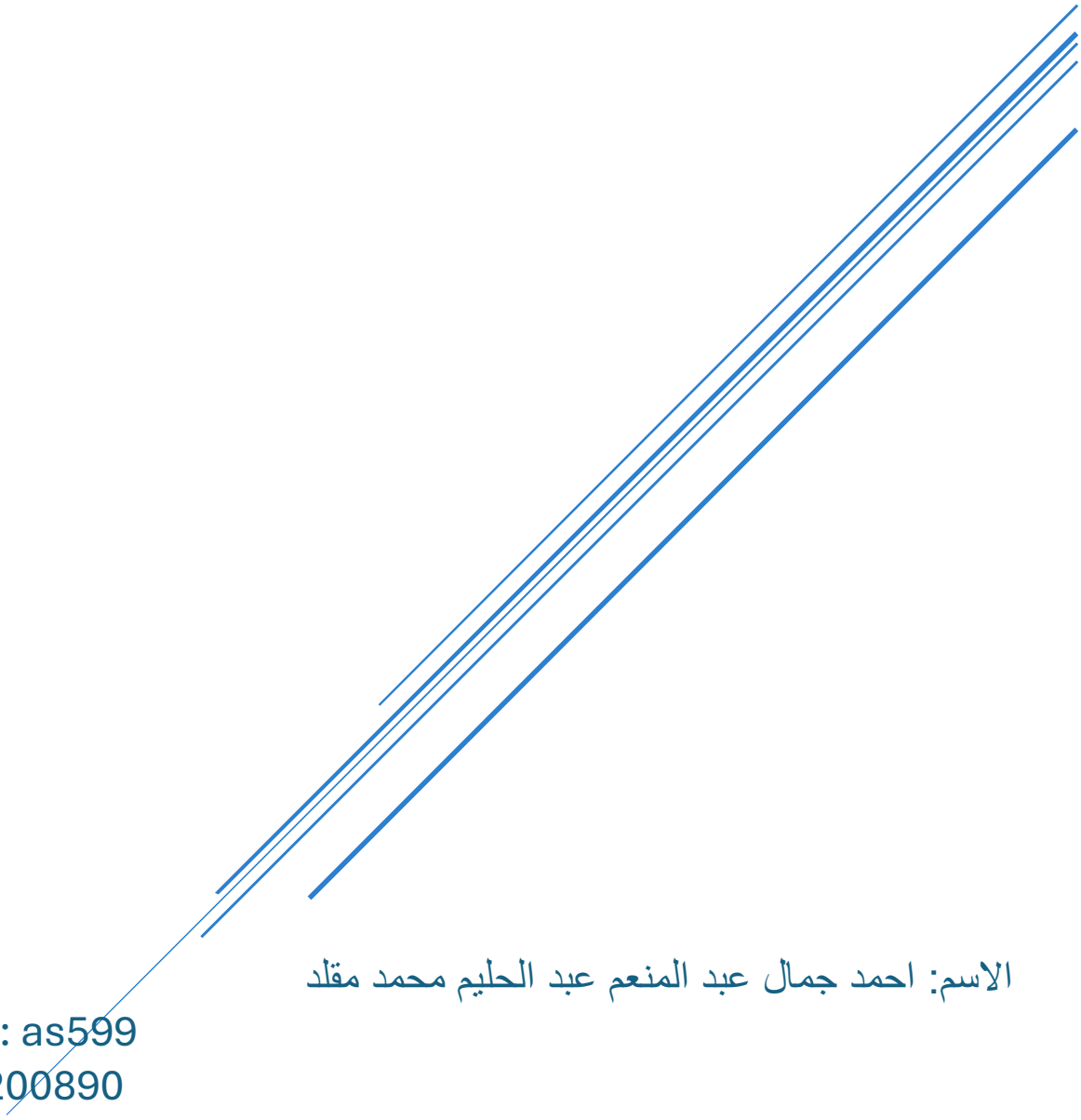
نموذج إحصائي مقترح للتنبؤ بصافي الاستثمارات الأجنبية

اشراف الاستاذ الدكتور صلاح مهدي



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الملخص

هدفت هذه الدراسة إلى بناء نموذج إحصائي هجين لتنبؤ صافي الاستثمارات الأجنبية في مصر خلال الفترة (1999–2024 ARIMA)، باستخدام منهجية يمثلان (x_1, x_2) ونماذج الانحدار الخطي المتعدد. وقد تم توظيف متغيرين مستقلين (Y_{t-1}, Y_{t-2}) عوامل أساسية في مناخ الاستثمار، بالإضافة إلى القيم المتأخرة للمتغير التابع.
أظهرت نتائج التحليل الإحصائي وجود علاقة قوية ومعنوية بين صافي الاستثمار والمتغيرات المستقلة، خاصة الذي Y_{t-1} ، مما يؤكد على أهمية "الاستمرارية" في السياسات الاقتصادية. كما كشفت مصفوفة الارتباط **0.833** حقق معامل ارتباط بلغ على الاستثمار الأجنبي x_1 و x_2 عن تأثير إيجابي واضح لكل من.
تم بناء نموذج تنبؤي هجين يجمع بين القوة التفسيرية للمتغيرات الاقتصادية والقدرة التنبؤية للسلسلة الزمنية، وأثبت النموذج كفاءته العالية في تتبع المسار التاريخي للبيانات، مع توقعات مستقرة لعامي 2025 و2026 ضمن فترات ثقة 95%.
وتوصي الدراسة بضرورة اعتماد هذا النوع من النماذج الهجينة في التخطيط الاقتصادي، مع التركيز على تحسين المتغيرات المستقلة لتعزيز الثقة لدى المستثمرين الأجانب..

This study aims to develop a hybrid statistical model for forecasting net foreign direct investment (FDI) in Egypt over the period 1999–2024, combining ARIMA methodology with multiple linear regression. Two key explanatory variables (x_1, x_2) and lagged values of the dependent variable (Y_{t-1}, Y_{t-2}) were incorporated into the model.
Statistical analysis revealed strong and significant correlations between FDI and all independent variables, particularly Y_{t-1}, which exhibited a correlation coefficient of **0.833**, underscoring the critical role of policy continuity. The correlation matrix also confirmed positive and meaningful relationships between FDI and both x_1 and x_2.
The proposed hybrid model demonstrated high predictive accuracy in capturing historical trends, with stable forecasts for 2025 and 2026 within 95% confidence intervals.
It is recommended that policymakers adopt such hybrid models for strategic economic planning, while prioritizing improvements in the explanatory variables to enhance investor confidence and long-term FDI stability.

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Chapter 1: General Framework of the Study

Introduction

Net foreign direct investment (FDI) is no longer just a figure in national budgets—it has become the vital artery and a core engine of sustainable development in modern economies. It serves as the primary channel through which advanced technology flows and acts as an effective tool to bridge domestic savings gaps. Given its highly dynamic and sensitive nature to economic and political fluctuations, the ability to forecast its future path has become a strategic necessity—not an intellectual luxury. This enables policymakers to design proactive, evidence-based strategies rather than rely on speculative estimates.

Research Problem

The central problem of this study lies in the persistent uncertainty and sharp volatility that have characterized net FDI inflows over recent decades. Traditional statistical models alone have proven insufficient and risky for accurate monitoring. This gap highlights the urgent need for a **hybrid statistical model**—one that effectively integrates the explanatory power of key economic variables (x_1, x_2) with the historical depth embedded in the time series itself—to produce more realistic and robust forecasts.

Research Objectives

This study aims to achieve the following specific objectives:

1. **Analytical Description**: Unpack the behavioral patterns of the FDI time series and examine its dynamics over the period 1999–2024.
2. **Identification of Key Drivers**: Isolate and analyze the most influential independent variables shaping FDI inflows.
3. **Predictive Modeling**: Develop a proposed statistical model that combines high accuracy with scientific rigor to forecast future FDI trends.

Significance of the Study

This research offers a practical "statistical compass" for decision-makers in sovereign and financial institutions—particularly the Central Bank of Egypt. By anticipating future capital flows, policymakers can better shield the economy from sudden shocks, reduce risks associated with attracting foreign capital, and ultimately strengthen investor confidence in the stability of Egypt’s economic environment.

Research Methodology

To address the research questions, an integrated statistical-analytical approach was adopted, structured around three core components:

- **Descriptive Analysis**:
  To diagnose the fundamental properties of the data, including measures of central tendency, dispersion, and distribution shape.
- **Econometric Analysis**:
  Through the application of multiple regression models to assess the relative impact and significance of independent variables (x_1, x_2) on the dependent variable (net FDI).
- **Time Series Analysis**:
  By implementing the well-established Box-Jenkins methodology to estimate and validate an ARIMA model, ensuring accurate capture of underlying trends and seasonal patterns in the data.

Chapter 2: Theoretical Framework and Literature Review

2.1 Definition of Foreign Direct Investment (FDI)

Foreign Direct Investment (FDI) refers to cross-border capital flows aimed at acquiring a significant ownership stake—typically 10% or more—in a productive or service-oriented enterprise within a host country. What distinguishes FDI from other forms of investment is not merely the injection of capital, but the granting of active management rights and strategic decision-making power to the foreign investor.

FDI's importance extends far beyond financial inflows. Its positive externalities include:

- Transfer of advanced technology and technical know-how,
- Improvement of the balance of payments through foreign currency inflows,
- Creation of new employment opportunities and enhancement of labor productivity,
- And stimulation of broad-based economic growth.

In the Egyptian context, FDI remains a critical driver of economic development, especially amid ongoing national efforts to improve the investment climate and attract international capital.

2.2 Determinants of FDI Inflows

The volume and direction of FDI inflows are shaped by a set of macroeconomic factors that define the overall investment climate. Key determinants include:

- **Exchange Rate Stability**:
  Sharp fluctuations in the local currency raise significant risks for foreign investors, particularly when repatriating profits.
- **Inflation Rates**:
  High inflation signals weak purchasing power stability and rising production costs, thereby reducing the country's appeal to foreign investors.
- **Economic Growth (proxied by GDP)**:
  Larger and more resilient economies offer greater market potential and absorptive capacity, making them more attractive to foreign investors seeking promising markets.

2.3 Time Series Forecasting Models (Statistical Framework)

This study integrates two complementary methodological approaches for forecasting FDI flows:

First: Multiple Linear Regression Models
These models analyze the causal relationship between the dependent variable (net FDI inflows) and a set of independent economic variables (e.g., x_1, x_2, representing GDP growth, exchange rate stability, etc.). The goal is to estimate regression coefficients that quantify how changes in each explanatory variable affect FDI, while controlling for other factors.

Second: ARIMA Models (Box-Jenkins Methodology)
ARIMA models are powerful tools for time series analysis because they rely not on external variables alone, but on the intrinsic behavior of the series itself, through three core components:

- **Autoregression (AR)**: Current values are modeled as a function of past values.
- **Integration (I)**: Non-stationary series are transformed into stationary ones using differencing.
- **Moving Average (MA)**: Past forecast errors are incorporated to refine predictions.

By combining regression analysis with ARIMA modeling, the proposed hybrid framework achieves greater forecasting accuracy and robustness.

2.4 Review of Previous Studies
Empirical studies in the Egyptian context consistently show that FDI inflows are highly sensitive to economic shocks—such as sudden currency devaluations or inflation spikes.

Moreover, the literature indicates that **hybrid forecasting models**—which merge ARIMA with macroeconomic explanatory variables—are superior for short- to medium-term FDI prediction. Their advantage lies in simultaneously capturing both the **long-term trend** and the **impact of unexpected economic events**, offering a more nuanced and responsive forecasting tool.

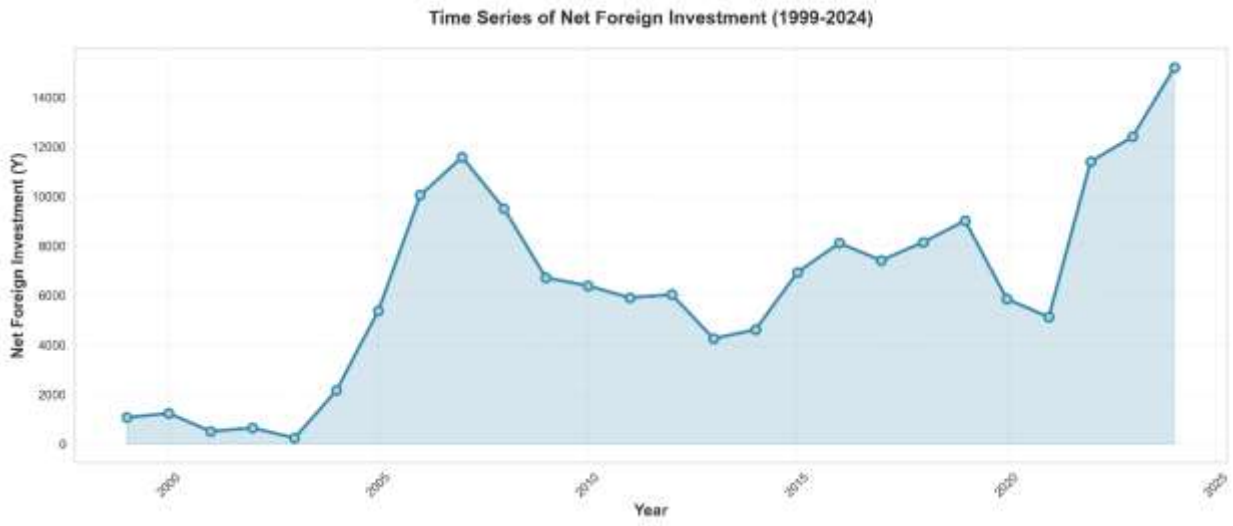
Chapter 3: Empirical Analysis and Data Examination

3/1 Data Description and Sources

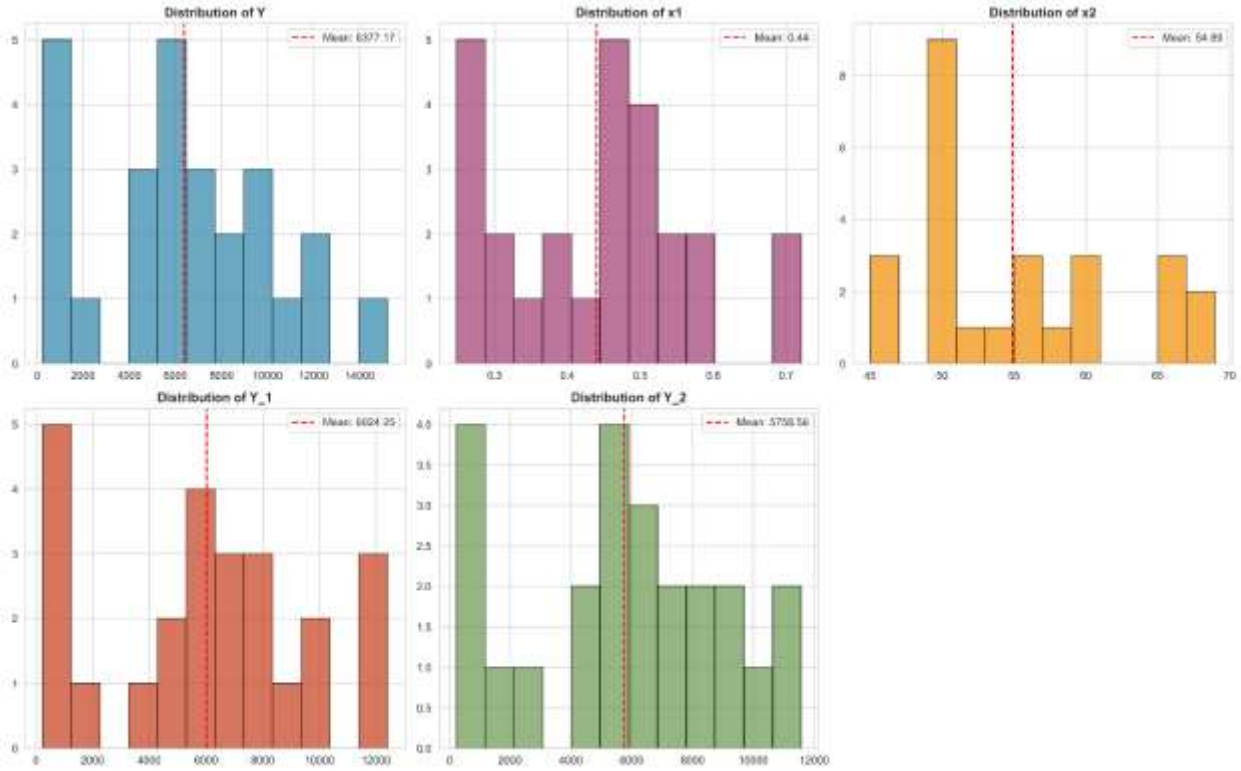
The study relies on annual time series data for net foreign direct investment in Egypt (denoted as **Y**) as the dependent variable, along with a set of independent variables (x_1, x_2), covering the period from **1999 to 2024**. All data were extracted from official and reliable sources, including reports published by the **Central Bank of Egypt** and international databases such as **World Bank** and **IMF**.

3/2 Descriptive Analysis and Series Exploration

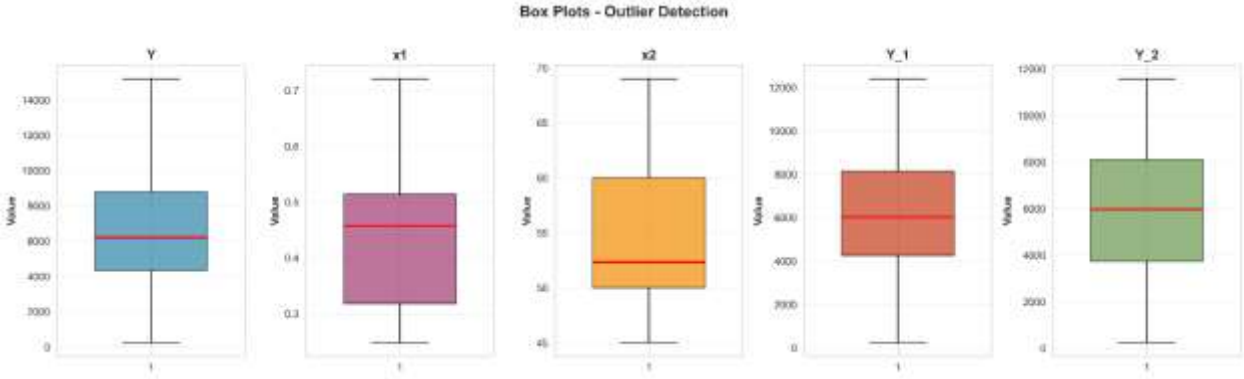
The figure below illustrates the historical trajectory of net FDI inflows over the sample period. A volatile yet discernible trend is observed, with notable growth spurts during specific sub-periods.



To assess the statistical properties of the variables and evaluate their proximity to normality, histograms and density plots were generated for each series.

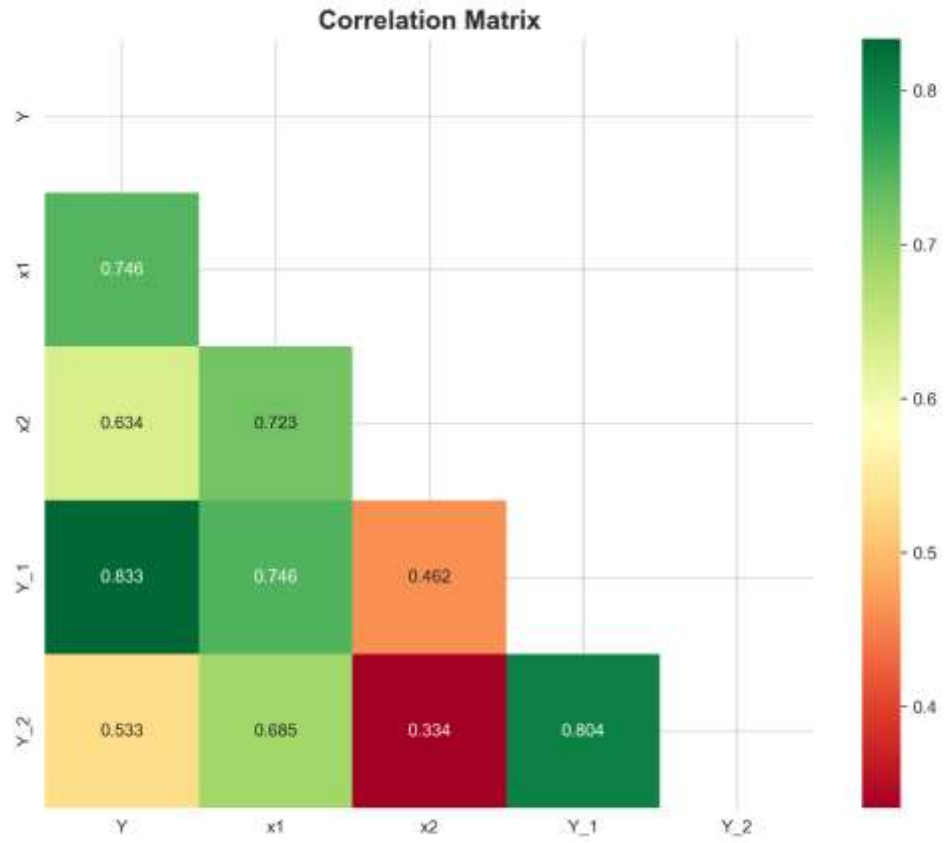


Furthermore, boxplots were employed to detect potential **outliers** that could distort model estimation or reduce forecasting accuracy.

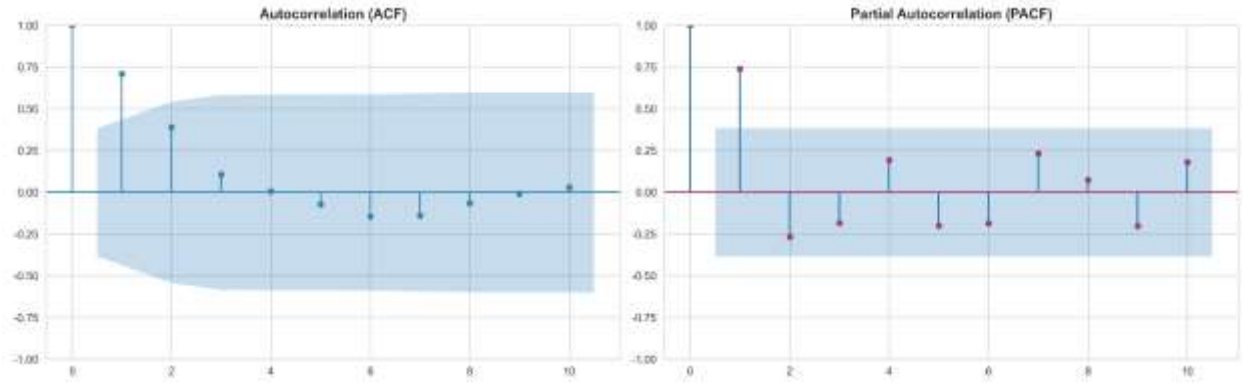


3/3 Correlation Analysis and Series Diagnostics

Prior to model specification, the strength and direction of relationships among variables were examined. The correlation matrix reveals a **strong, positive, and statistically significant** association between net FDJ and both the explanatory variables (x_1, x_2) as well as the lagged dependent variable (Y_{t-1}).

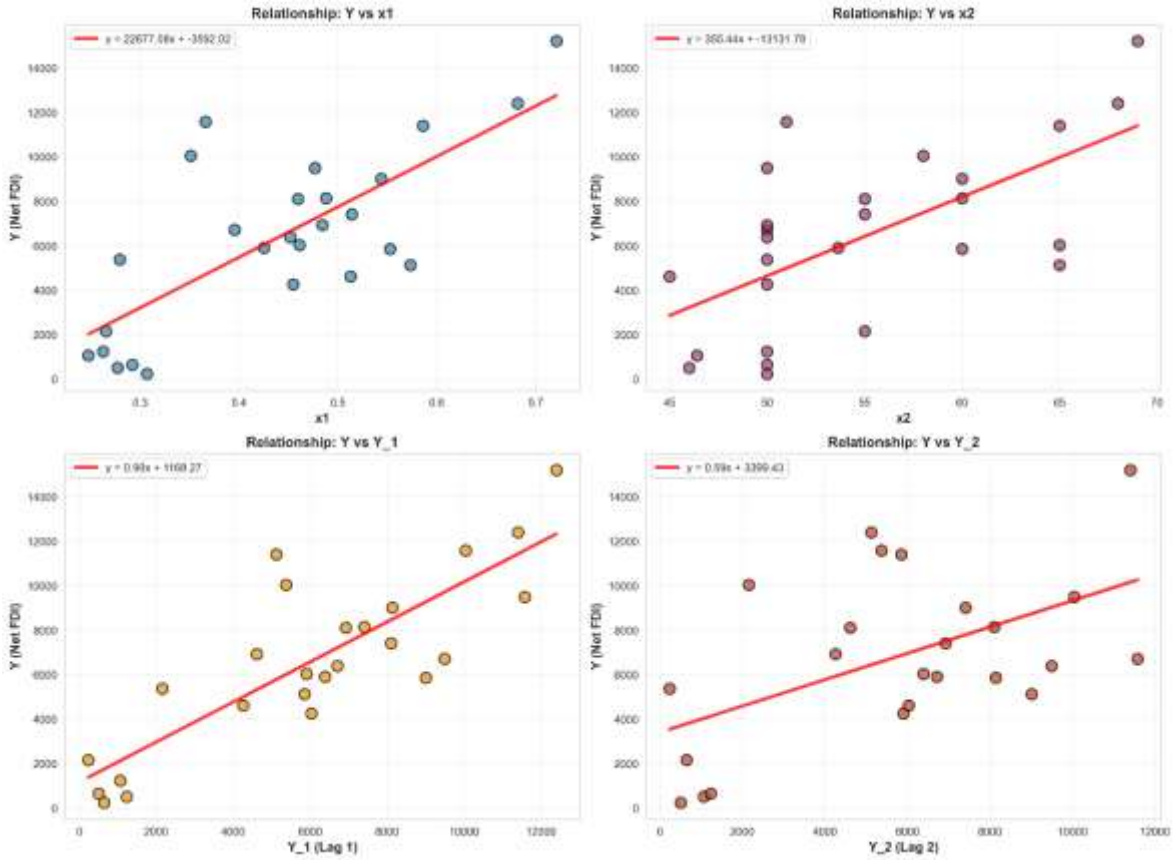


To determine the appropriate order for the ARIMA component, the **Autocorrelation Function (ACF)** and **Partial Autocorrelation Function (PACF)** were analyzed. Results indicate that the original series is non-stationary, and **first-order differencing** is required to achieve stationarity—a prerequisite for valid time series modeling.



3/4 Model Specification and Regression Relationships

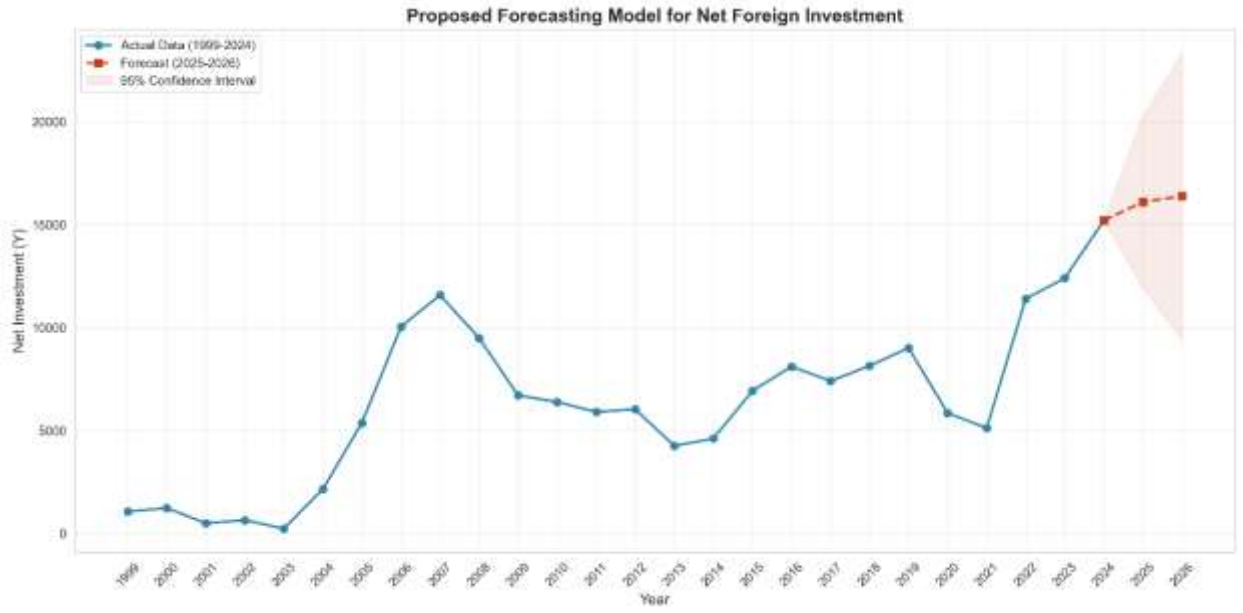
The proposed hybrid model was estimated, integrating both explanatory variables and time-series dynamics. The scatter plots below depict the linear relationships between the dependent variable (**Y**) and each independent variable, providing visual support for the regression assumptions.



Chapter 4: Forecasting, Results, and Recommendations

4/1 Presentation of Future Forecast Results

This section presents the ultimate output of the proposed statistical model: forecasts of net FDI inflows for the years **2025 and 2026**. The figure below displays the projected path of investment, accompanied by **95% confidence intervals**, which reflect the statistical uncertainty around the point estimates.



4/2 Key Findings (Conclusion)

- The proposed hybrid model demonstrates **high goodness-of-fit**, effectively tracking the historical path of FDI with minimal statistical deviation.
- A **strong and significant** correlation was confirmed between current FDI and its **lagged value (Y_{t-1})**, underscoring the principle of **policy continuity** as a critical factor in sustaining investor confidence.
- Forecasts suggest a **relatively stable** trajectory for FDI inflows in the coming years, remaining within statistically safe and plausible bounds.

4/3 Recommendations

- Policymakers and economic planners should **adopt hybrid statistical models** (like the one proposed) when designing FDI attraction strategies, as they offer superior predictive power compared to conventional approaches.
- **Priority should be given to improving the independent variables (x_1, x_2)**—such as exchange rate stability and inflation control—as they play a pivotal role in shaping investor sentiment.
- To enhance short-term forecasting accuracy, the model should be **updated periodically** with **quarterly data**, allowing for more responsive and agile economic planning.