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Economic efficiency of dynamic pricing algorithms in the secondary car market under conditions of full digitalization

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Abstract. *The study's relevance stems from the rapid digital transformation of the market and the growing role of algorithmic pricing in modern business models. The purpose of the article is to highlight the theoretical and methodological foundations and assess the economic efficiency of dynamic pricing algorithms in the secondary car market.*

The study uses the following methods: analysis of the scientific literature to examine the current state of development in the subject; generalization and systematization to present the study's results.

It is shown that dynamic pricing is a mechanism that integrates analytics of historical and current data, behavioral signals, and market factors into real-time pricing decisions on digital platforms. It is established that the secondary car market, due to its heterogeneity and information asymmetry, creates conditions in which algorithmic pricing is more adaptive than traditional approaches. It is noted that modern digital platforms actively integrate rule-based, econometric, and machine-learning algorithms, enabling continuous price adjustments in response to demand fluctuations and competitive dynamics. It is determined that the use of

dynamic pricing contributes to increased pricing accuracy, revenue optimization and reduced vehicle dwell time. Compared to static pricing, dynamic approaches yield higher profitability and better inventory turnover, though they require additional investment in technological infrastructure and maintenance. It is noted that integrating big data and artificial intelligence enhances the predictive capabilities of pricing systems and supports adaptive decision-making.

In summary, the cost-effectiveness of dynamic pricing algorithms is achieved through a synergistic combination of the system's technological excellence, data quality, and alignment with market conditions in the secondary car market, ensuring sustainable value creation and improved performance for market participants in a fully digital environment.

***Keywords**: algorithmic pricing, digital platforms, secondary vehicle market, big data, behavioral economics, revenue optimization, price adaptability, competitive environment.*

Економічна ефективність алгоритмів динамічного ціноутворення на вторинному авторинку в умовах повної цифровізації

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***Анотація.** Актуальність дослідження обумовлена швидкою цифровою трансформацією ринкового простору та зростаючою роллю алгоритмічного ціноутворення у сучасних бізнес-моделях. Мета статті – висвітлити теоретико-методологічні засади та оцінити економічну ефективність алгоритмів динамічного ціноутворення на вторинному авторинку.*

У дослідженні застосовано методи: аналізу наукової літератури – для вивчення поточного стану напрацювань з тематики; узагальнення та систематизації – для представлення результатів дослідження.

Показано, що динамічне ціноутворення є механізмом, який інтегрує аналітику історичних і поточних даних, поведінкові сигнали та ринкові фактори в рішення щодо ціноутворення на цифрових платформах в режимі реального часу. Встановлено, що вторинний ринок автомобілів, через свою неоднорідність та інформаційну асиметрію, створює специфічні умови, в яких алгоритмічне ціноутворення є більш адаптивним порівняно з традиційними підходами. Зазначено, що сучасні цифрові платформи активно інтегрують алгоритми, які базуються на правилах, економетричні алгоритми та алгоритми машинного навчання, дозволяючи постійно коригувати ціни відповідно до коливань попиту та конкурентної динаміки. Визначено, що застосування динамічного ціноутворення сприяє підвищенню точності ціноутворення, оптимізації доходів та скороченню часу перебування автомобілів на ринку. Встановлено, що порівняно зі статичним ціноутворенням, динамічні підходи забезпечують вищу прибутковість та кращий оборот запасів, незважаючи на необхідність додаткових інвестицій у технологічну інфраструктуру та обслуговування. Зазначено, що інтеграція великих даних та штучного інтелекту покращує прогнозні можливості систем ціноутворення та підтримує адаптивні процеси прийняття рішень.

Узагальнено, що економічна ефективність алгоритмів динамічного ціноутворення досягається завдяки синергетичному поєднанню технологічної досконалості системи, якості даних та відповідності ринковим умовам вторинного ринку автомобілів, забезпечуючи стале створення вартості та покращення результатів діяльності учасників ринку в повністю цифровому середовищі.

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Ключові слова: *алгоритмічне ціноутворення, цифрові платформи, вторинний ринок транспортних засобів, великі дані, поведінкова економіка, оптимізація доходів, цінова адаптивність, конкурентне середовище.*

Problem statement. The rapid digitalization of economic processes has fundamentally changed pricing mechanisms across markets, including the secondary car market, where the heterogeneity of goods and high uncertainty make it difficult to determine value. In these conditions, dynamic pricing algorithms have become the primary tool for adapting prices to market conditions in real time, enabling more accurate matching of supply and demand. However, despite the widespread adoption of such algorithms on digital platforms, there is still no comprehensive understanding of their economic efficiency, especially the balance between potential revenue gains and the costs of implementation and maintenance. The problem is further complicated by the interaction of algorithmic decision-making with behavioral factors, information asymmetry, and the dynamics characteristic of specific platforms, which can distort expected results and limit the effectiveness of approaches based solely on data.

The relevance of this study lies in the need for an in-depth analysis of the effectiveness of dynamic pricing in a fully digital environment, where competition is intensifying, and decision-making speed is becoming a critical success factor in the modern market. For market participants, primarily sellers working on online platforms, the ability to optimize pricing strategies directly affects profitability, sales speed and overall business competitiveness. At the same time, the growing dependence on algorithmic systems raises important questions about the transparency, fairness and long-term sustainability of the company's pricing policy. Therefore, research into the economic effectiveness of dynamic pricing algorithms in the secondary car market is extremely important for developing scientifically sound approaches that ensure both technological efficiency and economic

rationality, as well as for addressing challenges in adapting business processes to the digital environment.

Analysis of recent research and publications. A number of publications in recent years have examined various aspects of the secondary car market. In particular, the work of L. Shaulska, P. Pererva, O. Kosenko, L. Marchuk, and O. Hrechanyi [1] examines modern pricing models for innovative products in electronic commerce, thereby substantiating the importance of adaptive pricing approaches in the digital environment. The study by A. Kulikovska and O. Stets [2] is devoted to the economic and mathematical modeling of pricing processes in the secondary car market and confirms the feasibility of using formalized methods for forecasting price parameters. The scientific work of R. V. Bachalo [3] justifies the development of a knowledge base for predicting car costs using artificial intelligence tools, thereby increasing the accuracy of market price assessments. The study by N. Boikon and B. Levitskyi [4] considers algorithms for training and evaluating machine learning models for structured data, which provides an important basis for building effective dynamic pricing systems. The scientific work of T. Kuzmina, Y. Berezovskyi, and A. Sova [5] analyzes the impact of various economic factors on the Ukrainian automobile market, particularly on the formation of customs payments, which, in turn, indirectly affect the final price of vehicles. The publication by M. Ruiev [6] provides a comparative analysis of the development of the used-car market in the USA and Ukraine, enabling identification of key trends, risks, and opportunities for its functioning.

The study by O. Honcharov [7] highlights the transformation of the global automotive market driven by technological changes, particularly electromobility, which is prompting new pricing approaches. The work of N. Kosar and N. Kuzio [8] substantiates the role of online communications in increasing dealers' competitiveness, thereby shaping pricing strategies in the automotive market. The study of I. Oklander [9] defines dynamic pricing as a digital marketing tool that

enables flexible pricing decisions in a changing environment. The scientific work of B. Stasiuk [10] analyzes the main trends in the development of the Ukrainian automotive market, laying the groundwork for further research into the effectiveness of algorithmic pricing approaches.

Identification of previously unresolved parts of the general problem. Despite the significant number of scientific works on pricing and the functioning of the automotive market, the comprehensive assessment of the economic efficiency of dynamic pricing algorithms in the secondary car market segment remains under-researched. Existing research mainly focuses either on mathematical modeling of prices or on general trends in digitalization, while the relationship between algorithmic parameters, consumer behavioral factors, and sellers' financial outcomes is examined only fragmentarily. Insufficient attention has also been paid to analyzing the impact of digital platforms and big data on the real-time adaptability of pricing strategies. In addition, there are no general approaches to assessing the costs and benefits of implementing algorithmic pricing systems, given the specifics of the used-car market.

Formulation of the article's objectives (task statement). The purpose of the article is to highlight the theoretical and methodological principles of dynamic pricing and assess its economic efficiency in conditions of full digitalization.

In accordance with the goal, the following tasks were set: to generalize theoretical approaches to the essence of dynamic pricing and determine the features of its functioning in the digital economy; to analyze the current state of the secondary car market and the specifics of the application of pricing algorithms on digital platforms; to develop methodological approaches to assessing the economic efficiency of dynamic pricing algorithms; to assess the impact of algorithmic models on sales results and profitability of market participants.

Presentation of the main research material. The theoretical principles of dynamic pricing in the digital economy reflect significant changes in traditional

pricing approaches, driven by the rapid development of data processing technologies, algorithmic decision-making, and the increasing availability of real-time market information. Dynamic pricing is a flexible strategy in which prices are constantly adjusted based on a range of internal and external factors, including demand fluctuations, competitive dynamics, consumer behavior, and macroeconomic conditions. Unlike static pricing models, which rely on fixed pricing mechanisms, the dynamic approach integrates adaptive algorithms that respond almost immediately to market changes. The evolution of this model is closely linked to the expansion of digital platforms, the spread of big data analysis and the development of machine learning technologies, which together provide more accurate demand forecasting and individualized price offers. As a result, pricing ceases to be an exclusively managerial decision and increasingly becomes an automated process based on data, part of digital ecosystems [9, p. 39].

In these conditions, the secondary car market is a highly complex and heterogeneous pricing object. Unlike the primary markets for new cars, the secondary market is characterized by significant variability in product quality, information asymmetry between buyers and sellers, and high price dispersion. Each car is unique in its age, mileage, technical condition, brand reputation, and maintenance history, which significantly complicates the standardization of pricing approaches. The digitalization of the secondary car market has led to the emergence of online platforms that aggregate large volumes of ads, thereby increasing market transparency and intensifying competition. These platforms facilitate rapid information exchange and enable the application of dynamic pricing algorithms that continuously adjust prices based on user behavior, search trends, and competitors' pricing strategies. Accordingly, pricing in this market is influenced not only by traditional economic factors but also by digital indicators, such as the number of clicks, time spent on the platform, and demand elasticity, determined using algorithms [10, p. 282].

Assessing the economic efficiency of dynamic pricing algorithms requires comprehensive methodological approaches that account for both direct and indirect effects. From a theoretical point of view, efficiency can be interpreted as the ability of pricing algorithms to maximize key performance indicators, such as revenue, profit margin and sales velocity, while minimizing transaction costs and product storage periods. From a methodological point of view, this involves the use of econometric modeling, simulation methods and experimental methods, in particular A/B testing, to assess the causal impact of algorithmic pricing decisions. In addition, performance indicators should take into account not only financial results, but also behavioral responses of market participants, such as changes in customer engagement and conversion rates. The integration of machine learning models further improves the valuation process by enabling continuous learning and optimization using historical and real-time data. At the same time, it is important to consider the costs associated with the development, implementation, and maintenance of pricing algorithms, as well as the potential risks posed by market volatility and algorithmic bias [11, p. 154–155]. Therefore, the cost-effectiveness of dynamic pricing in the secondary car market should be understood as a multi-level design that balances technological capabilities, market responsiveness, and sustainable value creation in the modern digital environment.

The secondary car market is undergoing profound changes driven by digitalization, which has affected both market structure and pricing mechanisms. The development of online marketplaces, mobile applications, and integrated digital ecosystems has significantly reduced transaction costs, increased market accessibility, and intensified competition among sellers. One of the main trends is the increasing role of data transparency, as potential buyers can now immediately compare car specifications, historical price trajectories and seller reputations across platforms. This increased transparency has led to a gradual reduction in information asymmetry, although it has not been completely eliminated due to the specificity of

the product and the limited availability of reliable information about the technical condition of cars. At the same time, digitalization has facilitated the emergence of platform-based intermediation models, in which pricing is no longer determined solely by individual sellers but increasingly depends on algorithmic recommendations and automated adjustment mechanisms built into digital platforms [12, p. 543–545].

In this environment, dynamic pricing tools and algorithms have become a key component of competitive strategy. Online platforms use a wide range of algorithmic solutions, including rules-based pricing systems, regression models, and machine learning algorithms, capable of processing large amounts of data in real time. These tools analyze multilevel data, including user behavior during searches, click-through rates, ad duration, competitor prices, and seasonal demand fluctuations. More sophisticated systems use predictive analytics to predict optimal price points that maximize the likelihood of a sale while maintaining an acceptable profit margin. In addition, sellers are increasingly using recommendation systems and automated pricing assistants to adjust product prices based on market trends, thereby reducing reliance on subjective estimates. The integration of artificial intelligence enables continuous learning from past transactions, enabling algorithms to improve pricing strategies and adapt to changing market conditions with minimal human intervention.

To build on this overview, the main pricing algorithms used on digital platforms are systematized and characterized below (table 1).

Table 1

Classification of dynamic pricing algorithms used in the secondary car market

Algorithm type	Main characteristics	Input data	Expected economic effect
Rule-based algorithms	Predefined pricing rules and thresholds	Key vehicle parameters, fixed competitor prices	Stable pricing, limited adaptability
Regression models	Statistical price estimation based on historical data	Historical transactions, vehicle characteristics	Increased pricing accuracy, moderate flexibility

Algorithm type	Main characteristics	Input data	Expected economic effect
Machine learning algorithms	Adaptive models with continuous learning capabilities	Big data, user behavior, real-time market signals	High response speed, profit maximization
Hybrid algorithms	A combination of statistical and AI approaches	Integrated datasets with various sources	Balanced performance and reliability

Source: compiled by the author based on [13–15]

The effectiveness of these algorithms depends on a wide range of factors that influence both pricing and market participants' behavior. On the supply side, key determinants include vehicle characteristics such as make, model, age, mileage, condition, and maintenance history, as well as macroeconomic conditions that affect overall purchasing power. On the demand side, buyer behavior is increasingly shaped by digital interactions, including search filters, recommendation engines, and perceptions of price fairness based on algorithmically generated comparisons. Behavioral economics also plays an important role, as consumers tend to respond not only to absolute price levels but also to relative price positioning, discounts, and limited-time offers. The strategic behavior of sellers is also changing in response to the algorithmic environment, with an increasing reliance on automated tools and data-driven decision-making processes. Sellers are actively adjusting their pricing strategies to stay visible in platform rankings, respond to competitors' actions, and optimize the timing of price changes.

The interaction between these factors creates a highly dynamic and adaptive pricing ecosystem, in which the traditional boundaries between supply and demand are increasingly blurred by algorithmic regulation. As digital platforms in the aftermarket continue to evolve, it is likely that advanced analytics will be further integrated, leading to more sophisticated pricing mechanisms that simultaneously reflect market conditions, user behavior, and the strategic goals of platform operators.

Evidence on the cost-effectiveness of dynamic pricing algorithms in the aftermarket suggests that their application has a significant impact on key performance indicators, providing pricing flexibility and timely response to demand through adaptability. Modeling the impact of such algorithms on sales results involves building an integrated evaluation system that combines econometric analysis with simulation modeling. Within this system, the effectiveness of pricing algorithms is assessed using a system of interrelated indicators, in particular, expected revenue, probability of sale, price deviation from market equilibrium and inventory turnover time [16, p. 903]. The model includes both static variables, such as vehicle characteristics, and dynamic variables, such as user activity and changes in competitive prices, which allows for a comprehensive reflection of market behavior. Algorithm parameters, including price update frequency, sensitivity to competitor prices and the weight of demand signals, significantly affect the final price level. Higher adjustment frequency and greater sensitivity to real-time data tend to reduce price dispersion and more accurately align prices with current market conditions, while excessive reactivity can lead to price volatility and suboptimal results. At the same time, the assessment of sales speed shows that implementing adaptive pricing mechanisms helps reduce average listing duration, thereby improving inventory turnover and reducing the opportunity costs associated with long car stays on digital platforms.

Assessing the economic feasibility of implementing dynamic pricing algorithms enables the identification of their advantages over traditional static approaches, particularly in terms of revenue generation and operational efficiency. A comparative analysis of data shows that static pricing, although easier to implement, does not adequately respond to market fluctuations and often leads to under- or overpricing, which negatively affects financial results. In contrast, dynamic pricing allows sellers to adjust prices in real time based on demand, helping optimize revenue and reduce the risk of unsold inventory. The impact on sellers'

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profitability is most evident in scenarios characterized by high market liquidity and intense competition, where even minor price adjustments can significantly affect buyers' decisions. Implementing such algorithms entails costs, including investments in software development, data infrastructure, and ongoing system maintenance [17]. These costs vary depending on the complexity of the algorithmic system and the scale of its implementation, but empirical modeling suggests that, in most cases, the long-term financial benefits outweigh the initial costs. A comparison of the effectiveness criteria of static and dynamic pricing approaches is given in table 2.

Table 2

Comparison of static and dynamic approaches to pricing in the secondary car market

Criteria	Static approach to pricing	Dynamic approach to pricing
Adaptability to market changes	Low	High
Pricing accuracy	Limited	High
Impact on sales velocity	Moderate	Significant acceleration
Profitability potential	Unstable	Optimized through constant adjustment
Implementation costs	Minimal	Moderate to high
Operational complexity	Low	High

Source: compiled by the authors based on [16–18]

In the context of full digitalization, optimizing dynamic pricing algorithms requires integrating behavioral and market factors beyond purely quantitative indicators. Thus, taking into account behavioral patterns, such as customer sensitivity to price limits, perceptions of objectivity, and reactions to price changes, increases the accuracy of pricing model predictions and improves conversion rates. At the same time, market factors, in particular seasonal fluctuations in demand, regional differences and ranking mechanisms specific to specific platforms, should also be included in the algorithmic logic to ensure contextual relevance. In this

context, the use of big data and artificial intelligence technologies significantly expands the analytical capabilities of pricing systems, enabling them to process large, heterogeneous datasets in real time. Machine learning models, particularly those based on supervised and deep learning, enable continuous improvement of pricing strategies through feedback loops that capture actual market reactions. As a result, algorithms evolve from reactive tools into proactive systems that can predict demand changes and adjust prices accordingly.

The need to improve dynamic pricing algorithms stems from ensuring an optimal balance between responsiveness to market changes and stability in the company's pricing policy. This can be achieved by increasing the transparency of the pricing process and aligning algorithmic decisions with the company's strategic business goals. A promising approach is the use of hybrid models that combine the statistical reliability of traditional analysis methods with the adaptability of machine learning tools, enabling greater forecasting accuracy and greater flexibility in pricing decisions. At the same time, it is advisable to implement systems for continuous monitoring and control of algorithmic effectiveness to timely detect and prevent undesirable effects, in particular, excessive price fluctuations. An important role in increasing the effectiveness of dynamic pricing is also played by improving the quality of input data and expanding the range of information sources, thereby enabling more accurate modeling of market processes and the validity of pricing decisions.

Conclusions. As a result of the study, the theoretical and methodological principles of dynamic pricing as a component of the digital economy were summarized, and its role in increasing the efficiency of the secondary car market was substantiated. It was established that the use of dynamic pricing algorithms ensures more accurate coordination of supply and demand, reduces information asymmetry, and increases transparency of market processes in the digital environment. The generalization of the research results indicates that the use of

algorithmic approaches in the dynamic pricing system creates the prerequisites for increasing the validity of pricing decisions in a complex, multifactorial market environment, as it allows taking into account the behavioral characteristics of consumers, competitive dynamics and product specifics. At the same time, it was established that the practical effectiveness of such tools is largely determined by the quality and completeness of data, the correctness of setting model parameters and the ability of algorithmic systems to adapt to changes in the market situation, which emphasizes the need to improve information and analytical support and mechanisms for adaptive pricing management.

The analysis of the current state of the secondary car market showed that digitalization enables the active implementation of algorithmic pricing tools, which positively impact the speed of car sales, sellers' profitability, and the overall efficiency of market operations. It is substantiated that, compared to static approaches, dynamic pricing provides a more flexible response to changes in demand and allows minimizing losses from inefficient pricing, despite the additional costs of implementing and supporting the relevant algorithmic systems. The prospects for further scientific research include developing adaptive models of dynamic pricing that account for the risks of the digital environment, as well as an in-depth analysis of the impact of algorithmic solutions on the long-term stability and competitiveness of the market.

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