growth in the average check.

Thus, Ukraine is transitioning from a phase of explosive growth to a stabilization phase, with potential for further market digitalization, particularly in high-value segments. The strategic challenge is to maintain positive momentum amid global competition and to expand the consumer base through the integration of innovative e-commerce formats.

From a practical perspective, the results of this study can be applied in two main areas. First, for government authorities — as a foundation for shaping policies on trade digitalization, supporting cold-chain infrastructure, and developing standards and incentives for the growth of online food distribution channels. Second, for businesses — as a tool for strategic planning and scenario-based forecasting, enabling the adaptation of logistics, marketing, and investment decisions to changing market conditions. The ultimate beneficiaries of implementing such approaches are consumers, who will experience greater accessibility to food products, a wider assortment, and improved trust and service quality.

Special attention should be given to a detailed study of the infrastructural conditions for the functioning of food e-commerce in Ukraine, which will be the subject of the author's further research.

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ІННОВАЦІЙНА МОДЕЛЬ РОЗВИТКУ ЕЛЕКТРОННОЇ ТОРГІВЛІ ХАРЧОВИМИ ТОВАРАМИ В УКРАЇНІ

Вступ. В умовах сучасних викликів, зокрема воєнного періоду, що спричинив порушення логістичних ланцюгів, зниження купівельної спроможності та значні зміни у поведінці споживачів, особливо актуальним є розвиток електронної торгівлі харчовими товарами. Цей канал збуту набуває важливого значення як засіб забезпечення продовольчої доступності та стійкості ринку, адже він дозволяє компенсувати обмеження традиційних роздрібних мереж і адаптуватися до нових реалій.

Проблематика. Відсутність інтегрованих моделей прогнозування й управління ринком ускладнює прийняття стратегічних рішень і стримує масштабування сектору.

Мета. Формулювання інноваційної моделі розвитку електронної торгівлі харчовими товарами в Україні з урахуванням технологічних, економічних і соціальних чинників.

Матеріали й методи. Інформаційну базу дослідження становлять статистичні дані міжнародної платформи *Statista* (моніторинг за 2018—2024 рр. з використанням прогнозних оцінок на 2025—2029 рр.). Для комплексного аналізу обрано системний підхід, діалектичний і історичний підходи, методи теоретичного узагальнення, економіко-математичне моделювання, сценарний аналіз. Така комбінація методів забезпечує поєднання якісного системного бачення й кількісної прогнозної аналітики, необхідних для обґрунтування практичних рекомендацій.

Результати. Розроблена дескриптивна модель відображає ключові елементи системи та фактори, що впливають на електронну торгівлю харчовими товарами в Україні, а економіко-математична модель дозволила кількісно оцінити динаміку електронної торгівлі ними, визначити ключові драйвери її зростання (довіру споживачів, інфраструктурну готовність і середні витрати) та обґрунтувати сценарії подальшого розвитку ринку.

Висновки. Запропоновані інноваційні моделі й аналітичні результати можуть бути використані для формування державної політики, бізнес-стратегій і заходів підтримки, що сприятимуть підвищенню ролі електронної торгівлі у продовольчому секторі України, розвитку інфраструктури і цифровізації споживачів, а також забезпеченню стабільності та сталого зростання ринку.

Ключові слова: електронна торгівля, продовольчий сектор економіки, інноваційний підхід, дескриптивна концептуальна модель, сценарії розвитку, поведінка споживачів, цифровий канал збуту, цифрова трансформація, цифровий маркетинг, сталий розвиток.