

The asymmetric impact of global economic policy uncertainty on FDI in the GCC countries



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ABSTRACT

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This study examines the impact of global Economic Policy Uncertainty (EPU) on foreign direct investment (FDI) inflows into the Gulf Cooperation Council (GCC) countries, a region where investment plays a critical role in economic diversification beyond hydrocarbons. The purpose is to assess whether uncertainty discourages foreign investment and whether its effects are symmetric when uncertainty rises versus falls. The analysis uses annual data for the six GCC economies covering the period 1997–2023. Both linear and nonlinear panel autoregressive distributed lag (ARDL) models are employed to capture symmetric and asymmetric long-run dynamics, while controlling for GDP growth, gross fixed capital formation, trade openness, oil rents, and regulatory quality. To complement these econometric estimations, the study applies supervised machine learning methods, Random Forest and Decision Tree regression, to evaluate the predictive importance of macroeconomic and institutional determinants. The results demonstrate that EPU significantly reduces FDI inflows across the GCC, with both increases and decreases in uncertainty exerting negative effects, reflecting persistent investor caution. Gross fixed capital formation and oil rents emerge as positive drivers of FDI, whereas trade openness shows a counterintuitive negative impact. The machine learning analysis reinforces the importance of trade openness, EPU, and GDP growth as dominant predictors, with Random Forest delivering superior predictive performance relative to Decision Trees. The findings highlight the importance of reducing policy uncertainty and strengthening institutional credibility to attract sustainable FDI. For resource-dependent economies like the GCC, enhancing regulatory quality, investing in infrastructure, and diversifying trade strategies are key to mitigating vulnerability to global uncertainty shocks.

Contribution/ Originality: This study contributes to the existing literature by examining the impact of global EPU on FDI inflows in GCC economies. It uses panel ARDL and nonlinear ARDL methodologies, complemented by Random Forest and Decision Tree models. The paper's primary contribution is documenting asymmetric uncertainty effects with predictive insights.

1. INTRODUCTION

Foreign direct investment (FDI) is widely considered a significant driver of economic development, bringing a range of benefits such as job creation, foreign income, and greater access to domestically produced goods for host nations. The research clearly shows that FDI is not just about income generation; it actively boosts productivity, accelerates technology transfer, and supports infrastructure development, which collectively drive overall economic growth (Ahmad et al., 2022). FDI also creates new employment opportunities, helps the economic expansion of

specific production sectors, and often pressures governments into necessary regulatory reforms, all of which contribute to long-term prosperity (Adam & Alzuman, 2024; Kumari & Ramachandran, 2024). Feldmann (2025) specifically connects FDI to better educational outcomes, especially in tertiary enrollment, noting that this effect is amplified when financial markets are also developing well. Furthermore, the competition and skill upgrading that FDI introduces force local firms to become more efficient (Santos, 2023).

The Gulf Cooperation Council (GCC) countries present a fascinating case study. In the GCC nations, foreign direct investment (FDI) is just as vital but operates under a unique set of constraints, specifically the region's heavy reliance on hydrocarbons and its current push for economic diversification. Various studies point out that FDI is crucial for developing the non-hydrocarbon sectors that are essential for any sustainable growth model in the GCC (Al Samman & Jamil, 2018; Elheddad, Bassim, & Ahmed, 2021). Rafindadi, Muye, and Kaita (2018) look at how FDI influences energy use and environmental sustainability, while Mahmood (2023) highlights its role in improving carbon productivity. However, there are limitations to FDI's effect in the GCC countries. For example, Elmawazini (2014) notes that FDI spillovers in the GCC remain limited due to weak absorptive capacity and resource dependence. Despite these limitations, FDI remains central to the region's diversification strategy, with documented positive effects on stock market development and labor productivity. Through technology transfer and greater global market integration, FDI holds transformative potential for the GCC economies.

At the same time, global economic policy uncertainty (EPU) has emerged as a key factor influencing capital flows. A growing body of research finds that heightened uncertainty discourages FDI by increasing risk perceptions and reducing investor confidence (Haque, Biqiong, Arshad, & Yasmin, 2022; Nguyen & Lee, 2021). However, most of this literature focuses on developed or emerging economies outside the GCC. Moreover, few studies examine whether the effect of uncertainty is asymmetric, where FDI responds differently to increases versus decreases in uncertainty. Given the GCC's reliance on oil rents, vulnerability to external shocks, and ongoing diversification strategies, closer investigation of these dynamics is warranted.

Despite the beneficial effects of the role of FDI in economic growth and diversification strategies, the extent to which global EPU shapes investment flows into the GCC remains insufficiently understood as well as under-researched. While there is an extant literature on the economic effects of FDI, much of the existing research largely overlooks resource-dependent economies with high exposure to global volatility. Hence, this leaves a critical gap in understanding how uncertainty interacts with structural and institutional features unique to the GCC.

This paper addresses these gaps by analyzing the relationship between EPU and FDI inflows in the six GCC countries over the period 1997–2023. Using panel ARDL and nonlinear ARDL models, the study estimates both symmetric and asymmetric effects of EPU, while controlling for GDP growth, gross fixed capital formation, trade openness, oil rents, and regulatory quality. To complement the econometric analysis, this study also incorporates supervised machine learning methods, specifically Decision Tree Regression and Random Forest algorithms, to predict FDI inflows using macroeconomic and institutional indicators.

The study finds that EPU significantly reduces FDI inflows, with both rising and falling uncertainty deterring investment, reflecting persistent investor caution. Infrastructure investment and oil rents were shown to positively influence FDI. Interestingly, trade openness exhibited a negative effect. This counterintuitive result likely stems from the GCC's increased exposure to global commodity shocks through trade channels. This research contributes to the existing literature by formally highlighting the asymmetric effects of uncertainty and by detailing the role of macro-structural characteristics in shaping FDI behavior, specifically within the GCC context. Using a distinct approach, the machine learning analysis confirms that trade openness, policy uncertainty, and GDP growth are among the most influential drivers of FDI. In terms of methodology, the Random Forest model demonstrably outperformed the Decision Tree in predictive accuracy. This advanced approach significantly enhanced the empirical depth of the analysis by effectively capturing nonlinear interactions and providing robust variable importance rankings.

The novelty of this study lies in combining econometric and machine learning approaches to capture both the asymmetric effects of global EPU and the nonlinear interactions among FDI determinants. This approach to empirical analysis is rarely used in studies focusing on policy uncertainties. Unlike prior studies, which often focus on either traditional regression analysis or descriptive examinations, this paper integrates panel ARDL and nonlinear ARDL models with supervised learning methods to deliver both causal inference and predictive insights. By doing so, it contributes threefold: first, by clarifying how global uncertainty asymmetrically affects FDI inflows in the GCC; second, by evaluating the structural role of oil rents, trade openness, and institutional quality in mediating these effects; and third, by introducing a predictive dimension that identifies the most influential drivers of FDI inflows. These three effects are considered to be new and make an original contribution to the FDI literature in the GCC countries.

These findings are expected to have profound policy implications for GCC economies. To mitigate the adverse effects of uncertainty, governments must prioritize stable policy environments, enhanced institutional transparency, and consistent regulatory frameworks. Furthermore, targeted interventions are crucial. These should focus on attracting diversified FDI and reducing trade vulnerabilities, especially during periods of declining uncertainty. Such measures are essential for fostering sustainable economic growth amidst what remains a volatile global environment.

The next section presents a literature review. Section 3 presents methods, while a discussion of the results is presented in Section 4. Section 5 concludes with policy recommendations.

2. LITERATURE REVIEW

Economic determinants such as trade openness and economic growth have received considerable attention. [Pham, Pham, and Dang \(2023\)](#) found GDP growth and trade openness to be key drivers of FDI in ASEAN-6 countries, though determinants vary across nations. Similarly, [Livi, Simina, Catalina, and Laura \(2023\)](#) reported positive effects of trade openness and import diversification on FDI in Central Europe. For BRICS economies, [Chattopadhyay, Rakshit, Chatterjee, and Paul \(2022\)](#) highlighted both horizontal and vertical motivations behind FDI, while [Elia, Bani-Mustafa, Sawalha, Alsaber, and Pan \(2024\)](#) emphasized economic growth as a consistent driver, noting the limited significance of capital formation and trade openness. [Abdi, Sheik-Ali, Mohamed, and Mohamoud \(2024\)](#) found that GDP per capita attracts FDI in Africa, while trade openness had a negative effect.

Institutional quality is another critical factor. [Goswami \(2024\)](#) showed that corruption, legal systems, and political instability significantly influence FDI in India. [Patel, Mohapatra, and Yadav \(2024\)](#) used an NARDL model to show that the rule of law and political stability attract FDI, while regulatory quality unexpectedly deters it. Looking at a global context, [Doytch and Ashraf \(2023\)](#) highlighted law and order as a major factor for both greenfield FDI and cross-border Mergers & Acquisitions (M&As), though they noted that strict anti-corruption enforcement wasn't essential for greenfield projects. Furthermore, [Bothner \(2024\)](#) indicated that institutional quality particularly enhances FDI inflows in resource-rich developing countries. The broader political environment also matters. [Triarchi and Marangos \(2024\)](#) emphasized the importance of underlying governance structures, bilateral treaties, and the protection of property rights in drawing FDI. Likewise, [Kechagia and Metaxas \(2022\)](#) confirmed the importance of the rule of law and regulatory quality in emerging markets.

More recently, uncertainty has emerged as a significant factor in shaping FDI decisions. Several studies confirm that heightened EPU acts as a major deterrent. [Haque et al. \(2022\)](#) found that higher EPU reduces FDI in high-income countries. Similarly, [Nguyen and Lee \(2021\)](#) showed that EPU decreases FDI inflows globally, with a particularly pronounced effect in low-income economies. Additionally, [Lutfi, Ashraf, Watto, and Alrawad \(2022\)](#) and [\(Serfraz, Qamruzzaman, & Karim, 2023\)](#) both reported that EPU discourages FDI in Pakistan, though this adverse effect can be mitigated by financial development. [Clougherty and Zhang \(2023\)](#) observed that antitrust policy uncertainty deters FDI in the U.S., while [Olanipekun and Olasehinde-Williams \(2022\)](#) found that U.S. monetary policy uncertainty adversely impacts FDI in emerging markets. [Chi-Wei, Umar, and Chang \(2022\)](#) noted the

nonlinear effects of EPU on Chinese FDI, and Hornstein and Naknoi (2023) found that resolving uncertainty can improve FDI in Asia. Cieřlik and Gurshev (2023) showed that sanctions sharply affect FDI in resource-rich Russia.

Within the GCC, Osmanovic and Alvi (2022) found that economic growth and construction boost FDI, while high living costs deter it. Mina (2020) emphasized trade openness and infrastructure, but found human capital can have mixed effects. (Mameche & Masood, 2021) showed that while IFRS adoption initially attracts FDI, its long-term effects are negative due to reporting burdens. Al-Samman and Mouselli (2018) emphasized the positive roles of anti-corruption and political stability, but noted a negative effect of regulatory quality. Cieřlik and Hamza (2023) found that governance, particularly government effectiveness and political stability, drives FDI, whereas regulatory quality had a limited influence. Ibrahim, Devesh, and Shaukat (2022) showed that property rights and trade freedom significantly affect FDI in Oman. While these studies provide valuable insights into FDI in the GCC, none specifically examine the role of uncertainty. This paper addresses that gap.

3. METHODS

3.1. Theoretical Background

The determinants of FDI inflows vary across regions, shaped by economic, political, and institutional conditions. Building on the United Nations Conference on Trade and Development (2014) framework, this section provides a theoretical foundation for analyzing how global economic policy uncertainty (EPU) affects FDI inflows in the GCC. The underlying model is specified as:

$$FDI_{i,t} = f(EPU_t, gy_{i,t}, GFCF_{i,t}, openness_{i,t}, oil_{i,t}, regulation_{i,t}) \quad (1)$$

Where $FDI_{i,t}$ denotes net FDI inflows to the country i in period t . The main explanatory variable is EPU_t , with control variables including real GDP growth ($gy_{i,t}$), gross fixed capital formation ($GFCF_{i,t}$), trade openness ($openness_{i,t}$), oil rents ($oil_{i,t}$), and institutional quality ($regulation_{i,t}$).

EPU is generally expected to reduce FDI because it represents global macro-policy uncertainty. Heightened unpredictability inherently raises investment risk, which in turn dampens cross-border capital flows. However, it is worth noting that investor confidence may not immediately return even during periods of stabilizing or declining uncertainty, which suggests the potential for asymmetric effects. In contrast, other variables typically act as strong predictors. GDP growth reflects market size and overall economic momentum. It is expected to positively influence FDI by signaling both profitability and underlying macroeconomic stability. Similarly, GFCF, a proxy for infrastructure and capital accumulation, enhances the host environment by lowering operational costs and improving a country's productive capacity. Finally, trade openness is traditionally associated with greater FDI inflows because liberalized trade regimes make it easier for foreign firms to do business as well as access global markets. However, in oil-dependent economies such as the GCC, high openness may coincide with exposure to external shocks, potentially muting this effect. Oil rents present an ambiguous influence: while resource revenues can fund infrastructure and ensure macroeconomic stability, excessive reliance on hydrocarbons may hinder diversification and attract narrowly targeted, resource-seeking FDI. Institutional quality is expected to foster FDI by reducing transaction costs and uncertainty through regulatory clarity. Nonetheless, overregulation or rigid enforcement may generate unintended deterrents, underscoring the importance of balanced governance.

3.2. Data and Descriptive Statistics

This study utilizes panel data for the six GCC countries from 1997 to 2023. The dependent variable is FDI net inflows as a percentage of GDP, with the main explanatory variable being the EPU Index by Baker, Bloom, and Davis (2016), aggregated annually from monthly data. Control variables include GDP growth (Y), gross fixed capital formation (GFCF), trade openness (Trade), oil rents (Oil), and regulatory quality (Regulation). EPU data are from policyuncertainty.com, while the remaining variables' data are from the World Development Indicators (WDI) Table 1 summarizes the variables, definitions, and any relevant notes.

Table 1. Variables description.

Variable	Description	Measures
FDI	Foreign direct investment	Net inflows as % of GDP
EPU	Global economic policy uncertainty index	Developed by Baker et al. (2016), this index measures the relative frequency of newspaper articles in 21 countries that contain terms related to the economy, policy, and uncertainty.
<i>gy</i>	GDP growth	Annual percentage change in GDP
<i>GFCF</i>	Gross fixed capital formation	% of GDP serves as a proxy for domestic investment. For Qatar and Kuwait, gross capital formation is used instead due to the unavailability of data on gross fixed capital formation.
Trade	Trade openness	Sum of exports and imports as % of GDP
Oil	Oil rents	% of GDP, Oil rents are the difference between the value of crude oil production at regional prices and total costs of production.
Regulation	Regulatory quality	This indicator reflects perceptions of the government's ability to formulate and implement effective policies and regulations that support private sector development (WDI estimate).

Figure 1 shows that FDI inflows to the GCC have fluctuated markedly over the past two decades. For instance, between 1990 and 2014, Bahrain received most of the FDI net inflows, followed by Qatar (until 2011), with rising inflows to the United Arab Emirates (UAE) since 2014. Since 2015, FDI inflows increased in Saudi Arabia, UAE, and Oman, while in Kuwait, they remained almost steady, and in Qatar, inflows declined. The rising levels of FDI net inflows reflect the openness and liberalized investment environments of the GCCs. Conversely, Kuwait, with an average of just 0.36% of GDP, underscores the structural barriers that constrain investment.

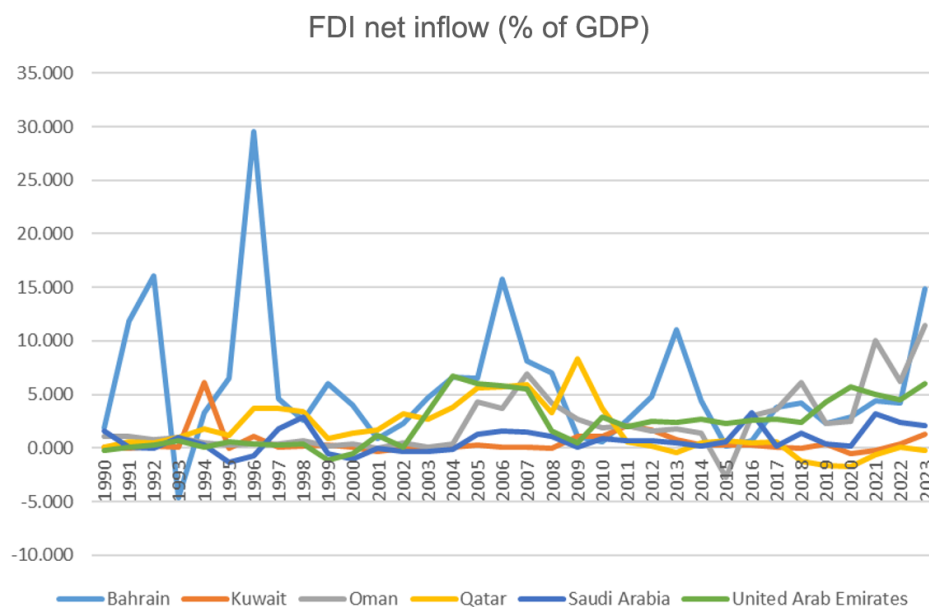


Figure 1. GCCs' long-term FDI net inflows.

Source: World Development Indicators of the World Bank (2025).

Table 2 presents summary statistics for the variables examined in this study. FDI net inflows have a mean of 2.28 and a standard deviation of 2.86. EPU has an average of 142.82 with a standard deviation of 69.84. The *gy* averages 4.23%, while the *GFCF* averages 24.76% of GDP. Trade has a mean of 105.18%, indicating a strong reliance on international trade in the region. Oil rent averages 28.28% of GDP, highlighting the GCC countries' resource-dependent nature. Regulatory quality, measured on an institutional effectiveness scale, averages 0.42 with a standard deviation of 0.35.

Table 2. Descriptive statistics.

Variable	Obs.	Mean	Std. dev	Min.	Max.
<i>FDI</i>	161	2.28	2.86	-2.76	15.83
<i>EPU</i>	168	142.82	69.84	62.80	320.89
<i>gy</i>	161	4.23	5.27	-7.08	30.01
<i>GFCF</i>	146	24.76	7.69	10.53	48.87
<i>Openness</i>	146	105.18	30.81	49.71	191.87
<i>oil</i>	149	28.28	12.60	6.70	58.37
<i>Regulation</i>	162	0.42	0.35	-0.31	1.10

To assess the stationarity properties of the variables, the Im, Pesaran, and Shin (IPS) panel unit root test is utilized (Im, Pesaran, & Shin, 2003). It tests the null hypothesis that all panels have unit roots against the alternative that some panels are stationary. The results of the IPS test, shown in Table 3, indicate varying integration orders among the variables. FDI, real GDP growth, and trade openness are stationary at levels, with test statistics significantly rejecting the unit root hypothesis. In contrast, EPU, oil rents, and regulatory quality are non-stationary at levels but become stationary at first differences, supported by highly significant test statistics at first differences. The mixed integration orders of the variables support the use of the panel ARDL framework, which can handle variables with different integration orders as long as none are integrated beyond first differences.

Table 3. Im-Pesaran-Shin (IPS) unit-root test.

Variable	level	1st difference
<i>FDI</i>	-2.24**	
<i>EPU</i>	1.65	-7.46***
<i>gy</i>	-4.14***	
<i>GFCF</i>	-1.27	-5.02***
<i>Openness</i>	-1.96**	
<i>oil</i>	-1.12	-8.23***
<i>Regulation</i>	-0.49	-4.85***

Note: ** and *** indicate significance at 5% and 1%, respectively. The null hypothesis of the IPS test is that all panels contain unit roots.

3.3. Econometric Model

This study employs a panel ARDL framework by Pesaran, Shin, and Smith (2001). The main advantage of this approach is to allow for the estimation of the underlying relationships while accounting for heterogeneity in both short-run dynamics and long-run coefficients among countries. This approach has been adopted to address similar questions (e.g., Elroukh (2025)) and used the panel ARDL framework to examine the impact of energy consumption on global EPU in the GCC countries. The linear panel ARDL model of Equation 1 takes the following form:

$$\Delta FDI_{i,t} = \beta_0 + \beta_1 FDI_{i,t} + \beta_2 EPU_t + \beta_3 gy_{i,t} + \beta_4 GFCG_{i,t} + \beta_5 openness_{i,t} + \beta_6 oil_{i,t} + \beta_7 regulation_{i,t} + \sum_{j=1}^p \gamma_j \Delta FDI_{i,t-j} + \sum_{k=0}^q \delta_k \Delta x_{i,t-k} + \epsilon_{i,t} \quad (2)$$

However, the literature suggests that the relationship between EPU and FDI may be asymmetric. It is to be noted that although a rise in EPU clearly increases perceived risk and deters investment, a decline in EPU may not necessarily result in a symmetrical boost to FDI. This is particularly valid if investors remain overly cautious or perceive the resolution of the uncertainty as insufficient to warrant new cross-border investment. These complex dynamics do suggest the need to use a nonlinear panel ARDL (NARDL) model, which is specifically designed to capture such asymmetric effects. The NARDL model extends the standard linear ARDL framework by decomposing the EPU variable into its positive and negative partial sum changes, thereby allowing us to distinctly estimate the differential impacts of increases and decreases in uncertainty on FDI inflows. The NARDL model is specified as follows:

$$\Delta FDI_{i,t} = \beta_0 + \beta_1 FDI_{i,t} + \beta_2^+ EPU_t^+ + \beta_2^- EPU_t^- + \beta_3 gy_{i,t} + \beta_4 GFCG_{i,t} + \beta_5 openness_{i,t} + \beta_6 oil_{i,t} + \beta_7 regulation_{i,t} + \sum_{j=1}^p \gamma_j \Delta FDI_{i,t-j} + \sum_{k=0}^q \delta_k \Delta x_{i,t-k} + \epsilon_{i,t} \quad (3)$$

With EPU^+ and EPU^- calculated as $EPU_t^+ = \sum_{l=1}^t \max(\Delta EPU_l, 0)$, and $EPU_t^- = \sum_{l=1}^t \min(\Delta EPU_l, 0)$.

Two widely used estimators in the panel ARDL framework are the Mean Group (MG) and Pooled Mean Group (PMG) estimators. The MG estimator fits separate regressions for each cross-sectional unit and averages the coefficients, allowing full heterogeneity.

In contrast, the PMG estimator assumes homogeneity in long-run coefficients but permits heterogeneity in short-run dynamics and error variances. This structure makes PMG particularly suitable for panels with shared structural characteristics, such as the GCC countries. The Hausman test is employed to determine the preferred estimator by testing whether the restrictions imposed by PMG are valid. If the null hypothesis of no systematic difference between MG and PMG is not rejected, the PMG is favored for its efficiency under the assumption of long-run homogeneity.

3.4. Non-Parametric Supervised Learning

To complement the panel ARDL and nonlinear ARDL models, this study incorporates two non-parametric supervised learning algorithms: Decision Tree Regression (DTR) and Random Forest Regression (RF). These machine learning methods are particularly well-suited to identifying complex interactions, threshold effects, and nonlinear dependencies among macroeconomic and institutional variables that may not be fully captured in parametric models.

To apply these techniques, the dataset is first filtered for complete cases and properly formatted. Country identifiers are converted to factors to ensure compatibility with tree-based models. This preparation phase ensures robust model training and evaluation.

3.4.1. Decision Tree Regression

Let $\mathcal{D} = \{(X_i, y_i)\}_{i=1}^n$ denote the dataset, where $X_i \in \mathbb{R}^p$ is the vector of predictors including $gy, gfcf, trade, oil, regulation, EPU$, and country and $y_i \in \mathbb{R}$ is the FDI inflow. A Decision Tree Regressor recursively partitions the input space into M disjoint regions $R_1, R_2, \dots, R_M$, assigning to each region the average value of y :

$$\hat{y}(X_i) = \frac{1}{|R_m|} \sum_{j \in R_m} y_j \quad (4)$$

The optimal splits minimize the residual sum of squares (RSS):

$$RSS = \sum_{m=1}^M \sum_{i \in R_m} (y_i - \bar{y}_{R_m})^2 \quad (5)$$

This method helps uncover thresholds and nonlinearities in FDI behavior based on regulatory quality, trade openness, and uncertainty indicators.

3.4.2. Random Forest Regression

Random forest extends the decision tree by aggregating predictions over multiple bootstrapped trees, each using random subsets of predictors. The resulting ensemble:

$$\hat{y}_{RF}(X) = \frac{1}{B} \sum_{b=1}^B T^{(b)}(X) \quad (5)$$

Offers superior predictive accuracy and robustness against overfitting. It also provides a variable importance ranking, allowing insights into the drivers of FDI inflows.

4. DISCUSSION OF RESULTS

4.1. The Panel ARDL Results

The results of the linear panel ARDL model are presented in Table 4 (column 1), while the nonlinear panel ARDL results are presented in column 2. Table 4 panel B presents the estimated chi-squared statistics of the Hausman test. For the linear model, the Hausman test yielded a chi-squared statistic of 7.06 with a p-value of 0.31, indicating that the null hypothesis of no systematic difference between the MG and PMG coefficients could not be rejected. Similarly, for the nonlinear model, the test produced a chi-squared statistic of 5.57 with a p-value of 0.47, again supporting the null hypothesis. The results of the Hausman tests suggest that the PMG estimator, which assumes homogeneity in the long-run coefficients across countries while allowing for heterogeneity in short-run dynamics, is the statistically preferred approach for both linear and nonlinear models.¹ The selection of the PMG estimator is further supported by the structural and economic similarities among GCC countries, including common institutional frameworks, economic dependencies on oil, and monetary policy objectives. These similarities justify the assumption of homogeneity in long-run relationships imposed by the PMG estimator. Additionally, the error-correction term is, as expected, negative and statistically significant at high levels in both the linear (-0.29) and nonlinear (-0.31) models, indicating convergence to the long-run equilibrium. This implies that deviations from equilibrium are gradually corrected, with approximately 29–31% of the adjustment occurring within a single period.

Table 4. Results of the symmetric and asymmetric panel ARDL regressions.

	(1) ARDL	(2) NARDL
Panel A: Long run estimates		
<i>EPU</i>	-0.02*** (-4.27)	
<i>EPU</i> ⁺		-0.03*** (-3.57)
<i>EPU</i> ⁻		-0.04*** (-3.48)
<i>gy</i>	0.03 (0.82)	0.06 (1.20)
<i>GFCF</i>	0.18*** (7.14)	0.14*** (4.11)
<i>Openness</i>	-0.21*** (-7.45)	-0.27*** (-5.35)
<i>oil</i>	0.20*** (5.81)	0.28*** (4.65)
<i>Regulation</i>	3.22*** (4.00)	1.75 (1.52)
Const.	3.35** (2.03)	3.55** (2.13)
Panel B: Diagnostics		
Error-correction	-0.29* (-1.76)	-0.31** (-2.24)
Hausman test	7.06	5.57
Log likelihood	-209.70	-202.48
Obs.	137	137

Note: *, **, and *** indicate significance at 10%, 5%, and 1%, respectively.

¹ It is worth noting that the covariance matrix of the difference in coefficients between the MG and the PMG estimators does not satisfy the positive definiteness property, which could be attributed to the presence of identical values of EPU across countries in the panel. However, this does not undermine the validity of the test results.

In the linear panel ARDL regression, the main explanatory variable, EPU, has a statistically significant negative effect on FDI, with a coefficient of -0.02. This finding aligns with prior expectations, as increased uncertainty in global economic policy discourages foreign investors who seek stable environments for long-term investments (Haque et al., 2022; Nguyen & Lee, 2021). In the context of the GCC, where economies heavily rely on oil revenues, heightened uncertainty may exacerbate investor concerns regarding macroeconomic stability and policy predictability, further dampening FDI inflows. Among the control variables in the linear model, GFCF shows a positive and statistically significant coefficient (0.18), indicating that infrastructure investment fosters FDI inflows by reducing operational costs and improving resource allocation (Elian et al., 2024). In the GCC, oil-funded infrastructure likely enhances the region's attractiveness to foreign investors. Conversely, trade openness has a negative long-term effect on FDI (-0.21). Although openness usually facilitates FDI through global integration, in the GCC context, dependence on oil exports exposes economies to external shocks, and excessive openness may heighten this vulnerability, discouraging investment in non-oil sectors (Abdi et al., 2024; Mina, 2020). Oil rents exhibit a significant positive impact (0.20), underscoring their dual role in the region. While oil revenues support infrastructure and economic development, they may also attract primarily resource-seeking FDI, potentially limiting diversification (Cieřlik & Hamza, 2023). Regulatory quality has a strong positive coefficient (3.22), highlighting the role of transparent and efficient institutions in attracting FDI. Recent governance reforms across the GCC aimed at strengthening regulatory frameworks likely contribute to this outcome, in line with the literature (Bothner, 2024; Goswami, 2024).

The results of the panel NARDL regression show that the coefficients for positive changes in EPU ($GEPU^+$) and negative changes in EPU ($GEPU^-$) are both negative and statistically significant, with values of -0.03 and -0.04, respectively. These results indicate that both increases and decreases in uncertainty deter FDI. This dual negative effect contradicts prior expectations that reduced uncertainty might encourage FDI. However, it aligns with the idea that even resolving uncertainty can make investors cautious, especially in regions like the GCC, where geopolitical and macroeconomic risks are significant. These findings highlight the importance of considering nonlinear dynamics when analyzing the relationship between uncertainty and FDI. The control variables in the nonlinear model largely mirror the linear model's results. GFCF remains positive and significant (coefficient: 0.14), reaffirming the role of infrastructure in attracting FDI. Oil rents continue to have a significant positive effect, with a higher coefficient (0.28), underscoring their dual role in supporting investment and influencing diversification. Trade openness retains its negative long-run impact (-0.27), reflecting vulnerabilities linked to openness in oil-dependent economies. However, regulatory quality becomes statistically insignificant. This shift suggests that the positive role of regulatory quality observed in the linear model may be overshadowed by the nonlinear effects of uncertainty. In other words, when uncertainty shocks dominate investment decisions, improvements in dimensions of governance, such as regulatory changes alone, may be insufficient to offset investor caution, which could explain why regulatory quality loses significance in the nonlinear specification.

4.2. Discussion of Machine Learning Analysis

The decision tree model was trained using repeated 10-fold cross-validation with three repetitions. This approach involved partitioning the 143 observations into 10 folds for resampling, repeated three times to improve estimate stability. A grid search across values of the complexity parameter (cp) was performed to determine the optimal model configuration. The lowest Root Mean Squared Error (RMSE) was achieved at $cp = 0.001$. The selected model produced an RMSE of 2.162, an R^2 of 0.401, and Mean Absolute Error (MAE): 1.571. These results suggest that the model explains approximately 40.1% of the variance in FDI inflows.

The decision tree model (Figure 2) identifies trade openness as the most important variable influencing FDI inflows, with a clear threshold at 107. This initial split divides countries into two main groups with different characteristics. The first group is the lower trade openness group with trade openness less than 107% of GDP. This

group includes 69% of the observations. Within this group, the model shows that countries with low GDP growth, low levels of capital investment (GFCF), and high EPU tend to receive lower FDI inflows. In some cases, predicted FDI values are negative, highlighting a pattern of weak investment environments. The second group is the higher trade openness group with a trade openness ratio of 107 or higher. Countries in this group, which make up 31% of the data, are associated with higher FDI inflows. However, the model further shows that this outcome depends on other factors. Specifically, high EPU ($epu \geq 88$), low-to-moderate growth, and even another trade threshold ($trade < 159$) affect the final FDI values. The highest predicted FDI inflows (around 7) are found in countries that combine high trade openness with moderate uncertainty and growth.

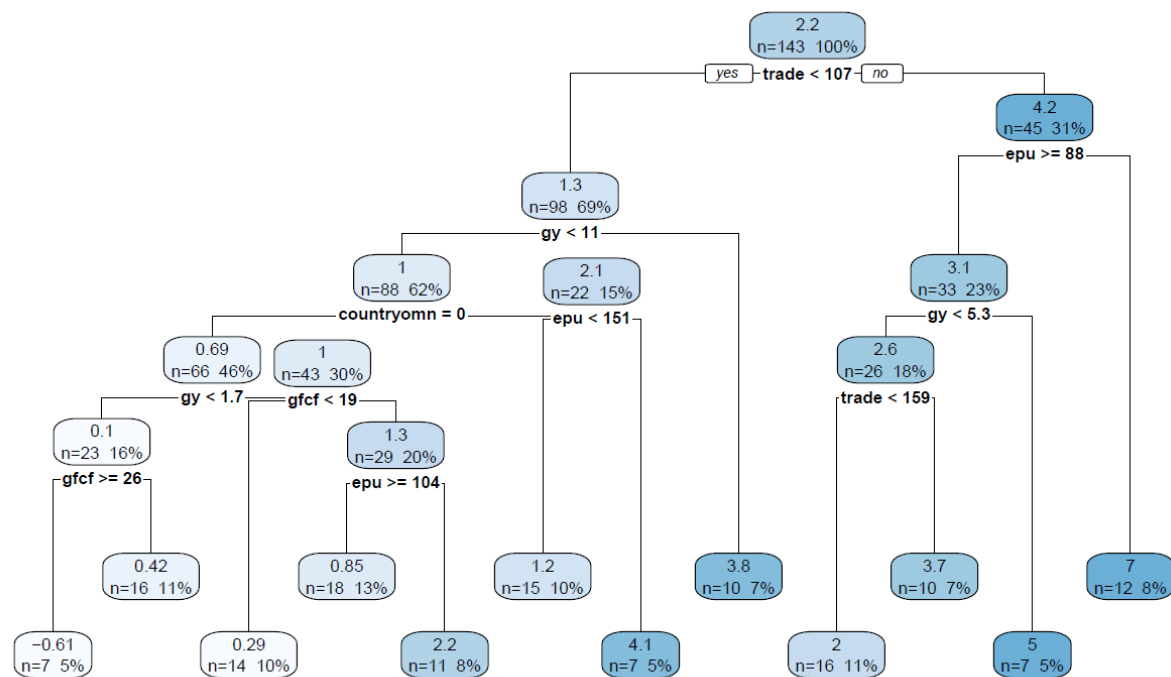


Figure 2. Decision tree for FDI prediction.

Variables such as economic growth and uncertainty appear in multiple locations within the tree, indicating that their effects depend on the values of other factors. Instead of assuming a uniform relationship across all conditions, the model identifies different scenarios under which each factor becomes more or less significant. This approach makes the tree valuable not only for prediction but also for understanding how various combinations of economic and policy conditions influence FDI.

Figure 3 displays the importance of each predictor in terms of node purity gain, i.e., how much each variable contributes to reducing variance in FDI inflows across all tree splits. Trade openness ranks as the most influential variable by a large margin. It is followed by EPU and GDP growth, indicating that these macroeconomic factors play a central role in explaining FDI variation. Oil rents and regulation quality also show moderate importance, suggesting they play supporting roles in investor decision-making. In contrast, gross fixed capital formation and country-specific indicators rank lower overall. Country-specific indicators, including the UAE, Oman, Kuwait, and Qatar, appear at the bottom of the importance ranking. While the UAE and Oman contribute modestly to the model, Kuwait and Qatar show negligible influence. This implies that FDI inflows are better explained by macroeconomic variables than by country identity alone. The model's strong reliance on trade openness and uncertainty reinforces the view that openness and stability are key drivers of FDI allocation in the dataset.

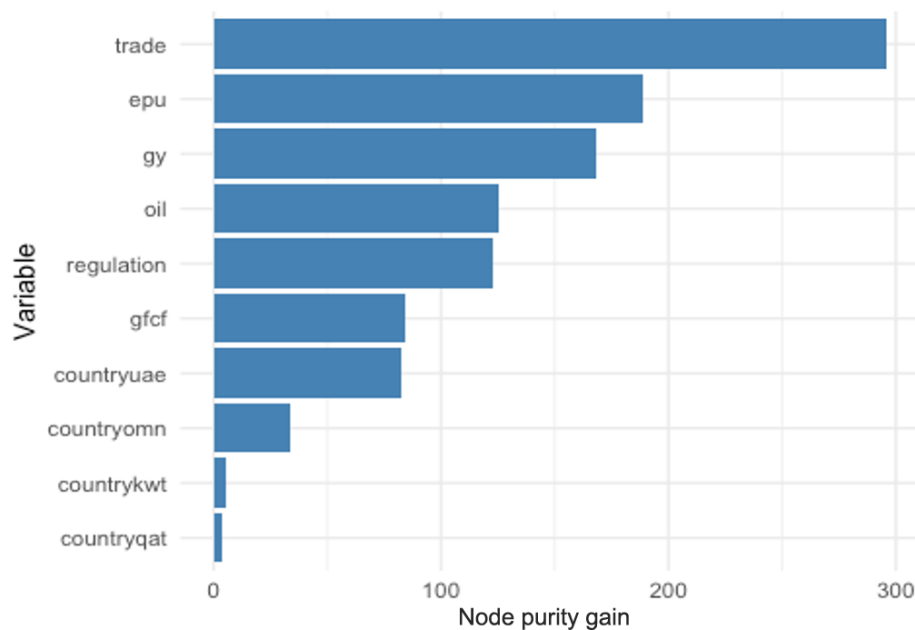


Figure 3. Decision tree: variable importance (Node purity).

This study also estimated the Random Forest regression model using the same dataset, which consists of 143 observations. To ensure consistent performance estimates and minimize overfitting, we employed repeated 10-fold cross-validation with three repetitions. A critical step involved a hyperparameter grid search for the *mtry* parameter. This parameter controls the number of predictor variables that are randomly selected for consideration at each node within a regression tree in the ensemble. Setting this parameter properly is crucial, as it directly influences the diversity of the individual trees and thus affects the overall model performance. Among all the values tested for the *mtry* parameter (the number of predictors randomly sampled at each node), the setting *mtry* = 4 achieved the lowest RMSE during the repeated cross-validation. This specific model configuration was then used to evaluate the overall predictive accuracy and analyze variable importance. The final model yielded an *RMSE* of 1.855, an R^2 of 0.565, and an *MAE* of 1.316. This configuration demonstrated clear improvements in predictive accuracy compared to the initial decision tree model, specifically achieving a lower *RMSE* and *MAE* while explaining a greater proportion of the variance in FDI inflows (R^2). The subsequent variable importance analysis indicated that trade openness remained the most influential predictor, followed by regulation quality and oil rents. These results ultimately highlight the Random Forest model's strength in identifying complex interactions and nonlinear relationships within the data.

Figure 4 presents the variable importance plot derived from the Random Forest model helps evaluate how much each predictor contributes to reducing the model's prediction error, specifically by measuring the mean decrease in accuracy across the ensemble of trees. The analysis clearly identifies trade openness as the most informative variable, consistently yielding the highest contribution to prediction accuracy. Following this are EPU, GDP growth, oil rents, and regulation quality. This lineup strongly suggests that macroeconomic conditions and institutional features are the primary factors relevant in explaining variation in FDI inflows. GFCF also contributes meaningfully to the model, confirming a measurable association with domestic investment activity. Interestingly, country-level dummy variables like Qatar, Oman, and Kuwait registered relatively low importance scores in the Random Forest analysis. The limited predictive contribution of these indicators suggests that once key macroeconomic and institutional drivers are accounted for, country-specific identifiers do not substantially enhance the model's accuracy. This outcome indicates that structural features, such as trade openness, economic uncertainty, and regulatory quality, are ultimately more influential in explaining the variation in FDI inflows.

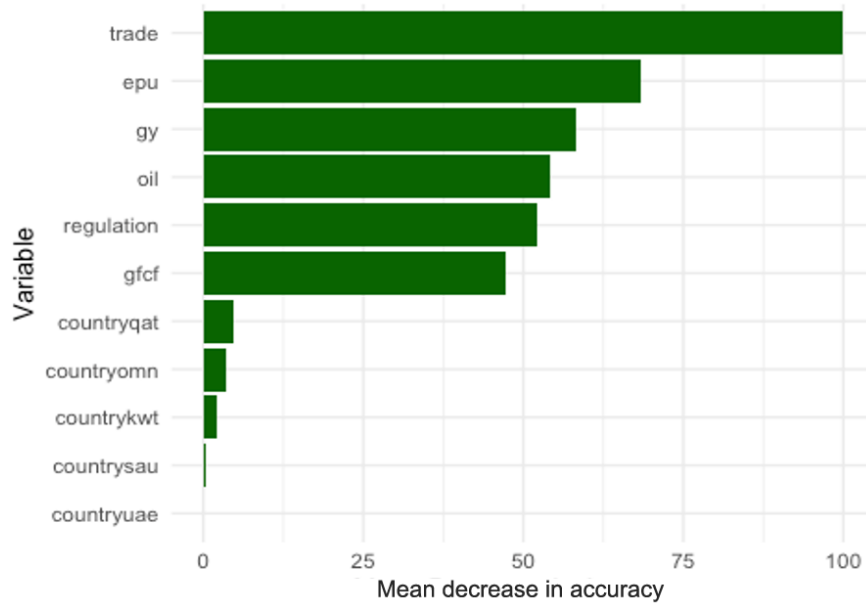


Figure 4. Random Forest variable importance.

Table 5 summarizes the performance of the Decision Tree and Random Forest models based on repeated 10-fold cross-validation. Evaluation criteria include RMSE, R^2 , and MAE. The Random Forest model outperformed the Decision Tree across all evaluated metrics. Specifically, Random Forest achieved a lower RMSE (1.855 vs. 2.162) and MAE (1.316 vs. 1.571), indicating more accurate and consistent predictions. It also yielded a higher R^2 (0.565 vs. 0.401), suggesting it captured a greater proportion of variance in FDI inflows. The relatively low R^2 of the Decision Tree reflects the inherent limitations of single-tree models in capturing the complex and nonlinear determinants of FDI, which highlights the advantage of Random Forest in modeling complex relationships in economic data, consistent with prior findings, such as Zhang (2023), who found that Random Forest outperformed decision tree models in predicting firm-level outcomes. These studies reinforce the applicability of Random Forest in high-dimensional, uncertainty-sensitive economic contexts such as FDI modeling.

Table 5. Comparison between the decision tree and random forest models.

Model	RMSE	R^2	MAE
Decision tree	2.162	0.401	1.571
Random forest	1.855	0.565	1.316

5. CONCLUSION AND POLICY RECOMMENDATIONS

This paper examines the impact of global economic policy uncertainty on FDI inflows in the GCC countries from 1997 to 2023, using panel linear and nonlinear ARDL estimation methods. The study complements its analysis with a machine learning approach to predict determinants of FDI in the GCC countries.

The main findings of this study are as follows. Firstly, global economic policy uncertainty has a significant negative effect on FDI inflows, indicating that foreign investors are sensitive to EPU. Both increases and decreases in uncertainty lead to reduced FDI, implying that declining uncertainty does not necessarily boost investor confidence. Secondly, the findings show that gross fixed capital formation and oil rents have a positive influence on FDI inflows, highlighting the importance of infrastructure development and resource wealth in attracting investment. However, the positive impact of oil rents also underscores the concentration of FDI in resource-intensive sectors, emphasizing the need for diversification. Lastly, trade openness has an unexpected negative effect on FDI, suggesting that the GCC's reliance on oil exports exposes it to external shocks, potentially deterring foreign investment in non-oil sectors. In addition to the panel ARDL results, the machine learning analysis confirms the importance of trade

openness, EPU, and GDP growth as key predictors of FDI inflows. In particular, the Random Forest model clearly demonstrated its value, achieving superior predictive accuracy compared to the simpler Decision Tree. Its performance suggests a key finding: macroeconomic and institutional factors play a more decisive role in explaining FDI variation than mere country-specific identifiers. Ultimately, these results highlight the substantial benefit of integrating machine learning tools into FDI research, as they allow us to effectively capture complex, nonlinear dynamics and, critically, strengthen our ability to draw meaningful policy inferences.

These findings offer profound policy implications for GCC countries that aim to attract sustainable FDI amidst ongoing global uncertainty. The significant negative impact of EPU highlights an immediate need for stable, transparent, and predictable policy environments to truly bolster investor confidence. Enhancing institutional clarity and ensuring regulatory consistency are essential steps for mitigating those uncertainty-related risks. Moreover, given the asymmetric effects of EPU (where lowering uncertainty does not automatically restore flows), targeted interventions during periods of declining uncertainty can be used strategically to further support investment recovery. Finally, the positive association between GFCF and FDI indicates the vital role of infrastructure. Investing in key areas like transport, energy, and digital systems is a tangible way to reduce operational costs and significantly improve the region's overall investment appeal. Conversely, the negative effect of trade openness suggests a need to reassess trade strategies. Diversifying exports, promoting intra-GCC trade, and forging strategic agreements may reduce exposure to external shocks and stabilize inflows. Specific diversification strategies could include expanding investment incentives for non-oil sectors, promoting renewable energy projects, and strengthening intra-GCC trade initiatives such as the GCC Customs Union and regional free-trade agreements. Prioritizing these strategies based on sectors with the highest growth potential and most resilience to external shocks can help stabilize FDI inflows. Overall, coordinated policies that address uncertainty, invest in infrastructure, and build trade resilience are vital for enhancing the GCC's competitiveness as an FDI destination in a volatile global landscape.

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