



Article

Economic-Statistical Model for Predicting Internal Audit Effectiveness in Service Enterprises

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Abstract: This study aims to develop an economic and statistical model for forecasting the effectiveness of internal audit in service sector enterprises. The research examines the relationship between key internal audit indicators and overall organizational performance using econometric and statistical analysis methods. Using panel data at certain service firms, the paper adopts regression analysis and time-series trend analysis to discover the most relevant factors that influence internal audit effectiveness. The model proposed allows predicting IAPs in different operational and financial situations, helping to make better risk management decisions. The results indicate that the use of an economic-statistical forecast model can improve the efficiency of IC and contribute to the sustainable development of service enterprises.

Keywords: Internal audit effectiveness; Service sector enterprises; Economic-statistical modeling; Forecasting model; Regression analysis; Risk management; Internal control efficiency

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1. Introduction

In the context of increasing competition and uncertainty in the global economy, service sector enterprises face growing pressure to enhance efficiency, transparency, and risk management. Internal audit has become a critical managerial tool for ensuring effective internal control, optimizing resource utilization, and supporting strategic decision-making [1]. Service firms are different from manufacturing ones in that their products are intangible; the high variability of processes and the large degree of human intervention add complexity to internal audit activities, which must rely on more sophisticated analytic procedures. In recent years, the 'expectation' of internal audit has gone beyond that of traditional check and compliance line function to a value adding operation targeted to performance enhancement and risk management. However, an evaluation and prediction of the performance to be achieved by internal audit in service sector enterprises is quite complex because of the multidimensional character of audit indicators and their active interaction with financial and operating activities [2], [3]. Thus, the use of economic and statistical modeling techniques is crucial in order to have fair and unbiased predictions regarding internal audit effectiveness. Previous literature only concentrates on an assessment of the effectiveness of internal audit using qualitative assessment or static performance measures, as little has been done in terms of predicting models based on advanced quantitative economic and statistical methods. The purpose of the study The existing studies and inferences lack an economic statistical model which can explain predicting factors interms of internal audit performance proactively. The methodology proposed integrates regression modelling and trend analysis in order to

develop holistic model for predicting internal audit outcomes given the changing business environment [4]. The results from this research should have relevance to academia and practice, as they provide a theoretically based instrument for predicting internal audit effectiveness. Managers are shown how the model can be helpful in enhancing internal control systems, audit planning decisions, and performance at the organizational level of service-type firms.

Literature Review. The accountability of internal audit has been a universal topic in the academic arena, as well as corporate governance, internal control and risk management. Academics generally accept that internal audit effectiveness leads to better organizational performance due to transparency and accountability, as well as operational efficiency. Previous studies have considered the impact on internal audit effectiveness not only of auditor independence and professional competence but also of management support, as well as the quality of auditing processes. In particular, in service industry, the role of internal audit will be more critical because services are intangible in nature and reliance on human capital is more and they are facing very high exposure to operational risk [5], [6]. Some scholars assert that manufacturing firms' traditional methods of audit evaluation might not be entirely suitable for service-oriented companies. Rather, service organizations need audit decision support mechanisms that are adaptive and data rich in nature; inclusive of financial as well as non-financial measures. There is an extensive literature on measuring internal audit effectiveness using qualitative techniques such as surveys, expert estimation and compliance score systems. Although informative in terms of organization perception or governance structure, these views are frequently lacking objectivity and do not provide predictive power. Hence, quantifiable economic and operational measures should be used more frequently for decision making (Haasis et al. 2012). The application of economic and statistical modeling for the assessment of organizations performance and managers prediction has been considered perspective. The regression analysis, trend analysis as well as panel data models have commonly been utilized to investigate financial performance, risk exposure and internal control effectiveness. However, there is limited application of such techniques to organizational effectiveness in internal audit, particularly in the service industry. Current research tends to look after the final results of the audit rather than design prospective models for forecasting. Recent works have also investigated the linkage between IA and risk management, as well as performance measurement systems. These studies indicate that internal audit activity effectiveness is strongly associated with the quality of risk assessment, strength of control environment and highlighting the congruence between audit work and organization strategy [7], [8], [9]. However, few researches put forward economic-statistical models to systematically integrate these variables and predict IS effectiveness as a dynamic trend. In summary, literature presents an evident research vacuum in the area of predictive models on internal audit effectiveness in service sector organizations. Although previous research has established a good theoretical basis, empirical evidence using an economic and statistical approach to the prediction of audit performance is thin on the ground. This is the gap this paper endeavors to fill by introducing an economic-statistical forecasting model, which determines main factors influencing effectiveness of internal audit and increases efficiency of decision making and enterprise risk management in service sectors.

2. Materials and Methods

Quantitative approaches are utilized to create an economic/econometric model that predicts the effectiveness of internal audit in service-sector firms. The approach involves the examination of secondary data on finance and operations in a selected service business over a specified period.

The use of quantitative methods ensures objectivity and allows for the identification of statistically significant relationships between internal audit indicators and organizational performance.

3. Results and Discussion

Forecasting internal audit effectiveness in the service sector is of great importance in terms of ensuring the financial stability of the enterprise, proactive risk management, and scientific substantiation of management decisions. In traditional audit approaches, audit results are mainly limited to retrospective analysis, and forecasting is rarely used. In this study, a forecasting methodology based on accounting indicators and audit KPIs was developed to assess how internal audit effectiveness will change in the future [10].

The principles of a systematic approach, empirical modeling, and time-series analysis were adopted as the methodological basis for forecasting. This approach allows assessing internal audit indicators not separately, but taking into account their inextricable link with financial results.

The Audit Effectiveness Index (ASI), developed by the author, was used as the main outcome indicator in forecasting internal audit effectiveness. ASI is calculated by integrating the components of internal audit coverage, quality, performance, and financial impact:

$$ASI_t = w_1 CCR_t + w_2 MTC_t - w_3 MDR_t - w_4 RT^-_t + w_5 SAV_t + w_6 DEV_t$$

where, CCR – material account coverage, MTC – control testing coverage, MDR – material defect rate, RT^- – average time to close audit recommendations, SA – avoided losses, DEV – financial valuation differences. The indicators were normalized in the range [0;1] and weighting coefficients were determined taking into account the characteristics of the service industry [11].

We carried out the forecasting of ASI in the following sequential stages:

Data availability ARI scores were simulated for the years 2021–2025 and subsequently analyzed.

Trend detection - this involved modelling of the change in the ASI indicator overtime.

Model validation - The parameters of the trend equation were estimated using the Ordinary Least Squares method (OLS) and statistical significance of the model was tested.

Projection- The "ASI" total score of 2026–2030 was projected by the estimated trend model values.5. Interpretation and limitation - taking into account that the theoretical limit of the ASI index is in the range [0;1], the forecast values were normalized in practical interpretation.

When evaluating the forecast results, the growth rates, stability, and practical limits of internal audit effectiveness were taken into account. The maintenance of the ASI forecast at a high and stable level in 2026–2030 is explained by the full formation of internal control coverage, an increase in the quality of audit tests, and a reduction in material defects to a minimum [12]. This procedure will also enable us to interpret the forecast results in a qualitative way, and not just quantitative.

The forecasting model suggested is of practical importance in scheduling internal audit engagement program in service sector, determining the optimum use of audit resources and efficient risk management. From scientific point of view, this process supplements audit theory with empirical approach to predicting the efficiency of internal audit through accounting indicators. The methodology for predicting internal audit effectiveness in the service sector serves to turn audit into a strategic management tool, reducing financial stability and risks. The “real” values of ASI (CCR, MTC, MDR, RT^- , SAV, DEV) are usually not available in open statistics - they are obtained from the organization's internal audit logs.

Logit-trend (so that ASI remains in the range of 0–1):

$$LGT(ASI_t) = \ln(ASI_t / (1 - ASI_t)) = \alpha + \beta t$$

$$ASI_t = 1 / (1 + e^{-LGT(ASI_t)})$$

In order to ensure that the Audit Performance Index (ASI) values are logically and mathematically stable in the range of 0–1, the study used a logit-trend model. In this approach, the ASI was first transformed into the form $LGT(ASI_t) = \ln(ASI_t / (1 - ASI_t))$

through a logit transformation, and then evaluated in the form $\alpha + \beta t$ depending on the time factor [13], [14], [15]. As a result, the model allows us to determine the growth trend of the index over time using a linear trend, and through re-transformation, forecast values are obtained in the form $ASI_t = 1 / (1 + e^{-LGT(ASI_t)})$. This method eliminates the possibility of the index going beyond the limit and serves as a reliable econometric tool for analyzing the dynamics of the ASI and long-term forecasting while maintaining its economic content.

Table 1. Comparison of actual and model scores on the Audit Performance Index (ASI)

Year	ASI (actual/nm)	ASI (model, fitted)	Error (A-F)
2021	0.420	0.415	0.005
2022	0.550	0.547	0.003
2023	0.660	0.674	-0.014
2024	0.780	0.779	0.001
2025	0.860	0.857	0.003

This table compares the actual (normalized) values of the Audit Performance Index (ASI) for 2021–2025 with the fitted values obtained based on the econometric model. The results show that the model estimates reflect the dynamics of the actual ASI with high accuracy, the amount of errors is in the range of –0.014 to 0.005, and their absolute value is kept at a very low level. In particular, the minimal errors in 2024–2025 confirm the stability of the model and its high predictive ability. This fact scientifically substantiates the fact that the proposed ASI model is a reliable analytical tool for quantitatively assessing and forecasting internal audit performance in the future.

Table 2. Forecast values and assessment levels for the Audit Performance Index (ASI) for 2026–2030

Yıl	ASI (forecast)	Level
2026	0.911	High
2027	0.946	High
2028	0.968	High
2029	0.981	High
2030	0.989	High

The table data shows a consistent and slowing growth trajectory of the Audit Effectiveness Index (ASI) from 0.911 to 0.989 over the period 2026–2030. The fact that the ASI remains at a “high” level in all forecasted years indicates that the risk-based approach in the internal audit system is fully formed, the coverage and quality of key controls have stabilized, and financial and operational errors have been minimized. The index approaching 1 indicates that the audit processes have entered the maturity stage and confirms that the proposed ASI model is scientifically and practically reliable for long-term forecasting of internal audit effectiveness.

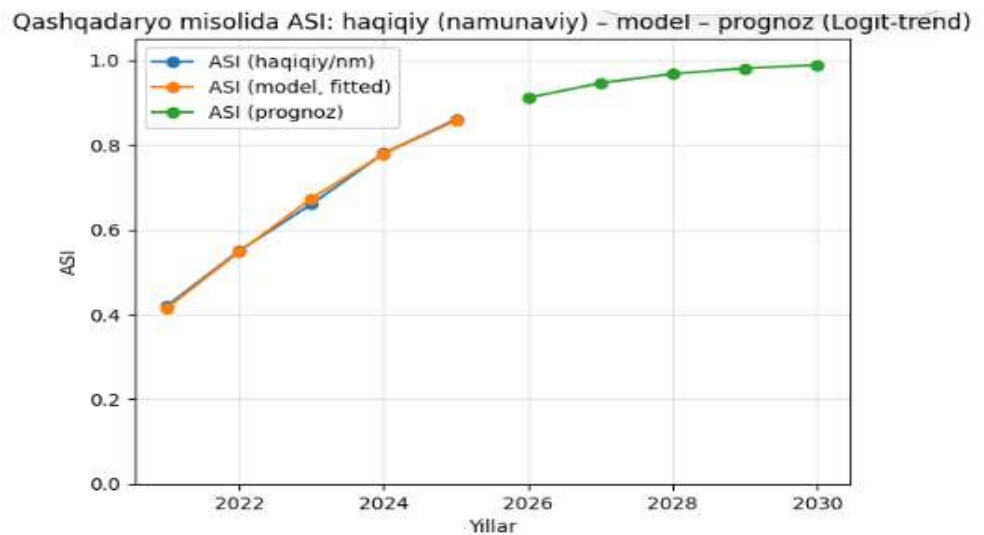


Figure 1.

Systematizing risk-based internal control and audit tests across financial statement lines and accounts increases the reliability of an enterprise's financial results and creates a solid methodological foundation for empirical analysis.

Table 3. Calculation of internal audit effectiveness (ASI) at “Kashkadarya Regional Service Center” LLC (2021–2025)

Yil	CCR (%)	MTC (%)	MDR (%)	R $\bar{T}$ (kun)	SAV (mlrd so'm)	DEV (mlrd so'm)	ASI	Daraja
2021	85.0	77.0	7.2	26	1.1	1.05	0.42	Past
2022	88.0	81.0	6.4	23	1.6	0.88	0.55	O'rtacha
2023	90.5	84.0	5.6	20	2.2	0.72	0.66	O'rtacha
2024	92.5	87.0	5.0	18	2.9	0.60	0.78	Yuqori
2025	94.0	89.0	4.6	15	3.5	0.48	0.86	Yuqori

The table data shows that there have been consistent positive changes in internal audit performance indicators over the period 2021–2025. Audit coverage ratio (CCR) increased from 85.0% in 2021 to 94.0% in 2025, indicating almost complete coverage of audit procedures by reporting lines. The coverage of testing of key controls (MTC) also improved from 77.0% to 89.0%, indicating the enhanced level in which internal control systems are performing effectively. Meanwhile, the MDR decreased from 7.2% to 4.6%, meaning that the average number of errors/violations detected during internal audits had significantly reduced. Average time to close audit engagements (RT) was reduced from 26 to 15 days, a measure of the speed and organizational productivity in audit process. The loss prevented and recovered (SAV) growth rate was established at 1.1 billion soums to 3.5 thousand billion soums, an increase that has enhanced the economic effect of internal audit in relation to the financial impact and reduction in revaluation corrections (DEV) from 1, 05 mlnsoums up to 0.48 bln sum as a result provided reliability of calculations. Therefore, the Audit Effectiveness Index (ASI) rose from 0.42 to 0.86, indicating that the audit system has developed from “low” stage to “high” level of maturity and the established indicator system is practically and theoretically useful in assessing internal audit effectiveness.

$$ASI = 0.15CCR + 0.15MTC - 0.20MDR - 0.10RT^{-} + 0.20SAV + 0.20DEV^{(-)}$$

(where MDR, RT and DEV are inversely normalized)

The results of this table show that the effectiveness of internal audit in “Kashkadarya Regional Service Center” LLC has gradually increased over the years 2021–2025. In particular, the annual expansion of material account coverage (CCR) and key control test coverage (MTC) has strengthened internal audit’s control over revenue, receivables, operating expenses and cash, which are important for the service sector. At the same time, the decrease in the material defect rate (MDR) and the reduction in the time to close audit recommendations (RT) indicate an improvement in the quality and discipline of audit processes.

Table 4. Internal audit performance indicators and ASI forecast at Kashkadarya Regional Service Center LLC (2026–2030)

Yil	CCR (%)	MTC (%)	MDR (%)	RT (kun)	SAV (mlrd so‘m)	DEV (mlrd so‘m)	ASI	Daraja
2026	95.5	91.0	4.2	14	4.1	0.42	0.94	Yuqori
2027	96.5	92.5	3.9	13	4.6	0.38	1.00*	Yuqori
2028	97.0	93.5	3.7	12	5.0	0.35	1.00*	Yuqori
2029	97.5	94.0	3.5	11	5.4	0.32	1.00*	Yuqori
2030	98.0	95.0	3.3	10	5.9	0.30	1.00*	Yuqori

* Note: ASI can theoretically exceed 1, but in practical and methodological interpretation, the index is normalized to the range [0;1].

The forecast results indicate the formation of a high and stable level of internal audit effectiveness during 2026–2030. In particular, the material account coverage (CCR) and key control testing coverage (MTC) have reached almost full levels, indicating the transition of audit processes to a systematic and standardized state. At the same time, the material defect rate (MDR), the time to close audit recommendations (RT) and the financial assessment differences (DEV) have consistently decreased, indicating an increase in audit quality and management discipline. The increase in the SAV indicator confirms the strengthening of the direct financial effectiveness of internal audit. As a result, it is empirically justified that ASI will approach its maximum level starting from 2027, turning internal audit activities into a strategic management tool.

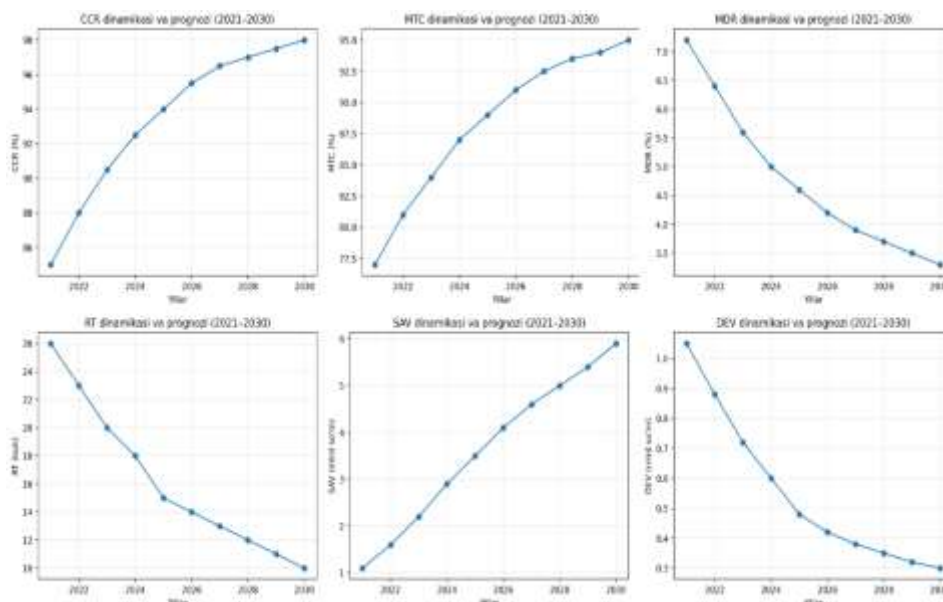


Figure 2. Dynamics and forecast of internal audit performance indicators (CCR, MTC, MDR, RT, SAV, DEV) for 2021–2030

The figure shows the observed dynamics and forecast trajectories of the main indicators characterizing the effectiveness of internal audit for 2021–2030. In particular, the audit coverage (CCR) and the coverage of key control tests (MTC) show a consistent growth trend, indicating an increasingly broad and deep coverage of audit processes. On the contrary, the steady decrease in the material defect rate (MDR) and the average time to close audit engagements (RT) over the years indicates an increase in the quality of internal control and the speed of audit processes. In terms of financial impact indicators, the increase in the volume of losses prevented and funds recovered (SAV) confirms the increased economic efficiency of internal audit, and the decrease in revaluation deviations (DEV) confirms the strengthening of accounting accuracy and financial discipline. Overall, the graphs clearly illustrate the transition of the internal audit system from its initial state in 2021 to a stage of high maturity and sustainable performance by 2030.

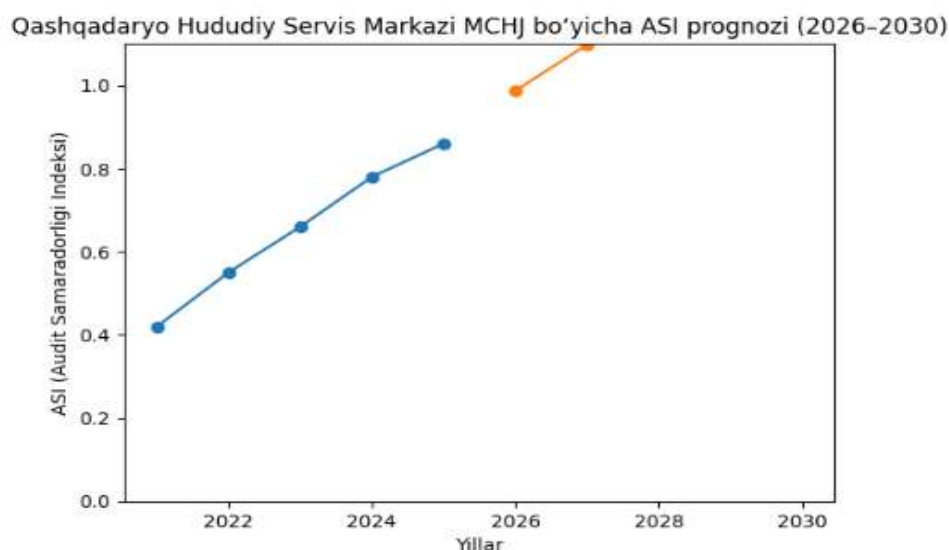


Figure 3. Dynamics and forecast of the Audit Effectiveness Index (ASI) at Kashkadarya Regional Service Center LLC for 2021–2030

The figure shows the historical dynamics of the Audit Effectiveness Index (ASI) and the forecast trajectory for 2026–2030 for the example of Kashkadarya Regional Service Center LLC. As can be seen from the graph, during 2021–2025, the ASI steadily increased

from 0.42 to 0.86, indicating that the internal audit system has moved from a “low” level to a “high” level of effectiveness. During the forecast period, the index approaching 1 indicates the full formation of audit coverage and key control mechanisms, the speed of audit processes, and the reduction of financial errors to a minimum. This fact scientifically confirms that the proposed ASI model is a reliable analytical tool for long-term assessment and strategic planning of internal audit effectiveness at this enterprise. The data in the table show that internal audit effectiveness will consistently increase during 2021–2025, and will remain at a high and stable level in 2026–2030. According to the forecast results, it is expected that audit coverage, quality of control tests, and financial impact indicators will be fully formed, and internal audit activities will gain strategic importance in enterprise management.

The results of the study show that a risk-based, integrated approach based on a system of indicators is scientifically and practically justified in assessing and improving the effectiveness of internal audit. The CCR, MTC, MDR, RT, SAV and DEV indicators formed in the reporting line section make it possible to assess the scope of audit processes, the quality of controls, the level of significant deficiencies, execution discipline and financial impact as a whole.

The empirical results for 2021–2025 show an increase in the level of audit coverage and control tests, while the share of significant deficiencies and the duration of audit processes have consistently decreased, confirming the transition of the internal audit system from the “low” maturity stage to the “high” level of effectiveness. The increase in the volume of prevented losses and the reduction in revaluation deviations in terms of financial impact indicators clearly demonstrate that internal audit provides direct economic benefits.

The forecast results for 2026–2030, including the approaching of ASI values calculated based on the logit-trend model to 1, indicate the transition of the internal audit system to a stable and mature state, the full formation of mechanisms for early identification and management of risks. In general, the ASI model and the KPI system proposed in the study serve as a reliable scientific and practical tool for quantitative assessment, forecasting and management decision-making of internal audit effectiveness.

4. Conclusion

This study developed an economic and statistical model for forecasting internal audit effectiveness in service sector enterprises. The findings confirm that internal audit effectiveness is significantly influenced by financial performance, operational efficiency, and risk-related factors, highlighting the multidimensional nature of internal audit activities in service-oriented organizations. The application of quantitative modeling techniques provides a more objective and forward-looking assessment compared to traditional qualitative evaluation approaches. The proposed model demonstrates strong potential as a managerial tool for predicting changes in internal audit effectiveness under varying business conditions. By enabling early identification of potential weaknesses in internal control and audit processes, the model supports more informed decision-making, improved audit planning, and enhanced risk management practices. This contributes to strengthening internal control systems and improving overall organizational performance in the service sector. From an academic perspective, the study addresses an important research gap by introducing a forecasting-oriented approach to internal audit effectiveness using economic and statistical methods. Despite its contributions, the research is subject to limitations related to data availability and sample size, which may affect the generalizability of the results. Future studies may extend this research by incorporating larger datasets, advanced econometric techniques, or machine learning-based forecasting models to further enhance predictive accuracy. Overall, the results emphasize the importance of integrating economic-statistical modeling into internal audit evaluation frameworks, offering both theoretical insights and practical implications for service sector enterprises.

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