EXCHANGE RATE, EXTERNAL RESERVES AND CURRENT ACCOUNT BALANCE NEXUS IN OIL-DEPENDENT COUNTRIES: A TODA-YAMOMOTO-BASED PANEL VECTOR AUTOREGRESSIVE (PVAR) APPROACH

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Abstract

The international monetary authorities have been consistently advising oil-dependent countries to change their exchange rate policy from a fixed to a floating exchange rate regime. While some of these countries including Nigeria have announced their adoption of a free-floating exchange rate system, evidence shows that the majority are suffering from "fear of floating", hence operating an abridged exchange rate system. This study employs the Toda-Yamomoto-based Panel Vector Autoregressive (PVAR) model to use the causality approach to determine the exchange rate system that best explains the de facto exchange rate policy system operating in these countries. This is explained by the dynamic causality between exchange rates and foreign reserves. The dynamic causality between the exchange rate and current account balance also explains the potential effect of devaluation to improve the external trade balance, which implies the J-curve and Marshall Lerner condition. The results show that there is no significant causality from foreign reserves and trade balance to the exchange rate, suggesting that oil-dependent countries are more aligned to a fixed exchange rate regime than a floating exchange rate regime. We also find significant negative causality from the exchange rate to foreign reserves, while foreign reserves have a positive causal effect on the current account balance. This implies that the expected devaluation gains that may be prompting oil-dependent countries to stick to fixed exchange rate regimes are not there, as currency devaluation tends to worsen trade performance and foreign reserves rather than improve them. While oil-dependent countries are not benefiting much from a fixed exchange rate system, it is recommended that appropriate policy to boost private sector generation of foreign exchange should be put in place before the adoption of a full-fledged floating exchange rate system.

Keywords: Exchange rate regime, Oil-dependent countries, Panel VAR**,** Marshall Lerner condition
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Introduction

Given the significance of exchange rate regimes in the macroeconomic analysis of the international activities of countries, numerous studies have been conducted, generally on the effect or implication of exchange rate regimes and specifically on the choice of exchange rate regimes by countries. According to Kimakova (2008), studies on the choice of exchange rate regimes can be grouped into two. First, those that analysed the choice of exchange rate regime from a "normative" perspective; and second, those that analysed the choice of exchange rate regime from a "positive" perspective. The dichotomy between "positive" and "normative" analysis remains the question of "what is" and "what ought to be", respectively. The present study belongs to the positive strand, as it sets to determine the exchange rate regime employed by oil-dependent countries based on their historical data (see also, Edwards, 1996; Berdiev et al., 2012; Rodriguez, 2016).

Many oil-dependent countries operate fixed/pegged exchange rate regimes. These include Iraq, Kuwait, Qatar, Saudi Arabia and Oman. Conventionally, the adoption of a fixed exchange rate regime allows the monetary authority to influence the current account position by changing the exchange rate officially. Specifically, the Marshall-Lerner hypothesis suggests that devaluation of the exchange rate by a country will improve its trade balance; provided the summation of the elasticities of demand for imports and demand for exports is greater than 1 (see Devereux, 2000; Nakatani, 2018). Given the nature of crude oil as a price-inelastic commodity (having low elasticity), the possibility of the sum of the elasticities of demand for imports and demand for exports taking a value less than 1 is susceptible. Meanwhile, evidence from Yousefi and Wirjanto (2003) shows that the result may be mixed; as the sum of the estimated long-run price elasticities of demand for imports and exports was found to exceed unity for Iran and Venezuela, but less than unity for Saudi Arabia. The finding for Russia follows that of Saudi Arabia, as Mironov (2015) revealed that devaluation of the ruble may lead to a more severe recession by worsening the trade balance.

The significance of external reserves in maintaining the exchange rate at its fixed value cannot be over-emphasized. Theoretically, the monetary authority is expected to sell foreign currency to mop up excess domestic currency in the foreign exchange (FX) market to prevent depreciation of domestic currency; while it is expected to buy excess foreign currency in the FX market to prevent domestic currency from appreciating (Akdogan, 2020). According to Aizenman et al. (2012), a relatively small increase in the average holdings of reserves by Latin American economies makes the implementation of a fixed exchange rate regime more effective to insulate the economy from external shocks. Similarly, Kasman and Ayhan (2008) find, in the case of Turkey, that the nominal exchange rate causes changes in foreign reserves.

There are, however, some oil-dependent countries that operate floating exchange rate regimes such as Kazakhstan, Norway and Russia, while some others suffer from "fear of floating" and, thereby, operate intermediate exchange rate systems such as stabilized arrangement and managed floating regime[1]. These include countries like Nigeria, Algeria, Angola, Azerbaijan and Iran. Theoretically, the relationship between the exchange rate, current account, and external reserves under these conditions can be defined by the simple model of exchange rate determination, where the exchange rate is determined by the interaction of the demand for foreign goods (imports) and supply of domestic goods (exports) in the international market (see Pilbeam, 1998). According to this model, the causality will move from the current account balance to external reserves and exchange rate (where the exchange rate is flexible). Specifically, a positive (negative) change in the current account will cause domestic currency to appreciate (depreciate) with no significant impact on external reserves (see Romelli et al., 2018; Vieira & MacDonald, 2020). This may be contrasted with the situation where the exchange rate is fixed. Under this condition, a positive (negative) current account position will cause no change in the nominal exchange rate but cause external reserves to increase (fall).

The main objectives of this study are to determine: (i) the appropriateness of fixed or floating exchange rate regimes for oil-dependent countries, and (ii) whether oil-dependent countries have technically moved from fixed to floating exchange rate regimes. This study contributes to the literature on exchange rate regime choice in commodity-dependent countries in two distinct ways. As the structure of the economy has been found to significantly influence the choice of exchange rate regime (see Edwards, 1996; Rodriguez, 2016),

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[1]The theory only deals with fixed and floating exchange rate regime, meanwhile, the 'de facto' exchange rate system has continuously revealed the practice of intermediate arrangements, with recurring evidence of "fear of floating" and "fear of fixing" (see Reinhart & Rogoff, 2004; Levy-Yeyati & Sturzenegger, 2005).

the first contribution of this study is to consider the case of oil-dependent countries, which are highly exposed to oil price shocks (Hendrix, 2017). As oil prices are inherently volatile which makes oil-dependent countries highly prone to current account volatility and economic instability, experts in international economics and international financial institutions have, severally, pressurized these countries to shift to a flexible exchange rate system. According to Setser (2007), the exchange rate peg makes oil exporting countries find it difficult to adjust to large swings in the price of oil. It also makes them experience too much deflation or inflation during adjustment and pursue procyclical macroeconomic policies. More so, Tosini (1977) noted that the practice of maintaining the status quo firmly by market intervention is against the "leaning against the wind" rule, and is as such sub-optimal.

In recent years, some oil-dependent countries have adopted flexible exchange rate regimes, some with a "fear of floating" are operating one form of intermediate exchange rate policy or the other, while some countries are still operating fixed exchange rate systems. This study employs panel study analysis to determine whether, on average, oil-dependent countries can be presumed to have shifted to a floating exchange rate regime as recommended by international economics experts. In addition, empirical evidence from this study will help to verify the proposition of the normative studies on exchange rate regime choice, that the larger the tradable sector the less likely that the government will fix the exchange rate (see Frieden et al., 2010; Rodriguez, 2016). In other words, this study will verify whether oil-dependent countries, with larger oil trade than the non-oil trade sector, have technically shifted to a floating exchange rate regime.

The second contribution of this study is in the area of methodology. This study employs the panel vector autoregressive (PVAR) model. The advantages of Panel VAR have been discussed in the earlier literature (see Grossmann et al. 2014; David, 2019; Liaqat, 2019; Babalos & Stavroyiannis, 2020). According to Grossmann et al. (2014), VARs are useful when there is little theoretical information about the relationships among the variables in the model, and are also designed to explicitly address the endogeneity problem, which is one of the most serious challenges of the empirical research on exchange rates. As the objective of this study is to determine the exchange rate regime operated by oil-dependent countries, the transmission mechanism of the exchange rate, external reserves and current account balance nexus are assumed to be unknown. In other words, we expect to determine whether the exchange rate is endogenously determined (as suggested by the flexible regime) or exogenously determined (as suggested by the fixed regime) in these countries; which can be suitably evaluated using the PVAR approach. However, to resolve the problem of stationarity without necessarily distorting the natural definition of the variables (by taking the first difference, for example), the conventional PVAR model was modified following the Toda and Yamomoto (1995) approach. The application of the Toda-Yamomoto-based PVAR model in this analysis will provide empirical evidence on the issues of exchange rate transmission channels, exchange rate determinants and Marshall Lerner conditions in these countries.

Lastly, this study expands the study by Gokhale and Raju (2013) which examines the causal relationship between exchange rate and foreign exchange reserves in the case of India by focusing on oil-dependent countries and adding another important variable, current account balance, in the nexus. This helps in evaluating the exchange rate regime and Marshal-Lerner's condition. Nwachukwu et al. (2016) also consider the relationship between exchange rate and external reserves, while Obstfeld and Rogoff (2005) examined the relationship between current account and exchange rate. Fratzscher et al. (2010) considered the nexus of three variables; exchange rates and the current account with asset prices as the third variable while we use external reserves in this study. The study that combined the exact three variables that we combined in this study is Adhikari (2018), which examined the impact of the exchange rate on trade deficit and foreign exchange reserve in Nepal.

The remaining sections are organized as follows. Section 2 presents the stylized facts and preliminary analysis. Section 3 discusses the Panel VAR model employed as the methodology for this study. The presentation and discussion of empirical results are detailed in Section 4. The conclusion is the last section.

Stylised Facts and Preliminary Analysis

The main objectives of this study are to examine the appropriateness of fixed exchange rate regimes in oil-dependent countries, and whether oil-dependent countries have technically moved from fixed to floating exchange rate regimes. Table 1 shows the list of oil-dependent countries considered in this study with their *de facto* exchange rate arrangement. The level of countries' oil export dependency is determined by reliance on oil revenue as the source of foreign exchange. Thus, our sample consists of top oil-exporting countries with a high oil export-to-non-oil export ratio[2]. The *de facto* exchange rate arrangements of the countries are described according to the International Monetary Fund (IMF) classification (see IMF, 2019).

As evident from Table 1, Nigeria is the topmost of the ten (10) oil-dependent countries considered. This is apparent as the country has the highest fuel export as a percentage of total merchandise export (95.38%) and export concentration index (of 0.76 points). The country appears to be suffering from a "fear of floating", as it operates an intermediate exchange rate policy, classified by the IMF as a stabilised exchange rate arrangement. Evidence from Figure 1 shows that Nigeria has devalued more frequently than the oil-dependent countries operating currency boards or conventional peg, such as; Brunei Darussalam, Congo Republic, Saudi Arabia, Kuwait and Qatar. More so, evidence from Table 1 suggests that the adoption of a flexible exchange rate system tends to aid export diversification in oil-dependent countries as the oil-dependent countries operating flexible exchange rate systems such as Norway, Colombia and Russia appear to have relatively lower levels of oil dependence. This tends to support expert opinion that a flexible exchange rate regime is better for oil-dependent countries.

Table 1: Oil-dependent countries with their exchange rate arrangement (2015 – 2019)

Countries	Fuel export (as % of total merchandise export)	Export concentration	Exchange rate arrangement
Nigeria	95.38	0.76	Stabilised Arrangement
Kuwait	92.45	0.59	Conventional Peg
Brunei Darussalam	91.54	0.63	Currency Board
Qatar	90.52	0.49	Conventional Peg
Saudi Arabia	77.67	0.56	Conventional Peg
Kazakhstan	65.83	0.55	Floating
Norway	57.57	0.33	Free-floating
Colombia	55.29	0.32	Floating
Russian Federation	53.10	0.31	Free-floating
Congo, Rep.	52.32	0.57	Conventional Peg

Source: Compiled by the authors

Note: Data for fuel export (as % of total merchandise export) was obtained from World Development Indicators (WDI); data for export concentration was obtained from the United Nations Conference on Trade and Development (UNCTAD), and exchange rate arrangement follows the International Monetary Fund (IMF) classification.

As evident from Figure 1, the exchange rates of Saudi Arabia and Qatar remained fixed through the period covered, while foreign reserves are rising. This may suggest that the foreign reserves of these countries are sufficient enough to keep their exchange rates constant. This may suggest that these countries reject the idea of shifting from a fixed to a floating exchange rate regime. Colombia, Kazakhstan, Norway, Nigeria and Russia, these countries experienced high rates of currency depreciation over the period. This may be attributed to falling external reserves in the cases of Kazakhstan and Russia and external reserves volatility in the case of Nigeria. For Norway and Colombia however, their external reserves are on the rising trend,

[2]Note that the selection of countries is limited with data availability, which makes some notable oil-dependent countries such as Iraq, Algeria, Angola, Azerbaijan, Oman and Iran to be excluded.

suggesting that the countries prefer foreign reserves accumulation to using the reserves to defend domestic currency. Thus, the fall in domestic currency in these countries may be attributed to the fall in current account position, suggesting that they are tilted towards the adoption of a flexible exchange rate regime. As for Kuwait and Brunei, these countries experienced volatility in domestic exchange rates despite rising external reserves. This suggests that they are also tilted towards the adoption of a flexible exchange rate regime.

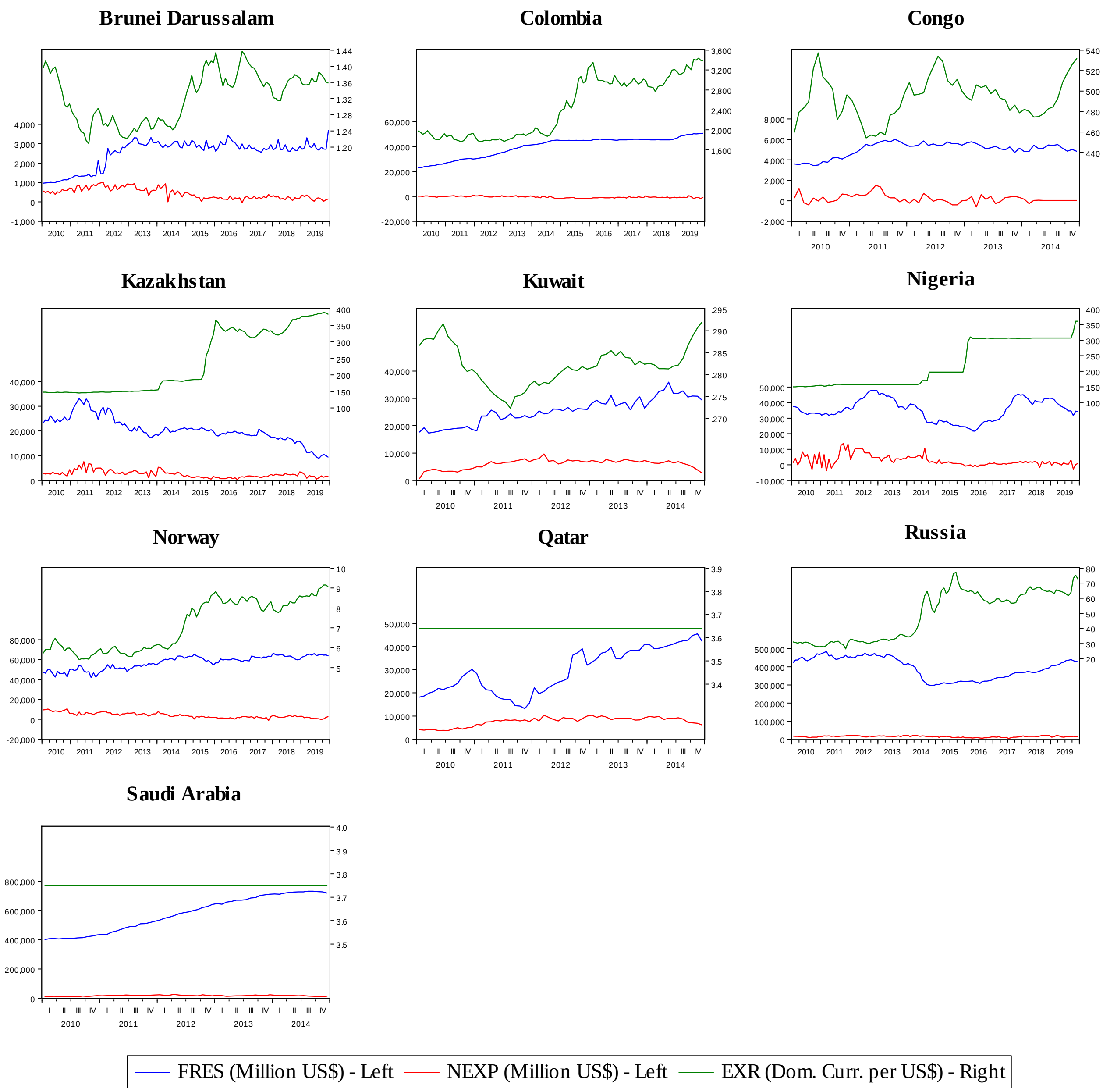

Figure 1: Trends in Net export, foreign reserves and exchange rate of oil exporting countries

The main variables for this study are foreign reserves (FRES), net export (NEXP) and the domestic exchange rate of countries per unit of US dollar (EXR). There is however limitation on the scope of study as six (6) out of the ten (10) countries considered have data ranging from 2010M01 to 2019M12, while the remaining four (4) countries have data ranging from 2010M01 to 2014M12 (see Table 2a). The country-specific summary statistic presented in Table 2a shows that Saudi Arabia, Russia and Norway had the highest average foreign reserve amongst the 10 oil-dependent countries considered, with an average foreign reserve of US$575,924 million, US$394,550 million and US$57,043 million, respectively. These are followed by Colombia, Nigeria, Qatar and Kuwait with average foreign reserves of US$39,798 million, US$ 35,224 million, US$29,540 million and US$25,389 million, respectively, in that order. Kazakhstan, Congo and Brunei have low foreign reserves over the period under consideration with mean foreign reserves of US$20,515 million, US$5,035 million and US$2,517 million, respectively.

Except for Colombia, all countries in our sample had positive average net exports over the period under consideration. This implies that most of these countries export more on average than they import. Of the countries sampled, Saudi Arabia, Russia and Qatar had the largest average net export value with US$16,780 million, US$14,957 million, and US$7,706 million respectively. Next to them are Kuwait, Norway, Nigeria and Kazakhstan with average net exports of US$5,989 million, US$4,024 million, US$2,812 million and US$2,505 million, respectively. Congo and Brunei have the least average net exports with US$2,024 million and US$433 million, respectively, while the net export of Colombia over the period considered is negative ofUS$587 million on average, which signifies net import.

Furthermore, it can be observed from Table 2a that exchange rate volatility is generally low in countries operating currency boards and conventional pegs; thus, confirming the appropriateness of the *de facto* exchange rate classification by the IMF. Specifically, the standard deviation statistics of the countries operating currency board and conventional peg countries (Brunei Darussalam, Congo Rep., Kuwait, Qatar and Saudi Arabia) range between 0.00 for Saudi Arabia and 20.43 for the Congo Republic. Meanwhile, the Congo Republic appears to be an outlier in this group, as the standard deviation of other countries is below 0.1. The standard deviation of the exchange rate of Russia and Norway is lower than that of the Congo Republic and Nigeria, suggesting that a free-floating exchange rate regime can produce lower exchange rate volatility compared to a fixed or stabilized exchange rate system. A free-floating exchange rate regime also produced lower exchange rate volatility than a (limited) floating regime as operated by Colombia and Kazakhstan. The exchange rate of Colombia is the most volatile with a standard deviation of 588.80. This is followed by Kazakhstan with the standard deviation of 95.10.

Table 2a: Country-specific descriptive statistics

Country	Data coverage	Variables	Mean	S.Dev.	Min.	Max.
BRUNEI	2010M01 – 2019M12	FRES	2517.15	716.66	965.83	3702.56
		EXR	1.32	0.06	1.21	1.44
		NEXP	433.03	273.71	-41.26	1006.04
COLOMBIA	2010M01 – 2019M12	FRES	39798.27	8057.42	23043	50527.8
		EXR	2439.80	588.80	1762.21	3437.34
		NEXP	-586.82	6676.04	-1982.24	996.75
CONGO REP.	2010M01 – 2014M12	FRES	5035.26	698.09	3431.06	6009.91
		EXR	493.21	20.43	454.21	537.30
		NEXP	2023.57	4100.31	-614.39	1515.53
KAZAKHSTAN	2010M01 – 2019M12	FRES	20514.71	5161.11	8839.91	33113.07
		EXR	239.18	95.10	145.45	389.19
		NEXP	2504.62	1395.88	327.78	7582.02

KUWAIT	2010M01 – 2014M12	FRES	25389.28	4694.63	17275.32	35895.31
		EXR	0.28	0.01	0.27	0.29
		NEXP	5989.06	1703.53	505.23	9680.30
NIGERIA	2010M01 – 2019M12	FRES	35224.3	6821.63	21629.55	47903.09
		EXR	221.83	71.91	150.10	361
		NEXP	2811.73	3448.08	-3849.38	13740.62
NORWAY	2010M01 – 2019M12	FRES	57043	6550.13	42125.02	66339.19
		EXR	7.13	1.26	5.41	9.15
		NEXP	4023.57	2529.12	-1116.46	10555.70
QATAR	2010M01 – 2014M12	FRES	29539.57	9618.60	13199.84	45456.45
		EXR	3.64	5.72E-15	3.64	3.64
		NEXP	7705.53	1955.27	3759.30	10366.13
RUSSIA	2010M01 – 2019M12	FRES	394549.8	59456.98	297086	483884.8
		EXR	49.10	16.21	26.43	77.22
		NEXP	14956.72	3987.15	5174.46	22351.17
SAUDI ARABIA	2010M01 – 2014M12	FRES	575923.5	119418.3	400920.3	731217.2
		EXR	3.75	0.00	3.75	3.75
		NEXP	16779.55	3984.87	7131.12	26337.96

Source: Computed by the authors
Note: Foreign reserves (FRES) and net export (NEXP) are expressed in million US dollars, while exchange rate (EXR) is expressed in domestic currency per unit of US dollar.

Table 2b presents panel descriptive statistics for oil-dependent countries. Due to the identified data limitation, we have two groups of countries named Group 1 and Group 2. Group 1 consists of six (6) countries with data periods ranging from 2010M01 to 2019M12. These are Brunei Darussalam, Colombia, Kazakhstan, Nigeria, Norway and Russia. On the other hand, Group 2 consists of ten (10) countries with data periods ranging from 2010M01 to 2014M12 (including countries in Group 1). As shown in Table 2b, the average foreign reserves for the countries in Group 1 range from US$966 million to US$483, 885 million; the net export ranges from -US$3,849 million to US$22,351 million and the exchange rate volatility is relatively high with standard deviation of 909.94. In contrast, the foreign reserve for the 10 countries in Group 2 ranges from US$966 million to US$731, 217 million; the net export ranges from -US$3,849.38 million to US$26, 338 million, and exchange rate volatility is also relatively high with a standard deviation of 557.16.

Table 2b: Panel Descriptive Statistics

Countries	Variables	Mean	S.Dev.	Min.	Max.	NT
Group 1	FRES	91607.87	138846.2	965.83	483884.8	720
	EXR	493.06	909.94	1.21	3437.34	720
	NEXP	4023.81	5687.32	-3849.38	22351.17	720
Group 2	FRES	121747	198824.6	965.83	731217.2	600
	EXR	273.88	557.16	0.27	2340.39	600
	NEXP	6231.091	6274.71	-3849.38	26337.96	600

Source: Computed by the authors
Note: Foreign reserves (FRES) and net export (NEXP) are expressed in million US dollars, while exchange rate (EXR) is expressed in domestic currency per unit of US dollar. Group 1 consists of six (6) countries with data periods ranging

from 2010M01 to 2019M12, while Group 2 consists of ten (10) countries with data periods ranging from 2010M01 to 2014M12 (including countries in Group 1). Also, N indicates the number of countries, T is the length of time and NT is the number of total observations.

The results of the panel unit root tests are presented in Table 2. This consists of the unit root tests with the null hypothesis of common unit root processes such as Breitung and LLC (Levin, Lin and Chu) and the unit root tests with the null hypothesis of individual unit root processes such as panel ADF, PP and IPS. The results of the various panel unit root tests presented in Table 2 clearly show that exchange rate and foreign reserve are stationary only at first difference. Thus, both series are integrated of order 1, that is, they are both I(1). In contrast, net export is stationary at level. Both the unit root tests with the null hypothesis of the common unit root process and those with the null hypothesis of the individual unit root process confirm that only net export is stationary at level. The mixture of I(0) and I(1) variables in the system further justifies our choice of the Toda-Yamamoto causality approach.

Table 3: Panel Unit root

Unit root tests	Exchange Rate		Foreign Reserve		Net Export	
	Level	1st Diff.	Level	1st Diff.	Level	1st Diff.
Group 1 (6 countries from 2010M01 – 2019M12)						
Null hypothesis: unit root with common unit root process						
Levin, Lin & Chu t*	0.5636	-14.4308***	-2.373**	-11.0688***	-3.3045***	-24.7010***
Breitung t-stat	2.9865	-12.2389***	4.4746	-11.4035***	-5.0653***	-20.3015***
Null hypothesis: unit root with individual unit root process						
Im, Pesaran and Shin W-stat	3.7046	-13.4895***	-0.3763	-16.8512***	-7.2625***	-22.7461***
ADF - Fisher Chi-square	3.3931	81.6791***	11.5962	77.5566***	12.2378	168.0958***
PP - Fisher Chi-square	2.6260	236.606***	17.6935	363.641***	90.2188***	215.081***
Group 2 (10 countries from 2010M01 – 2014M12)						
Null hypothesis: unit root with common unit root process						
Levin, Lin & Chu t*	0.9635	-6.0478***	3.89612	-7.0016***	-0.0531***	-11.0676***
Breitung t-stat	0.9997	-1.9754**	4.10434	-5.9685***	0.6477***	-10.3947***
Null hypothesis: unit root with individual unit root process						
Im, Pesaran and Shin W-stat	0.9955	-8.6865***	3.41564	-13.1741***	-2.8584***	-20.9945***
ADF - Fisher Chi-square	0.9685	99.5065***	10.9307	182.6620***	50.3552***	307.83***
PP - Fisher Chi-square	0.9990	141.7230***	23.0658	334.8440***	132.6080***	404.009***

Source: Computed by the authors
Note: Asterisks **** denotes significance at 1 per cent while ** denotes significance at 5 per cent.

Data and Methodology

Data description

This study employs monthly data covering the period January 2010 - December 2019 for the six (6) countries in Group 1 (Brunei Darussalam, Colombia, Kazakhstan, Nigeria, Norway and Russia) and the period January 2010 - December 2014 for the countries in Group 2 (Group 1 members + Congo, Kuwait, Qatar and Saudi Arabia). The data on net export was sourced from the online database of the International Trade Centre (see ITC, 2020) while the data on the exchange rate and foreign reserve were obtained from the International Financial Statistics (IFS) (see IMF, 2020). While the exchange rate is the local currency expressed per US dollar ($), the current account balance (net export) and foreign reserve are in billion and million US dollars respectively.

Model Specification

We employ the Panel Vector Autoregressive (PVAR) model to investigate the exchange rate, foreign reserve and current account balance nexus in oil-dependent countries. Our choice of PVAR is motivated by two main reasons: (i) the potential of PVAR to test all the associated theories concurrently. There are many theoretical grounds on which the relationship among the three variables can be examined. These include the Marshall-Lerner condition and its associated J-curve hypothesis, which validates fixed exchange rate regime and the classical exchange rate model which validates flexible exchange rate regime. (ii) PVAR has superiority in addressing the problem of endogeneity that is common with models involving exchange rates (see Grossmann et al. 2014).

The panel-data VAR methodology combines the traditional VAR approach, which treats all the variables in the system as endogenous, with the panel-data approach, which allows for unobserved individual heterogeneity (Grossmann et al., 2014). The baseline PVAR model for this study can be specified as follows:

$$Y_{it} = A_0 + A_1 Y_{it-1} + ... + A_p Y_{it-p} + \mu_{it} + \varepsilon_{it} \qquad (1)$$

where Y_{it} is the $k\,x1$ vector of the three dependent variables in this study. These are the log of the exchange rate (LEXR), log of foreign reserves (LFRES) and the export/import ratio, which was used as a proxy for the current account/trade balance (TBL), which cannot be log-transformed due to existence of some negative values. A_0 is the $k\,x1$ vector of the constant terms, $A_1,..., A_p$ representing $k\,x\,k$ the matrix of the PVAR coefficients ranging from the first lag to optimal lag *p*, while μ_{it} and ε_{it} are $k\,x1$ vectors of dependent variable-specific fixed effects and the idiosyncratic errors, respectively. Errors are assumed to have the following characteristics: $E(\varepsilon_{it}) = 0$, $E(\varepsilon_{it}{}'\varepsilon_{it}) = \sum$ and $E(\varepsilon_{it}{}'\varepsilon_{is}) = 0$ for all $t > s$ (see also, Holtz-Eakin et al., 1988; Abrigo and Love, 2016). The direction of causality is more visible when PVAR is expressed in an explicit form. Equation (1) can be expressed as:

$$\begin{aligned} LEXR_{it} &= \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} LEXR_{it-i} + \sum_{i=1}^{p} \alpha_{2i} LFRES_{it-i} + \sum_{i=1}^{p} \alpha_{3i} TBL_{it-i} + \mu_{1it} + \varepsilon_{1it} \\ LFRES_{it} &= \beta_0 + \sum_{i=1}^{p} \beta_{1i} LEXR_{it-i} + \sum_{i=1}^{p} \beta_{2i} LFRES_{it-i} + \sum_{i=1}^{p} \beta_{3i} TBL_{it-i} + \mu_{2it} + \varepsilon_{2it} \qquad (2) \\ TBL_{it} &= \delta_0 + \sum_{i=1}^{p} \delta_{1i} LEXR_{it-i} + \sum_{i=1}^{p} \delta_{2i} LFRES_{it-i} + \sum_{i=1}^{p} \delta_{3i} TBL_{it-i} + \mu_{3it} + \varepsilon_{3it} \end{aligned}$$

where p is the optimal lag, represents the oil-dependent countries in the panel (i =1,…,6 in Model 1, i = 1, …, 10 in Model 2), t is the monthly period (t = January 2010, …, December 2019 in Model 1, t = January 2010, …, December 2014 in Model 2), μ_{*it} and ε_{*it} denote normally distributed stochastic term for all country i and at time t, while the variables $LEXR$, $LFRES$ and TBL represents the log of exchange rate, log of foreign reserves and trade balance ratio.

Meanwhile, the baseline PVAR model as specified in equation (2) is only suitable when all the endogenous variables are stationary. As evidence from our preliminary results shows that $LEXR$ and $LFRES$ are not stationary, the PVAR in the form of equation (2) is not suitable. The problem of stationarity was dealt with in earlier studies by expressing the variables in returns or first difference form (see David, 2019; Salisu et al. 2020). As expressing the variables in their first difference will cause a loss of information and disparity between the way variables are defined in the theory and how they are modelled empirically, this study resolves to modify the PVAR model using the approach by Toda-Yamomoto (see Toda and Yamamoto, 1995). This is more efficient to avoid misrepresentation of variables in the model (Amiri and Ventelou, 2012). Thus, equation (2) is re-defined as:

$$
\begin{aligned}
LEXR_{it} &= \alpha_0 + \sum_{i=1}^{p}\alpha_{1i}^{1}LEXR_{it-i} + \sum_{j=p+1}^{p+d_{\max}}\alpha_{1j}^{2}LEXR_{it-j} + \sum_{i=1}^{p}\alpha_{2i}^{1}LFRES_{it-i} + \sum_{j=p+1}^{p+d_{\max}}\alpha_{2j}^{2}LFRES_{it-j} \\
&\quad + \sum_{i=1}^{p}\alpha_{3i}^{1}TBL_{it-i} + \sum_{j=p+1}^{p+d_{\max}}\alpha_{3j}^{2}TBL_{it-j} + \mu_{1it} + \varepsilon_{1it} \\
LFRES_{it} &= \beta_0 + \sum_{i=1}^{p}\beta_{1i}^{1}LEXR_{it-i} + \sum_{j=p+1}^{p+d_{\max}}\beta_{1j}^{2}LEXR_{it-j} + \sum_{i=1}^{p}\beta_{2i}^{1}LFRES_{it-i} + \sum_{j=p+1}^{p+d_{\max}}\beta_{2j}^{2}LFRES_{it-j} \\
&\quad + \sum_{i=1}^{p}\beta_{3i}^{1}TBL_{it-i} + \sum_{j=p+1}^{p+d_{\max}}\beta_{3j}^{2}TBL_{it-j} + \mu_{2it} + \varepsilon_{2it} \qquad (3) \\
TBL_{it} &= \delta_0 + \sum_{i=1}^{p}\delta_{1i}^{1}LEXR_{it-i} + \sum_{j=p+1}^{p+d_{\max}}\delta_{1j}^{2}LEXR_{it-j} + \sum_{i=1}^{p}\delta_{2i}^{1}LFRES_{it-i} + \sum_{j=p+1}^{p+d_{\max}}\delta_{2j}^{2}LFRES_{it-j} \\
&\quad + \sum_{i=1}^{p}\delta_{3i}^{1}TBL_{it-i} + \sum_{j=p+1}^{p+d_{\max}}\delta_{3j}^{2}TBL_{it-j} + \mu_{3it} + \varepsilon_{3it}
\end{aligned}
$$

where $d_{\max}$ indicates the maximum order of integration, which is 1 in our case. Suppose our optimal lag length is 2 as will be displayed in the next section (see Table 4), $p = 2$ and $p + d_{\max} = 3$ in our analysis. Oil export-dependent countries will tend more to implement flexible exchange rate regimes if the current account balances (TBL) Granger causes exchange rate, in which case, $\sum_{i=1}^{p}\alpha_{3i}^{1}$ is positive and the null hypothesis $\sum_{i=1}^{p}\alpha_{3i}^{1} = 0$ is rejected. Otherwise, oil-dependent countries cannot be said to have moved significantly away from a fixed exchange rate regime. In addition, the Marshall-Lerner hypothesis postulates that exchange rate devaluation will improve the current account balance provided the elasticities of demand for import and export of the country is greater than unity. This was further explained by the J-curve model which stated that even if the current account is worsened by currency devaluation in the short run, it will improve it in the long run (when the elasticities are assumed to have increased). This relationship can be analysed by the causality and impulse responses of the exchange rate to the current account balance. Exchange rate devaluation will cause improvement in the current account if $\sum_{i=1}^{p}\delta_{1i}^{1}$ is positive and the null hypothesis that $\sum_{i=1}^{p}\delta_{1i}^{1} = 0$ is rejected. The impulse response pattern can be used to examine the validity of the J-curve hypothesis among others. Other causal relationships in the exchange rate, external reserves and current account balance nexus can be analysed similarly.

Presentation and Discussion of Results

This section deals with the presentation and discussion of empirical results from the augmented Panel Vector Autoregressive (PVAR) model. To avoid loss of degree of freedom, the objective when choosing optimal lag length is to minimize the lags. Thus, we rely on the Schwarz Information Criterion (SIC) and Hannan-Quinn information (HQ) criterion to select 2 as the optimal lag for our proposed PVAR model (see Table 4). More importantly, SIC has been reported to penalize the inclusion of redundant lags in models as opposed to AIC (see Oloko, 2018). Thus, extra lags beyond 2 may be considered as being redundant.

Table 4: Lag length selection criteria

Lag	LogL	LR	FPE	AIC	SIC	HQ
0	-3015.647	NA	22.12148	11.61018	11.63472	11.61979
1	1345.936	8656.064	1.19e-06	-5.130523	-5.032358	-5.092068
2	1430.378	166.6114	8.88e-07	-5.420686	-5.248897*	-5.353390*
3	1439.052	17.01430	8.89e-07	-5.419432	-5.174019	-5.323294
4	1442.375	6.479077	9.09e-07	-5.397596	-5.078559	-5.272617
5	1460.392	34.92616*	8.78e-07*	-5.432278*	-5.039617	-5.278458
6	1465.369	9.588974	8.92e-07	-5.416803	-4.950518	-5.234141
7	1471.997	12.69648	9.00e-07	-5.407682	-4.867773	-5.196179
8	1477.422	10.32847	9.12e-07	-5.393933	-4.780400	-5.153588

Source: Computed by the authors

Note: Asterisk,*, indicates lag order selected by the criterion, LR implies sequential modified LR test statistic (each test at 5% level), FPE indicates Final Prediction Error, AIC means Akaike Information Criterion, SIC implies Schwarz Information Criterion, and HQ denotesHannan-Quinn information criterion.

The baseline PVAR model was augmented following the proposition of Toda and Yamomoto (1995) to deal with non-stationary variables in the model. The result of the Granger causality test from the modified PVAR model is presented in Table 5. The table comprises two models; Model 1 explains the dynamics of the exchange rate, external reserves and trade balance in the six oil-dependent countries with data ranging from January 2010 to December 2019, and Model 2 analyzes the dynamics of the exchange rate, external reserves and current account balance in 10 oil-dependent countries (including the six in group 1) with data ranging from January 2010 to December 2014. The null hypothesis for the Chi-square distributed Granger causality test is that the explanatory variable does not Granger cause the dependent variable, which technically implies that a change in the past values of the explanatory variable does not cause any change in the present value of the dependent variable.

Table 5: Results of Panel Granger Causality Test

	Model 1			Model 2		
Dependent variable: LEXR						
Excluded	*Chi-sq*	*df*	*Prob.*	*Chi-sq*	*Df*	*Prob.*
LFRES	2.492804	2	0.2875	0.833084	2	0.6593
TBL	1.887835	2	0.3891	0.054884	2	0.9729
All	4.203977	4	0.3791	0.892767	4	0.9256
Dependent variable: LFRES						
Excluded	*Chi-sq*	*df*	*Prob.*	*Chi-sq*	*Df*	*Prob.*
LEXR	8.499385	2	0.0143	6.132324	2	0.0466
TBL	2.213196	2	0.3307	5.114293	2	0.0775

All	10.97744	4	0.0268	11.20388	4	0.0244
Dependent variable: TBL						
Excluded	*Chi-sq*	*df*	*Prob.*	*Chi-sq*	*Df*	*Prob.*
LEXR	0.538790	2	0.7638	1.305861	2	0.5205
LFRES	5.107450	2	0.0778	0.968218	2	0.6162
All	5.752608	4	0.2184	2.597320	4	0.6273

Source: Computed by the authors

As evident, the result shows that changes in foreign reserves and current account balance do not have a significant impact on the exchange rate, as the null hypothesis that foreign reserves and trade balance do not Granger cause the exchange rate cannot be rejected. This indicates that the exchange rates of oil-dependent countries are exogenously determined. In other words, exchange rates of oil-dependent countries are not significantly determined by changes in foreign reserves or trade balance as would be suggested by the practice of a floating exchange rate regime. Hence, it appears that the behaviour of exchange rates of oil-dependent countries still follows a fixed exchange rate regime, despite that some of them are striving towards the implementation of a floating exchange rate regime. This result is consistent under the two models. It is also supported by the results of the joint test of statistical significance of the coefficients of foreign reserves and trade balance on the exchange rate, which shows the direction of causality (see Table 5).

According to this result, the effect of foreign reserves and trade balance on the exchange rate is insignificant, which confirms the causality result that exchange rates of oil-dependent countries are exogenously determined. This tends to support evidence from previous studies on exchange rate regime choice, which concluded that the choice of exchange regime is a political economy issue; determined based on the political goals of the government in power (see for example, Rodriguez, 2016).

Table 6: Joint significance for VAR estimated coefficients

	Model 1			Model 2		
Dependent variable: LEXR						
	Coeff.	*Std.Err.*	*Prob.*	*Coeff.*	*Std.Err.*	*Prob.*
LEXR	0.855336	0.037953	0.0000	0.939835	0.044532	0.0000
LFRES	0.012562	0.020502	0.5403	0.003746	0.014656	0.7983
TBL	0.001667	0.001976	0.3992	-0.000229	0.001282	0.8584
Dependent variable: LFRES						
	Coeff.	*Std.Err.*	*Prob.*	*Coeff.*	*Std.Err.*	*Prob.*
LEXR	-0.159299	0.071847	0.0269	-0.256402	0.128431	0.0464
LFRES	0.860584	0.038812	0.0000	0.917248	0.042267	0.0000
TBL	0.005413	0.003740	0.1483	0.006149	0.003696	0.0967
Dependent variable: TBL						
	Coeff.	*Std.Err.*	*Prob.*	*Coeff.*	*Std.Err.*	*Prob.*
LEXR	-0.503104	0.772357	0.5150	-1.672410	1.485574	0.2607
LFRES	0.824867	0.417224	0.0484	0.477894	0.488907	0.3288
TBL	0.759532	0.040210	0.0000	0.731496	0.042752	0.0000

Source: Computed by the authors

Meanwhile, the exchange rate was found to granger cause foreign reserves, as the null hypothesis that the exchange rate does not Granger cause foreign reserves can be rejected at 5 per cent under the two models. This is similar to the result obtained by Kasman and Ayhan (2008), that the nominal exchange rate causes changes in foreign reserves in the case of Turkey. As evident from the joint test for VAR estimated coefficients in Table 6, the direction of causality is negative. This indicates that a higher (lower) exchange rate in the current period will result in lower (higher) foreign reserves in the next period. This indicates that the devaluation of the exchange rate reduces foreign reserves rather than increasing them. By implication, the expected devaluation gains that may be prompting oil-dependent countries to stick to a fixed exchange rate regime are not there. This conclusion was supported by the relationship between the exchange rate and current account balance. The Granger causality result shows that the exchange rate does not Granger cause a current account balance, which suggests that a change in the exchange rate in one period does not cause any change in the trade balance in the next period. This is also supported by the results of the joint significance of VAR estimated coefficients (in Table 6) as the impact of exchange rate on trade balance was found to be statistically insignificant. Although not significant, the fact that the relationship is negative suggests that the trade balance of oil-dependent countries may tend to get worse due to exchange rate devaluation. This tends to support our hypothesis in this study that the Marshall-Lerner condition does not hold in oil-dependent countries, and currency devaluation may not likely cause their current account balance to improve.

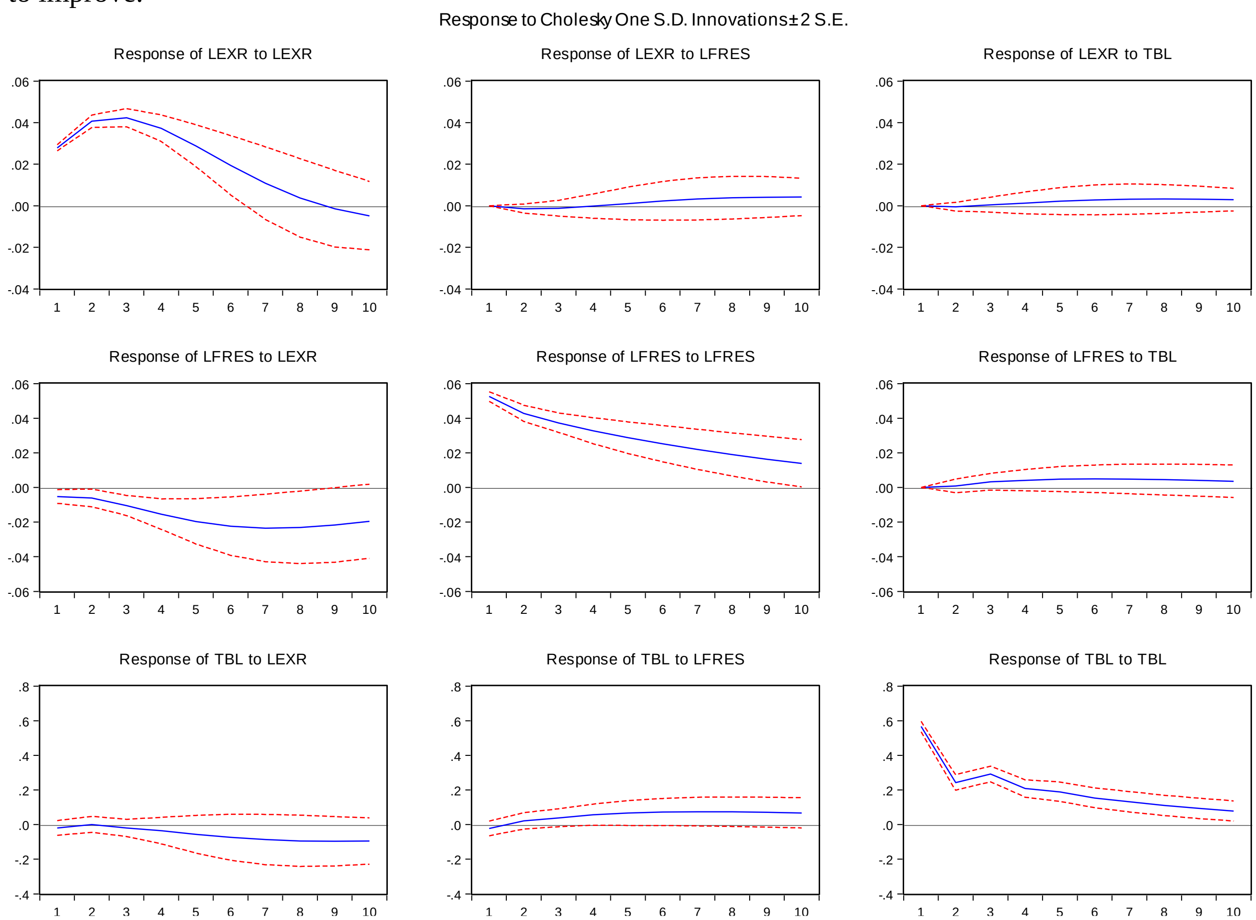

Figure 2: Impulse responses from Model 1

Application of the PVAR model enables the use of the Impulse Responses Function (IRF) to assess the short to medium-term dynamics of the response of each dependent variable to one standard deviation shock due to own and other variables in the model. The IRF showing the dynamic nature of dependence among exchange rate, foreign reserves and current account balance is presented in Figures 2 (for Model 1) and 3 (for Model 2). The impulse response function largely confirms the Granger causality results and the direction of causality indicated by the joint tests of significance. The response of the exchange rate to its shock and shock from foreign reserves and trade balance is presented in row 1 of Figures 2 and 3. The two figures show that the response of the exchange rate to foreign reserves and trade balance shocks is hardly significant as the midline of the graphs hardly deviates from zero. The relationship is revealed more prominently in Figure 3. Thus, IRF confirms our results from the Granger causality and the joint tests of significance that exchange rates of oil-dependent countries can be better attributed to a fixed regime than a floating regime.

More so, evidence from Figure 3 shows that foreign reserves and trade balance respond negatively to exchange rate shock. The negative response appears to be permanent as the midline of the first graph on rows 2 and 3 is not approaching zero. This permanent negative response is more pronounced in Figure 3. This confirms our earlier result about the direction of causality (see Table 6). It, however, implies that currency devaluation would worsen the trade performance and foreign reserves of oil-dependent countries over a long time. By implication, oil-dependent countries do not seem to meet the Marshall-Lerner condition which suggests long-term gain from currency devaluation when the sum of the elasticities of demand for imports and exports is greater than 1. As some of these countries are import-dependent and their main export, which is oil, is price inelastic, it is not surprising that the countries could not achieve trade and foreign exchange gains from currency devaluation.

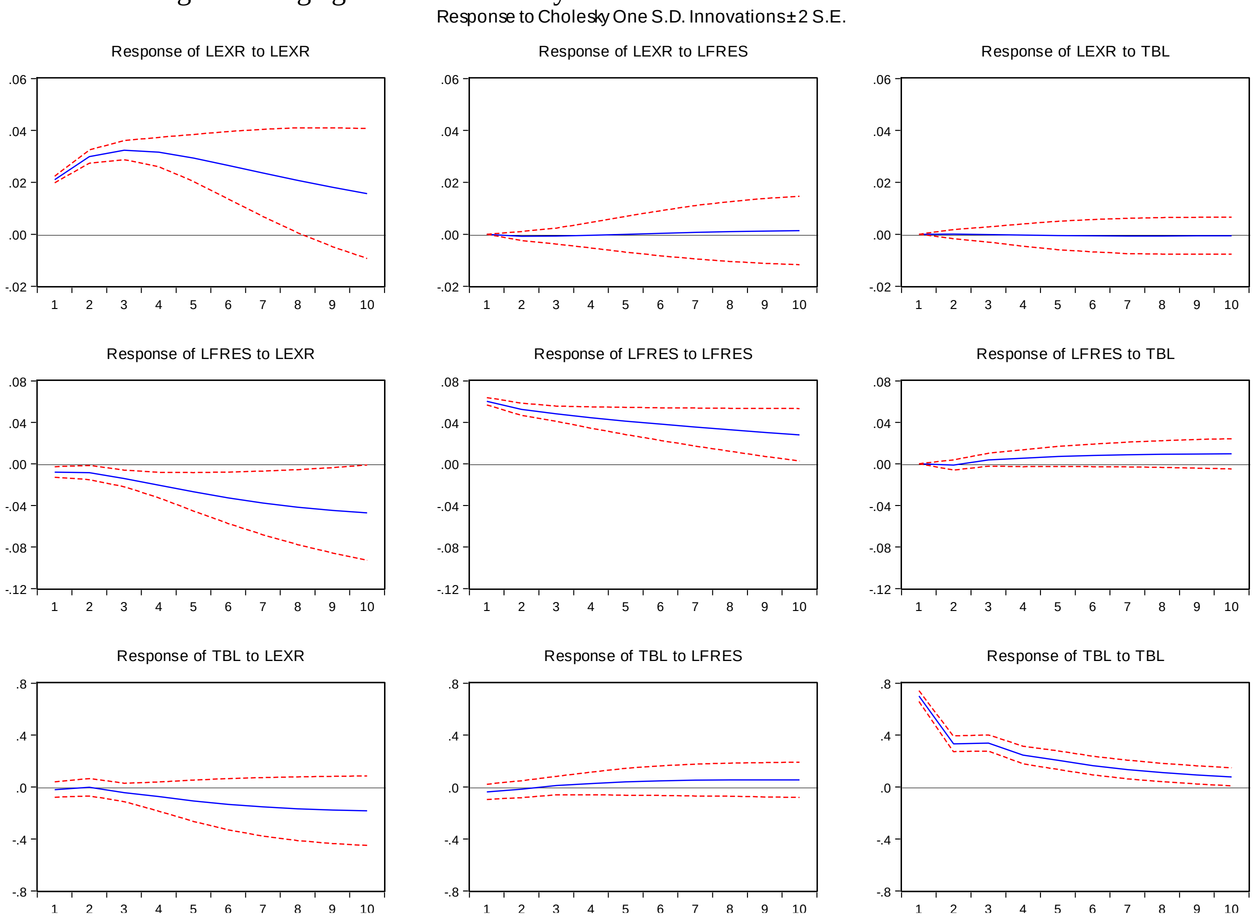

Figure 3: Impulse responses from Model 2

Furthermore, Figures 2 and 3 reveal that foreign reserve responds positively to trade balance shock, and on the other hand, trade balance responds positively to foreign reserve shock. The relationship however appears to be weak as the deviation from the middle line is close to zero. The weak relationship is also confirmed by the results of the Granger causality test and the joint significance for PVAR estimated coefficients. By implication, a better trade balance causes little or no short to medium-term improvement in foreign reserves, and higher foreign reserves cause little or no improvement in the trade balance of oil-dependent countries. The weak association between trade balance and foreign reserves of oil-dependent countries validates evidence that exchange rate regime choice by oil-dependent countries is more attributable to the fixed regime than the floating regime. This is apparent as a significant relationship will be expected between trade balance and foreign reserves where a floating exchange rate regime is operational. Meanwhile, the relatively insignificant effect of the trade balance on foreign reserves may be due to instability in the trade balance of these countries, which might be caused by the inherent oil price volatility. This relationship may be expected to improve with advancement in economic and export diversification (see also, Hendrix, 2017).

Conclusion

Oil-dependent countries have been repeatedly advised to change their exchange rate policy from fixed to floating exchange rate regimes to ameliorate the problem of high macroeconomic uncertainties occasioned by the adoption of a fixed exchange rate regime. This study employs the Panel Vector Autoregressive (PVAR) model to examine the appropriateness of fixed or floating exchange rate regimes in oil-dependent countries and whether these countries can be presumed to be technically operating floating exchange rate systems. Specifically, the PVAR model was used in a dynamic analysis of the exchange rate, external reserves and current account balance nexus, which has implications for the exchange rate transmission mechanism, exchange rate regime choice and Marshall Lerner condition in these countries.

Our results reveal that changes in foreign reserves and current account balances do not have a significant impact on the exchange rate. This indicates that the exchange rates of oil-dependent countries are exogenously determined. Hence, it appears that the behaviour of exchange rates of oil-dependent countries still follows a fixed exchange rate regime, despite that some of them are striving towards the implementation of a floating exchange rate regime. More so, we find a significant negative causal effect from the exchange rate to foreign reserves. The result of a positive causal relationship between trade balance and foreign reserves indicates that devaluation of the exchange rate reduces trade balance and foreign reserves rather than increasing them. By implication, the expected devaluation gains that prompted oil-dependent countries to stick to fixed exchange rate regimes are not there. On the relationship between exchange rate and current account balance, we find a negative insignificant Granger causality from exchange rate to current account balance. Although not significant, the fact that the relationship is negative suggests that the trade balance of oil-dependent countries tends to get worse due to exchange rate devaluation. This supports our hypothesis in this study that the Marshall-Lerner condition does not hold in oil-dependent countries, and currency devaluation may not likely cause their current account balance to improve. More so, the weak relationship between exchange rate and trade balance supports the evidence that the exchange rates of oil-dependent countries are much aligned with the fixed exchange rate regime.

To sum up, we find no significant causality from foreign reserves and trade balance to the exchange rate, suggesting that oil-dependent countries are more aligned to a fixed exchange rate regime than a floating exchange rate regime. We also find significant negative causality from the exchange rate to foreign reserves, while foreign reserves have a positive causal effect on the current account balance. This implies that the expected devaluation gains that may be prompting oil-dependent countries to stick to fixed exchange rate regimes are not there, as currency devaluation tends to worsen trade performance and foreign reserves rather than improve them. This tends to support our hypothesis in this study that the Marshall-Lerner condition does not hold in oil-dependent countries, and currency devaluation may not likely cause their current account balance to improve.

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