Oil Revenue Volatility, Supply Chain Digitization, and Logistic Performance: Impact on Foreign Exchange Reserves in Iraq

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ABSTRACT

Academic researchers closely follow oil revenues since it's significantly important in helping central foreign exchange reserves. Since these revenues, which accrue from the exports of crude oil, depend on a variety of factors including international prices of oil and volumes of exports, these revenues are subject to considerable volatility. The economy of Iraq, which has been defined as a rentier economy based on a single source, requires holding sufficient foreign exchange reserves to cushion against internal and external shocks in the economy. Moreover, the factors like logistic performance and supply chain digitalization have also been observed as macroeconomic indicators in determining the trends in the foreign exchange reserves. Considering this idea, the current research examines the nexus between oil revenue volatility, supply chain digitalization, logistic performance and foreign exchange reserves for the region of Iraq during 2007-2023. For this purpose, the study considers the quarterly time series observations during the given period for which the advanced econometric estimations entitled Autoregressive Distributed Lag (ARDL) model has been applied. The ARDL results show that foreign currency reserves (FER) are mainly affected by past reserves, oil revenue changes, and logistic performance. When reserves were higher before, they tend to be higher now. Oil revenue changes and better logistics also lead to more reserves. On the other hand, past oil revenue changes and logistics do not seem to have any real effect on the foreign exchange reserves of the given economy. Besides, the results indicate that supply chain digitalization only affects reserves after some time, meaning digital improvements help increase reserves in the future. The study also provides some meaningful policy suggestions for the targeted region along with the limitations and future directions.

Keywords: Oil revenues, foreign exchange reserves, supply chain digitalization, logistic performance, ARDL.

INTRODUCTION

Foreign exchange reserves, being an important part of country savings, indicate the credit risk and strength of monetary policy of a country to global financial markets. Economic flows such as exports and imports and money flows affect the level of reserves. It relies on the level of import requirement and existing exchange rate regime (Sari & Ekaputri, 2024). Foreign

exchange reserves comprise External assets that a country's monetary authorities maintain to offset payment imbalances and reduce the response of external economic shocks, as defined by the International Monetary Fund (IMF). In general, such reserves have two functions: enabling international settlements and acting as a shield against speculative pressure. Macro-economic policies that have the objective of stabilizing trade balances rely heavily on foreign exchange reserves in terms of designing and investigating them (Kumar & Singhal, 2022).

Supply chain digitalization or more precisely the term SCD aims to involve using digital technologies in supply chain activities. It has become a key topic in recent research (Björkdahl, 2020). The reason is that the growing interest comes from the belief that SCD can improve key activities like demand forecasting, reducing costs, and improving coordination between organizations (Frank et al., 2019). Moreover, such type of advance tends to bring the benefits like a better financial (Ali et al., 2018), operational (Ganbold et al., 2020), and innovation performance (Chi et al., 2018) for different organizations and business units. For this reason, there are some studies who have explored these benefits while others find little or no effect (Nasiri et al., 2020). At the same time, the concept of digitalization brings significant advantages to the supply chain, including better access to information, improved logistics practices, real-time data collection along with the inventory management (Bigliardi et al., 2022). However, the current studies are unable to explore the nexus between the supply chain digitalization and foreign exchange reserves.

Along with the above debate, the concept of logistics helps in moving the goods, information, and money from the source to the end customer in the global market. Additionally, it is admitted as a key part of the globalization due to the fact that it plays a significant role in economic growth and competitiveness for the global economies. Therefore, the efficiency of logistics is closely linked to creating value in the supply chain management and related activities. At the same time, the idea of logistics is a strategic tool for businesses to gain a competitive edge in the global market as it directly affects every part of a company and its profitability. According to Alpaslanoğlu (2022), logistics covers the elements like the planning, executing, and controlling all activities in the supply chain. For this reason, it can be expressed as a system that makes sure goods, services, and information with smooth flow.

In oil-dependent economies, particularly Iraq, oil revenues constitute a cornerstone of economic activity. The amount of oil revenues, which are the monetary gains made by nations that produce and export oil, is influenced by production levels, national control over oil resources, and worldwide oil prices. Stability in these factors directly enhances revenue streams (Mohammed et al., 2020). Oil earnings account for the largest percentage of Iraq's GDP and are the primary source of state revenue, funding government spending. According to Salim and al-Bakri (2025), this reliance on oil earnings is essential for funding public spending and attaining economic stability, which in turn supports exchange rate stability.

Since its economy heavily depends on oil exports, which are the primary source of foreign currency and governmental revenue, the economy of Iraq goes through observable cycles of upswing and downturn. Global volatility in oil prices has a direct impact on the revenues generated from oil in Iraq, and since the foundation of the country's economy, any change in such revenues either an upsurge or a decline affects the performance of the economy in real-time. More economic soundness and stability of the Iraqi dinar are facilitated by the accumulation of foreign reserves due to surpluses in oil revenue. Such assets function as a very important protection net in times of horrors and crises. Gold, foreign exchanges, special drawing rights (SDRs), the International Monetary Fund's (IMF) facility of reserve position, and other assets comprise the reserves of the world (Al-Rifai, 2023).

Countries maintain foreign exchange reserves to ensure liquidity, safeguard against unforeseen events, and mitigate sudden risks (Sheludko, 2025). Since it serves as the primary source of foreign income in rentier states such as Iraq, oil revenues play a fundamental part in the determination of GDP and the composition of expenditures by the government. Crude oil also serves both as a commodity and financial capital, and it prominently occupies the center of capital accumulation in oil-exporting nations. In light of value addition disparities at production levels, its financial importance arises due to the high revenues toggling to make it the cornerstone of oil-exporting nations (Thomassen, 2023).

Oil revenues are closely tied to global oil prices, where increased exports enhance the current account surplus, while declining prices reduce revenues, often the largest component of public revenues leading to diminished current account balances (Lebrand et al., 2024). Focusing on one export sector such as oil while ignoring other means of generating foreign exchange income creates an economy that is highly prone to external shocks (Sohag et al., 2024). Therefore, maintaining a level of foreign exchange reserves is of paramount importance for these economies in order to manage the impacts of such shocks and to use as a form of 'shock absorber' for these economies (Fanelli & Straub, 2021). Reserve accumulation is driven by a surplus in the balance of payments, while deficits, which are common for such economies as a result of declining oil revenues, are financed by reserves whenever these economies overspend the budget deficit for economic stability (Benigno et al., 2022).

LITERATURE REVIEW

Though approaching the problem in different ways, the relationship between oil revenues and the foreign exchange reserves has been a focus of multiple studies. For instance, (Rasheed, 2023) studied the relationship between oil revenues and Iraq's general budget from the years 2003 to 2020. As they concluded, 97% of the budget is financed by oil revenues, and owing to an increasing oil production, Iraq is currently the fourth largest oil exporter in the world. The present analysis, in contrast, is unique for focusing on the reserves, as opposed to the entire budget and focusing only on the impact of the income from oil on Iraq's foreign exchange reserves for the years 2005 to 2023.

Similar findings were made by Lim et al. (2023) and Igbinovia and Ogiemudia (2021), who used the GARCH-M and M-EGARCH models to evaluate reserve volatility and showed a favorable correlation between oil prices and Nigeria's foreign exchange reserves. While this study shares the same dependent variable (foreign exchange reserves) as the current study, it differs in its independent variable (oil prices versus oil revenues), study sample (Nigeria versus Iraq), and analytical models.

Purnama et al. (2024) also looked at the impact of Indonesia's imports and exports of oil and gas on its foreign exchange reserves from 2010 and 2017. They demonstrate, using SPSS multiple linear regression analysis, that imports and exports of gas and oil have a significant effect on foreign exchange reserves. While the analysis approach, time period, research sample (Iraq vs Indonesia), independent variables (oil and gas trade versus oil income), and focus on foreign exchange reserves as the dependent variable are all different, this study is similar to the current study in that regard (Abdlaziz et al., 2022). Similarities exist in the current study's examination of foreign exchange reserves as dependent variables and independent variables connected to oil, guaranteeing more accurate measurement and analysis (Shang & Hamori, 2021).

Using data from the World Bank and OPEC databases acquired between 1990 and 2014, Saidi and Rahman (2020) also investigated the connection between Nigeria's foreign currency reserves and shocks to the price of crude oil. Their Granger causality conclusions, which are based on basic econometric time-series methodologies, indicate that Nigeria's economic difficulties, rather than oil price shocks, are the cause of reserve depletion in the country. Although the independent variables (oil price shocks versus oil revenues), study sample (Nigeria versus Iraq), and time period are different, this study is similar to the current study in that it focuses on foreign currency reserves as the dependent variable (Success Ikechi & Anthony, 2020).

Dewi and Fauzan (2023) used a Vector Error Correction Model (VECM) and VAR Granger causality tests to analyze the relationship between the foreign currency reserves and exchange rates as well as crude oil prices and other monetary variables in Nigeria. The documentation states that over time, oil prices and the reserves of foreign exchange in Nigeria increase 1.8% and 0.04% respectively, for every 1% increase in the value of the naira to the dollar. The current study, though distinct in independent variable, study sample, and analytical techniques, does share a similarity with Gereziher and Nuru (2021) in that foreign exchange reserves are used as a dependent variable.

In the Ruslan et al. (2024) study, exports and the reserves of foreign currency of Indonesia from 2012 - 2021 were examined. This study has exported oil and gas and oil income. As indicated in the report, both exports were crucial in improving the foreign exchange reserves. Other than foreign exchange reserves, which will be analyzed in this work, the sample oil income to non-oil gas exports ratio, country Iraq as a sample country, analytical method, and period are different.

Employing the ARDL model for measurement and analysis in this study, in contrast to previous works, focuses only on the correlation of oil income and foreign exchange reserves in the Iraqi economy for the period of the 2007-2023.

METHODOLOGY

The study considers the role of logistic performance, digital supply chain, and oil revenue diversification in determining the trends in foreign exchange reserves. For this purpose, the time duration of the study was taken from 2007-2023 with quarterly observations. The reason for selection of this time is the purely based on the availability of the data for the given variables, considering the region of Iraq. Table 1 provides the descriptive layout of the variables covering their nature and symbols as used in the present study.

The analysis focuses on the quarterly data from 2007 to 2023 along with different statistical techniques. For example, the descriptive statistics were first applied to examine the basic characteristics of the data. In the next step, the study applies the variance inflation factor or VIF test in order to check for multicollinearity. In the next step, the study considers the stationarity analysis with the core aim to confirm that the data was free of trends or unit roots, as non-stationary data could lead to unreliable results. Various unit root tests, such as the Augmented Dickey-Fuller (ADF) test, were likely conducted to verify stationarity or determine if transformations were needed. After confirming stationarity, selection criteria, such as the Akaike Information Criterion (AIC) or Bayesian Information Criterion (BIC), were applied to determine the optimal lag length for the Vector Autoregressive (VAR) model. In the last step, the study has considered the Autoregressive Distributed Lag which is widely known as the ARDL model to analyze both the short-term and long-term relationships between the variables.

The ARDL approach was chosen for its ability to handle variables with different orders of integration.

Table 1: Variation of the classic model

Variable type	Variable name	Variable symbol
Independent	oil revenues	ORD
Independent	Supply chain digitalization	SCD
Independent	Logistic performance	LOP
Dependent	Foreign currency reserves	FER

RESULTS AND DISCUSSION

The table 2 below determines the descriptive statistics for four variables which are entitled as logistic performance (LOP), oil revenues volatility (ORD), foreign currency reserves (FER), and supply chain digitalization (SCD). As per the findings given, it is observed that the variable entitled LOP has an average value of 1.862, with a standard deviation of 0.912, ranging from -0.89 to 2.4. moreover, the factor of ORD shows a mean of 0.463, a standard deviation of 0.289, and values between 0.009 and 0.952. additionally, FER has a mean of 0.64 and a standard deviation of 0.276, with its values ranging from 0.163 to 0.981, respectively. Finally, SCD has an average of 2.21, a standard deviation of 1.128, and ranges from 0.744 to 4.308. These given scores provide a good layout for the measures of central points and dispersion from the mean trends too.

Table 2: Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
LOP	1.862	.912	-.89	2.4
ORD	.463	.289	.009	.952
FER	.64	.276	.163	.981
SCD	2.21	1.128	.744	4.308

ORV; Oil revenues volatility, SCD; supply chain digitalization, LOP; logistic performance, FER; foreign currency reserves.

For testing the level of multicollinearity, the study observes the VIF and tolerance values of the given explanatory variables. As it shows in Table 3, the VIF scores for the variables are 1.22, 1.21, and 1.03, respectively. Meanwhile, the average trend for the VIF values is 1.157 which is less than the described threshold level of 5. This reflects that the given variables are not linked with the higher level of correlation to each other. The same has been observed through the tolerance level as measured through 1/VIF where all the values are above 0.10.

Table 3: Variance inflation factor

	VIF	1/VIF
ORD	1.221	.819
LOP	1.216	.822
SCD	1.034	.967
Mean VIF	1.157	.

ORV; Oil revenues volatility, SCD; supply chain digitalization, LOP; logistic performance, FER; foreign currency reserves.

The findings for the variables of the study are given in Table 4 covering the stationarity investigation. The results from the Augmented Dickey-Fuller (ADF) tests reveal that LOP and ORD are stationary at their levels, as their test statistics are more negative than the critical values, and their p-values are well below 0.05. This indicates the fact that they do not contain a unit root. However, the variables like SCD and FER are non-stationary at their levels, with p-values above 0.05. It reflects that there is a presence of a unit root. When the first differences of these variables were taken, FER and SCD, they became stationary, as their test statistics became more negative than the critical values, and their p-values were below 0.05. the given findings provide enough evidence to infer that the variables of the study are showing some mixed orders as they are either stationarity at levels or at first difference.

Table 4: testing for the stationarity of the variables

Variable	Test Statistic (Z(t))	p-value	Stationarity
LOP	-5.424	0.0000	Stationary (Level)
SCD	-2.508	0.1136	Non-stationary (Level)
ORD	-3.588	0.0060	Stationary (Level)
FER	-2.431	0.1331	Non-stationary (Level)
FER (First Difference)	-4.697	0.0001	Stationary (First Difference)
SCD (First Difference)	-5.623	0.0000	Stationary (First Difference)

In order to apply the ARDL estimation for the relationships between the given variables, the study has varsoc command by using the Stata. It helps us determine the best number of lags to include in an ARDL model for the variables as observed for this study. The key statistics we look at are AIC (Akaike Information Criterion), HQIC (Hannan-Quinn Information Criterion), SBIC (Schwarz Bayesian Information Criterion), and the LR (Likelihood Ratio) test, respectively. As per the provided findings in Table 5, for lag 0, the model fit is poor, as indicated by high values for AIC, HQIC, and SBIC. This means that the consideration of lag zero is not acceptable under present study for these variables. However, when we add one lag (Lag 1), there is a significant output (see Table 5), where the scores for the AIC, HQIC, and SBIC are lowest. Moreover, the LR test shows that this addition is statistically significant (p-value = 0.000). This suggests that adding one lag provides the best model. However, for the rest of the lag options, it is found that there is a presence of higher AIC, HQIC, and SBIC values. The LR test for lag 2 has a high p-value of 0.748, indicating that adding a second lag does not improve the model on significant grounds. Therefore, this study has considered the lag 1 for the selected variables.

Table 5: Selection Criteria for Optimal Lag Length in VAR Model

Lag	LL (Log-Likelihood)	LR (Likelihood Ratio)	p-value	FPE (Final Prediction Error)	AIC (Akaike Information Criterion)	HQIC (Hannan-Quinn Information Criterion)	SBIC (Schwarz Bayesian Information Criterion)
0	-137.48	---	---	0.000978	4.42126	4.47441	4.55619
1	28.5922	332.14	0.000	9.0e-06	-0.268507	-0.002728	0.406144
2	34.5607	11.937	0.748	0.000012	0.044978	0.523381	1.25935
3	44.9994	20.877	0.183	0.000015	0.218769	0.909795	1.97286
4	70.7675	51.536	0.000	0.000011	-0.086483	0.817166	2.20733

The findings for the ARDL model have been provided in Table 6 below, showing the impact of the given explanatory variables along with the lag values of the FER on the main outcome variable. As per the given findings, it is found that FER or foreign currency reserves is showing a coefficient for FER L1 is 0.702, which shows that the foreign currency reserves in the previous period have a positive effect on the current period's foreign currency reserves. The given value of the coefficient has been observed as statistically significant with a p-value of 0.000, which confirms the presence of a strong relationship between both. This suggests that a higher level of reserves in the past leads to an increase in reserves in the current period for the selected economy of Iraq. In this regard, several channels can be observed. For example, the channel through which FER influences its own level could be through policy adjustments or market confidence, where the higher value of the reserves boost confidence in the stability of the economy, leading to more reserves, accordingly. Additionally, past reserves may allow the country to manage economic shocks better, thereby maintaining or increasing the reserves for the given region. Therefore, the presence of significant linkage between the past and the current value of the FER is quite logical.

Table 6: ARDL estimations

FER	Coef.	Std.Err.	t	P>t
FER L1.	0.702***	0.086	8.200	0.000
ORV	0.126***	0.016	7.875	0.000
ORV L1.	-0.055^{NS}	0.144	-0.380	0.705
LOP	0.243***	0.030	8.100	0.000
LOP L1.	-0.136***	0.046	-2.930	0.005
SCD	0.034^{NS}	0.124	0.270	0.786
SCD L1.	0.157***	0.045	3.490	0.001
_cons	0.140	0.099	1.420	0.161
ARDL (1,1,1,1) regression			Number of obs. =	67
F (7, 59) =	11.66		R-squared =	0.5805
Prob > F =	0.0000		Adj R-squared =	0.5307

ORV; Oil revenues volatility, SCD; supply chain digitalization, LOP; logistic performance, FER; foreign currency reserves.

In addition, the coefficient for ORV is 0.126, indicating that an increase in oil revenue volatility leads to a rise in foreign currency reserves. This relationship is statistically significant, with a p-value of 0.000. this relationship can also be explained by focusing on the different pathways and channels. For example, a higher volatility in oil revenues increases the reserves, due to a response to uncertain revenue flows. More specifically, the pathway for this effect could be through precautionary saving, where countries with higher oil revenue volatility may build up reserves to cushion against future fluctuations in oil income. Another possible channel is that governments might increase reserves as a strategic response to manage external vulnerabilities linked to oil price changes. These findings are well covered in Table 6.

Additionally, the findings in Table 6 also reveals the nexus between lagged values of ORV and FER. This indicates that the coefficient for ORV L1 is -0.055, but it is not statistically significant, with a p-value of 0.705 as provided in Table 6. This means that the previous time period's oil revenue volatility has no significant impact on the current duration's foreign currency reserves for the selected region. This can be explained in a way that the lack of a significant effect may imply that the impact of past oil volatility on reserves is temporary or

that it being absorbed by other factors in the economy, such as fiscal policies or other reserves management strategies. Therefore, the study did not observe any significant relationship between the lagged values of ORV and FER.

Regarding the effect of LOP on the main outcome variable, the coefficient for LOP is 0.243 as per the results in Table 6. this indicates that a better logistic performance leads to an increase in foreign currency reserves for the Iraqi region. More specifically, the relationship is statistically significant with a p-value of 0.000, showing the evidence that the improvement in logistic performance is contributing on positive grounds towards the reserves levels of the similar region. The channel through which logistic performance affects reserves in a better way could be more efficient trade flows, which lead to higher foreign exchange earnings and, in turn, increased reserves for the country. Additionally, the improvement in the logistics may reduce costs and increase trade volumes, therefore, helping the country accumulate reserves through a stronger economy.

On the other side, the findings are also showing the effect of the lagged values of the LOP on the foreign reserves. The coefficient for LOP L1 is -0.136, and it is statistically significant with a p-value of 0.005 (see Table 6). This suggests that a decline in logistic performance in the previous period negatively affects the current time duration's foreign currency reserves. This negative effect may indicate that past logistical challenges reduce the capacity to maintain reserves. The pathway might involve disruptions in trade and delays in supply chains, which reduce the inflow of foreign currency and harm the reserves. Poor logistics could also signal inefficiencies that undermine investor confidence, leading to lower foreign currency accumulation. The further investigation indicates that SCD is showing a coefficient value of 0.034, but it is not statistically significant, as the is 0.786 as shown in Table 6. Lastly, the study findings are showing the influence of the SCD L1. The coefficient for SCD L1 is 0.157, which is statistically significant with a p-value of 0.001. This shows that supply chain digitalization in the previous period has a positive effect on the current period's foreign currency reserves. This suggests that improvements in digitalization may enhance reserve levels over time.

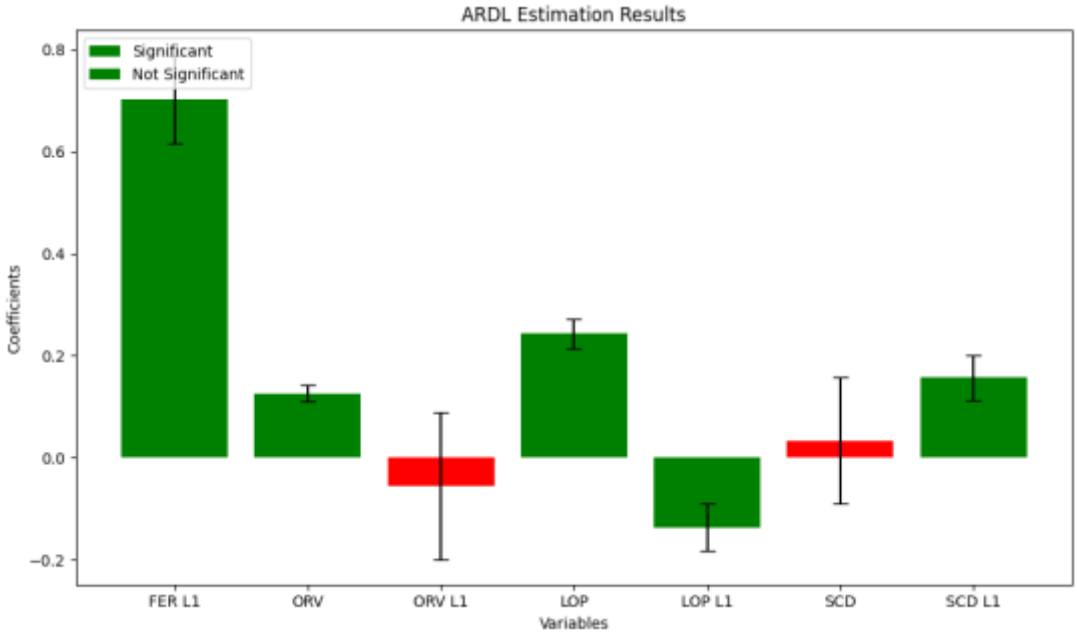

Figure 1: ARDL estimation results

CONCLUSION

This study aims to investigate the relationship between the foreign currency reserves, oil revenues, supply chain digitalization, and logistic performance. for this purpose, a quarterly data has been utilized from 2007 to 2023. Moreover, in terms of statistical estimations, the study has applied the methods like descriptive statistics, the VIF test, stationarity analysis, and the ARDL model. The study explored both short-term and long-term dynamics. The research results provide useful insight into how foreign exchange reserves in Iraq respond to oil revenues. More research is, however, required to determine remedies to reduce fluctuations in foreign exchange reserves by investigating foreign currency sources other than foreign revenues. Similar works would help realize monetary stability by introducing new solutions and knowledge additions and hence aid in creating a more diversified and stable monetary framework. The ARDL (1,1,1,1) regression results show that oil revenues and logistic performance (LOP) have a significant positive impact on foreign currency reserves (FER). The first lag of FER is also significant. However, the first lag of ORV, supply chain digitalization (SCD), and its first lag did not show significant results. The model explains about 58% of the variation in foreign currency reserves as determined by the given variables. The study provides the meaningful policy suggestions. For example, it is stated that the increasing investment in logistics performance can help boost foreign currency reserves. Another suggestion is to focus on improving oil revenues as they show a strong positive impact on reserves. Lastly, policymakers should consider how digitalization in supply chains could indirectly affect foreign currency reserves over time.

The results indicate that foreign exchange reserves are closely linked to oil revenues. Since oil revenues suffer from significant fluctuations due to their dependence on global oil prices, this has negatively affected foreign exchange reserves and their effects on economic activity in Iraq (Al Waeli et al., 2024). This supports the hypothesis that oil habits negatively impact foreign exchange reserves in Iraq. To mitigate the negative effects on the Iraqi government, it is essential to reduce reliance on oil revenues and diversify sources of foreign exchange by encouraging growth in other industrial, agricultural, and service sectors. These results are consistent with the study (Shani et al., 2024).

The research results provide useful insight into how foreign exchange reserves in Iraq respond to oil revenues. More research is, however, required to determine remedies to reduce fluctuations in foreign exchange reserves by investigating foreign currency sources other than foreign revenues. Similar works would help realize monetary stability by introducing new solutions and knowledge additions and hence aid in creating a more diversified and stable monetary framework.

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