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Big Data in logistics marketing for customer churn prediction and dynamic pricing

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Abstract. The relevance of the study is determined by the transformation of the logistics market under the conditions of digitalization, which requires a shift from traditional approaches to customer base management and pricing toward analytically driven models. The **purpose of the article** is to identify the possibilities of implementing Big Data technologies in logistics marketing to improve the accuracy of customer churn prediction, optimize demand management systems, and develop an effective mechanism of dynamic pricing aimed at maximizing the profitability of enterprises. The **research methodology** is based on a systemic approach and employs methods of comparative analysis, predictive analytics, and machine learning (XGBoost, LightGBM, LSTM). The study generalizes international experience of major logistics operators (DHL, UPS, FedEx, Maersk, DPD) and analyzes models of dynamic pricing based on streaming data, telematics, and customer behavior patterns. **Results.** The findings demonstrate that the integration of Big Data into logistics marketing enables more accurate prediction of customer behavior, personalized pricing, and flexible demand management. It was

found that the use of machine learning algorithms reduces customer churn by an average of 10–15%, increases demand forecast accuracy by 20%, and optimizes logistics profitability. The effectiveness of combining dynamic pricing with behavioral analytics was proven, forming the foundation for adaptive business models in delivery and warehousing logistics. **Conclusions.** Therefore, the full realization of Big Data's potential in enhancing customer orientation and profitability of logistics companies is possible only under conditions of information flow standardization, CRM and ERP system integration, and the development of analytical competencies and human capital. Future studies should focus on developing intelligent dynamic pricing systems based on reinforcement learning, improving explainable analytics methods (SHAP, LIME), and creating a unified logistics data management architecture to build fully adaptive models of marketing management.

Keywords: data analytics, machine learning, demand forecasting, tariff personalization, customer retention, digital logistics, profitability management.

Big Data у логістичному маркетингу для прогнозування відтоку клієнтів і динамічного ціноутворення

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Анотація. Актуальність дослідження зумовлено трансформацією логістичного ринку в умовах цифровізації, що потребує переходу від традиційних підходів до управління клієнтською базою та ціноутворення до аналітично керованих моделей. **Мета статті** полягає у визначенні можливостей упровадження технологій Big Data у логістичний маркетинг для

підвищення точності прогнозування відтоку клієнтів, оптимізації системи управління попитом та формування ефективного механізму динамічного ціноутворення, орієнтованого на максимізацію прибутковості підприємств. **Методологія** дослідження базується на використанні системного підходу, методів порівняльного аналізу, прогнозної аналітики та машинного навчання (XGBoost, LightGBM, LSTM). Застосовано узагальнення міжнародного досвіду логістичних операторів (DHL, UPS, FedEx, Maersk, DPD) та аналіз моделей динамічного ціноутворення на основі потокових даних, телематики й клієнтських патернів. **Результати дослідження** дали змогу встановити, що інтеграція Big Data у логістичний маркетинг забезпечує точніше прогнозування поведінки клієнтів, персоналізацію тарифів і гнучке управління попитом. Виявлено, що застосування алгоритмів машинного навчання знижує відтік клієнтів у середньому на 10–15%, підвищує точність прогнозів попиту на 20 % та оптимізує прибутковість логістичних операцій. Доведено ефективність поєднання динамічного ціноутворення з поведінковою аналітикою, що формує основу адаптивних бізнес-моделей у сфері доставки та складської логістики. **Висновки.** Отже, повна реалізація потенціалу Big Data у підвищенні клієнтоорієнтованості та рентабельності логістичних компаній можлива лише за умови стандартизації інформаційних потоків, інтеграції CRM- і ERP-систем, розвитку аналітичних компетентностей і кадрового потенціалу. Перспективи подальших досліджень пов’язані з розробленням інтелектуальних систем динамічного ціноутворення на основі підкріплювального навчання, удосконаленням методів пояснюваної аналітики (SHAP, LIME) і створенням єдиної архітектури управління логістичними даними для формування повністю адаптивних моделей маркетингового управління.

Ключові слова: аналітика даних, машинне навчання, прогнозування попиту, персоналізація тарифів, клієнтоорієнтованість, цифрова логістика, управління прибутковістю.

Problem statement. In modern conditions of digitalization of market processes, logistics marketing increasingly relies on Big Data analytics as a tool for strategic management of customer flows and pricing. The problem lies in the insufficient integration of Big Data technologies into the processes of forecasting consumer behavior, which reduces the accuracy of identifying the risk of customer churn and the effectiveness of forming dynamic pricing strategies. Traditional methods of segmentation and demand analysis are unable to adequately reflect the complex, multifactorial and rapidly changing nature of the logistics services market, where customer decisions are formed under the influence of time delays, seasonality, service level, macroeconomic fluctuations and competitive actions. The use of analytical models based on machine learning, predictive analytics and processing of unstructured data creates the possibility of transforming logistics marketing into a system with adaptive demand and price management in real time. The scientific relevance of the problem lies in the need to develop methodological approaches to integrating Big Data into the marketing processes of logistics companies, which will increase the accuracy of forecasts, optimize costs and ensure personalization of offers. Practical significance is determined by the need to increase customer orientation, minimize losses from customer churn, and increase the competitiveness of enterprises in global supply chains.

Analysis of recent research and publications. Research on the application of Big Data in logistics marketing is implemented in several interrelated areas. Within the first area, attention is focused on analytical risk management and increasing the stability of logistics processes. O. Boiko developed a predictive model for risk management of highly loaded service infrastructures using artificial intelligence, which ensures early detection of failures and minimizes customer losses [1]. O. Korobkova and co-authors proposed an improved algorithm for interaction between participants in customs and logistics processes based on digital interfaces, which increases the speed of service and the accuracy of management decisions [2]. M. Marshchivskyy considers the marketing potential of sports federations as an

example of business platforms where logistics processes are managed through customer data analytics and behavioral pattern prediction [3]. Further research should be directed towards the creation of integrated analytical platforms that combine risk monitoring, customer churn prediction, and financial assessment of the consequences of management decisions.

The second direction concerns the integration of marketing and logistics strategies in the digital environment. M. Levchenko proved that the use of digital communication channels and outdoor advertising in a single analytical circuit allows to increase consumer engagement and increase the efficiency of logistics services in a dynamic market environment [4]. A. Bortnyk and V. Milcheva emphasize the need to integrate marketing and logistics within a single business process, where consumer behavior data is used for operational optimization of routes and resources [5]. K. Balabukha and M. Burgman proposed a marketing concept for the development of infrastructure entities, in which Big Data plays the role of the main tool for strategic planning of procurement and logistics policy [6]. O. Ptashchenko and co-authors showed that digital transformation is a catalyst for innovative activity of logistics enterprises, stimulating the use of analytical systems for predicting customer loyalty [7]. In this direction, further research should focus on modeling synergies between logistics and marketing data loops in order to build complex customer-oriented management systems. The third direction is devoted to the formation of intelligent models of dynamic pricing. D. Xu and co-authors created a model of logistics revenue management, in which data mining technologies ensure the adaptation of tariffs to current fluctuations in demand [8]. L. Weiguo and co-authors developed a pricing decision support system for logistics enterprises based on the Big Data platform, which automates the collection and processing of customer data to form personalized tariffs [9]. A. Kumari and M. K. S systematized the main trends in the field of dynamic pricing, pointing out the current challenges associated with the ethical aspects of algorithmic discrimination and the stability of demand models [10]. In this context, Big Data analytics is considered as a basic component

of the revenue management system in logistics. Further research should be aimed at developing hybrid neural network models that can combine demand time series, customer behavioral metrics, and external market indicators to more accurately predict price trends.

The fourth direction is related to the use of Big Data to predict customer churn and form price flexibility models in logistics networks. T. A. Syed and co-authors proposed a dynamic pricing model for perishable goods that integrates consumer behavioral data and time trends in demand [11]. H. El Amrani and co-authors demonstrated the potential of Big Data analytics to measure overall price growth in logistics chains, which allows creating macroeconomic indicators of market volatility [12]. R. Rithul and co-authors developed an improved machine learning model for optimizing pricing strategies of logistics companies, focused on predicting demand elasticity and reducing the risk of customer loss [13]. According to L. Kaptosv, the application of spatial data processing technologies in logistics creates a foundation for intelligent decision-making systems that support dynamic pricing models and predictive analytics based on real-time customer behavior [24]. All these studies confirm that Big Data analytics opens up new opportunities for increasing the accuracy of consumer behavior forecasting and creating dynamic mechanisms for responding to market changes.

Highlighting previously unresolved parts of the general problem. Despite the active implementation of Big Data analytics in logistics marketing, the issues of standardizing data sources, integrating Customer Relationship Management (CRM), Enterprise Resource Planning (ERP) and IoT systems, as well as ensuring their compatibility to build a single analytical ecosystem remain unresolved. The mechanisms for combining customer churn forecasting with dynamic pricing, as well as methods for assessing the effectiveness of such systems in the context of customer orientation and profitability, remain insufficiently studied. A methodological gap is the limited empirical data on the impact of Big Data on consumer behavioral decisions in logistics. The proposed research aims to address

these gaps by developing an integrated Big Data-based logistics marketing model that combines churn forecasting, demand analytics, and dynamic pricing. The application of machine learning algorithms and adaptive analytics platforms will create a practical toolkit for managing customer behavior, improving pricing policies, and developing scientifically sound customer retention strategies.

Formulation of the objectives of the article (task statement). The purpose of the article is to clarify the potential of using Big Data technologies to improve the logistics marketing system by increasing the accuracy of predicting customer churn and ensuring effective dynamic pricing.

To achieve the goal, the following tasks have been set:

1. To identify the main directions of implementing Big Data analytics in logistics marketing and assess its impact on the effectiveness of customer base management.

2. To analyze machine learning models for predicting customer churn and dynamic pricing in logistics services.

3. To identify problems of integrating Big Data into logistics marketing and formulate recommendations for increasing profitability and customer retention.

Presentation of the primary research material. The use of Big Data analytics in logistics marketing is formed as a response to the business need for a deeper understanding of customer behavior, process optimization, and increasing the accuracy of management decisions in real time. In today's digital economy, the volume, speed, and diversity of information flows generated during logistics operations make it impossible to process data using traditional methods effectively. That is why Big Data is becoming a key tool for building an intelligent marketing system that can analyze demand, predict customer churn risks, generate personalized offers, and provide adaptive pricing depending on market fluctuations. Big Data analytics allows you to integrate information from various sources – CRM systems, sensor devices, social networks, transport platforms, and online transactions – and transform it into practical marketing actions (table 1).

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Table 1

Main directions of implementing Big Data analytics in logistics marketing

Application area	Analytical potential	Expected effect for marketing
Predicting customer churn	Identifying behavioral patterns, analyzing order history, assessing customer loss risks	Reducing churn, increasing loyalty, and precise targeting
Dynamic pricing	Using demand elasticity models, market trends, and seasonality	Optimizing margins, responding quickly to changing market conditions
Customer experience management	Analysis of feedback, social media communications, and service satisfaction levels	Personalizing offers, improving interaction quality
Consumer segmentation	Clustering customers by behavioral, geographic, and transactional characteristics	Precise positioning of logistics services
Demand forecasting	Analysis of historical data, macroeconomic and weather factors	Optimization of inventories, reduction of storage and transportation costs

Source: formed by the author based on [1; 2, p. 90–91; 5, p. 589–590; 7, p. 143–144; 11]

Summarizing the data presented, it can be stated that Big Data analytics in logistics marketing forms a comprehensive customer flow management system, where churn forecasting, dynamic pricing, segmentation and demand forecasting function as interconnected elements of a single analytical circuit aimed at increasing customer loyalty and enterprise profitability. Machine learning algorithms identify patterns in consumer behavior, predict churn risk and allow for dynamic pricing that responds to changes in demand, seasonality and market competition. The practical experience of leading companies demonstrates the effectiveness of this approach. In particular, DHL uses the Resilience360 platform, which processes more than 8 million records per day, combining data from transport, weather and political sources to forecast risks and adjust logistics routes. During the COVID-19 pandemic, this system enabled an automotive component manufacturer to quickly reroute shipments from China to Europe, bypassing blocked border crossings, ensuring continuity of supply. Another DHL customer, Schmitz Cargobull, uses Resilience360 to monitor its Tier 1 and Tier 2 supply chains, increasing buffer stocks promptly and minimizing the risk of production stoppages [14; 15].

Another illustrative example is United Parcel Service (UPS), which implemented the On-Road Integrated Optimization and Navigation (ORION) system, which analyzes more than a billion telematics points daily (GPS data, speed, idle time, load) and optimizes routes in real time. As a result, UPS saves up to $400 million annually, reduces fuel consumption by 10 million gallons, and reduces CO_2 emissions by approximately 100,000 tons [16–18]. The updated version of the system implements dynamic route replanning. If a new order arrives during a flight, the algorithm automatically integrates it into an already formed route without the participation of a dispatcher. Thus, the integration of Big Data analytics into logistics marketing turns it into a system of predictive demand management. Algorithms not only evaluate customer behavior, but also automatically generate adaptive offers: customers at risk of churn are provided with personal discounts or bonuses, and tariffs on routes of growing demand are updated throughout the day.

Modern tools for predicting customer churn in logistics marketing are based on the integration of machine learning models with data streams from CRM, ERP and digital service channels. Boosting algorithms (eXtreme Gradient Boosting, XG Boost, Light Gradient Boosting Machine, Light GBM) allow modeling of complex nonlinear relationships, recurrent networks (Long Short-Term Memory, LSTM) detect temporal patterns, and balancing methods (Synthetic Minority Oversampling Technique, SMOTE) eliminate sampling distortion when customers who leave are a minority. To increase the accuracy of forecasts, the metrics AUC-ROC (Area Under the Receiver Operating Characteristic), Precision-Recall Area Under Curve (PR-AUC) and Lift@k are used, which directly correlate with the business effect of marketing actions (table 2).

Table 2

Machine learning tools for predicting customer churn in logistics marketing

Tool/model	Main function	Data sources	Evaluation metrics	Practical effect for marketing

Logistic regression	Linear prediction of churn probability	CRM, order history, complaints	AUC-ROC, F1-score	Basic level of risk analysis; straightforward interpretation
XG Boost / Light GBM ensembles	Identification of complex nonlinear relationships	Transactional, geographic and behavioral data	AUC-ROC, PR-AUC, Lift@k	High accuracy of predictions; improved targeting up to 20–30%
Random Forest	Ranking customers by risk	CRM + ERP, behavioral patterns	Recall@k, Balanced Accuracy	Identification of «critical» customers; increasing retention accuracy
LSTM networks	Activity time series analysis	Tracking sessions, order frequency	Brier Score, AUC-ROC	Timely prediction of activity drops; dynamic triggers
Survival models (hazard analysis)	Time to churn prediction	Purchase intervals, duration of cooperation	Concordance Index, IBS	Determining the optimal moment for retention offers
SHAP / LIME	Explanation of model predictions	Post-hoc interpretations	None	Transparency of decisions; increasing management trust
SMOTE	Balancing training data	Sample structure	None	Reducing false negatives; more stable model results

Source: formed by the author based on [1; 7, p. 146; 8, p. 2–3; 9, p. 76–77; 13, p. 80–81]

In practice, these tools work as an «analytical layer» on top of operational data, automating both forecasting and subsequent marketing actions. A case in point is A.P. Moller–Maersk, where predictive analytics is used to detect demand disruptions and risks in supply chains early; this allows proactive communications to be launched, alternative service windows and routes to be suggested, reducing the likelihood of customer churn during peak periods. According to published materials, integrating artificial intelligence into forecasting yields business benefits in the form of double-digit percentage reductions in logistics costs and significant improvements in service levels; in general, companies that use artificial intelligence in supply chains record up to 15% reductions in logistics costs, up to 35% reductions in inventories, and up to 65% increases in service quality, which directly correlates

with reduced churn due to consistent delivery of service promises [19]. The second example is FedEx: FedEx Dataworks' analytics division has created a dynamic pricing infrastructure that, based on telematics, demand, and customer behavioral signals, adjusts rates and surcharges in real time. The peak surcharge mechanism adapts to the level of weekly coefficients for a specific shipper, which maintains margin manageability without «punitive» universal increases and reduces the risk of churn for price-sensitive customers by aligning the price with the actual intensity of service use [20]. Combined with churn risk models, this allows you to launch personalized retention offers precisely at those time intervals and in those directions where the probability of refusal is maximum, preserving revenue and long-term customer value. Big Data analytics in dynamic pricing systems of logistics services increases their economic adaptability. Unlike static models, Big Data provides real-time analysis of demand, seasonality, traffic, warehouse occupancy, and competitor actions, which allows you to automatically adjust delivery or storage rates according to current conditions (table 3).

Table 3

Main possibilities of using Big Data to build dynamic pricing in logistics services

Application	Data sources	Analytical tools	Expected effect	Practical value
Demand and peak load forecasting	Orders, seasonality, weather, holiday periods	Regression and temporal models, neural networks	Early determination of peak price windows	Increased accuracy of resource planning
Analysis of customer behavioral patterns	CRM, purchase history, order frequency	Clustering, segmentation models	Establishing individual tariffs	Price personalization, increasing loyalty
Monitoring competitive tariffs	Open marketplaces, partner APIs	Web scraping, NLP text analysis	Responding to changes in market rates	Ensuring competitiveness
Assess real-time transportation costs	GPS, IoT sensors, fuel data	Stream analytics, AI recommendation systems	Dynamic cost correction	Loss reduction and margin optimization

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Application	Data sources	Analytical tools	Expected effect	Practical value
Adaptive pricing in supply chains	ERP, financial reports, macro data	Optimization algorithms, Reinforcement Learning	Supply and demand balancing	Automated price and service matching

Source: compiled by the author based on [8, p. 4–5; 9, p. 77–78; 10, p. 3–4; 11; 12; 13, p. 83–85]

In modern logistics practice, such systems operate in real time, integrating Big Data analytics modules with operational delivery management platforms and customer interfaces. For example, DPD group has introduced the Dynamic Parcel Pricing (DPP) platform, which uses machine learning algorithms to take into account more than 50 parameters – from loading density to regional purchasing activity. It allows updating tariffs every hour, maintaining margins within 12–15%, even with fluctuations in delivery volumes during peak seasons. In 2023, the company reported that the implementation of DPP reduced the frequency of customer refusals by 9% and increased the average profitability of operations by 6% [21]. Another example is DHL Express, which in 2024 introduced the AI Demand Pricing Engine module, which analyzes historical order data, aircraft load factors and external factors (including fluctuations in fuel prices). The system dynamically generates fares based on booking time, route, and service type. According to the company, this has reduced underbooking losses by 11% and increased the share of bookings by 18% [22]. Flexport is implementing similar approaches by combining Big Data with Reinforcement Learning algorithms to balance rates between demand and available capacity. As a result, the average fare update time has been reduced to 15 minutes, which has reduced price volatility and increased revenue predictability [23]. Thus, the use of Big Data in dynamic pricing changes the very logic of interaction between the logistics operator and the customer. The price becomes not a fixed parameter, but the result of a continuous analytical process that combines operating costs, behavioral data, and market conditions.

Despite the many advantages, the main problems of using Big Data in logistics marketing are centered around quality, compatibility, and information flow management. Much of the data comes from different sources – CRM, ERP, IoT devices, delivery tracking platforms and external application programming interfaces (APIs) – which creates fragmentation and complicates integration [2, p. 90–91]. The lack of uniform formats and exchange standards causes duplication, inconsistencies, and time lags in updates [7, p. 143–144]. Quality issues include incompleteness, obsolescence, and a lack of unified customer and transaction identifiers, which reduces the accuracy of forecasting models.

The technological barrier remains the mismatch between analytical platforms, different data management systems and the lack of end-to-end security protocols, especially when working with personal information [9, p. 76–77; 13, p. 80–81]. The personnel factor creates an additional difficulty: the shortage of data engineering specialists and analysts who combine marketing, logistics and technical competence [6, p. 588–589]. Many companies are limited to fundamental business analysis, lacking the skills to build machine learning models or manage large volumes of unstructured data [12]. It slows down the implementation of intelligent systems for dynamic pricing and demand forecasting. Cyber risks are also a significant problem, since unauthorized access to logistics data can lead to a leak of commercial information and loss of customer trust [11]. As a result, without data standardization, development of analytical competences and strengthening cyber protection, the potential of Big Data in logistics marketing is only partially realized [13, p. 83–85].

Therefore, developing a strategy for implementing Big Data in logistics marketing requires a systematic combination of technical, analytical and managerial components. First of all, it is essential to create a single data architecture that integrates CRM, ERP, transport and financial systems, providing a complete picture of customer interaction and information reliability. The next step is to implement an analytical platform with machine learning tools, dynamic pricing and customer behavior forecasting based on hybrid models that take into account transaction

history, consumption patterns and churn risks. It makes it possible to personalize incentives – discounts, bonuses, flexible tariffs – and increase loyalty. The decisive factor for success is the development of human resources: the creation of interdisciplinary teams of analysts, marketers and data specialists capable of working with Python, SQL, Power BI, SHAP and LIME. It is advisable to form internal centers of analytical competence that will support the continuous improvement of models. The practical implementation of the strategy should be based on the principle of «data-to-action» – direct implementation of analytical insights into marketing processes (automatic adjustment of tariffs, demand forecast, personalized offers). The effectiveness is assessed using key metrics: ROI, CLV and churn rate. The Big Data implementation strategy should be based on data standardization, technological compatibility and customer orientation, ensuring sustainable growth in profitability and competitive advantages of logistics enterprises.

Conclusions. It has been established that Big Data analytics is a key resource in logistics marketing, which increases the accuracy of customer churn forecasts, pricing efficiency and personalization of solutions. Integration of Big Data with CRM, ERP and IoT platforms forms adaptive business models focused on the customer. The use of machine learning algorithms (XGBoost, LSTM, Random Forest) and streaming analytics ensures the flexibility of companies and optimization of pricing policy. The main implementation challenges are related to data fragmentation and low quality, lack of exchange standards, security risks and lack of analytical staff. It is recommended to create a centralized data architecture, unify quality and security standards, develop analytical competence centers and implement a «data-to-action» approach to transform analytics into practical marketing actions. Further research should be directed towards synergistic data management models, explanatory analytics (SHAP, LIME) and intelligent dynamic pricing systems.

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