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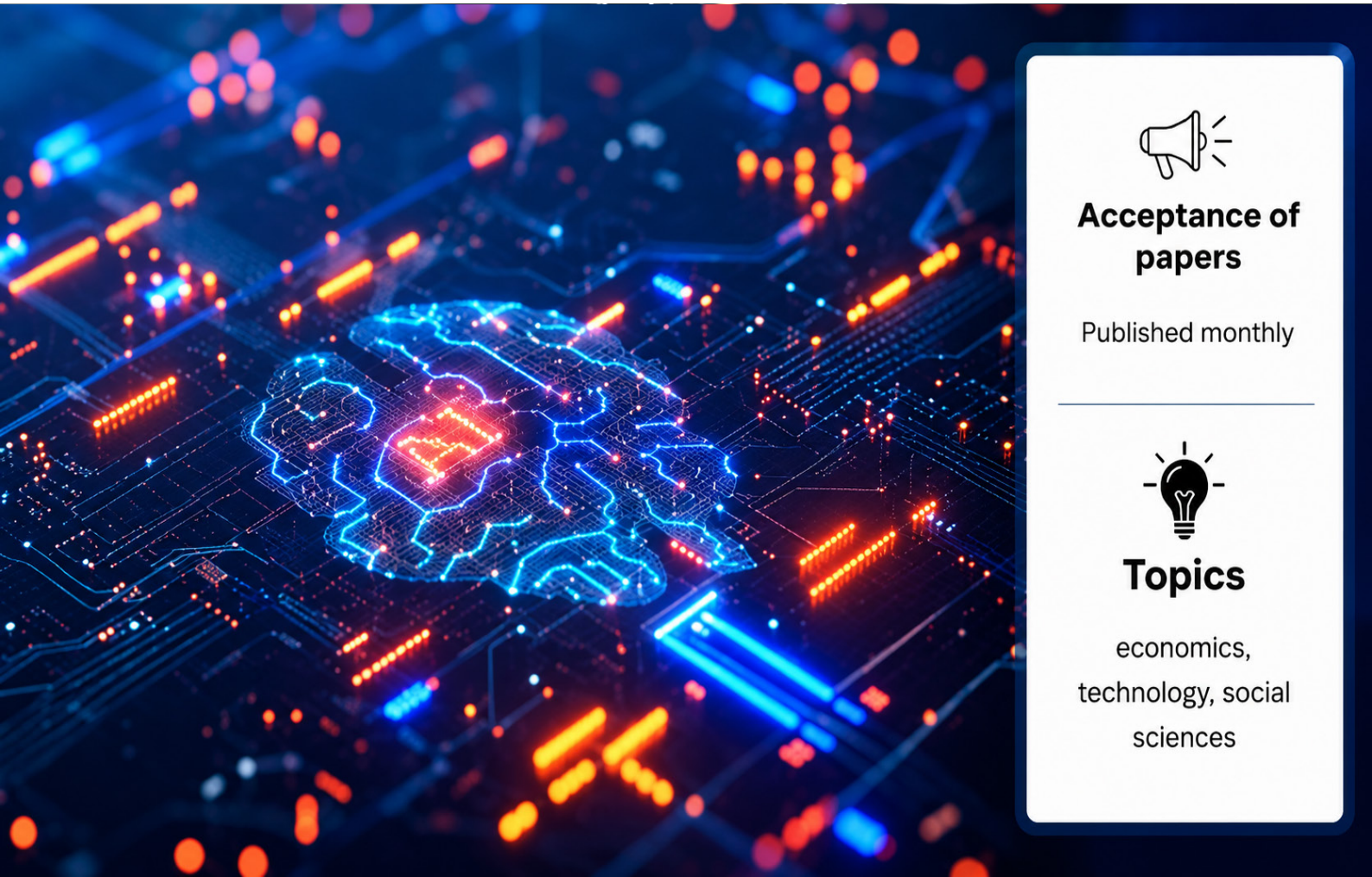

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CONTENTS

ENHANCING ECONOMIC EFFICIENCY AND FORECAST INDICATORS OF SCALING BIG DATA SOLUTIONS IN THE TOURISM INDUSTRY

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Abstract. This article analyzes the economic efficiency of scaling Big Data solutions within the tourism industry, outlining specific mechanisms for cost reduction and revenue maximization. Furthermore, it presents macroeconomic forecast indicators for Uzbekistan's tourism sector for the 2026–2030 period. Based on the Integrated Efficiency Index (ISIK), a three-scenario forecast, and sensitivity analysis, the study evaluates the comprehensive impact of Big Data and National Tourism Data Hub (NTDH) integration on tourism exports, GDP contribution, average tourist expenditure, and employment generation.

Keywords: Big Data, tourism economics, economic efficiency, ISIK, NTDH, forecasting, scenario analysis, digital integration.

Аннотация. В статье анализируется экономическая эффективность масштабирования решений Big Data в туристической отрасли, описываются конкретные механизмы сокращения затрат и максимизации доходов. Кроме того, представлены макроэкономические прогнозные показатели туристической отрасли Узбекистана на 2026–2030 годы. На основе Интегрального индекса эффективности (ISIK), трехсценарного прогноза и анализа чувствительности оценивается комплексное влияние интеграции Big Data и Национального туристического дата-хаба (NTDH) на экспорт туризма, долю в ВВП, средние расходы туристов и обеспечение занятости.

Ключевые слова: Big Data, экономика туризма, экономическая эффективность, ISIK, NTDH, прогнозирование, сценарный анализ, цифровая интеграция.

Annotatsiya. Maqolada turizm sanoatida Katta ma'lumotlar (Big Data) yechimlarini ommalashtirishning iqtisodiy samaradorligi tahlil qilinib, xarajatlarni qisqartirish va daromadlarni maksimal darajaga yetkazishning aniq mexanizmlari yoritilgan. Shuningdek, unda O'zbekiston turizm sohasining 2026–2030-yillarga mo'ljallangan makroiqtisodiy prognoz ko'rsatkichlari keltirilgan. Integrallashgan samaradorlik indeksi (ISIK), uch ssenariyli prognoz va sezgirlik tahliliga asoslanib, tadqiqotda Big Data hamda Milliy turizm ma'lumotlar xabi (NTDH) integratsiyasining turizm eksporti, YAITdagi ulushi, turistlarning o'rtacha xarajatlari va bandlikni ta'minlashga ko'rsatadigan kompleks ta'siri baholanadi.

Kalit so'zlar: Big Data, turizm iqtisodiyoti, iqtisodiy samaradorlik, ISIK, NTDH, prognozlash, ssenariyli tahlil, raqamli integratsiya.

INTRODUCTION

Evaluating the economic efficiency of Big Data and digital integration projects presents unique methodological challenges. Traditional financial evaluation methods, such as Net Present Value (NPV), Internal Rate of Return (IRR), and payback period, are essential but insufficient on their own. While capturing directly measurable financial flows, the vast majority of Big Data's economic value stems from indirect effects, including enhanced brand equity, customer loyalty, and expanded market share [8, p. 55]. Artificial intelligence tools were also utilized during the editing process of this text. The methodology proposed in this study relies on an integrated indicator system that simultaneously encompasses direct and indirect effects, ensuring alignment with the CSBI index.

Research Aim. This research aims to enhance the economic efficiency of Uzbekistan's tourism industry through Big Data technologies. This involves formulating an economic-mathematical model to forecast tourism demand, scientifically substantiating strategic mechanisms for integrating the national tourism ecosystem into international digital platforms, and deriving actionable recommendations for sectoral enhancement.

Research Tasks. The main research task is to calculate and substantiate macroeconomic forecast

indicators across three scenarios (pessimistic, realistic, and optimistic) for Uzbekistan's tourism sector for the 2026–2030 period using advanced economic-mathematical modeling.

Object of Research. The object of this study encompasses the tourism sector of the Republic of Uzbekistan and its emerging digital ecosystem, including tourism service providers (hotels, tour operators, airlines), state regulatory frameworks, digital infrastructure, and global integration mechanisms.

Subject of Research. The subject comprises the economic, organizational, and managerial relations arising during Big Data implementation in tourism and its global integration, alongside the methodology for modeling, evaluating, and refining these relations.

A robust assessment of economic efficiency requires a dual analytical approach that concurrently examines cost reduction and revenue expansion. These mutually reinforcing dimensions optimize enterprise competitiveness and ensure long-term financial sustainability. The mechanisms through which Big Data solutions impact both vectors are analyzed systematically in the following sections (Figure 1).

Figure 1. Economic Efficiency of Big Data Solutions: Cost and Revenue Structure
(Waterfall Analysis for Uzbekistan Hotel Sector, 1-Year Forecast)

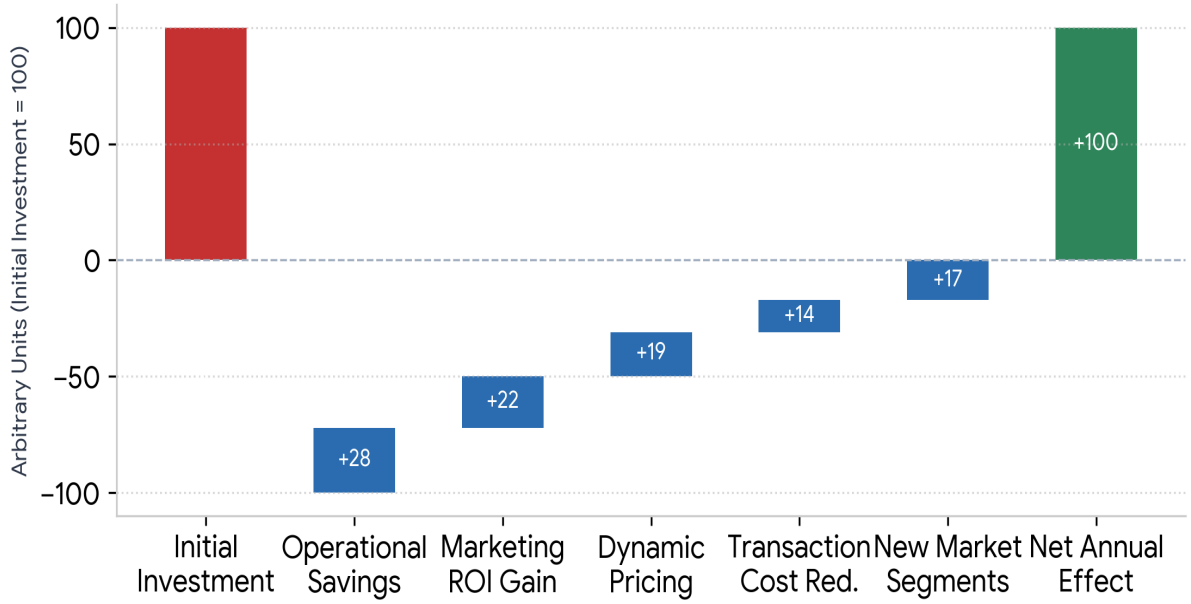

Figure 1. Economic Efficiency of Big Data Solutions: Cost and Revenue Structure (Waterfall Analysis for Uzbekistan Hotel Sector, 1-Year Forecast)

LITERATURE REVIEW

Foreign academic institutions have contributed substantially to the economics of digital tourism and Big Data. D. Buhalis and R. Law were among the pioneers in analyzing the economic evolution of information technology in tourism. H. Song, S. Witt, and G. Li developed econometric foundations for forecasting tourism demand. U. Gretzel, M. Sigala, and colleagues conceptualized «Smart Tourism» as a distinct economic category. B. Pan and Y. Yang empirically demonstrated the efficacy of leveraging Google Trends data for predicting tourism flows. In platform economics, foundational works by G. Parker, M. Van Alstyne, J. C. Rochet, and J. Tirole explain the core economic logic driving digital ecosystems. Within the CIS region, S. A. Yovkochev (Uzbekistan) examined digital economic theory in a national context. However, existing literature reveals a distinct gap regarding economic-mathematical modeling of Big Data-driven integration into international digital platforms specifically tailored to Uzbekistan's tourism sector—a gap this research aims to bridge.

RESEARCH METHODOLOGY

To measure the aggregate economic return, the author formulated the Integrated Efficiency Index (ISIK):

$$\mathbf{ISIK} = ((\Delta R - \Delta C)) / C_{BD} \times (1 + k_{indirect})$$

Where:

ΔR = Annual revenue increase following Big Data implementation (UZS);

ΔC = Annual operational cost savings generated by Big Data (UZS);

C_{BD} = Annual Big Data infrastructure expenditure (implementation + maintenance); $k_{indirect}$ = Multiplier for indirect economic effects (CLV growth, brand equity, market share), typically ranging from 0.25 to 0.45.

Interpretation thresholds: ISIK > 1.5 indicates high efficiency; 1.0-1.5 denotes acceptable efficiency; < 1.0 requires strategy revision. Empirical calculation for Uzbekistan's hotel sector in 2026 yields ISIK ≈ 2.1-2.8.

ANALYSIS AND RESULTS

As depicted in Figure 1, against an initial investment baseline of 100 units, the net economic effect reaches +100 units by the end of Year 1—demonstrating full capital recovery within the first year. Key revenue drivers include marketing ROI gains (+22), dynamic pricing (+19), expansion into new market segments (+17), operational cost savings (+28), and transaction cost reductions (+14). These projections align closely with international benchmarks reported by major global chains, including Marriott, Hilton, and Booking.com [1, p. 24; 2, p. 41] (Table 1).

Table 1

Economic Efficiency of Big Data Solutions: Directions, Mechanisms, and Quantitative Outcomes

Efficiency Dimension	Mechanism	Quantitative Effect (Avg)	International Validation
Operational Cost Reduction	Workforce planning optimization (demand forecast-based); energy management; inventory control.	-12% to -18% of annual operating costs	Hilton (-14.3%); Marriott (-12.8%)
Marketing Cost Efficiency	Targeted segmentation; optimal channel and timing execution; conversion gains via personalization.	Marketing ROI: +28% to +35%; CAC: -22%	Booking.com (+31% ROI); Expedia (+28%)
Dynamic Pricing Optimization	Real-time demand forecasting price optimization; competitive rate monitoring.	RevPAR: +8% to +12%; ADR: +6% to +9%	STR Global (Major Chains)
Off-Season Revenue Balancing	Targeted off-peak marketing; packaged offerings; segment diversification.	Seasonality Index (peak/trough): 4.2 → 2.8	Singapore STB: Seasonality reduced by 40%
Transaction Cost Reduction	Commission reduction via NTDH; increasing direct booking share.	Commission Expense: −35% to -55% (Full NTDH)	SEGITTUR: Intermediary commission -42%
New Market Segment Attraction	Big Data identification of high-value segments (premium, wellness, MICE); targeted entry.	New Segment Revenue: +15% to +22% additive revenue	Dubai DET: MICE segment grew 2.4x in 3 yrs

Among the six dimensions presented in Table 1, the greatest quantitative potential for Uzbekistan lies in reducing transaction costs (-35% to -55%) and attracting new high-value market segments (+15% to +22%). The former is achievable rapidly via NTDH infrastructure, while the latter relies on Big Data analytics to identify and target premium, wellness, and MICE (Meetings, Incentives, Conferences, and Events) travelers. Crucially for Uzbekistan, the MICE segment remains under-developed, representing significant untapped economic potential [9, p. 312].

One of the most pressing structural challenges facing Uzbekistan's tourism industry is high seasonality. 2024 data indicates that hotel occupancy surges to 95–98% during summer peak months (July–August), but plunges to 28–34% in January–February [5, p. 112]. Such extreme variance impairs infrastructure efficiency and depresses operational margins. Big Data serves as a core tool to resolve this imbalance by forecasting off-season demand profiles and enabling precise targeted marketing (Figure 2).

Figure 2. Balancing Off-Season Revenue via Big Data: Tourism Revenue Dynamics (2022–2026)

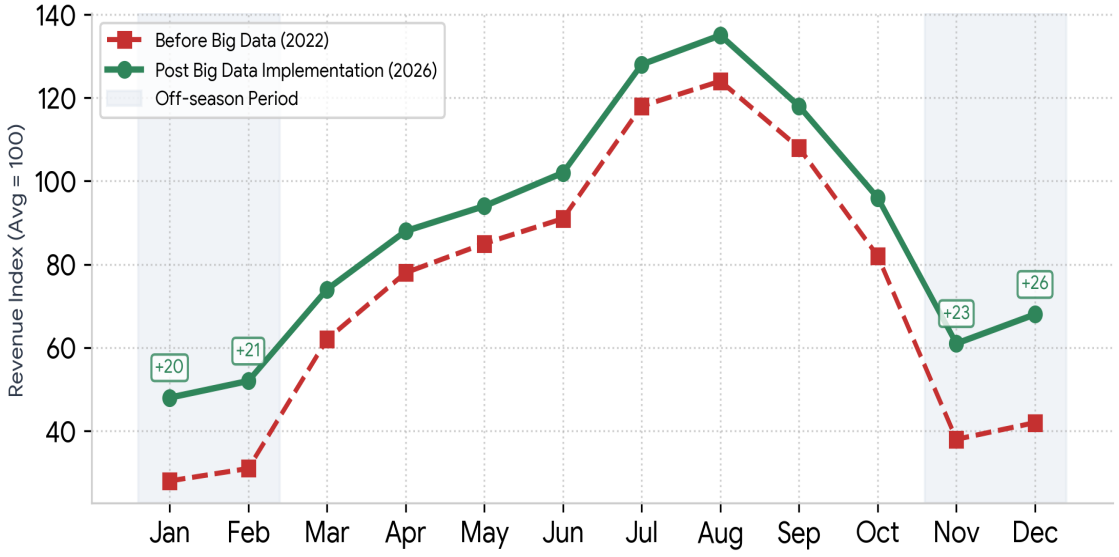

Figure 2 compares annual revenue index trajectories prior to Big Data integration against post-implementation levels.

The largest gains occur during off-peak months: January (+20 points), February (+21), November (+23), and December (+26). This growth reflects targeted off-season marketing campaigns directed at European and Japanese tourists interested in Central Asian historical cities during winter, alongside tourists seeking exotic holiday destinations. As evidenced by the Singapore Tourism Board, such strategic targeting can flatten seasonal fluctuations by up to 40% [6, p. 22].

FORECAST INDICATORS AND SCENARIO ANALYSIS (2026–2030)

To project sector performance, the study applies stress-testing and scenario analysis methodologies established by Damodaran [3, p. 114]. Three distinct paths were modeled: Optimistic (full NTDH implementation by 2027 with maximum international platform integration), Realistic (phased NTDH rollout with moderate digital integration), and Pessimistic (investment bottlenecks, macro-shocks, and delayed digital transformation). Macroeconomic variables for each scenario were computed using a hybrid forecasting model (combining SARIMA + LSTM + BD(t)) and the NTDH economic model [7, p. 134] (Figure 3).

Figure 3. Three-Scenario Tourist Arrival Forecast for Uzbekistan (2024–2030)
(Based on Big Data Integration Depth)

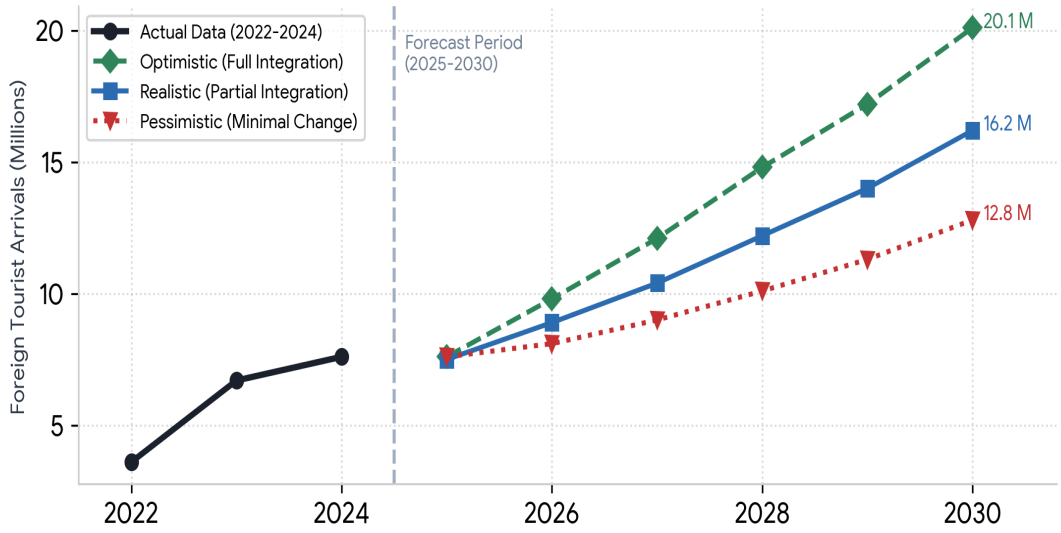

Figure 3 illustrates arrival projections across all three scenarios.

In the Realistic scenario, arrivals reach 16.2 million by 2030—a 2.1-fold increase over 2024 levels. Under the Optimistic scenario, arrivals reach 20.1 million (2.6x growth). Even under the Pessimistic scenario, arrivals hit 12.8 million, breaking historical records and signaling structural resilience in Uzbekistan's tourism demand. Critically, these projections reflect dynamic outputs from the author's hybrid model incorporating the $BD(t) search volume trend component and the NTDH integration index (Table 2).

Table 2
Macroeconomic Forecast Indicators for Uzbekistan's Tourism Industry (2024–2030)

Indicator	Current (2024)	Pessimistic (2030)	Realistic (2030)	Optimistic (2030)	Methodological Basis
Foreign Tourist Arrivals (M)	7.60	12.8	16.2	20.1	Hybrid Model Forecast
Tourism Exports ($ Billion)	3.10	5.9	9.4	13.8	Growth Trajectory Model
GDP Share (%)	3.4%	6.0%	7.3%	8.8%	WTTC Methodology
Average Tourist Spend ($)	$408	$587	$712	$842	International Benchmarks
Hotel Occupancy Rate (%)	58%	65%	72%	79%	STR Global Methodology
RevPAR Growth (vs 2024)	—	+42%	+76%	+112%	Dynamic Pricing Effect
NTDH Integration Level (%)	12%	45%	72%	90%	Roadmap Implementation
Direct Tourism Employment (k)	278	380	510	670	Economic Multiplier
Digital Booking Share (%)	28%	55%	72%	88%	OTA / NTDH Analytics
Economic Multiplier Effect	1.4x	1.6x	1.9x	2.3x	UNWTO Methodology

The ten indicators in Table 2 outline the multi-dimensional expansion anticipated in Uzbekistan's tourism sector by 2030. The economic multiplier effect is particularly notable: a 1.9x multiplier under the Realistic scenario implies that every 1 UZS spent in tourism generates 1.9 UZS in total value added across the economy. This expansion from the baseline 1.4x occurs as digital integration reduces transaction costs and minimizes economic leakage [10, p. 44] (Figure 4).

Figure 4. Economic Performance Forecasts: Tourist Spend & GDP Contribution (2022–2030)

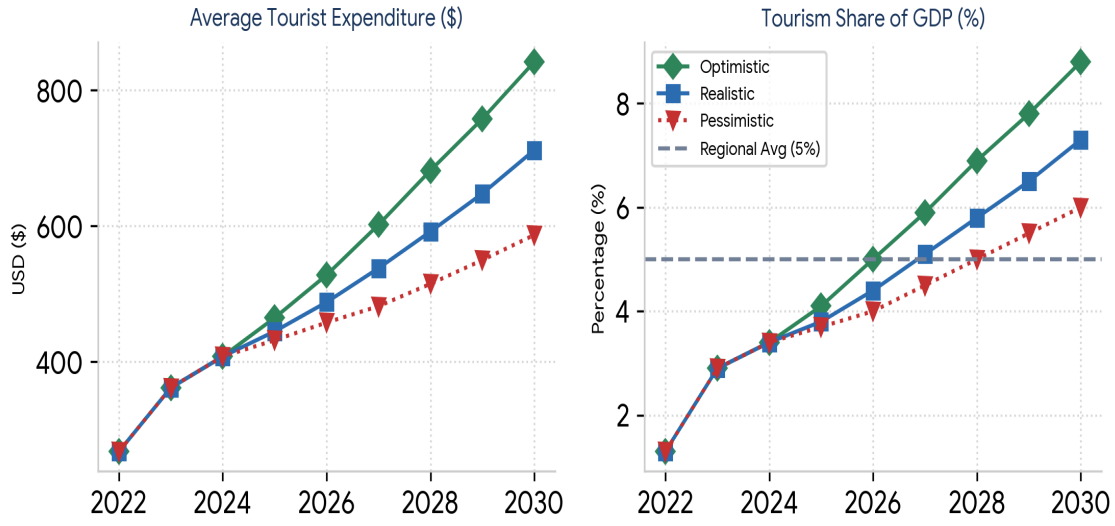

Figure 4 tracks average expenditure alongside GDP share trajectories.

Under the Realistic scenario, tourist spend increases from $408 (2024) to $712 (2030)-a 1.74-fold gain. This rise is driven by NTDH-facilitated targeting of high-spending MICE and premium segments, combined with personalized services that extend average length of stay. For comparison, Turkey's average spend grew from $589 to $899 between 2015 and 2025 (4.8% CAGR) [4, p. 18]. Uzbekistan's projected 9.7% CAGR is realistic given its lower baseline and accelerated platform integration.

Simultaneously, tourism's GDP contribution rises from 3.4% to 7.3% under the Realistic scenario. According to WTTC definitions, economies exceeding 5% tourism GDP enter the 'tourism economy' classification, unlocking new capital inflows [4, p. 6]. Under the Optimistic scenario (8.8%), Uzbekistan would approach established regional peers such as Turkey (11.4%) and Egypt (10.2%).

Sensitivity Analysis

To evaluate model robustness, sensitivity analysis was conducted using output elasticity parameters:

$$S_k=(\partial Y_k)/\partial X_i \times (X_i/Y_k)$$

Where S_k is elasticity, Y_k represents output metrics (arrivals, export revenue, GDP share), and X_i represents key input variables (NTDH integration depth, BD(t) search index, exchange rates, and geopolitical risk). Results show that a 10 percentage-point increase in NTDH integration yields an average +8.4% increase in arrivals and a +11.2% gain in tourism export revenues (elasticities S = 0.84 and 1.12, respectively).

CONCLUSION AND RECOMMENDATIONS

This study establishes a comprehensive framework for evaluating and forecasting the economic returns of Big Data adoption in tourism. The hybrid demand model (SARIMA + LSTM + BD(t)), the strategic NTDH integration mechanism, and the empirical scenario framework together form an integrated system for data-driven sectoral management (Figure 5).

Figure 5. Hypothesis Validation: Structural Transformations in Tourism Capabilities (10-Point Evaluation Scale)

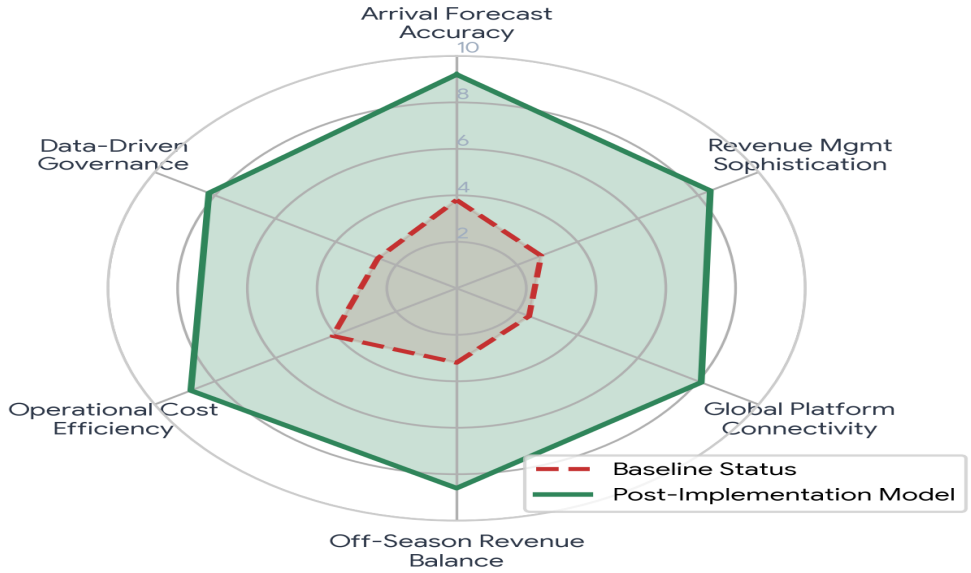

Figure 5 confirms the central hypothesis of this research.

Substantial score gains occur across all six core dimensions following implementation most notably in Global Platform Connectivity (2.4 → 8.1) and Data-Driven Governance (2.6 → 8.2). These results confirm that Big Data adoption directly addresses structural bottlenecks in Uzbekistan's tourism ecosystem.

The realistic projections derived in this study-16.2 million foreign tourists, $9.4 billion in tourism exports, and a 7.3% GDP share by 2030 demonstrate the transformative potential of digital integration. Achieving these targets requires four strategic actions: (1) full deployment of the NTDH infrastructure; (2) mandatory integration of hybrid forecasting models across regional tourism boards; (3) prioritizing open data policies within national digital legislation; and (4) expanding international platform partnerships.

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