SAMA Working Paper WP/2024/5

Examining the Nexus Between Real GDP and Uncertainty: An Econometric Inquiry in the Saudi Arabian Context

By:

Ebtehal Almutairi, PhD

Economic Research and Reports Department

September 2024

Disclaimer:

البنك المركزي السعودي
SAMA
Saudi Central Bank

Examining the Nexus Between Real GDP and Uncertainty: An Econometric Inquiry in the Saudi Arabian Context

Economic Research and Reports Department

September 2024

Abstract

This study aims to fill the gap in the literature by thoroughly investigating the dynamic relationship between GDP and uncertainty, employing geopolitical risk and oil price fluctuations as robust proxies for uncertainty, allowing fora comprehensive exploration of their impact on GDP. Using Vector Autoregressive Model (VAR) and Vector Error Correction Model (VECM), the findings reveal that geopolitical risk does not significantly affect GDP. While, the results suggest that the influence of oil prices on GDP is more significant. The study provides evidence of a Granger causality relationship running from oil prices to GDP. However, the findings demonstrate that geopolitical risk (GPR index) Granger does not cause GDP.

Keywords: GDP, oil prices, GPR index, VEC model, impulse response function, Granger causality.

JEL Codes: C31; C21; C32; Q43; E4.

1. Introduction

Economic policies are designed with the primary goal of achieving stability by implementing flexible strategies capable of withstanding adverse shocks. Consequently, decision-makers recognize the significant importance of studying and analyzing the dynamic relationships between macroeconomic indicators and factors driven by uncertainty. Uncertainty factors, including fluctuations in oil prices and geopolitical risks, exert a significant influence on various macroeconomic indicators. This influence is particularly pronounced in countries heavily reliant on oil exports, as exemplified by Saudi Arabia which is widely recognized as one of the largest oil-producing countries and possesses the second-largest proved oil reserves in the world as of 2020 (EIA). Various studies have focused on examining the impact of oil price fluctuations on economic activity and exploring the connections between oil prices and several macroeconomic and financial variables (Hamilton 1983; Hooker 1996; Eltony and Al-Awadi 2001; Ito 2008; Mukhtarov et al. 2020). Saudi Arabia's fiscal policy has historically heavily relied on oil revenues to fuel development. However, this significant dependence on a single, volatile revenue source poses considerable risks, as energy markets are often influenced by commercial and geopolitical uncertainties. Effectively addressing these challenges is crucial for bolstering economic growth and sustainability. Despite extensive research on the impacts of oil prices, geopolitical risks have received relatively less attention in literature. Understanding the influence of geopolitical risks on the economy is essential (Huang et al. 2021). These risks, which include political instability, conflicts, and trade tensions, directly affect oil prices. In response to ongoing uncertainties, the Saudi government has recognized the importance of implementing proactive policies to navigate fluctuations by focusing on diversifying non-oil sectors such as tourism, entertainment, and technology through substantial financial restructuring and strategic investments. This comprehensive strategy is aimed at enhancing economic adaptability.

This study aims to fill a research gap by investigating the influence of oil prices and geopolitical risk on Gross Domestic Product (GDP) in Saudi Arabia. Figure 1. illustrates the long-term trends of lnGDP alongside independent variables like oil prices(lnOP), geopolitical risk (lnGPR), and the interest rate (3m SAIBOR) in the country. While the movements in GDP do not perfectly align with those of the GPR index and the interest rate, it is evident that oil prices have a significant impact on GDP, particularly during specific periods.

Our empirical investigation delves into the question of how uncertainty influences GDP. To analyze the effect of uncertainty on GDP, we utilize a Vector Autoregressive model (VAR) along with a Vector Error Correction Model (VECM). The remainder of the paper is organized as follows: Section 2 provides a summary of the existing literature. Section 3 presents the contribution of this study. Section 4 presents the methodology applied. The data and empirical findings are detailed in Sections 5 and 6, respectively. Finally, Section 7 concludes the paper.

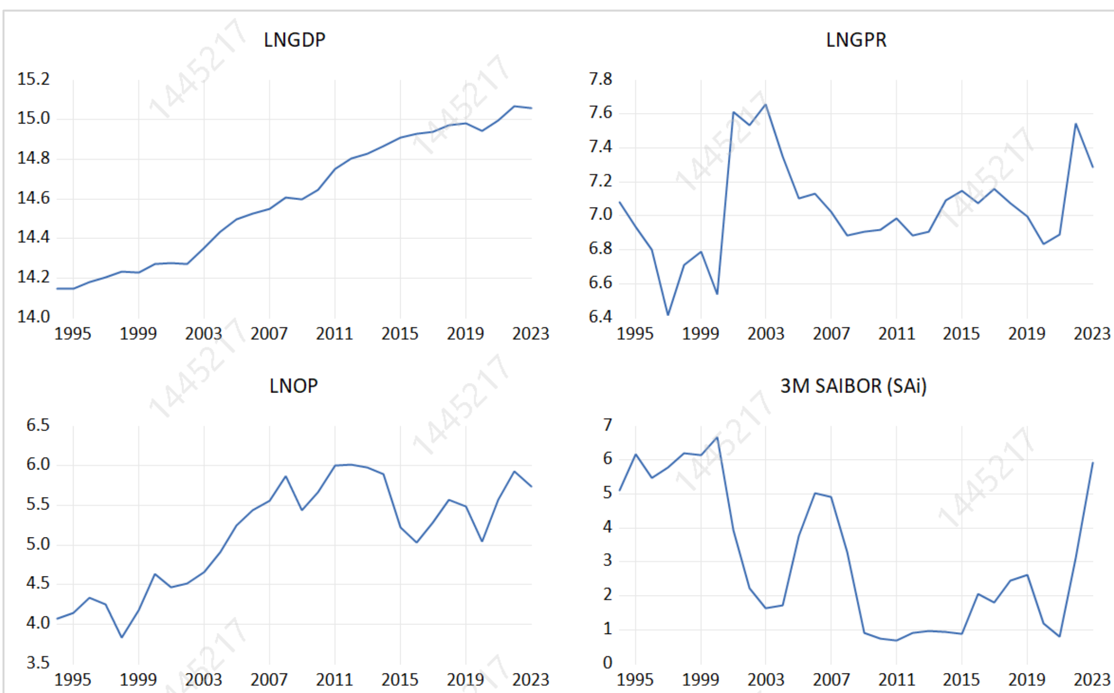


Figure 1. Long-Term Trends in Saudi Arabian lnGDP, lnOil Prices, lnGPR, and 3m SAIBOR.

2. Literature review

Numerous studies have explored the relationship between real GDP and various indicators, including oil prices, geopolitical risk and interest rates. For instance, regarding the impact of oil prices , Wei and Guo (2016) used the frequency domain causality tests and impulse response analysis to analyze the impact of oil prices on China’s economy. They found that oil price shocks have positive effects on China’s GDP and a negative impact on China’s interest rate. In contrast, Salisu et al. (2023) examined the effects of oil price uncertainty shocks on the actual Gross Domestic Product (GDP) across a group of 33 economies, including both developed and emerging nations. Through the utilization of a Vector Autoregression (VAR) model covering the time frame from 1980Q1 to 2019Q2, their study reveals a statistically significant adverse impact of oil price uncertainty shocks on the GDP of 28 out of the 33 countries, demonstrating varying levels of impact and persistence. Notably, the adverse impact on real GDP is observed to be relatively stronger for the developed countries.

Examining the interplay between geopolitical risk and GDP, Soybilgen et al. (2019) investigated the connection using annual panel data across 18 emerging nations from 1986 to 2016. They utilized the Geopolitical Risk (GPR) index as a proxy for geopolitical risk and found that a 10-point increase in the GPR index correlates with a 0.2-0.4% reduction in the GDP growth rate. This underscores how heightened geopolitical risk adversely affects economic growth in emerging economies. In a related context, Zaman and Georgescu's 2015 study delves into Romania's response to recent financial and economic crises, with a focus on regional resilience. They emphasize the importance of factors such as external economic openness, well-defined specialization strategies, and environmental investments in enhancing resilience and fostering sustainable regional economic development. This underscores how endogenous factors act as buffers against crises, a concept exemplified by Barro's (1991) development and testing of the endogenous growth theory, which represents a significant advancement in economic growth theories. This theory suggests that growth originates internally within the system rather than being solely influenced by external factors, providing a novel perspective on the dynamics of economic growth.

In terms of the relationship between interest rate and GDP, De Gregorio and Guidotti (1995) reached the conclusion that an excessively low real interest rate can lead to financial turbulence within the economy, ultimately hampering economic growth. These results were also confirmed by Fry (1995), who concluded that there is a positive relation between GDP and interest rate. Similarly, Simionescu et al. (2017) employed Granger causality analysis, along with Bayesian approach, on quarterly data covering the period from the first quarter of 2000 to the second quarter of 2015 in Romania. Their findings indicate that an increase in interest rates leads to higher GDP growth, suggesting a positive relationship between the two variables. On the contrary, Jilani and Asim (2010) carried out a study employing multivariate regression analysis, revealing a notable adverse effect of interest rates and inflation on Pakistan's GDP. Their findings indicated that reduced interest rates encourage increased investment levels, subsequently leading to a positive GDP impact from 1980 to 2013.

Similarly, SAITI and TRENOVSKI (2023) focused on evaluating the influence of short-term and long-term interest rates on nominal GDP between 2004 and 2021 in the Republic of North Macedonia. Through the utilization of the VECM model and Granger causality test, their findings highlighted a negative correlation between long-term and short-term interest rates and nominal GDP in North Macedonia.

In the realm of Saudi Arabian economic studies, Al-Rasasi and Banafea (2015) studied the effects of oil price shocks on economic activity, inflation, and exchange rates in Saudi Arabia. The researchers utilize Kilian's (2009) measures of oil shocks, including aggregate demand, oil-specific demand, and supply shocks. The findings indicate that both aggregate oil demand shocks and oil-specific demand shocks have significant impacts on all variables under consideration. However, the study suggests that oil supply shocks have a relatively minimal impact on the examined variables. Moreover, Al-Rasasi et al. (2019) examined the effects of oil shocks through oil revenues on nonoil private GDP in Saudi Arabia from 1970 to 2017 and reported that oil revenues have a significant impact on nonoil private GDP. In addition, they found Granger causality running from oil revenues to non-oil private GDP. Similarly, Belloumi et al. (2023) investigated the impact of oil price fluctuations on economic output and inflation in Saudi Arabia between 1980 and 2021. Findings indicate that while increases in oil prices enhance long-term output growth, decreases do not affect growth in the short or long term. Furthermore, oil price changes lower inflation rates in both the short and long term. Recently, prompt fiscal interventions notably enhanced Saudi Arabia's GDP, underscoring the crucial significance of proactive fiscal strategies. For example, Abdelkawy and colleagues (2024) examined the influence of Government Consumption (GC) on Saudi Arabia's GDP throughout significant economic crises spanning from 1969 to 2022. Through their employment of ARDL methodology, their research unveiled that while GC might not yield immediate effects on GDP, its long-term vary across crises. GC has functioned as a safeguard against sudden economic disruptions such as the COVID-19 crisis. Nonetheless, during the period of the 2014-2016 oil price downturn, GC alone was insufficient in mitigating economic declines, emphasizing the necessity of diversified revenue approaches for enduring economic resilience. Moreover, Guendouz and Ouassaf (2020) employed the Non-Herfindahl-Hirschman Index (NHHI) as a proxy for economic diversification to investigate the level of diversification within the Saudi economy. Economic diversification is a central focus of Vision 2030, aimed at establishing a resilient and sustainable economy. The primary objective of their study was to evaluate and identify the determinants of economic diversity in Saudi Arabia through a multiple regression analysis conducted over the period from 1991 to 2016. The findings demonstrated a direct correlation between the economic diversification index and key economic indicators such as Gross Domestic Product (GDP), Gross Fixed Capital Formation (GFCF), and the percentage contribution of

Foreign Direct Investment (FDI) to the GDP. In a related study, Raid et al. (2024) explored the role of non-oil institutional sectors in Saudi Arabia's economic growth over the period 1970-2020. Their study, conducted using a VAR model, highlighted the vulnerability of the oil sector to shocks and the stabilizing influence of the non-oil sector on economic growth. This emphasizes the critical nature of economic diversification as a protective measure against economic shocks and crises.

3. Contribution

To the best of our knowledge, this study is the first to investigate the combined influence of geopolitical risk and oil prices on GDP by utilizing a novel methodology called chain-linking measurement for GDP evaluation, which enhances the accuracy of GDP data. Moreover, this research emphasizes the utilization of updated data that aligns with the latest economic conditions, focusing more on the long and short term. This approach provides a more precise depiction of the country's economic landscape. Consequently, the results will offer empirical insights into the impact of uncertainty on shaping economic activities.

4. Methodology

This section outlines the empirical methodology utilized in this paper to analyze the dynamic interactions and effects among crucial macroeconomic variables, including interest rates, GDP, and money supply, as well as external factors such as geopolitical risk and oil prices. These include the Augmented Dickey-Fuller (ADF) test to examine stationarity and cointegration between the variables; the Vector Autoregressive Model (VAR) and the Vector Error Correlation Model (VECM) to define the long and short-run equilibrium relationships of the empirical model, the causality in the long and short run, and estimate impulse responses.

4.1 Unit Root Test

There are various unit root tests to check the stationarity of variables, most notably, the Augmented Dickey-Fuller test (ADF) (1979) and Phillips- Perron (P-P) (1988) test. We conduct these tests to avoid spurious relationships between the variables and to examine the stationarity of the time series. We use the Augmented Dickey-Fuller (ADF) to identify if the time series is stationary, examine the existence of unit roots, and show the order of integration for each variable. The unit root in the series is the null hypothesis; thus, when the result is statistically significant, the null hypothesis is rejected, which means the variable is stationary at level I (0).

$$\mathrm{H_0}: \delta = 0, (\text{ the variable is non stationary})$$
$$\mathrm{H_1}: \delta \neq 0, \ (\text{ the variable is stationary})$$

The P-P test shares similarities with the ADF test in its specification. However, it differs by utilizing a nonparametric statistical method to address the problem of serial correlation in the error terms while excluding lagged differences.

4.2 Cointegration tests

We use the cointegration test to determine the long-run equilibrium relationship between the variables and to confirm if a group of non-stationary variables is cointegrated or not. When the trace statistics or maximum eigenvalue statistics are greater than critical values at 1% or 5% level, the maximum rank is not equal to zero, which means there is a long-run relationship among the variables; thus, the null hypothesis is rejected. The Johansen and Juselius (1990) test for cointegration is considered a popular test for checking the number of cointegrating vectors (r). The cointegration test is essential to assert the presence of a long-run relationship between the variables before using the Vector Error Correction Model (VECM).

4.3 The Granger Causality Test

After confirming the existence of at least one co-integrating vector, we use the Granger (1969) causality test to examine Granger causality between two variables in the time series and determine if one variable helps forecast another. If X Granger causes Y, that means Y can be predicted through the present value of X and its previous value.

$$Y_t = \gamma_0 + \sum_{i=1}^{p} \gamma_i Y_{t-i} + \sum_{m=1}^{q} \lambda_m X_{t-1} + \mu_t$$

$$X_t = \varphi_0 + \sum_{i=1}^{p} \delta_i X_{t-i} + \sum_{m=1}^{q} \psi_m Y_{t-1} + \varepsilon_t$$

The coefficients we needed to estimate are λ_m and ψ_m.The null and alternative hypothesis are as follows:

The null hypothesis: $H_0 = \lambda_m = \psi_m = 0$

The alternative hypothesis:$H_1 = \lambda_m, \psi_m \neq 0$

Therefore, when both ψ_m and $\lambda_m$are significant, then there is a bidirectional Granger causality between X and Y. However, if $\lambda_m$is not significant that means Y Granger causes X.

4.4 Impulse Response Function

To estimate the Impulse Response Function (IRF), we employ the Vector Autoregression model (VAR). The VAR model captures simultaneous interactions among multiple variables, thus enabling us to generate accurate impulse response functions. We use IRFs to investigate the dynamic repercussions of shocks or impulses on a system of variables over a period.

4.5 Vector Error Correction

We use Vector Error Correction (VECM) to examine the long-run relationships among variables and short-run deviations at equilibrium in case there is a presence of cointegrating or long-run relationships among the system of variables. The underlying VAR model is as follows:

$$Y_t = c + \gamma_1 Y_{t-1} + \gamma_2 Y_{t-2} + \gamma_p Y_{p-1} + \varepsilon_t$$

Where Y_t is a vector of (k×1) outcomes, including GDP, Money supply, interest rate, GPR and oil price, c is a vector of constants (k×1). Therefore, when there is (r) cointegration relationships, the VAR model can be transformed to a VECM model as follows:

$$\Delta Y_t = c + \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t$$

Where Γ_i is the short-run coefficients, ΔY_{t-i} is lagged difference for short-run impact, c is vector constant, p is the lag length, and ε_t is a vector impulse. The rank of the matrix Π=r shows the number of cointegrated vectors (r). VECM is employed if 0 < r < k. Π=$\alpha\beta'$, where α is a vector of adjustment coefficients (k × r) and β is a vector of coefficients (k × r). If Π= (k × k) this means the matrix is full rank.

4.6 Stability Tests

We utilize Cumulative Sum of Squares (CUSUMSQ) tests and the Eigenvalue stability condition to assess the stability of both long and short-run parameters. If the CUSUM and CUSUMSQ test results fall within the critical boundaries at a significant level of 5%, the null hypothesis of stable coefficients cannot be rejected. Similarly, if the Eigenvalues are situated within the unit circle, the estimated model demonstrates dynamic stability.

5. Data

This study utilizes annual data on the Gross Domestic Product (GDP) measured by the chain-linkage methodology, Geopolitical risk (GPR) index, Oil price (OP), and interest rate, which is a 3M SAIBOR, (SAi) during 1994-2023. All series were converted to natural logarithms to modify the model to be in a linear form (i.e. real GDP, GPR, OP, were converted into the growth rate form). Data on GDP and oil prices were collected from the General Authority for Statistics (GASTAT), while Saudi interest rate was obtained from the Saudi Central Bank (SAMA). Additionally, data on geopolitical risk index (GPR) were obtained from Dario Caldara and Matteo Iacoviello (2022). This data measures the adverse geopolitical events and associated risks by counting the number tally of newspaper articles that cover geopolitical tensions since 1900. This measure utilizes 10 newspapers in building the GPR index as displayed in Figure 2. These newspapers include, the Chicago Tribune, the Daily Telegraph, Financial Times, The Globe and Mail, The Guardian, the Los Angeles Times, The New York Times, USA Today, The Wall Street Journal, and The Washington Post. The index is divided into eight groups: War Threats, Threats to Peace, Military Buildups, Nuclear Threats, Terror Threats, Beginning of War, Escalation of War, and Terror Acts. Utilizing the GPR index as a proxy for measuring geopolitical risk allows for the assessment of its impact on Saudi Arabia's economy. This approach is chosen due to the GPR index's ability to capture multiple risk dimensions, such as political instability and policy uncertainty, making it a valuable tool for analyzing the influence of geopolitics on economic outcomes. Furthermore, the index provides quantifiable indicators and enables the examination of the dynamic relationship between geopolitical risk and economic variables over time.

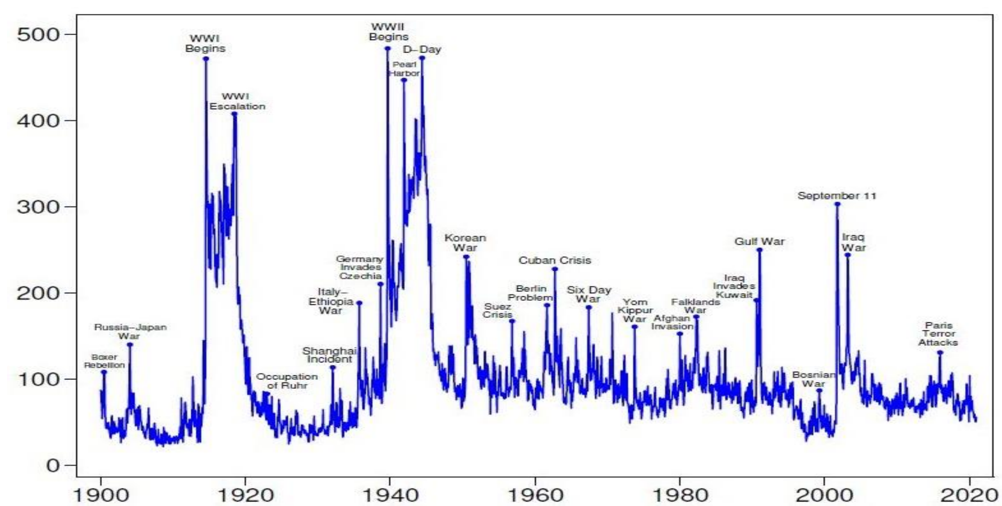


Figure2. Historical Geopolitical Risk Index from January 1900 through December 2020. Geopolitical Risk (GPR) Index (matteoiacoviello.com)

6. Results and Discussion

6.1 Implementation of the Unit Root Test

Table 6.1 presents the Augmented Dickey-Fuller (ADF) test results indicating the presence of unit root. The results show that all variables are non-stationary in level. Moreover, lnGDP, lnGPR, lnOP and interest rate appear to be stationary at the first differences Δ^1 (for a 5% level of significance). However, when we performed the P-P test, the results indicated that all variables are stationary at the first difference, or I (1), except interest

Interest rate which is stationary at the second differenceΔ^2.

Table 6.1. ADF & PP unit root test results

	Augmented Dickey Fuller unit root test results (ADF *t*-Test Statistic		**Phillip Perron (PP) *t*-Test Statistic**		
	Level	Δ^1	**Level**	Δ^1	Δ^2
lnGDP	-0.3721	-4.4095***	-0.3792	-4.6484***	-
lnGPR	-2.8268	-6.3291***	-2.8518	-6.3404***	-
lnOP	-1.58311	-4.8854***	-1.5008	-4.9176***	-
SAi	-2.6634	-3.2188**	-1.4332	-2.3849	-5.6835***

Note: (***), (**) and (*) indicate rejection of null hypothesis of unit root at 1%, 5%, and 10%, respectively

6.2 Cointegration Tests

Akaike information criterion (AIC) suggests that the optimal lag of the model is four. Thus, after determining lag lengths of unrestricted co-integration, the Johansen test reveals the relationships among the variables by testing the null hypothesis of no cointegration versus the alternative hypothesis (maximum rank > 0). Table 6.2 points out that at a maximum level of zero, the trace statistics exceed critical values. Therefore, the null hypothesis of no cointegration is rejected, this suggests that the time series variables are cointegrated.

Table 6.2. Johansen Test for Cointegration

Maximum rank	Parms	LL	Eigenvalue	trace statistic	5% critical value
None*	20	19.401086	.	47.5841	47.21
At most 1	27	31.751177	0.58611	22.8839*	29.68
At most 2	32	39.426607	0.42204	7.5530	15.41
At most 3	35	42.103572	0.17404	2.1791	3.76
At most 4	36	43.193126	0.07487		

Trace test indicates 1 cointegrating equation(s) at the 0.05 level
* Denotes rejection of the hypothesis at the 0.05 level

6.3 Granger Causality Results

To assess the causal relationship among the variables we implement the Granger (1969) causality test. The Granger causality test results presented in Table 6.3 indicate that there is a strong bidirectional Granger causality between the real GDP and oil prices. Also, the results reveal that geopolitical risk does not have a Granger causality relationship with the GDP, perhaps implying that GPR are an exogenous variable. Furthermore, in term of interest rate, oil prices and GPR have a Granger causality relationship with the interest rate.

Table 6.3. Granger Causality Wald Test

Null Hypothesis	F Statistic	Decision
lnOP does not Granger- cause lnGDR	16.983***	Reject H_0
lnGPR does not Granger-cause lnGDP	5.6003	Accept H_0
lnOP does not Granger-cause SAi	12.808**	Reject H_0
lnGPR does not Granger-cause SAi	34.674***	Reject H_0
lnOP does not Granger-cause lnGPR	9.2536	Accept H_0
lnGPR does not Granger-cause lnOP	4.8857	Accept H_0

Notes: (***), (**) and (*) denote the rejection of the null hypothesis at 1%, 5% and 10% level of significance

6.4 Impulse Response Function

The impulse response function results presented in Figure 3 below indicate that the initial impact of geopolitical risk shocks on GDP is relatively modest in the first period, but gradually increases until the third period. However, this effect eventually stabilizes without further significant changes over time. Conversely, the response of GDP to oil price shocks exhibits a consistently positive and highly significant pattern across all periods. Examining the response of the interest rate to a one standard deviation shock in geopolitical risk reveals an immediate and substantial increase until the second period, followed by a period of stability until the fifth period. Subsequently, the effect gradually increases, eventually converging to a steady-state value by the end of the period.

In contrast, the impulse response of the interest rate to an oil price shock exhibits a rapid decline until the fourth period, followed by a gradual increase from the fifth period until the eighth period.

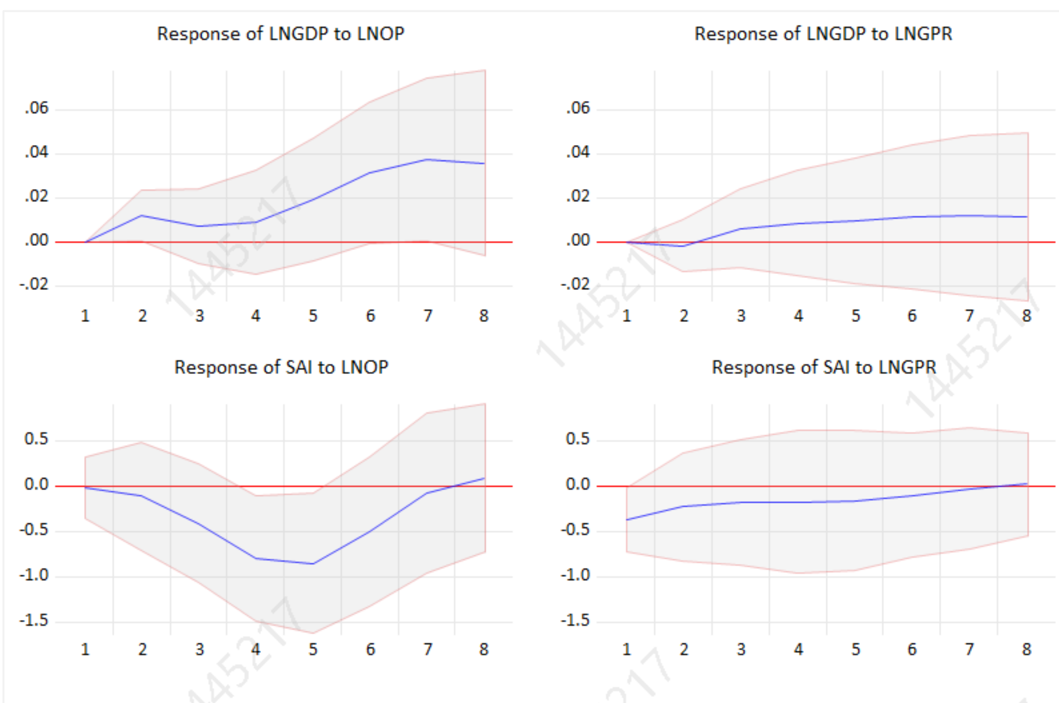


Figure 3. Impulse response function of ln GDP and SAi to lnGPR and lnOP

6.5 The Vector Error Correction Model (VECM)

To examine long-run relationships among variables and short-run deviations at equilibrium in the existence of cointegrating or long-run relationships among the system of variables, we utilize a VECM model to evaluate the dynamics between the variables.

$$\Delta \mathbf{GDP_t} = 0.353 - .354\Delta \ln GDP_{t-1} - ..0036\Delta LnGPR_{t-1} + .054\Delta LnOP_{t-1} + 0.076\Delta SAi_{t-1} - .0905ECT_{t-1} \quad (1)$$

P-value = (0.000^{***}) (0.50^{**}) (0.823^{ns}) (0.002^{***}) (0.156^{ns}) (0.000^{***})

P-value in (), *** significant at the 1% level, and **at the 5% level and ns means not significant.

Equation (1) reveals that the results indicate that changes in GDP from the previous period have a negative short-run impact on the current period's GDP. Thus, if the lagged period of GDP increases by 1%, the current GDP would decrease by 0.35%. This finding aligns with the conventional understanding that a decline in GDP growth can dampen subsequent GDP growth in the short run. Moreover, external factors, particularly global economic conditions, can contribute to the negative impact of the previous GDP on the current GDP through the oil sector. As Saudi Arabia's GDP heavily depends on oil, fluctuations in oil prices have a significant influence on the demand and, consequently, affect the GDP. Moreover, the results show that geopolitical risk is insignificant, implying that the Saudi's economy demonstrates remarkable resilience towards such risks, bolstered by various factors. One significant factor is the Saudi government's unwavering commitment to economic diversification through Vision 2030. The economic reforms aims to reduce the country's reliance on oil as the primary driver of the economy by expanding sectors such as tourism, entertainment, manufacturing, and technology. This diversification effort not only expands the economic base but also reduces vulnerability to oil price fluctuations and geopolitical risks within the energy sector. Additionally, Saudi Arabia maintains a strong financial position with ample foreign reserves and low levels of public debt, serving as a buffer against external shocks.

Furthermore, the coefficient changes in the logarithm of oil prices from the previous period is positive (0.054), and it is statistically significant at the 1% level. This suggests that an increase in oil prices from the previous period has a positive short-run impact on the current GDP. Higher oil prices can benefit oil-exporting countries by increasing revenue and stimulating economic activity, ultimately leading to higher GDP. In addition, the error correction term is highly significant at 1% and 5% levels, which means the long-run equilibrium relationship among the variables is valid, suggesting that the previous year's errors are corrected within the current year at a coverage speed about of .090 .

6.6 Robustness Test

To estimate the long-term regression relationship between variables and ensure the validity and robustness of our model, we employ the Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) methodologies as seen in Table 6.4. Employing these techniques proves beneficial due to their notable consistency, even in the presence of endogeneity and serial correlation challenges.

To capture the impact of economic reformations in Saudi Arabia, we estimate two models one with a dummy variable, which serves as an exogenous variable, and one without. The dummy variable reflects Vision 2030, an initiative aimed at diversifying the economy and reducing dependence on oil to enhance its resilience to uncertainty.

Before the launch of the economic reformation plan, the dummy variable takes a value of 0, indicating the absence of the event. After the reformation, it takes a value of 1, representing the presence of the economic reforms under Vision 2030. This approach allows us to analyze and compare the effects of Vision 2030 on GDP under uncertain conditions.

Generally, the results from the Fully Modified Ordinary Least Squares (FMOLS) in Table 6.4 indicate a strong long-run relationship between GDP and oil prices, both with and without the inclusion of the dummy variable (D), as shown in Table 6.4. The findings reveal that a 1% increase in the natural logarithm of oil prices (lnOP) may have a significantly positive impact on GDP, with an estimated effect of 33%. However, the coefficient of the natural logarithm of geopolitical risk (lnGPR) appears to have an insignificant impact on GDP (see Eq 3).

Furthermore, the inclusion of the dummy variable representing Vision 2030 suggests that the economic reform initiative has a positive and significant effect on GDP, estimated at 36%. These results indicate that the implementation of Vision 2030 has had a substantial and beneficial impact on Saudi Arabia's economic growth.

Similarly, the Dynamic Ordinary Least Squares (DOLS) approach, which provides more robust estimates, supports these findings. According to the DOLS estimates, a 1% increase in oil prices leads to a 25% increase in GDP. Additionally, the findings reaffirm the positive impact of Vision 2030 on GDP. However, similar to the FMOLS results, the coefficient of lnGPR remains insignificant, suggesting that Saudi Arabia's economy exhibits resilience towards geopolitical risks. The interest rate correlates negatively with GDP when the dummy variable is included, in line with economic theory.

Based on the results from both FMOLS and DOLS, it is evident that recent economic reforms have impacted GDP over time, acting as a safeguard against uncertainties and bolstering overall economic stability, which aligns with Guendouz and Ouassaf (2020) where the economic diversification effect positively on GDP. The Saudi economy has recently demonstrated resilience in the face of diverse crises, be they political or trade-related, by employing proactive and efficient fiscal strategies to tackle major challenges. For instance, Saudi Arabia has proactively adopted measures and implemented successful fiscal policies to alleviate the repercussions of the economic downturn caused by Covid-19. Meisenbacher and Wilson (2023) stress the pivotal role of discretionary fiscal measures in mitigating economic downturns and aiding recovery during crises like the pandemic.

Table 6.4. Test of Robustness: FMOLS and DOLS Estimation

Variable	FMOLS		DOLS	
	(3)	(4)	(5)	(6)
LNOP	0.3269**	0.2524***	0.2692**	0.2319***
LNGPR	0.01124	-0.0424	-0.0567	-0.0566
SAi	-0.03165	-0.0297***	-0.0518	-0.0396***
Dummy(Vision 2030)	-	0.3639***	-	0.35168***
C	12.968***	13.6149***	13.800***	13.862***
R-squared	0.641224	0.9278	0.7652	0.9964
Adjusted R-squared	0.598170	0.91578	0.7011	0.9907

Note: (***), (**) and (*) indicate rejection of null hypothesis of unit root at 1%, 5%, and 10%, respectively

6.7 Stability Tests

CUSUM test and the CUSUM of squares tests

Brown et al. (1975) suggested using both the CUSUM test and the CUSUM of squares test to assess model stability. The results illustrated in Figure 4 show that the data surpasses the critical lines at a 5% significance level in the CUSUM test. Furthermore, the CUSUM of Squares test indicates instability, implying changes or structural disturbances in the relationships among variables.

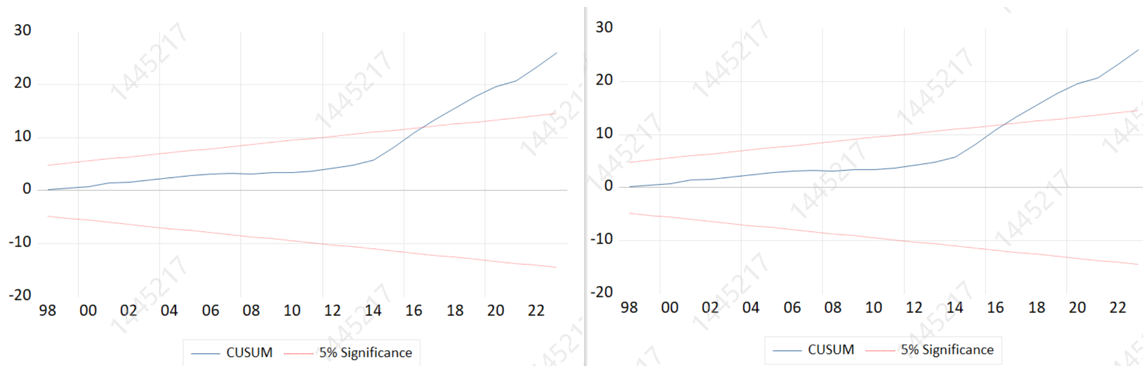


Figure 4. CUSUM test and CUSUM of squares test

According to the accumulated sum of residuals in Figure 5. , it is evident that there are structural breakpoints, notably when the line exceed the critical lines of 5% significance in 2001, 2014, 2016 and 2022.

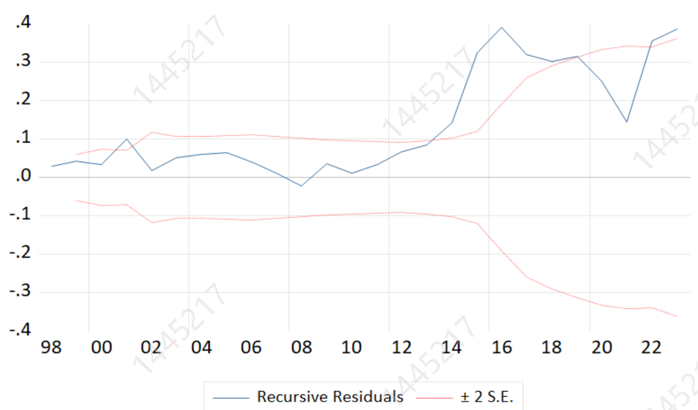


Figure 5. Structural break using Recursive Residuals

These statistical findings are linked to significant events such as the September 11 attacks in 2001, the 2014 collapse in oil prices, the launch of Vision 2030, and the Russia Ukraine war in 2022. To mitigate the impact of these crises on the model, three dummy variables were introduced to capture these events and remove their influence on the time series. Following this adjustment, we re-administered the CUSUM and CUSUMSQ tests, observing both tests to fall within the critical boundaries for a 5% significance level, indicating the stability of our model (see Figure 6).

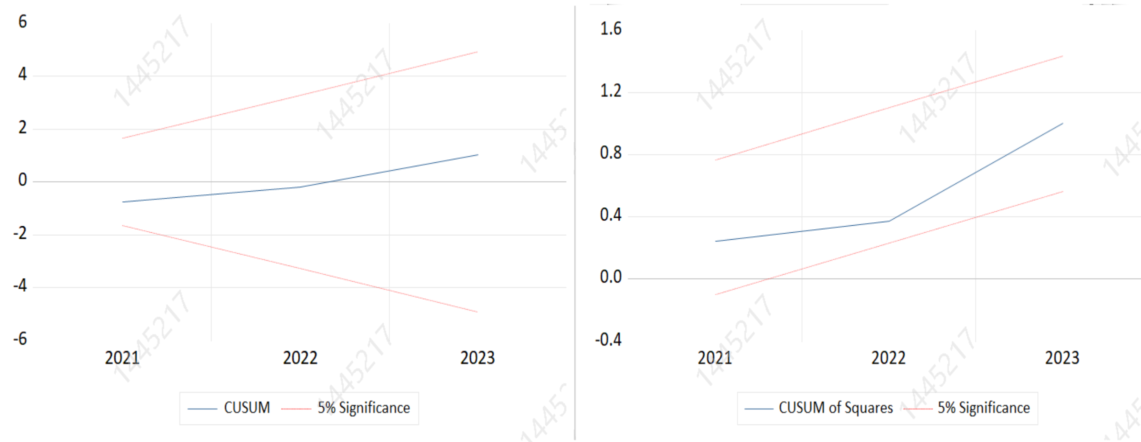


Figure 6. CUSUM test and CUSUM of squares test after adjustment

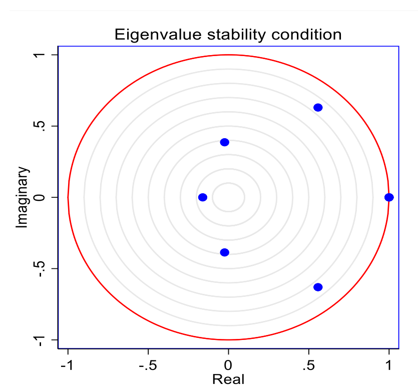
Eigenvalue stability condition

The results presented in Table 6.5 indicate that the VECM specification imposed 3 unit moduli, signifying that all the eigenvalues are situated within the unit circle. Therefore, the estimated model demonstrates dynamic stability.

Table 6.5 Test of Stability – Eigenvalue stability condition

Eigenvalue		Modulus
1		1
1		1
1		1
.5575087 +	6302776i	.841466
.5575087 -	.6302776i	.841466
-.0243921 +	.3864835i	.387252
-.0243921 -	3864835i	.387252
-.1608147		-160815

The VECM specification imposes 3-unit moduli.



7. Conclusion

The dynamic relationships between GDP, interest rate and uncertainty factors such as geopolitical risk and oil price fluctuations are complex. Understanding these relationships is crucial for policymakers to make informed decisions that ensure sustainable economic growth, financial stability, and resilience in the face of challenges. Johansen's test of cointegration reveals a long-run relationship among these variables. According to the results, oil price fluctuations have a more pronounced positive effect on GDP compared to other variables selected for the study. The study shows that there is Granger causality running from oil prices to GDP, while geopolitical risk does not have a Granger causality relationship with the GDP. Additionally, the results indicate that recent economic reforms have had a positive impact on GDP, enhancing economic stability and resilience in Saudi Arabia during various crises through proactive fiscal policies.

Based on the findings of this study, it can be concluded that Saudi Arabia may have effective monetary and fiscal policies in place. The absence of a direct effect of geopolitical risk on GDP suggests that the fiscal policies of the Saudi government, encompassing budget allocation and expenditure decisions, have been successful in fostering economic growth amidst external uncertainties. However, it is essential to recognize that this does not render Saudi Arabia impervious to potential indirect repercussions of geopolitical risks on the economy. Given the influence of oil prices on GDP, it remains crucial for the Saudi government to persist in managing oil price fluctuations through a blend of fiscal and monetary measures. This strategy may involve upholding a stable fiscal regime, diversifying revenue sources, and implementing appropriate monetary policies to alleviate the impact of oil price fluctuations on the economy.

References:

Abdelkawy, N. A., & Al Shammre, A. S. (2024). Fiscal Policy and Economic Resilience: The Impact of Government Consumption Alongside Oil and Non-Oil Revenues on Saudi Arabia's GDP during Crises (1969–2022). *Sustainability*, *16*(14), 6267.

Al Rasasi, M., & Banafea, W. A. (2015). The effects of oil shocks on the Saudi Arabian economy. *J. Energy & Dev*, *41*, 31.

Al Rasasi, M., Qualls, J., & Alghamdi, B. (2019). Oil revenues and economic growth in Saudi Arabia. *International Journal of Economics and Financial Research, 5(3)*, 49-55.

Barro, R. J. (1991). Economic growth in a cross section of countries. The quarterly journal of economics, 106(2), 407-443.

Belloumi, M., Aljazea, A., & Alshehry, A. (2023). Study of the impact of crude oil prices on economic output and inflation in Saudi Arabia. *Resources Policy*, *86*, 104179

Brown, R.L., J. Durbin, and J.M. Evans (1975), "Techniques for Testing the Constancy of Regression Relations Over Time,*" Journal of the Royal Statistical Society,* Series B, 37, 149-163

De Gregorio, Jose. & Guidotti, P. E. (1995) financial development and economic growth. *World Development,* Vol. 23(3), 433-448

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American statistical association, 74*(366a), 427-431.

Eltony, M. N., & Al-Awadi, M. (2001). Oil price fluctuations and their impact on the macroeconomic variables of Kuwait: a case study using a VAR model*. International Journal of Energy Research, 25*(11), 939-959.

Fry, M. (1995) Money, Interest, and Banking in Economic Development. Johns Baltimore & London: Hopkins University Press.Granger, C. W. (1969). Investigating causal relations by econometric models and cross-spectral methods. *Econometrica: journal of the Econometric Society,* 424-438.

Guendouz, A. A., & Ouassaf, S. M. (2020). The economic diversification in Saudi Arabia under the strategic vision 2030. *Acad Account Financ Stud J*, *24*, 1-23.

Hooker, M. A. (1996). What happened to the oil price-macroeconomy relationship?. *Journal of monetary Economics, 38*(2), 195-213.

Huang, J., Ding, Q., Zhang, H., Guo, Y., & Suleman, M. T. (2021). Nonlinear dynamic correlation between geopolitical risk and oil prices: A study based on high-frequency data. *Research in International Business and Finance, 56,* 101370.

Ito, K. (2008). Oil price and the Russian economy: A VEC model approach*. International Research Journal of Finance and Economics, 17,* 68-74.

Jarque, C. M., & Bera, A. K. (1987). A test for normality of observations and regression residuals. *International Statistical Review,* 163-172.

Jilani, S., & Asim, M. (2010). Exploring impact of macro economic variables on GDP of Pakistan. *IBT Journal of Business Studies (JBS)*, *2*(2).

Jilani, S., & Asim, M. (2010). Exploring impact of macroeconomic variables on GDP of Pakistan. *IBT Journal of Business Studies (JBS)*, *2*(2).

Johamen, S., & Jtiselius, K. (1990). Maximum likelihood estimation and inference on cointegration—with appucations to the demand for money. *Oxford Bulletin of Economics and statistics,* 52(2), 169-210.

Meisenbacher, B., & Wilson, D. J. (2023). Recent and Near-Term Fiscal Policy: Headwind or Tailwind?. *FRBSF Economic Letter*, *2023*(09), 1-5.

Meisenbacher, B., & Wilson, D. J. (2023). Recent and Near-Term Fiscal Policy: Headwind or Tailwind?. *FRBSF Economic Letter*, *2023*(09), 1-5.

Mukhtarov, S., Aliyev, S., & Zeynalov, J. (2020). The effects of oil prices on macroeconomic variables: Evidence from Azerbaijan*. International Journal of Energy Economics and Policy, 10*(1), 72-80.

Phillips, P. C., & Perron, P. (1988). Testing for a unit root in time series regression. *biometrika, 75*(2), 335-346.

Raid, M., Ahmad, N., Bagadeem, S. A., Alzyadat, J., & Alhawal, H. (2024). The non-oil institutional sectors and economic growth in Saudi Arabia. *Cogent Economics & Finance*, *12*(1), 2300819.

SAITI, D., & TRENOVSKI, B. (2023). RECONSIDERING MONETARY POLICY: EXAMINATION OF THE RELATIONSHIP BETWEEN INTEREST RATE AND NOMINAL GDP GROWTH IN NORTH MACEDONIA. *ECONOMIC VISION International Scientific Journal in Economics, Finance, Business, Marketing, Management and Tourism*, *10*(19-20), 71-83.

Salisu, A. A., Gupta, R., & Olaniran, A. (2023). The effect of oil uncertainty shock on real GDP of 33 countries: a global VAR approach. *Applied Economics Letters*, *30*(3), 269-274.

Simionescu, M., Popescu, J., & Firescu, V. (2017). The relationship between gross domestic product and monetary variables in Romania. A Bayesian approach. *Economic research-Ekonomska istraživanja*, *30*(1), 464-476.

Soybilgen, B., Kaya, H., & Dedeoglu, D. (2019). Evaluating the effect of geopolitical risks on the growth rates of emerging countries. *Economics Bulletin*, *39*(1), 717-725.

Wei, Y., & Guo, X. (2016). An empirical analysis of the relationship between oil prices and the Chinese macro-economy. *Energy Economics*, *56*, 88-100.

Zaman, G., & Georgescu, G. (2015). Resilience to crisis and GDP recovery at county level in Romania.