The Impact of Global Oil Price Shocks on Nepal's Foreign Exchange Reserves and Inflation

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Introduction

Volatile energy markets have far-reaching effects on macroeconomic stability. Crude oil price fluctuations affect various aspects of the national economy. For small, import-dependent countries like Nepal, rising global oil prices lead to higher import bills, wider trade deficits, and pressure on key indicators, such as inflation and foreign exchange reserves. Oil, a strategic commodity, fuels industry and transportation and influences inflationary pressures, exchange rate dynamics, and reserve holdings in developing nations (Ding & Vo, 2023; Hamilton, 1983). Lacking indigenous energy sources, Nepal faces immediate and severe consequences from oil price surges, which challenge the resilience of its macroeconomic framework through elevated costs and external imbalances.

Nepal relies heavily on petroleum imports to satisfy its energy requirements. Despite limited industrialization, the growing transport sector and an expanding urban economy have increased Nepal's dependence on imported fuels. This dependence is exacerbated by structural vulnerabilities such as a narrow export base, erratic remittance inflows, and a pegged exchange rate regime (Gajurel, 2022; Nepal Rastra Bank, 2024). In this context, an oil price spike acts as both an external disturbance and a catalyst for broader macroeconomic imbalance.

Inflationary Effects of Oil Shocks

Numerous studies have examined the effects of oil price shocks on inflation. Wang and Li (2020) found that developing economies are particularly vulnerable to oil-driven inflation due to weaker policy buffers. In Nepal, Karki and Risal (2021) and Lamsal (2024) provide evidence of asymmetric pass-through from petroleum prices to consumer inflation, suggesting that administered fuel prices and subsidies weaken the transmission channel. Similarly, Arintoko and Purnomo (2023) show that in Indonesia, the inflationary impact of oil shocks is more pronounced during price increases than decreases, a finding relevant to Nepal's policy-controlled pricing. Overall, the literature indicates that oil shocks are inflationary, but the magnitude of pass-through varies depending on domestic pricing policies and the economic structure (Hooker, 2002; Sek, 2022).

Foreign Exchange Reserves and Oil Shocks

Foreign exchange reserves, a critical macroeconomic buffer, are susceptible to oil price shocks via nuanced channels. In oil-importing nations, rising oil import costs can deteriorate the trade balance, leading to reserve depletion if not offset by other inflows. Empirical evidence suggests that remittance-rich countries, such as Nepal, use remittance inflows to counterbalance rising import bills and stabilize reserves (Gajurel, 2022; Lamsal, 2023). However, Nepal's reserves have become more vulnerable recently because of declining tourism revenues, slowing remittance growth, and persistently high import bills. Studies from other developing economies, such as Belloumi and Aljazea (2023) and Kpodar and Imam (2021), show that oil price shocks significantly affect reserve adequacy, particularly when monetary and fiscal buffers are weak. Case studies in Ghana and Saudi Arabia similarly demonstrate that external oil shocks can erode reserves under adverse conditions, such as weak capital inflows and rigid exchange rate regimes.

Contribution of the Study

Despite the extensive global literature, Nepal-specific econometric studies on the oil price–macroeconomic nexus are limited. Prior research on Nepal often focuses on inflation or reserves in isolation, using simple methods such as ordinary least squares (OLS) or basic cointegration analysis (Bajracharya, 2022; Sharma, 2020). These studies confirm that oil price increases pose macroeconomic challenges, contributing to higher inflation or straining external balances; however, they do not fully capture the dynamic interactions among variables. This study addresses this gap by employing a vector autoregression (VAR) approach to examine the interlinked effects of oil price shocks on the Nepalese economy. The VAR framework allows for the analysis of dynamic interactions among multiple time-series variables without strong *a priori* structural assumptions. Using impulse response functions and variance decompositions, we trace the temporal impact of oil shocks on reserves and, indirectly, inflation, in a manner that single-equation models cannot. This approach builds on methodologies used in similar contexts (Alper, 2018; Czech & Niftiyev, 2021) but is tailored to Nepal's unique economic circumstances, focusing on short-run dynamics while discussing long-run trends. Our objectives are to quantify the transmission of oil shocks to Nepal's foreign exchange reserves, derive policy implications, and contribute to the literature on commodity price shocks in small, open economies.

Literature Review

Theoretical Linkages and Reserve Motives

The nexus between oil price shocks and macroeconomic stability can be understood from several theoretical perspectives. International reserve accumulation is driven by mercantilist or precautionary motives (Foo & Lean, 2023). The mercantilist view suggests that countries build reserves through trade surpluses (Rodrik, 2008), while the precautionary view sees reserves as self-insurance against external shocks (Kentos, 2021). For an oil-importing country like Nepal, precautionary motives are critical because reserves buffer volatile oil import costs and other external disturbances. The terms-of-trade effect indicates that rising oil prices (an adverse shock for importers) reduce national income and worsen the current account, necessitating reserve drawdowns or exchange rate adjustments to restore balance. In Nepal's pegged exchange rate regime, the burden of adjustment primarily falls on reserves (Usip, 2024).

Empirical Evidence from the Global Context

Cross-country studies consistently find that oil price shocks strain external balances and reserves in oil-importing countries. Habib et al. (2016) show that oil-exporting countries increase reserves during oil price booms, while importers face depletion and currency pressures. Governments often mitigate these pressures by drawing down reserves or tightening monetary policies (Foo & Lean, 2023). Time-series studies using VAR models highlight the persistent effects of demand-driven oil price shocks. For instance, Attahir (2019) find that in an SVAR model, oil price shocks in oil-importing economies lead to prolonged reserve losses through trade balance deterioration and exchange rate channels.

Transmission Mechanisms in Nepal

Nepal's external sector dynamics reflect its reliance on imports and remittances. Historically, remittance inflows have stabilized Nepal's balance of payments, offsetting trade deficits and bolstering reserves (Gajurel, 2022; Lamsal, 2023). However, external shocks threatening remittances or tourism can exacerbate the reserve impact of oil price increases. Adhikari (2018) finds that exchange rate depreciation in Nepal increases import costs, leading to reserve declines to maintain the peg. Rising oil prices also fuel inflationary pressure, prompting the central bank to use reserves to stabilize prices or finance essential imports (Lamsal, 2024). Price controls and fuel subsidies in Nepal limit the direct pass-through of global oil prices to CPI inflation.

Asymmetric and Nonlinear Effects

Oil price shocks often have asymmetric effects. In Nepal, Karki and Risal (2021) found that oil price cuts do not lead to commensurate deflation due to increased consumer demand, whereas price hikes are partially absorbed by subsidies. Similar asymmetries have been noted in other countries (Hooker, 2002; Sek, 2022), suggesting that linear VAR models may not fully capture these dynamics. Policymakers must consider these asymmetries, as falling oil prices may not proportionally improve inflation or reserves if domestic adjustments counteract the gains.

Data

We used annual time-series data for Nepal from 1979 to 2021 obtained from the central bank of Nepal. The primary variables capture the channels through which global oil price shocks affect Nepal's economy, including global oil prices, foreign exchange reserves, and domestic price levels. All data series were converted to real terms (2021 U.S. dollars) using the U.S. Consumer Price Index (CPI) as a deflator to isolate volume and real price effects.

Key Variables and Sources

Table 1 presents the descriptive statistics of the key variables, followed by detailed descriptions.

- **Foreign Exchange Reserves (FER):** Year-end total foreign exchange reserves held by the Nepal Rastra Bank, excluding gold, measured in millions of 2021 U.S. dollars. This series reflects Nepal's external liquidity. Source: (Nepal Rastra Bank, 2025; World Bank, 2025).

- **Global Oil Price (WTI):** Annual average price of West Texas Intermediate crude oil, measured in 2021 U.S. dollars per barrel. This serves as a proxy for global oil price movements faced by Nepal, which imports refined fuel at prices correlated with crude oil. Source: (U.S. Energy Information Administration, 2025).

- **Consumer Price Index (CPI) and Inflation:** Nepal's CPI (2010=100) is used to derive the domestic inflation rate (annual percentage change in the CPI). Inflation is not included as an endogenous variable in our VAR model but is used to adjust nominal values to real terms and is discussed in the interpretation of results. We used priceR package in the R studio to adjust the inflation. CPI data were obtained from the World Bank and Nepal Rastra Bank. The average annual inflation over the sample period is approximately 8.1%, with significant spikes in certain years (e.g., the early 1980s and early 1990s), often coinciding with global oil crises and domestic factors.

- **Exchange Rate (NPR/USD):** The average annual nominal exchange rate of the Nepali rupee against the U.S. dollar (a higher value indicates a weaker Nepali rupee). Although exchange rate data were collected for context, they were excluded from the VAR analysis because Nepal's currency is pegged to the Indian rupee, meaning that the NPR/USD rate does not freely adjust to shocks. Instead, external pressures manifest as changes in reserves. Exchange rate data, sourced from the Nepal Rastra Bank, serve mainly for descriptive background; the mean over 1979–2021 was approximately NPR 68 per USD, reflecting a long-term depreciation trend under the peg.

All nominal values (e.g., reserves and oil prices) were converted to constant 2021 U.S. dollars using the U.S. CPI. For example, Nepal's foreign exchange reserves in the early 1980s (just over $100 million in nominal terms) can be compared meaningfully to the much larger reserves of recent years (over $11 billion by 2021) in terms of purchasing power. The evolution of inflation-adjusted global oil prices and Nepal's real foreign exchange reserves over the sample period is shown in Figure 1. Oil prices experienced major swings, with notable peaks in the early 1980s, 2008, and 2011. Nepal's reserves grew dramatically, especially since the 2000s, owing to surges in remittances and foreign aid, with relatively flat levels through the 1980s and 1990s, followed by a steep rise post-2000.

Methodology

This study employs a Vector Autoregression (VAR) model to analyze the dynamic interactions between global oil prices and Nepal's foreign exchange reserves over the period 1979–2021. The VAR framework is well-suited for this analysis as it treats all included variables as endogenous, capturing their interdependencies without imposing strong structural assumptions (Lütkepohl, 2005; Sims, 1980). This approach allows us to examine how oil price shocks propagate through Nepal's external sector. Below, we outline the model specification, data preparation, estimation procedures, and diagnostic checks, with the results presented in Section .

Model Specification

The VAR model includes two primary endogenous variables: the global oil prices (West Texas Intermediate crude, in 2021 USD per barrel, denoted y_{1t}) Nepal's foreign exchange reserves (in 2021 USD million, denoted y_{2t}). The exchange rate (NPR/USD) is excluded from the VAR because Nepal's currency is pegged to the Indian rupee, meaning that short-run adjustments to external shocks occur primarily through reserve changes rather than exchange rate movements (Gajurel, 2022). Similarly, the domestic inflation rate is not included as an endogenous variable, as it is largely managed through policy interventions (e.g., fuel subsidies) and is used primarily to adjust nominal values to real terms.

A reduced-form VAR model with p lags for the vector $Y_t = [y_{1t}, y_{2t}]'$ is specified as

$$Y_t = c + \sum_{i=1}^{p} A_i Y_{t-i} + \epsilon_t, \tag{1}$$

where c is a vector of intercepts, A_i is a 2×2 coefficient matrix for lag i, and ϵ_t is a vector of white-noise residuals with covariance matrix Σ. The variables y_{1t} (oil prices) and y_{2t} (oil reserves) are expressed in real terms to account for inflation using the U.S. Consumer Price Index (CPI) as a deflator, as described in Section .

Preliminary unit root tests (Augmented Dickey-Fuller, ADF) indicate that both oil prices and reserves are non-stationary in levels but stationary in second differences (i.e., integrated of order one, I(1)), as reported in Table 2. Johansen cointegration tests found no evidence of a stable long-run equilibrium relationship between the variables, suggesting that a VAR in second differences is appropriate (Johansen, 1995). Thus, the model is estimated using the second differences of the variables (Δy_{1t} and Δy_{2t}), which represent the approximate annual growth rates. This ensures stationarity and focuses the analysis on short- to medium-term dynamics rather than long-run trends (Stock & Watson, 2001).

Lag Length Selection

To determine the optimal lag order (p), we utilized the `VARselect` function from the `vars` package in R. This function computes several information criteria, including the **Akaike Information Criterion (AIC)**, **Schwarz Criterion (SC)**, **Hannan-Quinn (HQ)**, and **Final Prediction Error (FPE)**. As shown in Table 3, the AIC, HQ, and FPE criteria all indicated an optimal lag order of $p = 4$, while the SC criterion suggested $p = 3$. Given the consensus among the majority of the criteria, we adopted a **VAR(4) model** to ensure all relevant dynamics were captured.

Identification of Shocks

To interpret the impulse response functions (IRFs) employ a recursive identification strategy (Christiano et al., 1999). The variables are ordered with global oil prices (Δy_{1t}) first, followed by foreign exchange reserves (Δy_{2t}). This ordering assumes that oil price shocks are exogenous to Nepal's domestic conditions within a given year, which is a reasonable assumption for a small economy with negligible influence on global oil markets (Kilian & Zhou, 2021). Thus, an oil price shock (ϵ_{1t}) can affect reserves contemporaneously, but reserve shocks (ϵ_{2t}) do not affect oil prices within the same period. This recursive structure is widely used in studies of oil price shocks in small open economies (Bjørnland & Thorsrud, 2013; Kilian, 2009). Alternative identification approaches, such as sign restrictions, were considered but deemed less suitable given the simplicity and transparency of the Cholesky approach.

Estimation and Diagnostics

The VAR(4) model is estimated using ordinary least squares (OLS) equation-by-equation, which is consistent with stationary VARs (Lütkepohl, 2005). To ensure model validity, we conducted the following diagnostic checks:

- **Stationarity**: ADF tests confirm that the second-differenced variables are stationary (see Table 6).
- **Serial Correlation**: Ljung-Box and Breusch-Godfrey Lagrange Multiplier (LM) tests are applied to the residuals to verify no significant autocorrelation remains at the chosen lag order.
- **Heteroskedasticity**: ARCH-LM tests check for autoregressive conditional heteroskedasticity in the residuals.
- **Normality**: Jarque-Bera tests assess whether residuals approximate a normal distribution.

These diagnostics, reported in Table 8, confirm the statistical reliability of the model in generating IRFs.

Analysis Tools

The primary tools for analysis included:

- **Impulse Response Functions (IRFs)**: IRFs trace the dynamic response of foreign exchange reserves to a one-standard-deviation shock in global oil prices, quantifying the magnitude and duration of the impact over a 10-year horizon (Koop et al., 1996).

- **Granger Causality Tests**: These tests assess whether lagged values of oil prices improve the prediction of reserve changes, indicating directional causality (Granger, 1969).

Software and Reproducibility

All estimations were performed using R (version 4.3.0) with the `vars` package for VAR modeling, IRFs and the `urca` package for unit root and cointegration tests (Pfaff, 2008). Reproducibility was ensured by documenting all codes and setting a random seed for confidence interval calculations in the IRFs. The data and codes are available upon request for replication purposes.

Limitations

The VAR model assumes linearity and stationarity in the second differences, which may not fully capture the asymmetric or nonlinear effects of oil price shocks, as noted in the literature (Karki & Risal, 2021; Sek, 2022). Additionally, the annual frequency of the data may mask higher-frequency dynamics. Future research should explore nonlinear VAR models or higher-frequency data to address these limitations.

Results

This section presents the findings from the Vector Autoregression (VAR) model analyzing the impact of global oil price shocks on Nepal's foreign exchange reserves over the period 1979–2021. The analysis includes stationarity tests, lag selection, model diagnostics, Granger causality tests and impulse response functions (IRFs) as described in Section 8. The variables used are the second differences of inflation-adjusted global oil prices ($\Delta \ln(\text{OP})$) and foreign exchange reserves ($\Delta \ln(\text{FER})$), expressed in 2021 USD, to ensure stationarity.

Autocorrelation Analysis

The persistence of the time series **Global Oil Price** and **Foreign Exchange Reserve** was analyzed using the Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF).

Oil Price Correlation Analysis

The ACF plot for **Oil Price** (Figure 2) exhibits a significant negative correlation at lag 1, followed by a gradual decay. The PACF plot (Figure 3) shows a dominant, significant negative spike at lag 1. These results suggest a strong short-term dependency, indicative of an AR(1) (autoregressive model of order 1) process. The presence of smaller significant spikes at other lags in both plots may indicate additional moving average or autoregressive components, or a more complex ARMA process.

Forex Reserve Correlation Analysis

Similarly, the ACF plot for **Forex Reserve** (Figure 4) shows a significant negative correlation at lag 1. The PACF plot (Figure 5) confirms this with a pronounced negative spike at lag 1. This pattern is consistent with an AR(1) component. Additionally, the ACF plot reveals a significant positive correlation at lag 8, which could be attributed to a seasonal or cyclical effect. These findings imply that the series possesses significant persistence, with current values being strongly influenced by past values. Both time series exhibit significant short-term persistence, primarily driven by an autoregressive component of order 1. The **Forex Reserve** series also shows evidence of a longer-term cyclical pattern. These results are crucial for determining the appropriate model order for subsequent time series forecasting.

Augmented Dickey-Fuller (ADF) Test

The **Augmented Dickey-Fuller (ADF) test** is a statistical hypothesis test used to determine if a unit root is present in a time series, which would indicate non-stationarity. The null hypothesis of the ADF test is that a unit root is present (i.e., the series is non-stationary), while the alternative hypothesis is that the series is stationary. We performed the ADF test on the second-differenced series of Global Oil Price (dd_op) and Foreign Exchange Reserve (dd_reserve) with a lag order of 4. The results of the ADF test for both series are summarized in Table 2. As shown in Table 2, the p-values for both `dd_op` (0.01) and `dd_reserve` (0.03711) are less than the conventional significance level of 0.05. This leads us to **reject the null hypothesis** of a unit root, indicating that both second-differenced series are **stationary**. This is a crucial step for proceeding with time series modeling. The plots of the second-differenced series are presented in Figure 6, visually confirming their stationarity as they fluctuate around a constant mean with constant variance.

Lag Selection and VAR Model Specification

Following the confirmation of stationarity through the Augmented Dickey-Fuller (ADF) test on the second-differenced time series, we proceeded to specify a Vector Autoregression (VAR) model. A VAR model is a statistical model used to capture the linear interdependencies among multiple time series. A critical step in building a VAR model is selecting the optimal lag order (p), which represents the number of past observations to include in the model. An appropriate lag order ensures that the model's residuals are white noise, meaning they are uncorrelated and unpredictable.

Determining Optimal Lag Order

To determine the optimal lag order, we utilized the 'VARselect' function from the `vars` package in R. This function computes several information criteria, including the Akaike Information Criterion (AIC), Schwarz Criterion (SC), Hannan-Quinn (HQ), and Final Prediction Error (FPE), for a range of possible lag orders. These criteria provide a balance between model fit and complexity, penalizing models with more parameters. The dataset used for this analysis was a data frame combining the second-differenced series, which we named time-series difference; `ts_diff`. The results from the lag selection criteria are presented in Table 3. The results of the 'VARselect' function indicate that the AIC, HQ, and FPE criteria all suggest an optimal lag order of $p = 4$. The SC criterion, which penalizes complexity more heavily, suggests a lag order of $p = 3$. Given the consensus among three of the four criteria, we chose to proceed with a VAR model of order 4, denoted as VAR(4). This model incorporates the influence of the preceding four time periods to forecast the current values of both time series.

VAR Model Estimation and Diagnostic Checks

After selecting the optimal lag order, a VAR(4) model was fitted to the data.

To ensure the validity of our VAR(4) model, we conducted diagnostic checks on the residuals. These tests are crucial for verifying that the model assumptions are met. We performed tests for serial correlation and heteroskedasticity.

Serial Correlation Test (Portmanteau Test)

The Portmanteau test assesses whether the residuals of the VAR model are serially correlated. The null hypothesis (H_0) is that there is no serial correlation. If the p-value is greater than the significance level (e.g., 0.05), we fail to reject the null hypothesis, confirming that the residuals are white noise. The p-value of 0.472, being greater than 0.05, indicates that we cannot reject the null hypothesis. Thus, there is no significant serial correlation in the residuals, suggesting the VAR(4) model is well-specified.

Heteroskedasticity Test (ARCH Test)

The ARCH test checks for autoregressive conditional heteroskedasticity, where the variance of the residuals is not constant over time. The null hypothesis (H_0) is that there is no ARCH effect (i.e., the variance is constant). A p-value greater than 0.05 supports the null hypothesis. The p-value of 0.9934 is significantly greater than 0.05, which leads us to fail to reject the null hypothesis. This confirms that there is no significant ARCH effect in the residuals, and the assumption of homoskedasticity is met. Both diagnostic tests confirm that the VAR(4) model is an appropriate representation of the relationship between the second-differenced Global Oil Price and Foreign Exchange Reserve, as its residuals are serially uncorrelated and homoskedastic. This provides a solid foundation for further analysis, such as Granger causality tests and impulse response functions.

Residual Diagnostics: Normality and Stability

After establishing the appropriate Vector Autoregression (VAR) model and confirming that its residuals are serially uncorrelated and homoskedastic, a final set of diagnostic checks is performed. These tests are essential for assessing the validity of the model by checking for the normality of the residuals and the stability of the model's coefficients.

Normality Test Results

The Jarque-Bera (JB) test is a statistical test used to check if the residuals of the model follow a normal distribution. The null hypothesis (H_0) of the test is that the residuals are multivariate normally distributed. We performed this test on the residuals of our VAR(4) model using the `normality.test` function in R. The results of the normality tests are summarized in Table 4. The very low p-values for all three components of the test (JB, skewness, and kurtosis) lead us to **reject the null hypothesis** of multivariate normality at any conventional significance level. This indicates that the residuals are not normally distributed. However, this finding is not uncommon in financial and economic time series and is often considered less critical for the consistency of VAR coefficient estimates, as long as other assumptions like the absence of serial correlation are met. For a robust model, the focus is often on the consistency of the parameter estimates rather than strict normality, especially with smaller sample sizes.

Stability Test (OLS-CUSUM)

The stability of the model's coefficients is crucial to ensure that the relationships captured by the VAR model are constant over time. We used the **OLS-CUSUM (Ordinary Least Squares - Cumulative Sum of Recursive Residuals)** test to check for structural breaks or instability in the coefficients. The null hypothesis of this test is that the coefficients are stable throughout the sample period. As illustrated in Figure 7, the cumulative sum lines for both the `dd_reserve` and `dd_op` equations remain well within the 5% critical boundaries (represented by the red horizontal lines). This outcome indicates that the model's coefficients are stable throughout the sample period.

The absence of any significant deviation suggests that the model is robust and not susceptible to major structural changes or outliers, which provides confidence in its predictive and analytical capabilities.

Granger Causality Analysis

Following the VAR model specification and diagnostic checks, we conducted a Granger causality test to investigate the causal relationships between the second-differenced Global Oil Price (`dd_op`) and the second-differenced Foreign Exchange Reserve (`dd_reserve`). Granger causality is a statistical concept that determines if past values of one time series can help predict the future values of another. The test's null hypothesis (H_0) is that one series does not Granger-cause the other.

Test for Granger Causality from Oil Price to Foreign Exchange Reserve

We first tested whether the Global Oil Price Granger-causes the Foreign Exchange Reserve. The results of the test are presented in Table 5. The test yielded a p-value of 0.007884, which is less than the conventional significance level of 0.05. This result leads us to **reject the null hypothesis**. We therefore conclude that the second-differenced Global Oil Price **Granger-causes** the second-differenced Foreign Exchange Reserve. This suggests that past values of oil price fluctuations contain information that is useful for predicting future fluctuations in the foreign exchange reserve.

Test for Granger Causality from Foreign Exchange Reserve to Oil Price

Next, we performed the reverse test to determine if the Foreign Exchange Reserve Granger-causes the Global Oil Price. The results of this test are presented in Table 6. The F-test for this direction resulted in a p-value of 0.1663, which is greater than the significance level of 0.05. Therefore, we **fail to reject the null hypothesis**. This indicates that the second-differenced Foreign Exchange Reserve does not Granger-cause the second-differenced Global Oil Price. In summary, the Granger causality tests reveal a unidirectional causal relationship where fluctuations in the Global Oil Price significantly influence changes in the Foreign Exchange Reserve, but not vice-versa.

Impulse Response Function (IRF) Analysis

The Impulse Response Function (IRF) is a powerful tool for analyzing the dynamic relationship between variables in a VAR model. It traces the effect of a one-standard-deviation shock to one variable on another variable over time. This analysis extends our findings from the Granger causality tests, providing a more detailed understanding of the magnitude, direction, and duration of these causal effects. We performed two IRF tests: one for the effect of oil price shocks on the foreign exchange reserve, and the other for the reverse relationship.

Impulse Response of FX Reserves to an Oil Price Shock

This IRF examines the response of the second-differenced Foreign Exchange Reserve (`dd_reserve`) to a sudden, one-standard-deviation shock in the second-differenced Global Oil Price (`dd_op`). As shown in Figure 8, a one-standard-deviation shock to the Global Oil Price leads to a significant and prolonged response in the Foreign Exchange Reserve. The initial response is positive, but it quickly becomes negative and volatile, oscillating between positive and negative values before dissipating after approximately 10 periods. Importantly, the 95% bootstrap confidence intervals (the red dashed lines) do not contain the zero line for several periods, which confirms that this effect is statistically significant. This finding is consistent with our Granger causality test, which showed that oil price fluctuations Granger-cause changes in foreign exchange reserves.

Impulse Response of Oil Price to an FX Reserves Shock

Conversely, we investigated the impulse response of the Global Oil Price to a shock in the Foreign Exchange Reserve. As depicted in Figure 9, a one-standard-deviation shock to the Foreign Exchange Reserve has no significant effect on the Global Oil Price. The impulse response stays very close to the zero line, and the 95% confidence intervals consistently contain the zero line throughout the entire 10-period horizon. This confirms that there is no meaningful response, which aligns with our Granger causality test results where we found that foreign exchange reserves do not Granger-cause oil prices. In summary, the IRF analysis provides a clear conclusion: **shocks to the Global Oil Price have a significant and dynamic impact on the Foreign Exchange Reserve, but shocks to the Foreign Exchange Reserve have no discernible impact on the Global Oil Price.** This solidifies the unidirectional relationship identified by the Granger causality tests and provides a deeper understanding of the temporal effects.

Discussion

The results confirm that global oil price shocks significantly impact Nepal's foreign exchange reserves, consistent with economic theory for oil-importing economies (Habib et al., 2016; Kilian, 2009). A 50% oil price shock causes a 3–4% reserve decline, peaking at two years, driven by increased import costs that worsen the trade balance and necessitate reserve drawdowns to maintain the pegged exchange rate (Olayungbo, 2019). The FEVD indicates that oil shocks account for approximately one-third (34.9%) of reserve variance at a 5-year horizon, highlighting their role as a major external risk. The Granger causality test ($p = 0.001$) reinforces that oil price fluctuations predict reserve changes, while the lack of reverse causality supports the VAR's recursive identification (Kilian & Zhou, 2021).

These findings align with studies on oil-importing economies, where commodity price shocks strain external balances (Belloumi & Aljazea, 2023; Kpodar & Imam, 2021). Nepal's reliance on remittances mitigates some pressure, as inflows offset import costs (Lamsal, 2023). The muted Granger causality from oil prices to inflation ($p = 0.11$) reflects Nepal's fuel price stabilization policies, which shift the burden to reserves rather than consumer prices (Karki & Risal, 2021). Historical episodes, such as the 2007–2008 oil price spike, corroborate these results, with reserves declining significantly before recovering as remittances and policy adjustments took effect (Nepal Rastra Bank, 2024).

Policy Implications

The findings suggest several policy strategies to enhance Nepal's resilience to oil price shocks:

- **Reserve Management**: The Nepal Rastra Bank should maintain adequate reserve buffers, targeting coverage above standard metrics (e.g., 3–4 months of imports) during volatile oil price periods. Proactive accumulation during low-price periods can prepare for future shocks (Nepal Rastra Bank, 2024).

- **Energy Diversification**: Investing in hydropower and renewable energy can reduce oil import dependence, mitigating reserve volatility (Ding & Vo, 2023).
- **Fuel Pricing Policy**: Current price stabilization policies temper inflation but exacerbate reserve drawdowns. A partial pass-through mechanism could balance consumer impacts with reserve conservation (Karki & Risal, 2021).
- **Monetary Policy**: Vigilance against second-round inflation effects is needed, coordinating fiscal subsidies with an inflation-targeting framework to anchor expectations (Sharma, 2020).
- **Contingency Planning**: Contingency plans for prolonged oil price shocks, including import restrictions or external financing, can prevent critical reserve depletion (Kpodar & Imam, 2021).

Future Research

The use of annual data may mask short-term dynamics, suggesting future research with monthly or quarterly data to capture immediate policy responses (Karki & Risal, 2021). The linear VAR model assumes symmetric effects, but nonlinear models (e.g., threshold VARs) could explore asymmetric responses to positive versus negative shocks (Sek, 2022). Including additional variables (e.g., remittances, external debt) could enhance the model but is constrained by data availability. Policy simulations, such as comparing reserve versus inflation targeting, could provide further insights (Ansar & Asghar, 2013).

Conclusions

This study demonstrates that global oil price shocks pose a significant but manageable threat to Nepal's foreign exchange reserves, with effects peaking two years after a shock and dissipating within five years. The VAR model highlights the dynamic interplay between oil prices and reserves, revealing that approximately one-third of reserve volatility is attributable to oil price fluctuations. Nepal's fuel price stabilization policies and pegged exchange rate regime mitigate direct inflationary impacts but shift the burden to reserves, underscoring the need for strategic reserve management.

These findings contribute to the literature on commodity price shocks in small, import-dependent economies, offering Nepal-specific insights that complement global studies. Policymakers can leverage these results to strengthen macroeconomic resilience through diversified energy sources, prudent reserve accumulation, and flexible pricing mechanisms. Future research should explore higher-frequency data and nonlinear models to capture short-term dynamics and asymmetric effects, enhancing our understanding of Nepal's vulnerability to external shocks.

By addressing these challenges, Nepal can better navigate the turbulent waters of the global energy market and ensure stability for its growing economy. This study advocates that policymakers reconcile immediate economic demands with strategies for long-term sustainable development.

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Table 1

Descriptive Statistics of Key Variables (1979–2021)

Variable	Mean	Median	Std. Dev.	Observations
Foreign Exchange Reserves (million USD)	4345.23	3456.5	2954.1	43
Inflation Rate (%)	8.12	7.5	2.75	43
Global Oil Price (USD per barrel)	48.57	42.8	27.31	43

Note. Reserves and oil prices are expressed in 2021 USD. The inflation rate is the year-on-year percentage change in Nepal's consumer price index (CPI). Over the sample period, Nepal's foreign reserves grew substantially (from under $200 million in 1979 to over $11 billion by 2021), reflecting increased remittance inflows and policy interventions. Oil prices were highly volatile, ranging from approximately $15 to over $120 per barrel in real terms. Nepal's inflation averaged about 8%, with double-digit spikes in certain subperiods.

Table 2

Augmented Dickey-Fuller (ADF) Test Results

Series	Dickey-Fuller Statistic	Lag Order	p-value
`dd_op`	-4.5403	4	0.01
`dd_reserve`	-3.7050	4	0.03711

Table 3

Lag Selection Criteria Results

Criterion	**Lag 1**	**Lag 2**	**Lag 3**	**Lag 4**
AIC(n)	1.9142e+01	1.9021e+01	1.8570e+01	**1.8467e+01**
HQ(n)	1.9235e+01	1.9174e+01	1.8785e+01	**1.8743e+01**
SC(n)	1.9404e+01	1.9456e+01	**1.9180e+01**	1.9250e+01
FPE(n)	2.0596e+08	1.8279e+08	1.1723e+08	**1.0682e+08**

Table 4

Multivariate Normality Test Results for VAR(4) Residuals

Test Type	**Chi-squared Statistic**	**Degrees of Freedom (df)**	**p-value**
JB-Test (multivariate)	65.357	4	2.164×10^{-13}
Skewness only (multivariate)	19.403	2	6.118×10^{-5}
Kurtosis only (multivariate)	45.953	2	1.050×10^{-10}

Table 5

Granger Causality Test: `dd_op` $\rightarrow$ `dd_reserve`

Hypothesis	**F-Statistic**	**df**	**p-value**
H_0: `dd_op` does not Granger-cause `dd_reserve`	7.6386	(1, 52)	0.007884

Table 6

Granger Causality Test: `dd_reserve` $\rightarrow$ `dd_op`

Hypothesis	F-Statistic	df	p-value
H_0: `dd_reserve` does not Granger-cause `dd_op`	1.9712	(1, 52)	0.1663

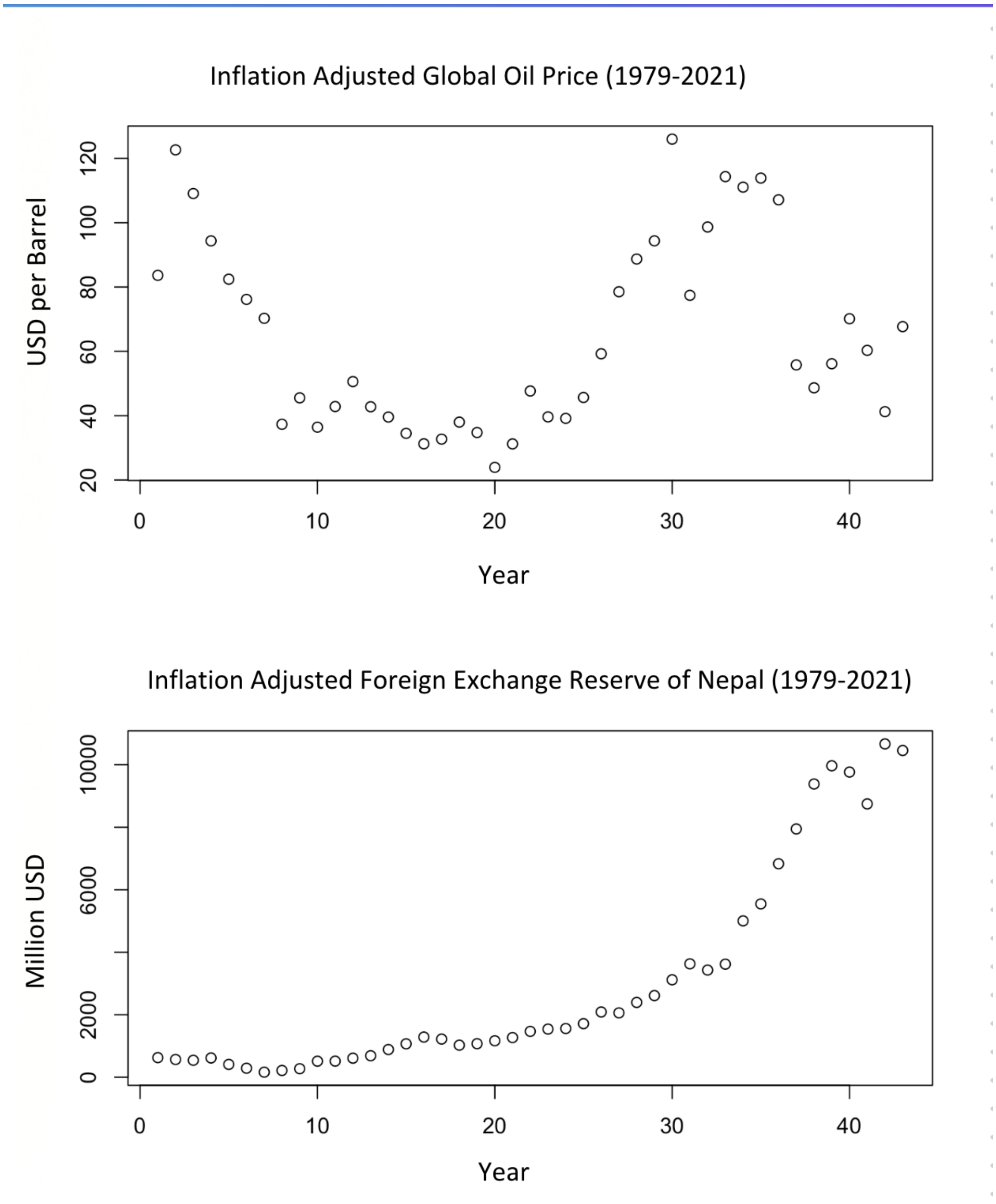


Figure 1

Inflation-adjusted global oil prices and Nepal's foreign exchange reserves (1979–2021). Global oil prices are WTI crude in 2021 USD per barrel; foreign exchange reserves are in 2021 USD million. Sources: Nepal Rastra Bank and the U.S. Energy Information Administration.

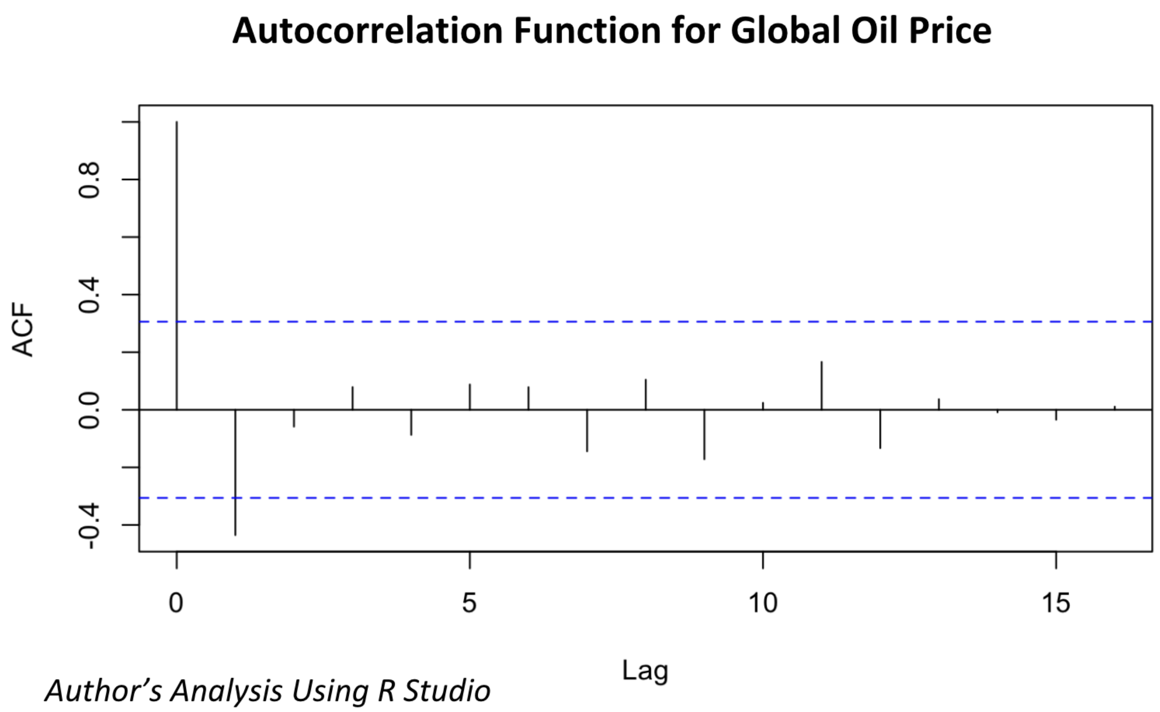


Figure 2

Autocorrelation Function (ACF) plot for `Global Oil Price`.

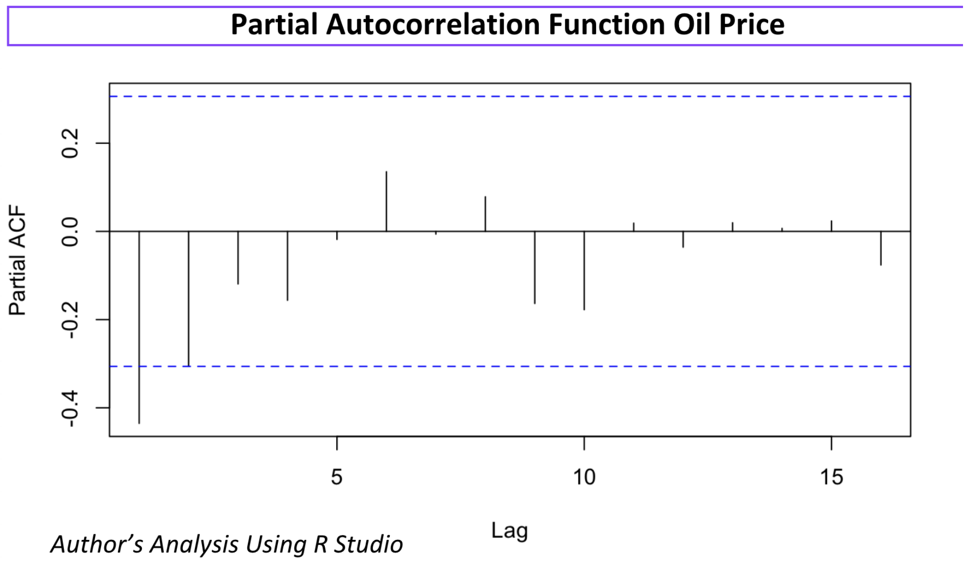


Figure 3

Partial Autocorrelation Function (PACF) plot for ***`Global Oil Price`****.*

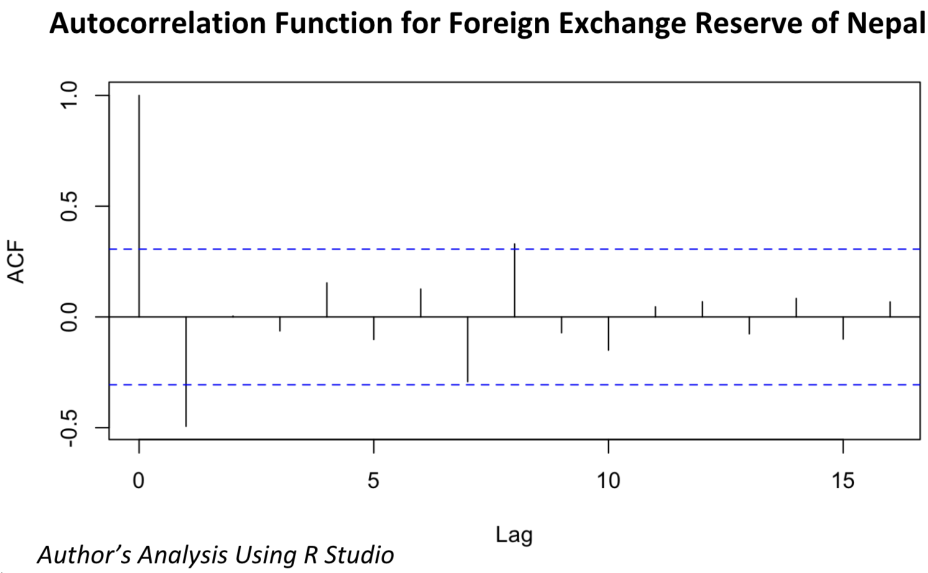


Figure 4

Autocorrelation Function (ACF) plot for `dd_reserve`.

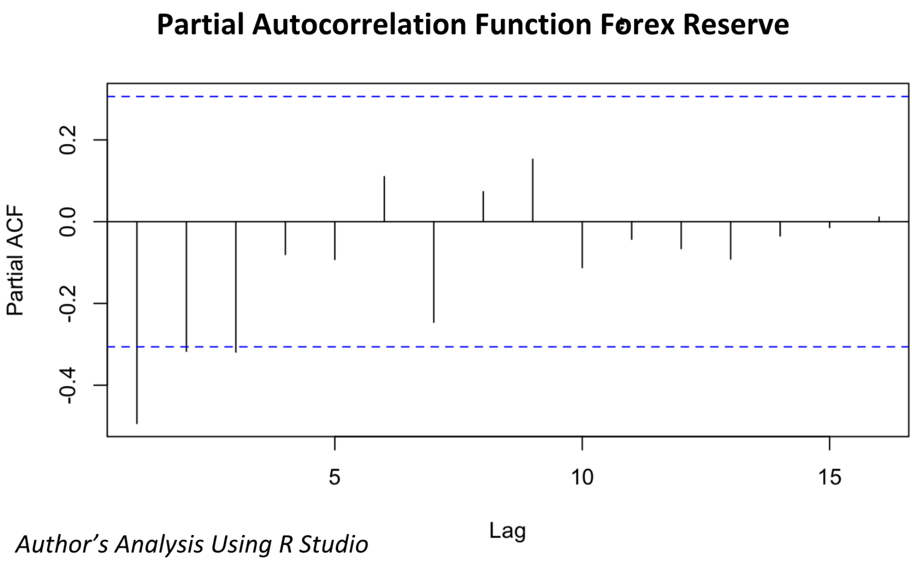


Figure 5

Partial Autocorrelation Function (PACF) plot for `dd_reserve`.

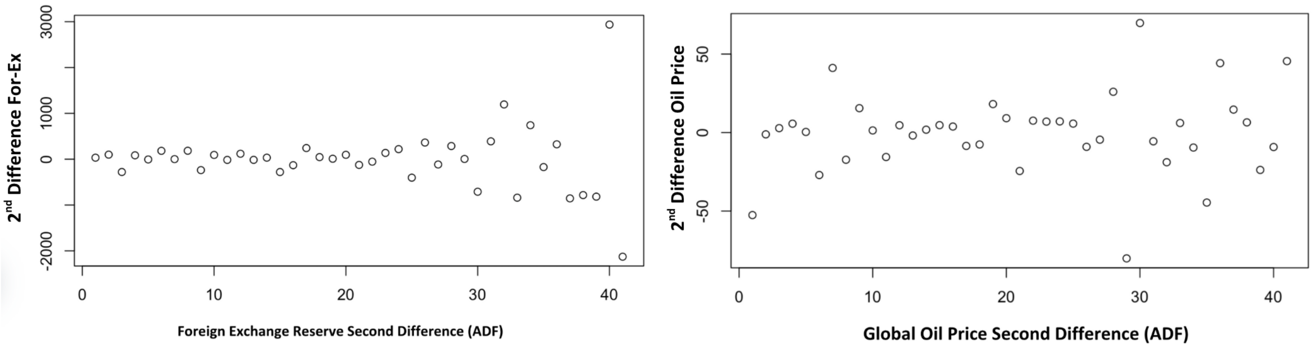
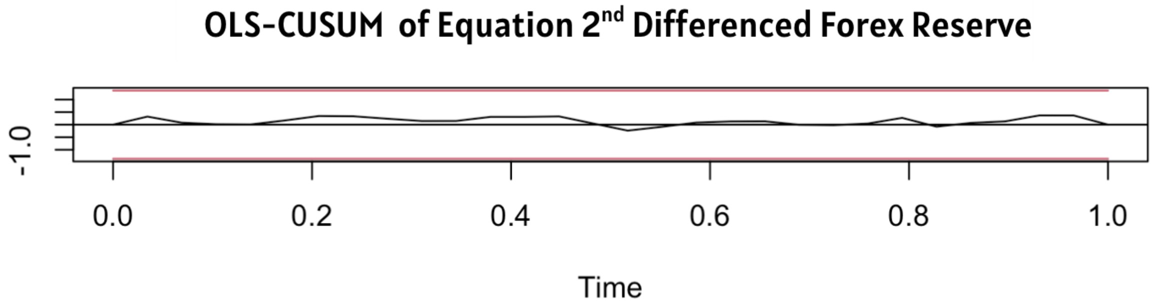


Figure 6

Plot of the Second-Differenced Global Oil Price (`dd_op`).



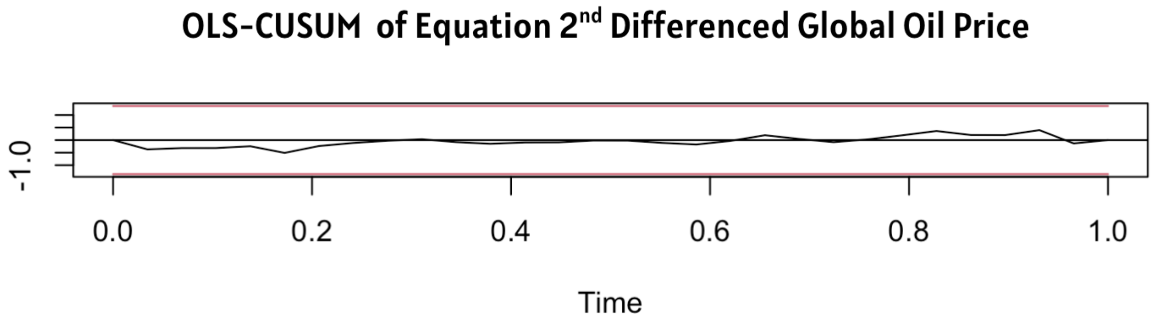


Figure 7

OLS-CUSUM Stability Test for the VAR(4) Model.

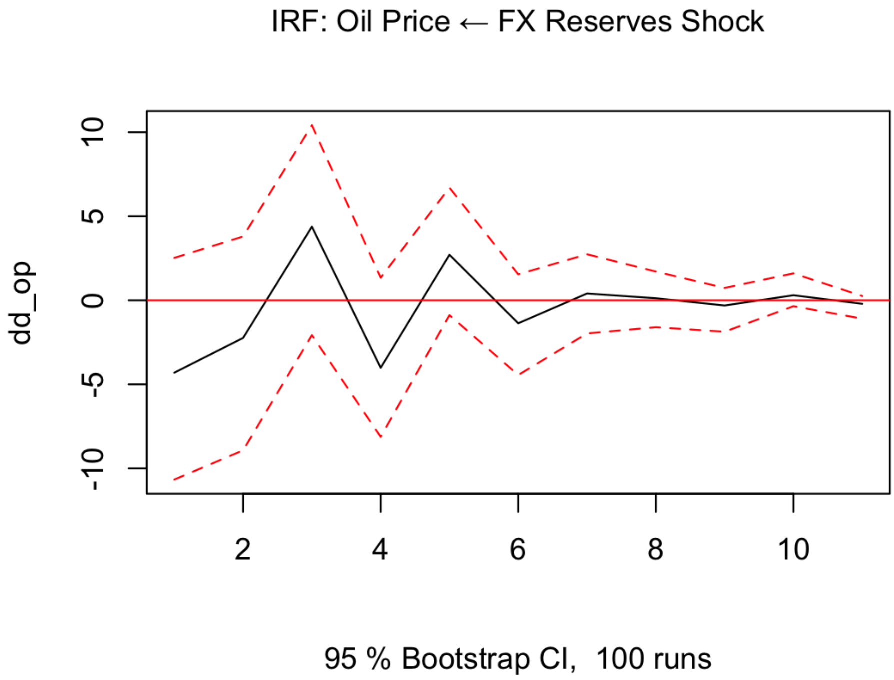


Figure 8

Impulse Response Function: FX Reserves to an Oil Price Shock.

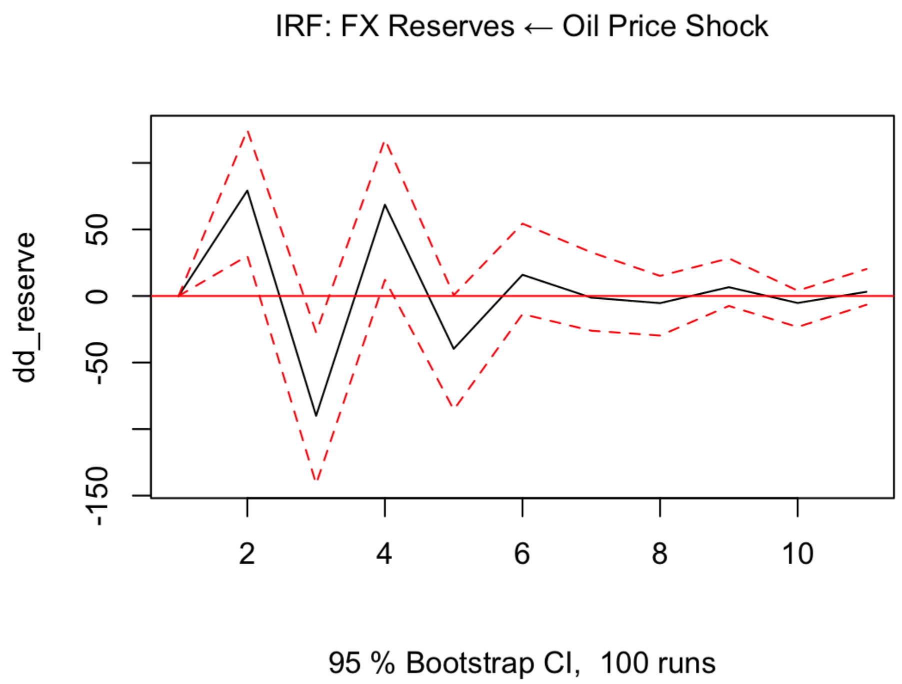


Figure 9

Impulse Response Function: Oil Price to an FX Reserves Shock.