MODERN APPROACHES AND PRACTICAL ASPECTS OF FORECASTING THE PERFORMANCE OF ENTERPRISES WITH FOREIGN CAPITAL PARTICIPATION

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Abstract. *In the context of an innovative economy, enterprises with foreign capital participation have become a significant driver of economic diversification, job creation, export expansion, and accelerated growth in developing countries. Consequently, forecasting the performance of such enterprises has emerged as a priority area of economic research. This article provides a comparative analysis of modern approaches to forecasting the performance of enterprises with foreign capital participation, namely panel data models, time-series (ARIMA) methods, and machine learning techniques, and complements this analysis with an original statistical illustration of global foreign direct investment (FDI) dynamics and a structured, criterion-based comparison of the methods reviewed. The findings suggest that a hybrid approach combining the interpretability of classical econometric models with the high predictive accuracy of artificial-intelligence methods is the most effective strategy in transition economies. The conclusions are of practical relevance for investment-policy design and corporate-governance decision-making.*

Keywords: *enterprises with foreign capital participation, foreign direct investment, forecasting, panel data, ARIMA, machine learning, hybrid models, MAPE, RMSE.*

INTRODUCTION

The digital economy remains the fastest-growing sector of the global economy, yet foreign direct investment (FDI) continues to account for a substantial share of world economic activity [10]. FDI can help narrow the digital divide, but the risks associated with such investment are persistent, and expected benefits are not realised automatically.

A considerable number of legacy agreements between investors and host countries constrain the policy space available to governments, or lead to the erosion or non-fulfilment of contractual terms after a certain period. This largely stems from the fact that host authorities seek to negotiate agreements that bind investors to support domestic industry, strengthen local supplier networks, and encourage technology transfer; in practice, however, roughly two-thirds of international agreements exclude such requirements, and they are fulfilled in only about one-third of cases. Against this background, the terms under which FDI has been attracted into the Uzbek economy is a question of particular scholarly interest.

Forecasting the performance of enterprises with foreign capital participation is methodologically more demanding than forecasting domestic firms, owing to distinctive characteristics such as technological superiority, international management practice, cross-border financial flows, and heightened sensitivity to the institutional environment. Contemporary forecasting science addresses this complexity by developing multi-method quantitative approaches capable of capturing both the structural determinants and the dynamic time patterns embedded in financial data.

Despite the topic's relevance, the empirical literature devoted to forecasting the performance of foreign-capital enterprises in transition economies remains limited. Most existing studies examine mature multinational corporations in advanced economies, or focus on macroeconomic FDI aggregates rather than firm-level financial trajectories. This study seeks to address that gap. The purpose of the study is to conduct a comparative analysis of modern approaches to forecasting the performance of enterprises with foreign capital participation and to develop evidence-based recommendations for their practical application in a transition-economy setting.

In line with this purpose, the following objectives were defined: to systematically review the relevant scientific literature; to compare classical econometric and modern machine-learning forecasting methods; to identify the advantages, limitations, and fields of application of each approach; and to substantiate a methodological approach suited to the conditions of a transition economy.

LITERATURE REVIEW

This section systematically reviews contemporary theories, empirical studies, and scholarly perspectives on forecasting the performance of enterprises with foreign capital participation.

Nigerian researchers A. Adamu and B. Barde argue that foreign direct investment exerts a direct or indirect positive effect on the recipient country's economy [1]. A. Lagendijk and B. Hendrikx note that FDI affects the host economy across multiple dimensions, ranging from asset, technology and capital flows to the creation of new jobs [2].

S. Makki and A. Somwaru examined the impact of FDI and external trade on economic growth using data from developing countries. Their results show that foreign investment is among the key drivers of economic growth, exerting a positive effect through technology transfer, the stimulation of domestic investment, and human-capital development. The authors note that the synergy between FDI and external trade serves to accelerate the pace of economic development [3].

L. Alfaro and co-authors used instrumental-variable regression to demonstrate that the depth of the local financial sector moderates the relationship between FDI and firm-level outcomes — a finding with direct practical implications for financial-sector deepening policy [4].

Panel-data econometrics constitutes one of the principal methodological foundations for analysing multi-subject, long-horizon observational data. The theoretical basis of this approach was formulated by Y. Mundlak [5] and J. Hausman [6], who developed methods enabling the joint estimation of time and individual effects in the behaviour of firms and economic agents. B. Baltagi provides a detailed treatment of the Fixed Effects (FE) and Random Effects (RE) specifications of panel-data models and substantiates the importance of the Hausman test as the principal instrument of model selection [7]. These results reinforce the scientific rationale for using panel-data models to forecast the performance of foreign-capital enterprises and make it possible to identify long-run relationships between investment, output volume, and financial performance.

In recent years, approaches based on machine-learning technologies have been widely applied to forecasting firm performance. In particular, G. Atsalakis and K. Valavanis, summarising research on the application of artificial neural networks in financial forecasting, note that hybrid models combining ARIMA with artificial neural networks (ANN) deliver higher forecast accuracy than traditional methods [8].

At the same time, S. Makridakis, E. Spiliotis and V. Assimakopoulos observe that classical statistical models retain their importance in forecasting. They emphasise that traditional econometric models such as regression, panel data, and ARIMA stand out for their ability to explain the economic

meaning of forecast results [9]. This capacity is particularly important for policy formulation, investment decision-making, and corporate-governance practice, where explaining the causal logic behind a forecast is essential.

The literature review indicates that, while the macroeconomic effects of FDI have been extensively studied, the methodology for forecasting the firm-level performance of foreign-capital enterprises in transition economies remains underdeveloped. This gap defines the scientific novelty of the present study.

RESEARCH METHODOLOGY

The study employed general methods of scientific inquiry — systemic analysis, comparative analysis, induction and deduction, scientific abstraction — together with specific economic-mathematical methods. The empirical basis of the study comprises UNCTAD reports, empirical studies published in international scientific journals (including Scopus-indexed publications), and foundational works on forecasting methodology.

Panel data models.

A panel-data approach is applied for the long-term observation of a group of enterprises with foreign capital participation. In its general form, the model is expressed as:

$Yit = \alpha + \beta Xit + \mu i + \varepsilon it$

where Yit is the outcome indicator of firm i in period t (e.g. net profit, output volume, or export volume); Xit is the vector of explanatory variables (investment volume, assets, employee count, etc.); μi is the unobserved individual effect; and εit is the random error term. The choice between the Fixed Effects (FE) and Random Effects (RE) specifications is made on the basis of the Hausman test [6; 7].

Time-series (ARIMA) models.

An ARIMA(p, d, q) model is applied to forecast the dynamics of an individual firm's financial indicators. The model relies on the Box–Jenkins methodology to stationarise the series (differencing of order d) and to identify the autoregressive (AR) and moving-average (MA) components.

Machine learning and hybrid models.

Artificial neural networks (ANN) were examined for the purpose of identifying non-linear relationships. In the hybrid approach, the linear component of the time series is modelled through ARIMA, while the non-linear component embedded in the residuals is modelled through an ANN; the two forecasts are then combined [8]. Model accuracy is assessed using the Mean Absolute Percentage Error (MAPE) and the Root Mean Square Error (RMSE):

$MAPE = (1/n)\ \Sigma\ |((Yt - \hat{Y}t) / Yt)| \times 100\% \qquad RMSE = \sqrt{[(1/n)\ \Sigma\ (Yt - \hat{Y}t)^2]}$

where Yt is the actual value, Ŷt is the forecast value, and n is the number of observations. Lower MAPE and RMSE values indicate higher forecast accuracy; both criteria are recommended for the empirical validation stage of the proposed hybrid framework.

RESULTS

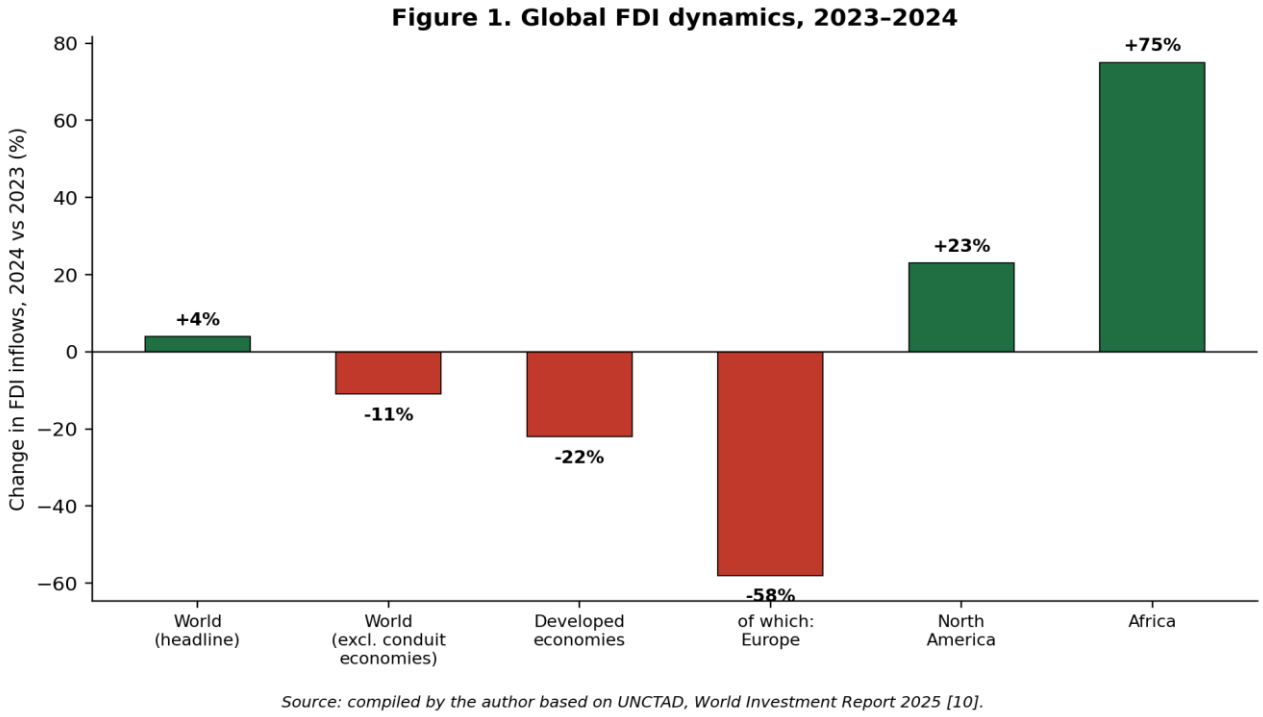
The comparative analysis made it possible to systematise the advantages, limitations, and fields of application of the principal approaches used to forecast the performance of enterprises with foreign capital participation (Table 1).

Table 1. Comparative characteristics of forecasting approaches

Method	Advantages	Limitations	Field of application
Panel data models (FE/RE)	Jointly captures individual and time effects; high economic interpretability; controls for unobserved heterogeneity	Requires correct specification testing (Hausman test); does not fully capture non-linear relationships	Long-term observation of a group of enterprises; assessment of structural determinants
ARIMA / time-series models	Accurately reflects dynamic time patterns; stable results for short-term forecasts	Limited incorporation of exogenous factors; sensitive to structural breaks	Short-term forecasting of an individual firm's financial indicators
Machine learning (ANN and others)	Detects non-linear and complex dependencies; high accuracy on large datasets	"Black-box" nature complicates economic interpretation; requires large volumes of quality data	High-precision forecasting based on multidimensional financial data
Hybrid models (ARIMA + ANN)	Combines linear and non-linear components; higher accuracy than single methods [8]	Methodological complexity; high computational demand	Complex forecasting of the financial performance of foreign-capital enterprises

Compiled by the author based on the reviewed literature [5–9].

The relevance of forecasting foreign-capital enterprise performance is underscored by the current volatility of global FDI flows. According to the UNCTAD World Investment Report 2025, global FDI inflows nominally rose by 4% in 2024, to USD 1.51 trillion; however, once volatile flows through conduit economies are excluded, global FDI actually contracted for a second consecutive year, falling by 11%, from USD 1.67 trillion in 2023 to USD 1.49 trillion in 2024. The decline was driven primarily by a 22% fall in inflows to developed economies (–58% in Europe alone), while North America recorded a 23% increase and Africa a 75% increase, largely on the strength of a single large project [10]. This divergence across regions and the sensitivity of headline figures to conduit flows illustrate precisely the type of structural volatility that firm-level forecasting models for foreign-capital enterprises must be able to accommodate.



Source: compiled by the author based on UNCTAD, World Investment Report 2025 [10].

To visualise the comparative profile of the four approaches presented in Table 1, each method was scored on an ordinal scale from 1 (low) to 5 (high) across five evaluation criteria, based on the qualitative characteristics reported in the reviewed literature (Table 2, Figure 2).

Table 2. Criterion-based scoring of forecasting approaches (ordinal scale, 1–5)

Method	Interpretability	Predictive accuracy	Robustness to shifts	Data efficiency	Computational simplicity
Panel data (FE/RE)	5	3	3	4	4
ARIMA	4	3	2	4	5
Machine learning (ANN)	1	4	3	2	2
Hybrid (ARIMA + ANN)	3	5	4	3	2

Author's synthesis of the reviewed literature [5–9]; scores are qualitative and illustrative, not derived from a single empirical estimation.

Figure 2. Qualitative comparison of forecasting approaches (author's synthesis of the reviewed literature, ordinal scale 1–5)

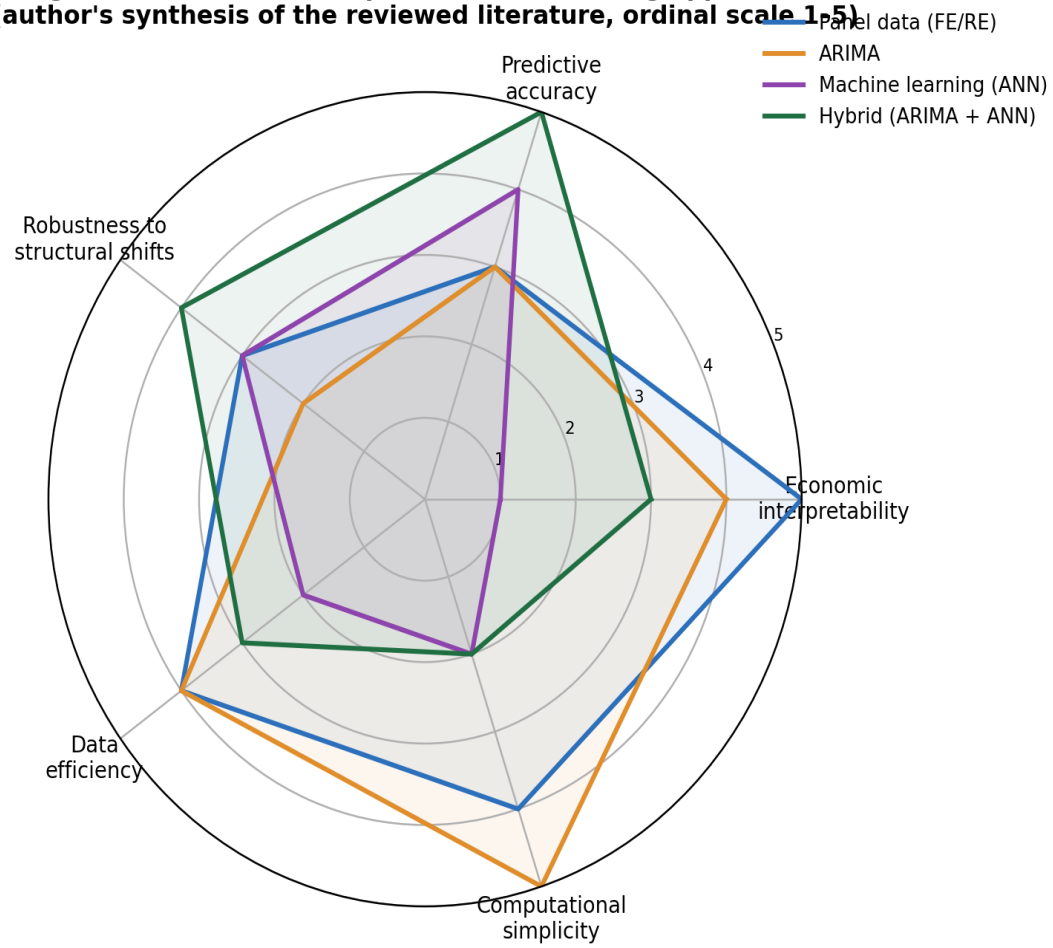
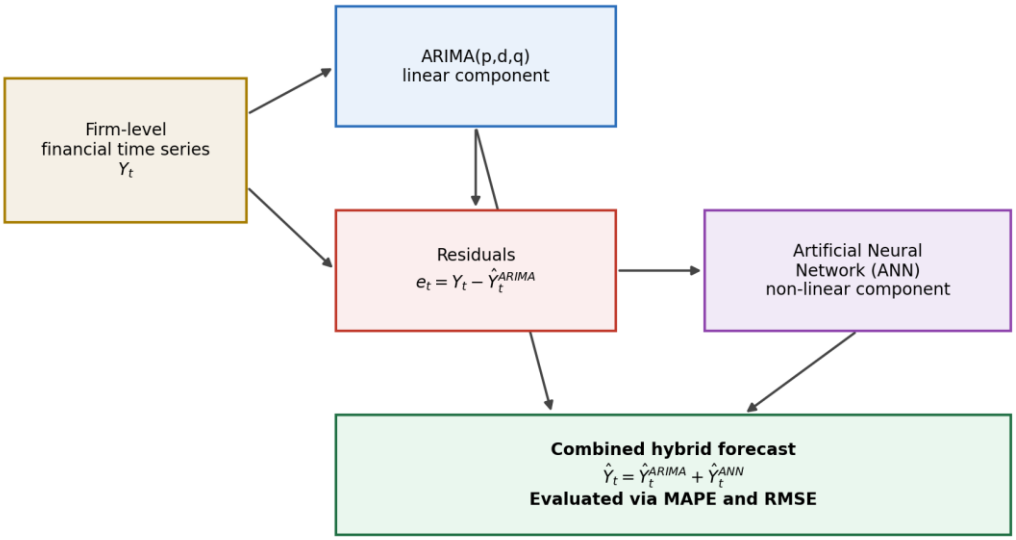


Figure 2. Radar comparison of the four forecasting approaches across five evaluation criteria.

Figure 2 makes visually explicit the trade-off already implicit in Table 1: panel-data models and ARIMA dominate on interpretability and computational simplicity, whereas ANN-based methods dominate on predictive accuracy but score lowest on interpretability. The hybrid ARIMA–ANN configuration occupies an intermediate position on most axes while achieving the highest score on predictive accuracy, which is consistent with its role as a bridge between the two method families.

The internal logic of the hybrid model is summarised in Figure 3: the linear component of the firm-level time series is first extracted using ARIMA, the resulting residuals are passed to an artificial neural network to capture any remaining non-linear structure, and the two forecasts are then combined into a single output that is evaluated using MAPE and RMSE.

Figure 3. Conceptual architecture of the ARIMA-ANN hybrid forecasting model



Source: compiled by the author based on the ARIMA–ANN combination logic described in [8].

The analysis yields the following principal conclusions.

First, panel data models constitute the most appropriate structural framework for studying the performance of a group of enterprises with foreign capital participation, since they make it possible to identify long-run relationships between investment and financial performance while controlling for inter-firm heterogeneity — management quality, technological level, and industry-specific characteristics — that would otherwise remain unobserved [5–7].

Second, while ARIMA models produce stable results in short-term operational forecasting, they do not adequately reflect structural shifts specific to transition economies, such as changes in the institutional environment or currency-policy reforms. This creates the need to enrich such models with exogenous variables or to combine them with other methods.

Third, machine-learning methods, and artificial neural networks in particular, achieve high forecast accuracy on multidimensional data, but their "black-box" nature complicates the causal interpretation required for public-policy and corporate decision-making [9].

Fourth, hybrid models based on the combination of ARIMA and ANN achieve higher accuracy than either method used in isolation by jointly modelling linear and non-linear components [8], which positions them as the preferred approach for forecasting the complex financial dynamics of enterprises with foreign capital participation.

DISCUSSION

The results obtained are consistent with the principal conclusions of the international literature. In particular, the finding on the superiority of hybrid models confirms the results of Atsalakis and Valavanis [8], while the advantage of classical econometric models in terms of interpretability corresponds to the position of Makridakis and co-authors [9]. At the same time, this study indicates the need to adapt these general conclusions to the context of a transition economy — and, specifically, to the conditions of Uzbekistan.

Forecasting the performance of foreign-capital enterprises in a transition-economy setting has several distinctive features: relatively short statistical series, structural shifts arising from institutional reform, and limited availability of open firm-level data. Under these conditions, reliance solely on

data-driven "black-box" methods risks producing misleading conclusions. It is therefore advisable to retain economic-theory-grounded panel models as the structural core of the analysis while enhancing their forecast accuracy with machine-learning components — a design choice that is also reflected in the criterion profile shown in Figure 2, where panel models score highest on interpretability while hybrid models score highest on accuracy.

A limitation of the study should be noted: it is methodological and comparative in character. Future research is planned to empirically test the proposed hybrid approach using real firm-level data on enterprises with foreign capital participation in Uzbekistan, applying the MAPE and RMSE criteria formalised in Section 3, which would also fill the existing empirical gap.

CONCLUSION AND RECOMMENDATIONS

Enterprises with foreign capital participation constitute an important driver of economic diversification, job creation, and export-potential expansion in developing countries, including Uzbekistan; forecasting their future performance on a scientifically sound basis is therefore of strategic importance for economic policy and corporate governance.

Based on the study's findings, the following conclusions were formulated: (1) for studying groups of enterprises with foreign capital participation, panel data models (with FE/RE specification selected via the Hausman test) are the most appropriate instrument of structural analysis; (2) ARIMA models are effective for short-term operational forecasting, provided they are enriched with exogenous factors; (3) a hybrid approach (ARIMA + ANN) combining high accuracy with economic interpretability constitutes the most promising methodological solution under transition-economy conditions.

In practical terms, it is recommended that government agencies rely on interpretable econometric models when monitoring the effectiveness of investment policy, while enterprises and analytical centres are advised to introduce hybrid forecasting systems into financial planning. Future research will focus on empirical evaluation based on Uzbekistan's official statistics.

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