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DATA SCIENCE METHODS IN MODELING ASSET DYNAMICS AND COST ALLOCATION

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Abstract. This article examines the application of Data Science methods in forecasting enterprise asset dynamics and optimal cost allocation in the context of the digital economy. The limitations of traditional accounting models in asset and cost management have become highly relevant on a global scale, particularly since the mid-2010s, with the practical implementation of Big Data and Machine Learning algorithms. In the economy of Uzbekistan, this approach has been actively studied and put into practice over the last five to six years, particularly following the implementation of the "Digital Uzbekistan — 2030" strategy and the initiation of transformation processes in the banking, financial, and large-scale manufacturing sectors. The article highlights the advantages of non-linear and Time-Series Forecasting models in activity-based costing (ABC) within management accounting and asset profitability analysis. The research results show that the transition from traditional methods to correlation and predictive models allows enterprises to reduce waste resources and improve the accuracy of strategic decision-making.

Keywords: Asset dynamics, cost allocation, Data Science, management accounting, predictive analytics, machine learning, digital economy, resource optimization.

INTRODUCTION

In the modern market economy, effective management of enterprise resources is directly dependent on the accurate assessment of asset dynamics and the optimal allocation of costs. However, traditional accounting systems possess limited capabilities in dynamically analyzing large volumes of data. For this reason, the integration of Data Science and predictive analytics tools into management accounting has become an essential necessity in today's context. In Uzbekistan as well, the modernization of the financial system through digital technologies represents one of the priority directions of state policy. In particular, the "Strategy for the Development of Artificial Intelligence Technologies until 2030," approved by Resolution No. PQ-358 of the President of the Republic of Uzbekistan dated October 14, 2024, sets forth objectives for optimizing processes in the banking and financial sector as well as across branches of the economy through the formation of a "Big Data" infrastructure. This, in turn, serves as the legal and practical foundation for modeling asset and cost analysis through the application of modern algorithms. The present article examines the role of Data Science tools in addressing systemic deficiencies inherent in traditional accounting practices. Within the scope of the research, the issues of forecasting the turnover dynamics of enterprise assets through Time-Series Forecasting, as well as the algorithmization of Activity-Based Costing (ABC) models for the functional distribution of expenditures have been analyzed. In conclusion, practical recommendations have been developed regarding the real-time management of enterprise resources through data analysis.

LITERATURE REVIEW

The problem of enhancing the operational efficiency of enterprises and optimizing cost structure has consistently remained at the center of economic research. The modern foundation of strategic cost allocation originated with the Activity-Based Costing (ABC) model developed by R. Kaplan and S. Cooper [1]. Subsequently, this approach was transformed into a dynamic Time-

Driven Activity-Based Costing (TDABC) model, with the purpose of reducing practical complexities and incorporating the time factor, which enabled a more precise real-time assessment of resource utilization [2].

In the management of assets and the analysis of their dynamics, the multi-factor economic valuation approaches of E. Fama and K. French served as the primary standard for many years [3]. However, the rapid growth of the digital economy necessitated a renewed approach to these static models. As a result of the advancement of information technologies, and as emphasized by A. McAfee and E. Brynjolfsson, Big Data brought about a revolutionary turning point in management and economic decision-making, creating the opportunity to track asset movements and costs with exceptional precision [4].

In contemporary economic analysis, Data Science and predictive modeling are demonstrating their superior effectiveness alongside traditional methods. Economist H. Varian illustrated the new prospects of large-scale data analysis in economics, substantiating that nonlinear forecasting methods are replacing conventional linear models [5]. Applying this process to practice, S. Mullainathan and J. Spiess demonstrated revolutionary approaches to forecasting asset values and operational costs through the application of Machine Learning algorithms to economic and financial analysis [6]. The research of Stanford University professor S. Athey indicates that data science and artificial intelligence are becoming not merely auxiliary tools, but rather the very foundation of fundamental economic decision-making in enhancing enterprise efficiency and allocating financial and economic resources [7].

RESEARCH METHODOLOGY

This research was conducted based on a mixed methods approach, combining both quantitative and qualitative analysis methods. Throughout the research process, comprehensive methodological approaches were applied with the purpose of evaluating the impact of artificial intelligence and Data Science tools on the operational efficiency of enterprises, as well as examining the possibilities of optimizing cost structure. In particular, time-series analysis and predictive modeling methods were employed on the basis of historical economic databases in order to forecast asset management and inventory movements in advance.

ANALYSIS AND RESULTS

The growth dynamics of information and communication technology services volume represents one of the most significant indicators in assessing the impact of macroeconomic reforms and digital economy transition processes at the enterprise level. The expansion of information and communication technology infrastructure in the economy of the Republic of Uzbekistan is creating the necessary environment for enterprises to transition from traditional management methods to data-driven analytical approaches. Drawing upon the official data of the Statistics Agency of the Republic of Uzbekistan, the volume of this sector recorded continuous and exponential growth throughout the period spanning from 2021 to 2025 [1]. This positive tendency confirms that the technological demand for Big Data analysis and predictive models is increasing at a rapid pace within the national economy, particularly among small and medium-sized business entities.

Table-1.

Five-Year Dynamics of the Volume of Information and Communication Services in the Republic of Uzbekistan (2021-2025)

Indicators	2021	2022	2023	2024
Volume of information and	17.4	24.5	32.4	43.8

communication services (trillion UZS)				
Growth rate compared to the previous year (%)	120.2	123.3	124.5	126.1
Share in total services (%)	6.1	6.7	6.9	7.4

Despite such rapid digitalization at the macroeconomic scale and the growing technological base, at the microeconomic level, business asset management mechanisms continue to rely on outdated static methods. In the real sector, particularly in retail trade and small manufacturing enterprises, systematic errors in warehouse inventory management are sharply reducing operational efficiency. Standard accounting entries that record only past-period transactions in operational activities do not allow for real-time analysis of the enterprise's cost structure. Traditional accounting systems register events only after they have occurred, yet are incapable of forecasting how capital should be directed toward its highest-yielding points.

As a consequence of this, the inefficient allocation of working capital arises in commercial enterprises. The accumulation of excess goods (overstock) resulting from the inaccurate forecasting of demand freezes valuable working capital and increases storage costs. In the opposite scenario, the unexpected depletion of high-demand goods (stockout) leads directly to the loss of profit and a decline in market share. In order to minimize these economic losses, enterprises are required to abandon the traditional approach and implement predictive models based on Machine Learning algorithms [2]. Table 2 below presents a comparative analysis of the impact of the traditional management model and the "Smart Inventory Management" system integrated with Data Science technologies on the operational cost structure of an enterprise.

Table-2.

Analysis of Operational Cost Structure Optimization in Retail and Small Manufacturing Enterprises

Operational Cost Category (Cost Structure)	**Average Share in Traditional Accounting System (%)**	**Expected Share Post-Implementation of Data Science Models (%)**	**Economic Efficiency Outcome**
Inventory holding and management costs	20 - 25%	10 - 12%	Reduction in overstock due to precise forecasting, leading to an accelerated rate of capital turnover.
Losses from deficits and logistical disruptions (Stockout & shortage costs)	12 - 18%	4 - 6%	Minimization of lost sales through the forecasting of demand fluctuations.
Asset depreciation and technical	15 - 20%	11 - 13%	Decrease in repair expenses via the

maintenance			preemptive assessment of asset deterioration (Predictive maintenance).
Administrative and data processing expenses	10 - 15%	5 - 7%	Cost savings derived from the comprehensive automation of financial analysis and management accounting

As evidenced by the preceding table, the implementation of predictive models substantially diminishes total operational expenditure. Nevertheless, this transformation is not instantaneous; rather, it manifests as a cumulative economic benefit that expands over a given timeframe in correlation with the algorithm's learning progression. This phenomenon is distinctly observable within the dynamics of economic indicators modeled via time-series analysis.

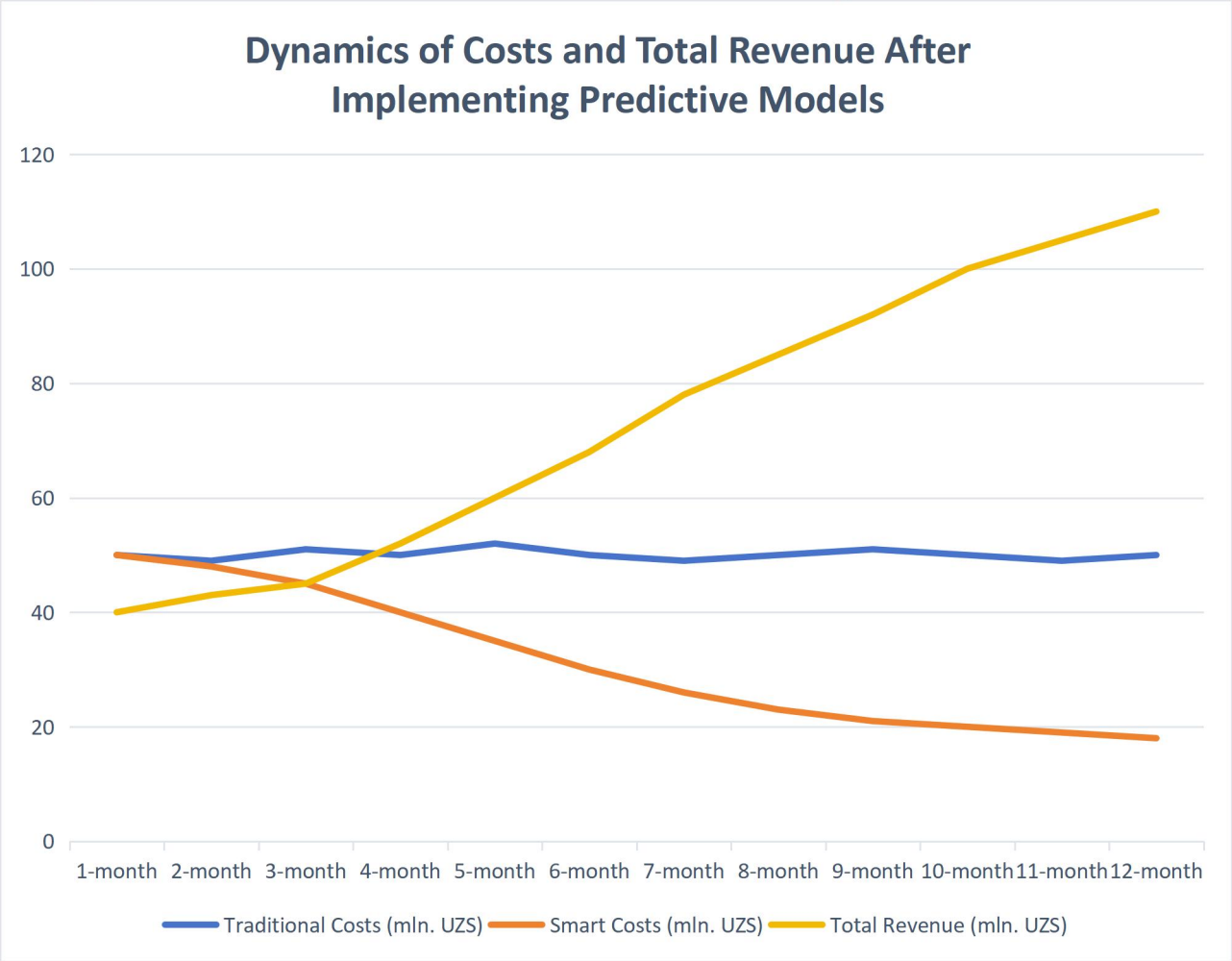


Figure 1. Dynamics of Costs and Total Revenue After Implementing Predictive Models

The graphical data developed within the scope of this research, entitled “Dynamics of Costs and Total Revenue After Implementing Predictive Models,”corroborates this process. Throughout the 12-month modeling period, the expenditures of an enterprise operating under traditional management remained consistently high (averaging approximately 50 million UZS). Conversely, following the integration of the Smart Inventory system, the algorithm—by analyzing historical data and seasonal trends—initiates a precipitous decline in costs starting from the third month, ultimately decreasing to 18 million UZS by the twelfth month. Crucially, the reduction in holding costs and the optimization of inventory balances lead to an accelerated rate of capital turnover. This, in turn, drives continuous growth in total revenue, exhibiting an upward trajectory from 40 million UZS in the initial month to 110 million UZS by the twelfth month. This paradigm substantiates that digital modeling serves as a direct driver for enhancing profitability. In conclusion, the research findings demonstrate that merely maintaining financial records is insufficient for modern enterprises; rather, there is a critical necessity for the active application of Big Data and artificial intelligence tools in asset management. Under contemporary conditions, sustaining competitiveness based solely on traditional accounting records is unfeasible. The optimization of the operational cost structure via digital algorithms is emerging as a fundamental prerequisite for ensuring economic stability among small and medium-sized enterprises (SMEs).

CONCLUSIONS AND RECOMMENDATIONS

Traditional accounting reflects the enterprise's past; however, in today's fiercely competitive environment, businesses require broader economic tools capable of forecasting their future trajectory. The analysis of macroeconomic trends and the modeling of the operational cost structure conducted within the framework of our research unequivocally confirm that merely recording historical transactions is insufficient to safeguard an enterprise against the risk of economic downturn. Observations of actual operational processes within small businesses and retail establishments indicate that traditional approaches to inventory management—reliant on human factors and static accounting—consistently engender systemic errors. The resultant issues of overstocking and stockouts constitute "hidden costs" that erode the enterprise's primary working capital. The integration of Big Data and Machine Learning algorithms into corporate management transcends mere IT innovation; it is a fundamental prerequisite for economic stability. The findings from the 12-month dynamic modeling in this study substantiate that optimizing inventory flow via artificial intelligence tools precipitously reduces operational expenditures over time, while concomitantly driving continuous growth in total revenue through accelerated capital turnover.

Based on the aforementioned scientific and empirical analyses, the following recommendations have been formulated to enhance the operational efficiency of enterprises and accelerate the digital transformation within the national economy:

- **Implementation of Smart Inventory Management models:** It is imperative for commercial and manufacturing enterprises to transition away from traditional warehouse software and deploy predictive algorithms. By automatically analyzing historical sales data and seasonal trends, these algorithms forecast future demand with exceptional precision, thereby eliminating uncertainties inherent in asset management.
- **A paradigm shift in education and personnel training:** The academic preparation of accounting professionals must transcend the mere instruction of financial reporting standards (e.g., NAS, IFRS). It is highly advisable for higher education institutions to incorporate the fundamentals of Data Science—specifically data analytics and predictive modeling—as mandatory disciplines for

economists and accountants. This strategic enhancement will supply the labor market with analytical managers capable of data-driven decision-making, rather than traditional bookkeepers.

- **Algorithmic control of the cost structure:** Enterprises should automate their management accounting not strictly for regulatory compliance with tax authorities, but to drive internal operational efficiency. Data aggregated across each cost center must be continuously processed through machine learning models to ensure that financial resources are dynamically reallocated toward the most profitable operational nodes.

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