ISSN: 2415-0304 (Print)
ISSN: 2522-2465 (Online)

Indexing/Abstracting

Published by
Department of Economics

University of Management and Technology
Lahore, Pakistan

Empirical Analysis of Crude Oil Price Effects on Exchange Rate Volatility

Author: Reinhold Kamati[1c]

Affiliation: [1]Senior Economist, Research Department, Bank of Namibia, Windhoek, Namibia.
[c] **Email:** reinh.academic@gmail.com

Submission: June 6, 2018 **Acceptance:** December 14, 2018

Article Information:
To cite this document
Kamati, R. (2018). Empirical Analysis of Crude Oil Price Effects on Exchange Rate Volatility. *Empirical Economic Review*, *1*(2), 17-48.

The online version of this manuscript is available at
https://journals.umt.edu.pk/sbe/eer/volume1issue2.aspx
DOI: https://doi.org/10.29145/eer/12/010202

Additional Information
For Subscriptions Email: editorasst.eer@umt.edu.pk
For further information, please visit
http://journals.umt.edu.pk/sbe/eer/Home.aspx

Empirical Economic Review
Vol. 1, No. 2 (Winter, 2018), pp. 17-48

Empirical Analysis of Crude Oil Price Effects on Exchange Rate Volatility

Reinhold Kamati[1]

Abstract

This study examined the effects of crude oil price on nominal exchange rate volatility for oil and non-oil exporting countries. Immediately after the global financial crisis, the swings in the movement of crude oil price revealed how vulnerable the currencies of oil exporting countries and other commodity exporting countries. Using the Structural VAR method and the sample data from 2011 to 2016, the study estimated the effects of crude oil price on exchange rate stability and its impulse responses. Empirical results show that exchange rates for oil exporting countries are highly vulnerable to crude oil price shocks. As crude oil price declines, exchange rate volatility increases, similarly large crude oil price increases are associated with low exchange rate volatility. Currencies such as Angolan Kwanza, Russian Ruble, and Mexican Peso are very sensitive to crude oil price shocks. SVAR results show that oil price shocks significantly reduce exchange rate volatility of oil exporting countries. Meanwhile, the exchange rate volatility for non-oil exporting countries was driven by other factors than the price of crude oil.

***Keywords*:** Commodities, External Supply Shocks, Foreign Exchange Rates, Open Economy Macroeconomics, Prices.
JEL Classifications: F31, F37, F41

[1] Senior Economist Research Department, Bank of Namibia, Windhoek, Namibia.
E-mail: reinh.academic@gmail.com

1. Introduction

Over the past five years (2011-2016), exchange rate volatility in commodity exporting countries has risen drastically, thereby causing external imbalances in the emerging markets and developing economies. During this period, the volatility of nominal bilateral exchange rates rose significantly in some advanced economies, and in the emerging markets and developing economies. Apart from traditionally well-known macroeconomic fundamentals for exchange rate volatility, it seems for the period between 2011 and 2016 there was one rarely mentioned major factor that explained the excessive nominal exchange rate volatility for commodity dependent countries. For many countries in Sub-Saharan Africa (SSA) and Emerging Market Economies, the period from 2011 to 2016 was a roller-coaster, because the vulnerabilities in these economies were laid bare. Much of this vulnerability had to do with the decline of crude price which caused excessive exchange rate volatility with significant disruptive effects on fiscal balance and the balance of payments.

A pertinent question therefore is: what explains the exchange rate volatility between 2011 and 2016? This study tried to answer this question by analysing exchange rate volatility and the crude oil price during 2011 to 2016 because, in the aftermath of the 2007/2008 global financial crisis, the global crude oil prices recovered with a significant upward trend to new record levels. During the first half of this period oil exporting economies initially, recorded stable currencies due to rising crude oil price, but this stable exchange rates did last not for long when crude oil price changes the direction, thereby revealing the vulnerability of commodity exporting economies. Some economists, such as Auclair et al. (2016), have alleged that lower commodity prices, particularly those of crude oil, have increased the level of instability of many currencies; and thus, the past heightened volatility rarely emanated from the well-known traditional macroeconomic fundamentals of exchange rate movements. Firstly, during the same period there were extraordinary increases in the price of crude oil, which resulted in elevated government spending for many countries that produce and export crude oil. Secondly, over the same period there was a sudden swing in the direction of the price of crude oil. The reverse gear in the direction of crude oil prices led to panic among commodity exporting countries due to anticipated large corrections on government expenditures for these economies. Some oil producers such as Angola, Nigeria, Saudi Arabia, Brazil and Russia faced both fiscal and external balance sustainability concerns mainly as a result of falling crude oil price, currency depreciation and the rising exchange rate volatility. Therefore, on the back of the negative crude oil price developments, there was a subsequent chain of reactions, starting with low exchange rate volatility, followed by depreciation and explosive volatility of nominal exchange rate for many currencies. Next, exchange rate volatility created feedback effects to other commodity prices which collapsed, leading to a fall in export receipts, foreign reserves and government revenues. Furthermore, there was a chain of exchange rate instability with round effects back to commodity price declines and amplifying further the degree of economic uncertainty in emerging markets and developing economies. This situation was puzzling, because many economies had accumulated more foreign reserves because of all time high crude oil prices in the global markets. But, despite more reserves built up previously in countries such Angola, Nigeria, Brazil and Russia, the exchange rate instability rose significantly, thereby raising concerns about fiscal sustainability in emerging markets and developing economies. According to Auclair, et al. (2016) the lower oil prices have propelled the Russian economy into recession and caused the Ruble to depreciate.

The decline in the price of crude oil exhausted the amount of foreign reserves generated from oil exports and, thus, had a further negative impact on the current accounts, raised unemployment, financial sector risks, with significant consequences for the economic growth of oil exporting countries. Obviously, the ultimate outcome was then some prolonged recessions in large economies in Sub Saharan Africa: Angola and Nigeria, and some of the BRICS members – Russia and Brazil. Empirical evidence shows that some advanced and emerging economies were not spared either by the new level of nominal exchange rate volatility. For example, the volatility of the Canadian dollar increased from 1.0 percent to as high as 5.0 percent, the volatility in the Russian Ruble increased from 3.0 percent to as high as 23.0 percent and the Mexican Peso from 1.0 percent to as high as 5.0 percent in a month.

Given this background, this empirical study analysed the following questions: Did the changes in crude oil prices have a significant impact on currency volatility over the 2011-2016 sample period? How does exchange rate volatility respond to crude oil price shocks? Understanding the response of the exchange rate to oil shocks is of the utmost importance because past empirical evidence showed that currency volatility tends to bias monetary policy decisions towards exchange rate policy. Large crude oil price movements are historically disruptive, and significant changes in price lead to fiscal and balance of payments vulnerability (York & Zhan, 2009). Meanwhile, policy decisions aimed at stabilising the exchange rate are often piecemeal, thereby breeding further economic instability[2].

This study examined the effects of oil price shocks on exchange rate volatility for major oil exporting and non-oil exporting countries, respectively (see Table A1 for a list of countries in the sample). In addition, the study estimated the impulse responses of exchange rate volatility to random shocks from commodity prices such as base metals and precious metals. The later analysis was done to relate the exchange rate volatility from non-oil producing to other commodity development in non-oil exporting countries. This contributes to knowledge as it shows that crude oil price contributes to vulnerability and fragility of oil exporting economies. It shows that sudden changes in the direction of crude oil price increase volatility and significant risk on economic growth and development for both oil exporter and net-importers. In all, this shows that both internal and external sustainability assessment must be done in conjunction with developments in crude oil price.

The sample used in this analysis includes Brent crude oil price, Metals Price Index[3], a set of bilateral nominal exchange rates

---

[2] See also Hussain and Nora (2013).

[3] Metals Price Index, 2005 = 100, includes Copper, Aluminium, Iron Ore, Tin, Nickel, Zinc, Lead, and Uranium Price Indices

for the following currencies (all per one US Dollar): Angolan Kwanza AOA, Australian Dollar AUD, Botswana Pula BWP, Canadian Dollar CAD, Russian Ruble RUB, Mexican Peso MXN, South African Rand ZAR, Saudi Arabia Riyal SAR, Norwegian Krone NOK, Kuwait Dollar KWD, Nigerian Naira NGN, United Arab Emirates Dirham AED, and the Namibian Dollar NAD[4]. The sample period spanned from September 2011 to February 2016, and that makes a total of 54 monthly observations. This analysis was limited to the exchange rate volatility of the currencies relative to the US Dollar, i.e. ZAR per 1US$, primarily because the crude oil is traded in USD. The bilateral exchange rate data were sourced from the OANDA Historical Rates website[5] and the metal price index, and Brent crude oil prices were sourced from the International Monetary Fund database, and the foreign reserves from the Bank of Namibia and South Africa Reserve Bank websites.

2. Literature Review

Many studies in macroeconomic literature have shown that the volatility of macroeconomic fundamentals alone is not capable of explaining and predicting nominal exchange rate volatility. According to Irena and Andrius (2013), many fundamental models and technical models fail to explain and predict exchange rate volatility.[6] Devereux and Engel (2003) showed that factors such as local currency pricing, heterogeneity in international price-setting and goods distribution, highly volatile productivity shocks and expectational biases in international financial markets may raise exchange rate volatility without the traditional macroeconomic fundamental being perturbed. Other authors, such as Flood and Rose (1999) and Rogoff (1999), suggested that exchange rate volatility may be disconnected from fundamentals; meaning that it is not only the manifestation of economic volatility that generates exchange rate instability, but there is a host of other possible factors that

[4] By default, the statistics about the USDNAD and USDZAR must be almost the same. This this due to the peg. It also served as a form of consistency check in the analysis.

[5] https://www.oanda.com/fx-for-business/historical-rates

[6] These authors examined the advantages and drawbacks of exchange rate forecasting models.

generate volatility in the nominal exchange rate. The lack of determination concurs with the Efficient Market Hypothesis, which argues that the movement of exchange rate contains all necessary information, hence there is nothing new to be gleaned from macroeconomic fundamentals, because the exchange rate generating process works in a random way.

Other recent literature, such as Dizioli, Guajardo, Klyuev, Mano, and Mehdi (2016) and the European Central Bank (2017), point to recent global developments as major sources of exchange rate volatility. For example, there are possible explanatory factors from a global perspective, and one is China's domestic economy rebalancing. China's economic rebalancing over the 2011 - 2016 period is another important factor to consider when analysing the recent exchange rate volatility in emerging markets and developing economies. It is anticipated that China's domestic economy restructuring towards domestic consumption and the adjustment in global commodity demands away from China may have contributed to exchange rate volatility for many countries, especially those from emerging markets and Sub Saharan Africa. According to Calderón and Kubota (2009), exchange rate volatility can be driven by many factors, such as trade and financial openness. And thus, crude oil producers, by mark of their openness to world trade, will continuously experience high currency volatility. Although trade-openness and macroeconomic factors matter in the determination of exchange rate volatility, a question remains: do they account for much of the last episode in the bilateral exchange rate for most of these countries, or must we look further for other factors to explain the rise in nominal exchange rate volatility?

Irena and Andrius (2013) showed that, when it comes to exchange rates, it is worth exploring further, as the Purchasing Power Parity (PPP), Uncovered Interest Rate Parity (IUP), Flexible Price Monetary and Mundell Fleming models have rarely succeeded in explaining exchange rate volatility. When it comes to explaining nominal exchange rate volatility, few studies have focused on the commodity factor, such as crude oil, in examining the possibility of a strong relationship between nominal exchange rate volatility and commodity price.

3. Methodology

To analyse the impact of crude oil price on volatility, this study used Structural Vector Auto-regression (SVAR) method. The study employs a SVAR as opposed to ordinary VAR which does not consider the correlations between contemporaneous shocks. According to Ouliaris, Pegan, and Restrepo (2016), the SVAR approach considers correlations between shocks which arise due to contemporaneous correlations between variables, and therefore the errors in the estimated structural equations can now be taken to be uncorrelated. Meanwhile the VAR takes care of the past correlation between shocks. First, the OLS method was used to establish whether there was a statistically significant relationship between changes in crude oil price and exchange rate volatility. Theoretically, it is a priori expectation that successive increases in crude oil price induce lower exchange rate volatility and, on the contrary, a down swing in the crude oil price with successive decreases causes heightened exchange rate volatility. Empirical analysis presents the scatter plots and estimates the OLS regression results. Secondly, since there are feedback effects from exchange rate volatility to oil price, the study examined the impact of random shocks in crude oil price on exchange rate volatility while controlling for the contemporaneous systematic responses between changes in oil price and exchange rate volatility. The study's main variables of interest were: the unconditional exchange rate volatility calculated from a 6-month moving average of bilateral exchange rates of currencies mentioned above. As in MacDonald (2007), the dependent variable exchange rate volatility was represented by a Coefficient of Variation (CV) statistic[7]. This is different from the traditional measure of volatility used in past studies - the standard deviation which is often used to represent historical volatility. The transformation of exchange rate standard deviation into a coefficient of variation statistic was done to examine the volatility on a relative basis. This is because some bilateral exchange rates have larger mean values than others, so each currency standard deviation was

[7] MacDonald (2007) used the second moment expressed relative to its mean to calculate the coefficient of variation statistics. This is then used to describe exchange rate volatility.

expressed relative to its mean value. The coefficient of variation is a unit free statistic expressed as a percentage of the standard deviation relative to the sample mean. In contrast, the standard deviation is expressed in different units' measurements as given by respective currencies in the analysis (Sørensen, 2002).

Exchange rate volatility was regressed on the differenced log price of crude oil in US$/barrel as the main predictor variable. In addition, foreign currency reserves were used (where the data were available) as a control variable along with crude oil as a predictor variable. The foreign reserve variable was used in the regression equation for USDNAD (Namibia) and USDZAR (South Africa). This was done to determine if the total foreign reserve variable helps to improve the effects of crude oil price on currency volatility. Further, other changes in price indices, such as base metals and precious metals indices, were used as independent variables instead of crude oil price for countries that are dependents on export of other mineral commodities than crude oil. In the list, this includes countries such as: Australia, Botswana, South Africa and Namibia. It is worth mentioning that often exchange rate volatility is examined using the ARCH and GARCH methods. However, there are some drawbacks from using the ARCH and GARCH methods.

MacDonald (2007) argued that these methods perform well in the domain of high frequency data, i.e. when the intraday, daily and weekly data frequencies are used. However, results from ARCH and GARCH turn out often insignificant when low frequency data, such as monthly and quarterly data, are used in the econometric data analyses.

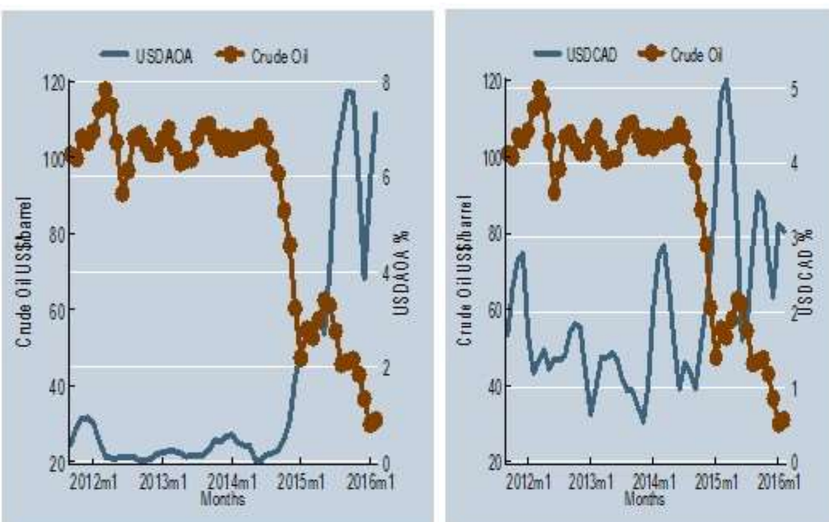
4. Empirical Analysis

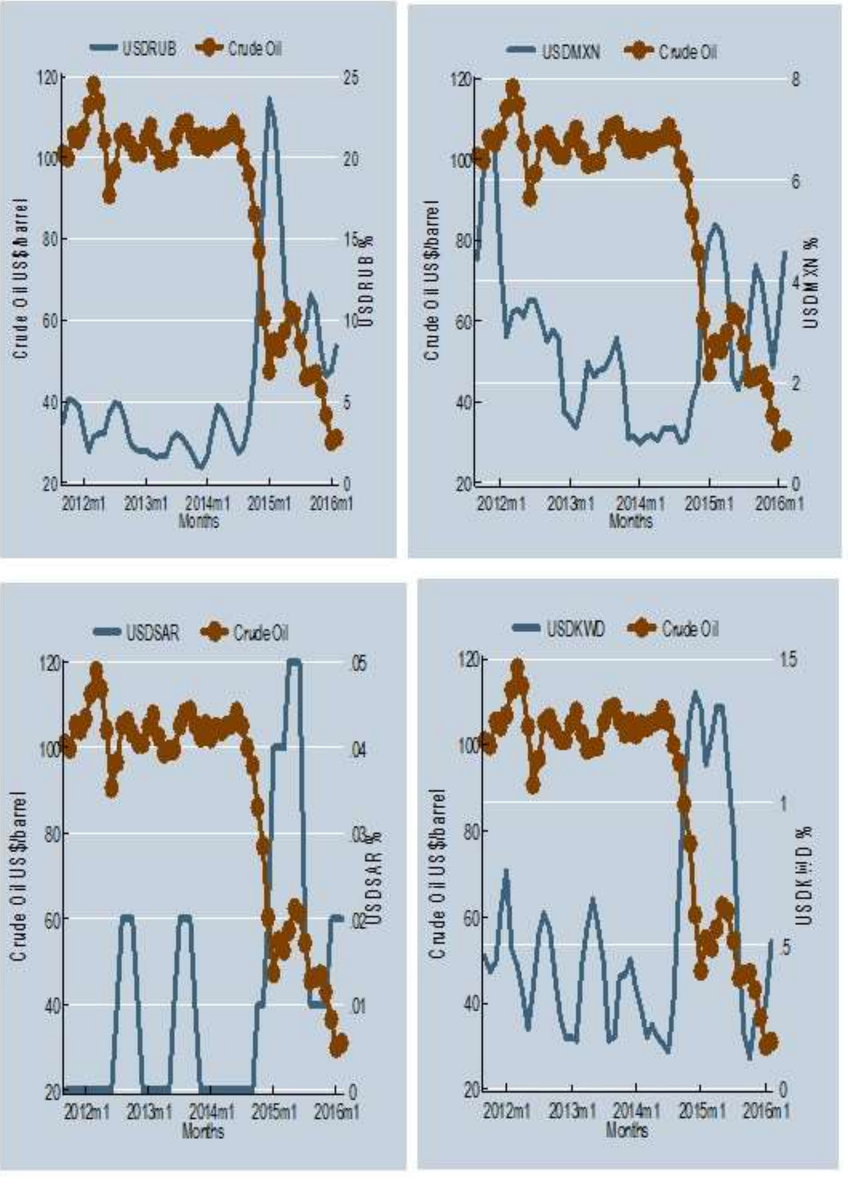
Section 4.1 presents the basic statistics and correlation analysis of crude oil price along with exchange rate volatility. Correlation analysis will help to identify at first sight whether the statistical relationships between the variables examined pre-conforms to theory and a priori expectations. Next, section 4.2 discusses the regression results, along with an interpretation and evaluation of the results. Section 4.3 estimated the SVAR and presents the impulse responses results of exchange rate volatility on crude oil price shocks. Finally, section 5 presents the conclusion of the study.

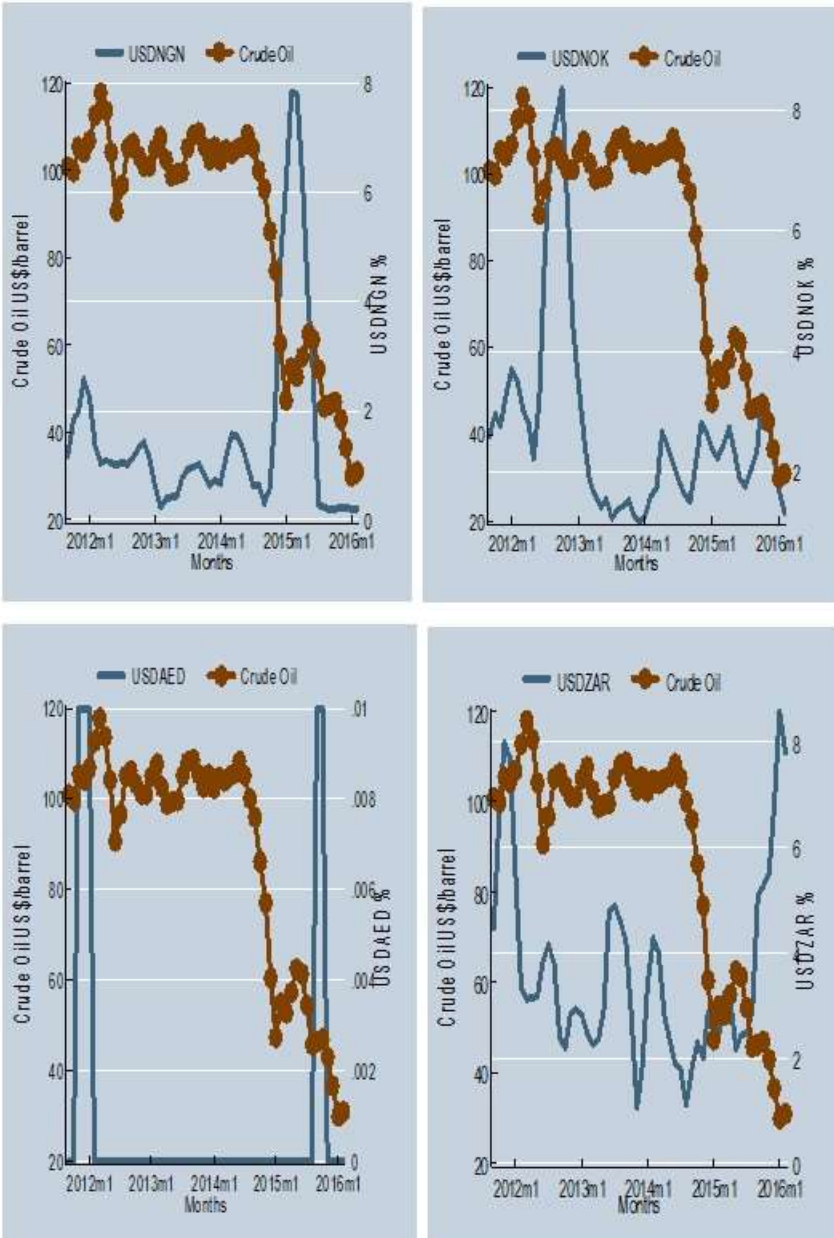
4.1. Basic Statistics and Correlation Analysis: Exchange rate volatility and Crude Oil price

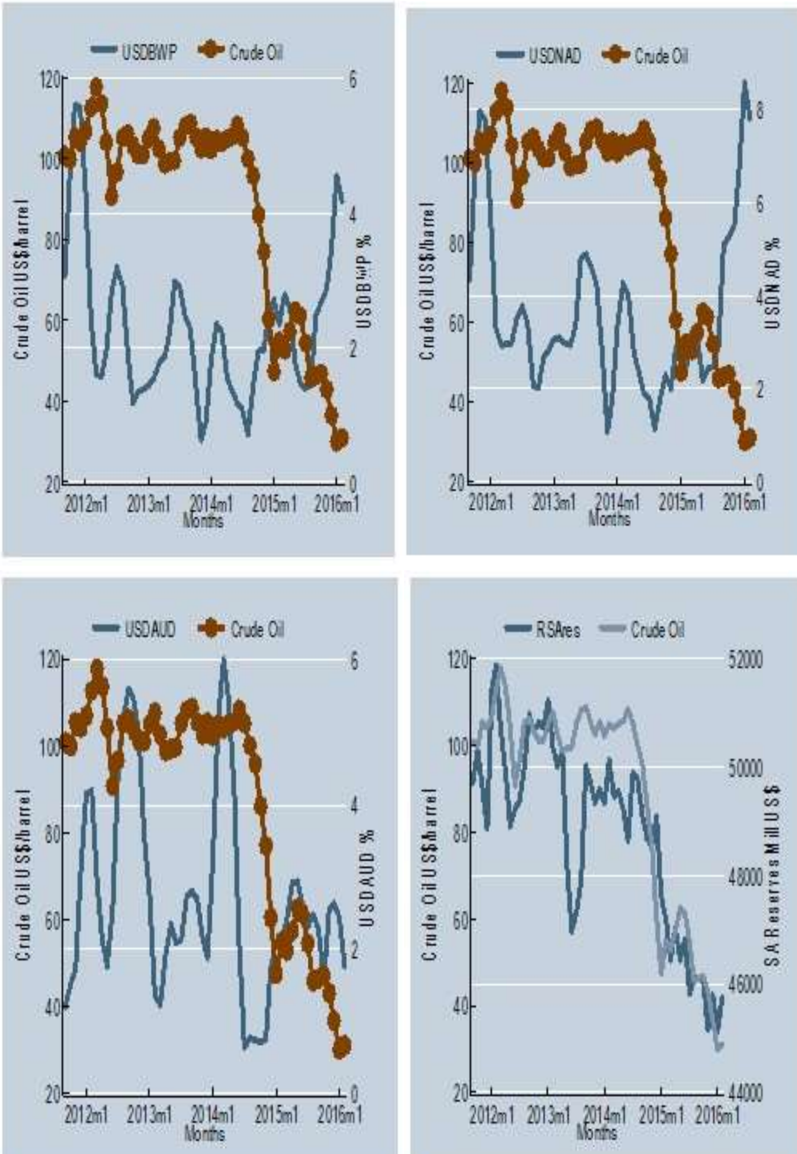
Figure 1 shows a panel of time series plots of crude oil price in US$ per barrel plotted together with the 6-month moving average of exchange rate volatility. In the panel, the first to the ninth graph present the exchange rate volatility of the USDAOA - Angola, USDCAD-Canada, USDRUB-Russia, USDMXN-Mexico, USDSAR-Saudi Arabia, USDKWD-Kuwait, USDNGN-Nigeria, USDNOK-Norway and USDAED-United Arab Emirates – these are all oil-producing countries, with some of them in the top ten global producers of crude oil. Meanwhile, the tenth to thirteen graph show the volatility for the USDZAR-South Africa, USDBWP-Botswana, USDNAD-Namibia and USDAUS-Australia – all non-oil producing countries, but heavily dependent on export of other mineral commodities. In addition, the last two graphs in Figure 1 show total reserves for South Africa and Namibia plotted together with the price of crude oil.

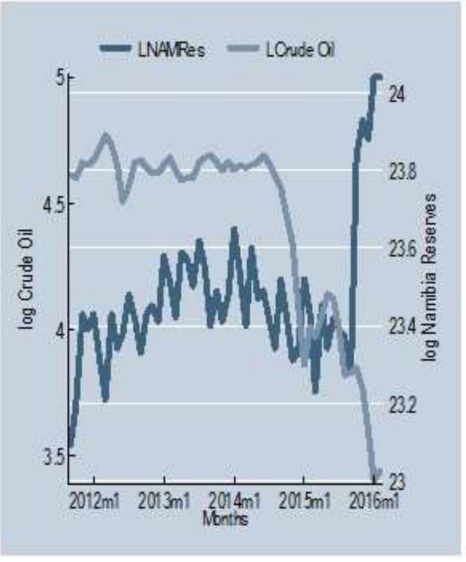
Figure 1: **Time Series Plots: Exchange Rate Volatility(%), Crude Oil Price($) and Reserves (N$&R), May 2011 – February 2016**




USDRUB
Crude Oil
Crude Oil US$/barrel
USDRUB %
2012m1
2013m1
2014m1
2015m1
2016m1
Months
USDMXN
Crude Oil
Crude Oil US $/barrel
USDMXN %
Months
USDSAR
Crude Oil
Crude Oil US $/barrel
USDSAR %
Months
USDKWD
Crude Oil
Crude Oil US $/barrel
Months


USDNGN
Crude Oil
Crude Oil US$/barrel
USDNGN %
Months
USDNOK
Crude Oil
Crude Oil US$/barrel
USDNOK %
Months
USDAED
Crude Oil
Crude Oil US$/barrel
USDAED %
Months
USDZAR
Crude Oil
Crude Oil US$/barrel
USDZAR %
Months


USDBWP
Crude Oil
Crude Oil US$/barrel
USDBWP %
120
100
80
60
40
20
6
4
2
0
2012m1 2013m1 2014m1 2015m1 2016m1
Months
USDNAD
Crude Oil
Crude Oil US$/barrel
USDNAD %
120
100
80
60
40
20
8
6
4
2
0
2012m1 2013m1 2014m1 2015m1 2016m1
Months
USDAUD
Crude Oil
Crude Oil US$/barrel
USDAUD %
120
100
80
60
40
20
6
4
2
0
2012m1 2013m1 2014m1 2015m1 2016m1
Months
RSAres
Crude Oil
Crude Oil US$/barrel
SA Reserves Mill US$
120
100
80
60
40
20
52000
50000
48000
46000
44000
2012m1 2013m1 2014m1 2015m1 2016m1
Months



Initial observations about the graphs in Figure 1 suggest that there is an inverse relationship between the price of crude oil and currency volatility. When the price of crude oil was high, the exchange rate volatility was low, and this pattern switched in the later part of the sample period. The low exchange rate volatility was persistent until the crude oil price reached an all-time high during 2014. As the crude oil price successively increased, the phenomenon of currency instability subsided until successes in the energy sector bred instability and volatility. Ratti and Vespignani (2016) showed that there is a strong relationship between oil prices innovations and global factor macroeconomics variables, such that positive shocks in global oil prices tighten global interest rates which potentially leads to financial instability. Furthermore, Figure 1 shows that, when the price of crude oil was above 100US$/barrel, most currencies exhibited low volatility, - see, for example, the trend for exchange rate volatility for USDAOA, USDRUB, USDSAR, USDCAD, USDKWD and USDNGN. One common feature of this list is that these countries are all oil producing countries. In addition, it is also apparent that the magnitude of volatility ranges from means of 0.2 percent to 5.0 percent before mid-2014. This exchange rate volatility is relatively low compared to the level of volatility exhibited in the remainder of the sample period.

As from mid-2014, when the price of crude oil price started to decline, the level of currency volatility increased considerably. For example, the volatility of the Kwanza significantly increased from the stable levels of less than 2.0 percent to about 8.0 percent in 2016, the Canadian dollar increased from 1.0 percent to as high as 5.0 percent, the volatility in the Russian Ruble increased from 3.0 percent to as high as 23.0 percent, the Saudi Riyal increased from 0.02 percent to 0.05 percent, and the Mexican Peso from 1.0 percent to as high as 5.0 percent in a month. Similarly, volatility for the ZAR, BWP and NAD have doubled the average over the same period. The ZAR and NAD volatility have risen from as low as 4.0 percent average to 8.0 percent, while the Pula has risen from 1.5 percent to as high as 5 percent level of volatility over the same period.

Further, Figure 1 shows that the ZAR, NAD and BWP have very similar cyclical trends over the sample period. The Pula is pegged to the basket, with 60 percent of the weight of the basket carried by the ZAR. Meanwhile, the NAD is pegged to the ZAR one-on-one. However, the volatility of the ZAR, BWP, AUD and NAD were high at some points in the past, even when the price of crude oil was higher, above 100US$ per barrel. This seems to suggest that the exchange rate volatility for these currencies might be driven by other factors than by the changes in the price of crude oil. It means that, for the ZAR, BWP, AUD and NAD, there were other main factors that explained the variation in the exchange rate volatility. Meanwhile, the trend of volatility of Naira USD-NGN, Krone USDNOK and the Dirham USDAED does not seem to match the movements of crude oil price throughout the sample period, even though these are currencies from major oil exporting countries.

Next, the analysis examined the correlation between the crude oil price and exchange rate volatility over the sample period. The pairwise correlation coefficient statistic shows the strength and direction of the association between two variables. Although there are no hard-binding rules on classifying the strength of correlation, Cohen (1988) provided guiding principles in that regard as follows: with a correlation $0.1 < | r | < 0.3$ regarded as small, $0.3 < | r | < 0.5$ regarded as moderate correlation, and the $| r | > 0.5$ strong correlations. Table 1 shows the pairwise correlation coefficient statistics between the price of crude oil and exchange rate volatility.

Table 1: Pairwise Correlation Coefficient Statistic of Exchange Rate Volatility vs Crude Oil Price

	USD NAD	USD ZAR	USD BWM	UDS AOA	USD RUB	USD NGN	USD AUD	USD NOK	USD SAR	USD CAD	USD MXN
C-O	-0.32 (0.01)	-0.32 (0.01)	##	-0.90 (0.00)	-0.72 (0.00)	-0.31 (0.00)	##	##	-0.66 (0.00)	-0.72 (0.00)	-0.30 (0.00)

Note: O=Crude Oil Price, () = significant @ 0.05 Significance level, ## indicates the correlations not significant @ 0.05 Significance level, Correlation for USDZAR=USDNAD, because NAD is pegged to the ZAR.

The pairwise correlation results show that there is a medium to strong statistically significant negative correlation between crude oil price and exchange rate volatility. With a p-value of close to zero, it means that the probability: that these correlation results are out of chance (i.e. lucky) is less than 5 percent. Thus, empirically, it means that when crude oil price declines, exchange rate volatility will significantly increase, or vice-versa. Furthermore, the result in Table 1 shows that the correlations between the USDZAR, USDNAD, USDBWP and crude oil price were relatively weak; meanwhile, the correlation coefficient between crude oil price and exchange rate volatility of USDAOA, USDRUB, USDCAD and USDSAR was very strong. In addition, the results show that there was a negative relationship between reserves and exchange rate volatility. It is apparent that these results are consistent with the theoretical expectation that lower crude oil price will be associated with heightened level of exchange rate volatility and vice-versa. Further, the evidence suggests that there is a strong negative correlation between changes in crude oil price and changes in exchange rate volatility. This relationship is clearly manifested, particularly between the monthly changes in crude oil price and the volatility for USDAOA, USDRUB, and the USDMXN. However, the relationship is in reverse for USDCAD and USDAUD.

Before regression analysis was applied, all series were tested to establish the stationarity property using the Philip-Perron test. The results of the PP test are reported in Table 2, panels (a) and (b). According to PP test, all series are non-stationary at the 5 percent significance level; Table 2 panel (b) reported the results after all series were first differenced. After the first difference, all series become stationary.

Table 2: Philip-Perron Stationarity Test.

(a) Stationarity Test Results in Levels

Variable	**PP statistic**	**PP crit. value (0.05 sign. level)**
USDNAD	-1.805	-2.928
USDZAR	-1.808	-2.928
USDBWP	-2.381	-3.576
USDAOA	0.237	-3.576
USDRUB	-1.962	-3.576
USDNGN	-2.370	-3.576
USDAUD	-2.952	-3.576
USDNOK	-2.169	-3.576
USDSAR	-2.201	-3.576
USDCAD	-2.353	-3.576
USDMXN	-2.171	-3.576
USDEAD	-3.058	-3.576
USDKWD	-2.216	-2.928
CRUDE OIL	1.672	-3.576
LMMI	0.088	-3.576
LBMXIORES	-0.273	-3.576
LPMETAL	-0.940	-2.928

Note: LMMI = log of Mineral Metal Index, LBMXIORES = log of Base Metal Index, LPMETAL = Precious Metal Index.

(b) Stationarity Test in First Difference

Variable	**PP statistic**	**PP crit. value (0.05 sign. level)**
USDNAD	-5.102	-3.577
USDZAR	-5.102	-3.577
USDBWP	-4.659	-3.577
USDAOA	-4.272	-3.577
USDRUB	-3.427	-3.577
USDNGN	-3.540	-3.577
USDAUD	-3.778	-3.577
USDNOK	-3.800	-3.577
USDSAR	-5.070	-3.577
USDCAD	-4.195	-3.577

Variable	**PP statistic**	**PP crit. value** **(**0.05 sign. level**)**
USDMXN	-4.782	-3.577
USDEAD	-6.737	-3.577
USDKWD	-3.782	-3.577
CRUDE OIL	-4.681	-2.928
LMMI	-5.241	-2.928
LBMXIORES	-4.782	-2.928
LPMETAL	-6.477	-2.928

Note: LMMI = log of Mineral Metal Index, LBMXIORES = log of Base Metal Index, LPMETAL = Precious Metal Index.

4.2. Effects of Crude Oil Price on Currency Volatility

In Section 4.1, the trend analysis and summary statistics show that a lower crude oil price is associated with heightened currency volatility. This section estimates the marginal effects of changes in crude oil price on exchange rate fluctuations. First, differenced log exchange rate volatility was regressed on differenced log crude oil price without controlling for the effects of foreign reserves in the OLS regression. Next, in the regressions for USDZAR and USDNAD the model considered the total foreign reserves as an additional factor that affects exchange rate volatility. The specification of the linear equation is as follows:

$$\Delta lnExch.rate\ Vol_t = \beta_0 + \beta_1 \Delta lnCrudeoil_t + u_t \qquad \textbf{(1)}$$

The results are presented in Table 3 and Table 4. Firstly, the effects on exchange volatility in oil exporting countries are given in Table 3 and followed by the results from non-oil exporting countries in Table 4.

Table 3: Effects of Crude Oil Price on Exchange Rate Volatility in Oil Exporting Countries

	ΔUSD AOA Vol %	**ΔUSD CAD Vol %**	**ΔUSD RUB Vol %**	**ΔUSD MXN Vol %**	**ΔUSD SAR Vol %**	**ΔUSD KWD Vol %**	**ΔUSD AED Vol %**
Const (β_0)	0.071	-0.046	-0.177	-0.088	0.00	-0.001	-0.000
	(0.82)	(-0.06)	(-0.77)	(-0.83)	(0.13)	(-0.06)	(-0.61)
ΔCrude Oil	-2.511	-3.016	-10.99	-3.743	-0.011	-0.094	-0.002
Price (β_1)	(-2.1)*	(-2.9)*	(-2.6)*	(-3.4)*	(-1.0)	(-0.3)	(-1.5)
Adj-R^2	0.09	0.18	0.20	0.14	0.02	0.00	0.05
Fstats P Value	0.03	0.00	0.01	0.00	0.32	0.76	
Observations	53	53	53	53	53	53	53

Note: * t-stats significant @ 0.05 t. ** t-stats significant @ 0.1 . HAC-West robust standard errors in () were applied in the OLS regressions.

Table 3 presents the results from OLS regression as specified in equation (1). Table 3 shows that the estimated effects of changes in crude oil are negative and were statistically significant, except against the exchange rate volatility for USDAED and the USDKWD.

Starting with result for USDAOA (i.e. the volatility of the Angolan Kwanza USDAOA), the regression results in Table 3 show that the growth rate of the price of crude oil explains about 9 percent of the total variation in the volatility of the Kwanza AOA, 18 percent for the Canadian Dollar, 20 percent of the volatility for the Ruble RUB and 14 percent of the volatility in the USDMXN Peso. Empirically, it means that, the movements of the USDAOA, USDCAD, USDRUB and USDMXN over the sample period were explained by the developments in the price of crude oil over the same period. From Table 3, the results for USDAOA show that a 1.0 percent decline in the growth rate of crude oil price increases the volatility of USDAOA by 2.5 percent in a month. As shown in Table 3, the response is steeper indicating that the USDAOA volatility is highly sensitive to the decline of crude oil price. Thus, a 2.5 percent increase in the level of volatility indicates that the heightened volatility of the Kwanza was hurting for ordinary Angolans and foreign investors. Exchange rate volatility hurts because currency instability in foreign exchange markets feeds into another high volatility, which amplifies from the external sector to the other sectors of the economy.

Further, these results show that the effects of changes in crude oil price were also pronounced on the volatility of USDRUB and USDMXN (see Table 3). On average, a 1.0 percent decline in the price of crude oil will increase the volatility for the Ruble and the Peso by 10.9 and 3.7 percent, respectively. Furthermore, the results show that on average the volatility of USDCAD decreased by -3.0 percent and the USDKWD by -0.1 percent in response to 1.0 percent decline in the price of crude oil. This indicates that the decline of crude oil price not only increases the exchange rate's volatility, but it also breeds more volatility as the variance of volatility reduces the increase in the price of crude oil. This regression analysis found that the effects of crude oil price on the exchange rate volatility for currencies of non-oil exporting countries were very small, but nevertheless maintain the same negative sign. Table 4 shows the regression results for the effects of crude oil price on the exchange rate volatility of the USDNGN, USDZAR, USDBWP, USDNAD, USDNOK and USDAUD. These show that the effect of changes in crude oil price on the volatility of USDZAR, USDNAD and USDBWP were not statistically significant.

Table 4: Effects of Crude Oil Price on Exchange Rate Volatility Non-Oil Exporting Countries

	ΔUSD NGN Vol %	**ΔUSD ZAR Vol %**	**ΔUSD BWP Vol %**	**ΔUSD NAD Vol %**	**ΔUSD NOK Vol %**	**ΔUSD AUD Vol %**
Const (β_0)	-0.112	-0.008	-0.027	0.013	-0.033	-0.021
	(-1.13)	(-0.06)	(-0.30)	(0.10)	(-0.34)	(-0.18)
ΔCrude Oil Price (β_1)	-3.892	-2.293	-2.015	-2.174	-0.388	-1.330
	(-2.87)	(-1.26)	(-1.70)	(-1.20)	(-0.32)	(-1.14)
Adj-R^2	0.16	0.04	0.06	0.04	0.00	0.02
Fstat pvalue	0.00	0.21	0.09	0.23	0.76	0.25
Observations	53	53	53	53	53	53

Note: * t-stats significant @ 5percent. ** t-stats significant @ 10percent. HAC-West robust standard errors in () were applied in the OLS regressions.

In the case of non-oil exporting countries in the sample, OLS results showed that the volatility in the currencies for these countries was less sensitive to the changes in the price of crude oil. This means that the variation in the volatility observed over the sample period was caused by other factors than it could be attributed to the slowdown in the price of crude oil. Finally, the results in Table 4 showed that the relationship between the volatility of USDNOK, USDAUD and the growth rate of the crude oil price were almost statistically insignificant or non-existent. Although the sign on the estimated coefficients for crude oil price was correct, the marginal effects are practically no different from zero; and therefore, it is possible that changes in crude oil price do not explain any of the variation of exchange rate volatility for these currencies over the sample period. The same sign on marginal impacts of crude oil, in both oil and non-oil exporting countries, might be wrong since strong growth in commodities draw in capital inflows which strengthen exchange rate. The non-significant results for countries such as Norway and Australia are possibly explained by lower inflation and strong housing market which neutralise the impacts of higher oil price on exchange rate. In short, this analysis showed that there is empirical evidence which confirms the effects of changes in crude oil price on exchange rate volatility.

Finally, this empirical study examined how exchange rate volatility responds to a random shock in the price of crude oil. The initial result showed that, for most currency exchange rates, volatility is negatively related. In the last analysis, examined the dynamic response of exchange rate volatility to oil price shock after considering the systematic response or taking the endogenous relationship into account. The underlying structural VAR equations are in the following form:

$$Ay_t = C(l)y_t + Bu_t \qquad \textbf{(2)}$$

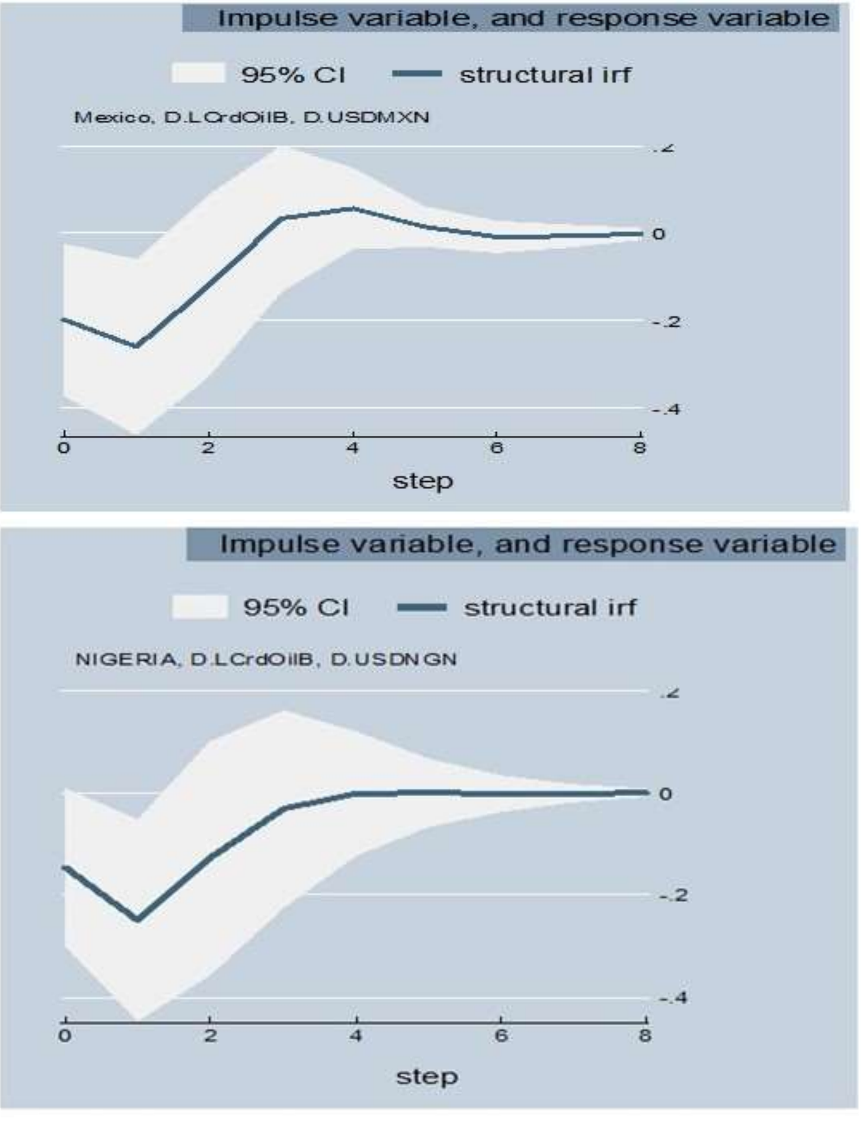
Where the structural shocks u_t are normally distributed $u_t \sim N(0, \Sigma)$ where $\sum$ is generally assumed to be diagonal matrix, usually the identity matrix such that $u_t \sim N(0, I_n)$. Procedurally, the estimated equation first is the unrestricted VAR:

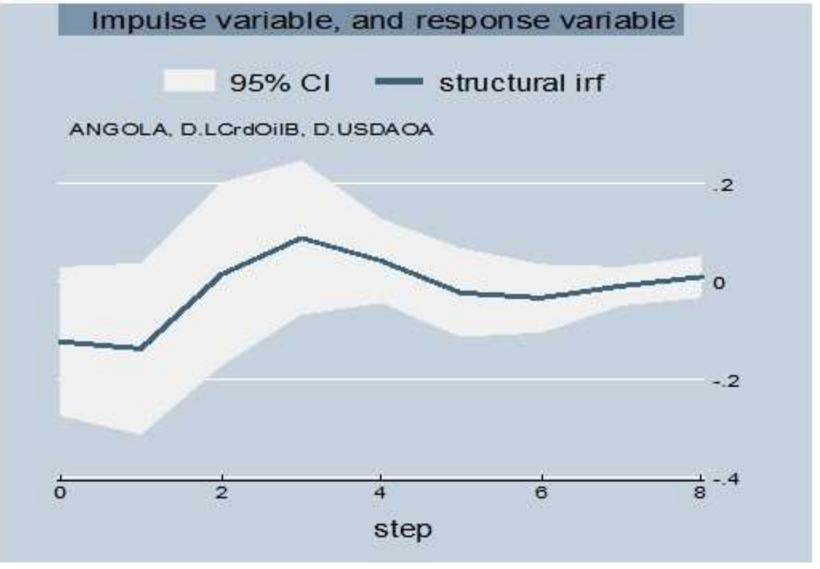
$$
\begin{aligned}
y_t &= A^{-1}C(l)y_t + A^{-1}Bu_t \\
&= H(l)y_t + \varepsilon_t
\end{aligned}
\qquad \textbf{(3)}
$$

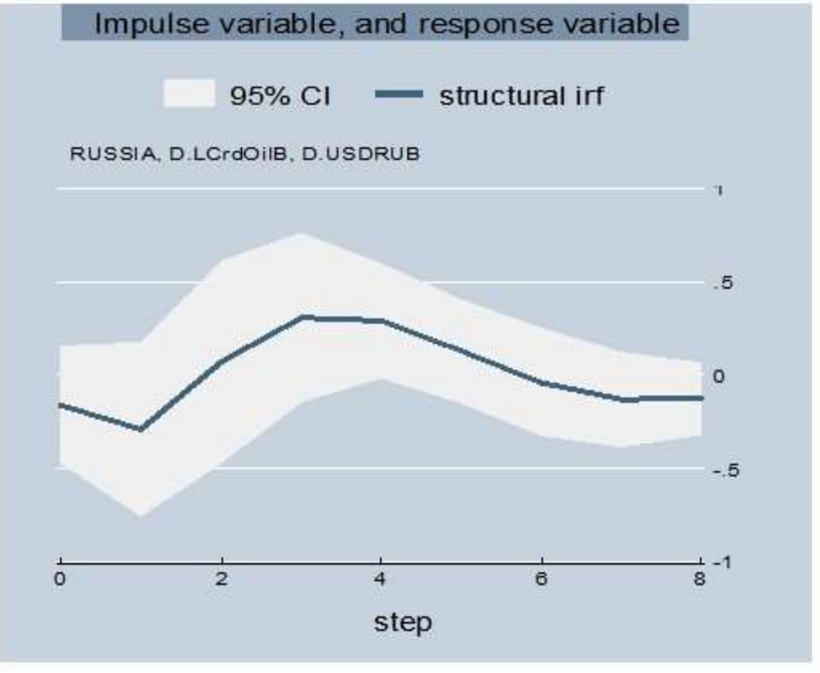
The matrices A, B and $C_i's$ are not separately observable for the estimated H_i's and the covariance matrix $E(\varepsilon_t\varepsilon_t') = \Omega$, of the reduce-form shocks, u_t. The SVAR estimation followed the AB identification model discussed by Amisano and Gianini (1997). In this case, the SVAR AB model has two endogenous variables, crude oil price followed by exchange rate volatility, and one structural dummy as exogenous variable. The dummy variable was aimed to capture the structural break possible as crude oil price changed the direction in mid-2014. However, the dummy was statistically insignificant, hence this was dropped out from the SVARs.

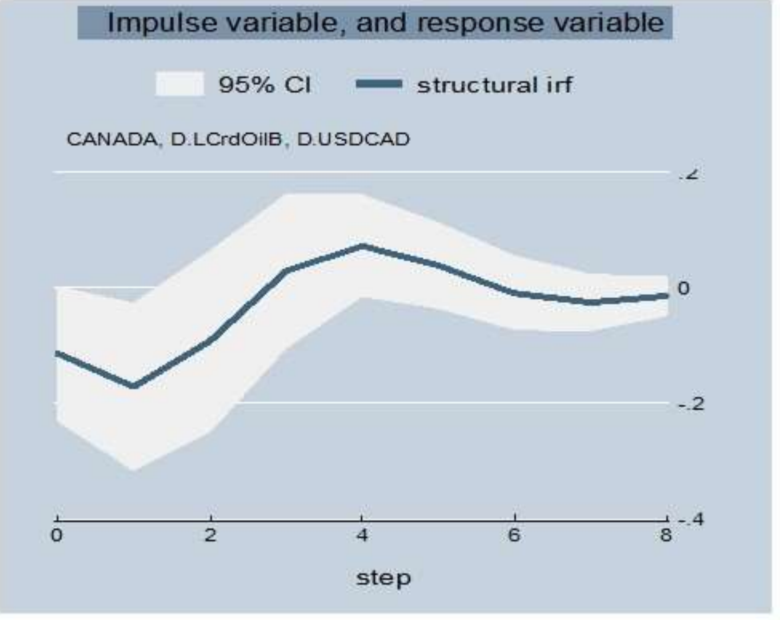
The SVAR results show a positive random shock in the growth rate of crude oil price will significantly reduce exchange rate volatility for an oil exporting country. Figure 2 below shows the impulse response to a shock in the crude oil. Firstly, we observe the structural impulse functions of the exchange rate volatility for the USDMXN, USDNGN, USDAOA, USDRUB, USDCAD, USDSAR, USDAED, USDKWD, and USDNOK (all oil exporting countries) in response to a shock in crude oil price. These impulse responses show that exchange rate volatility USDMXN, USDNGN, USDAOA, USDRUB, and USDCAD significantly decline by more than 0.2 percentage points to a shock in crude oil price. Similarly, the volatility for USDSAR, USDAED, USDKWD, and USDNOK show negative impulse responses to random shock in crude oil price, however, these are accompanied by great uncertainty. Meanwhile, the impulse responses for non-oil exporting countries USDZAR, USDBWP and USDAUS also show high degree of uncertainty about the effects from crude oil price shock.

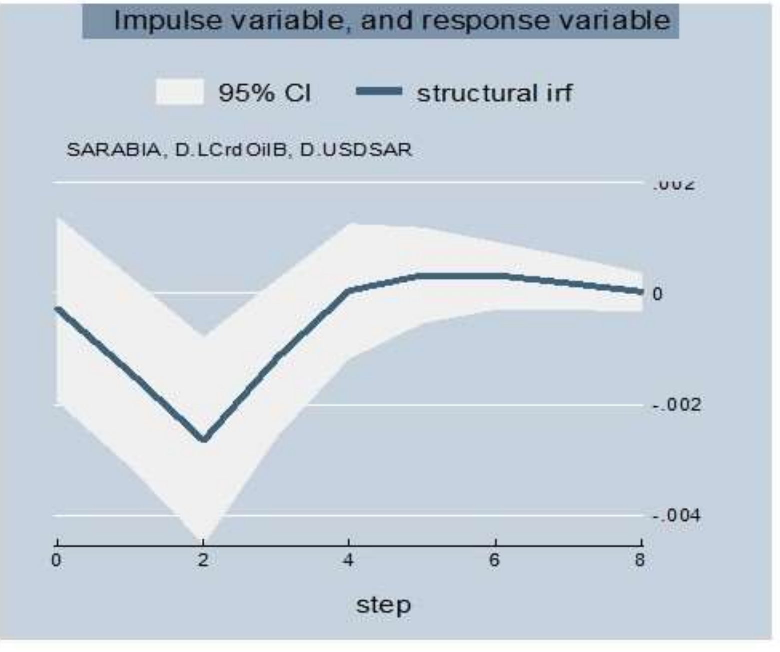
Figure 2: Impulse Responses of Exchange Rate Volatility to Crude Oil Price Shock

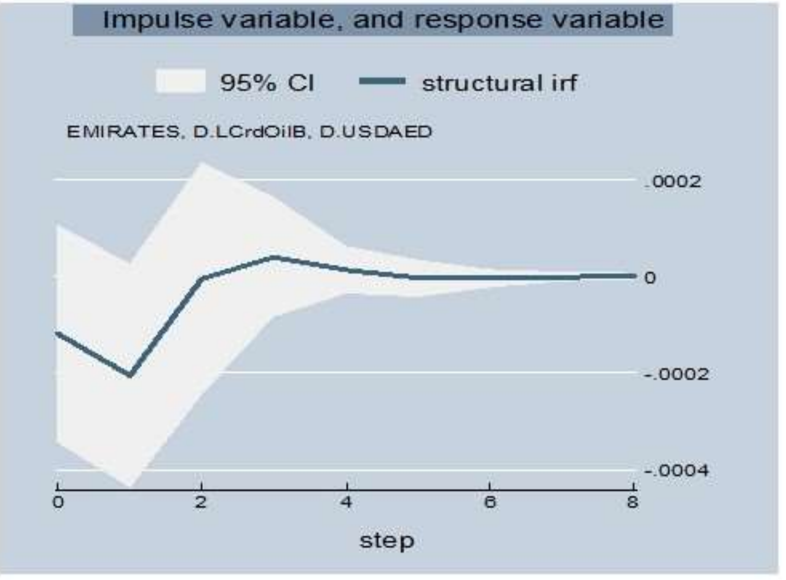


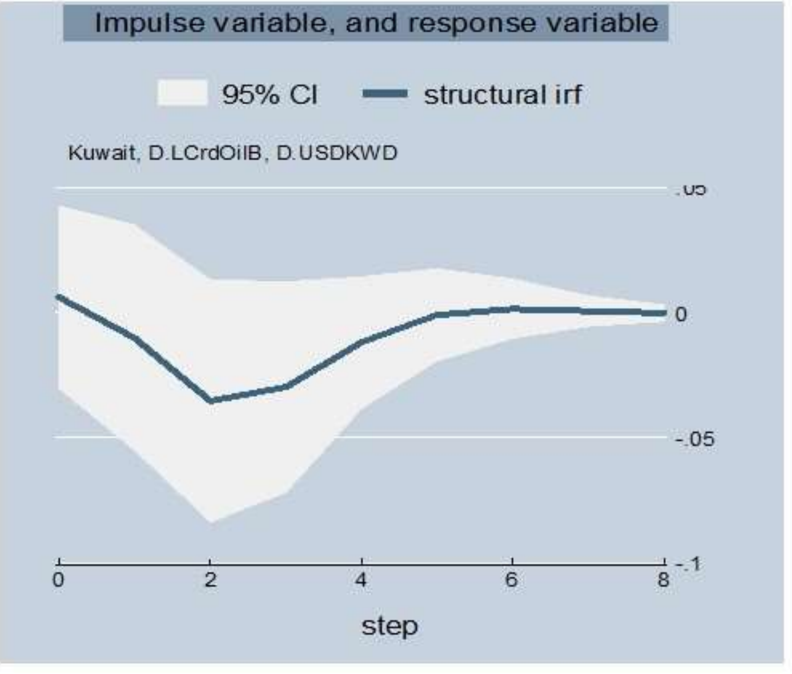

Impulse variable, and response variable
95% CI
structural irf
ANGOLA, D.LCrdOilB, D.USDAOA
.2
0
-.2
-.4
0
2
4
6
8
step

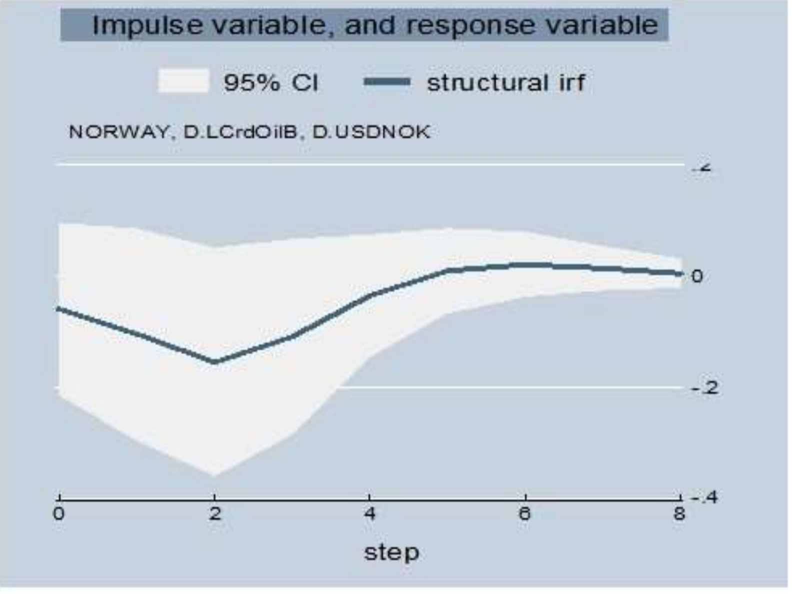

Impulse variable, and response variable
95% CI
structural irf
RUSSIA, D.LCrdOilB, D.USDRUB
1
.5
0
-.5
-1
0
2
4
6
8
step


Impulse variable, and response variable
95% CI
structural irf
CANADA, D.LCrdOilB, D.USDCAD
.2
0
-.2
-.4
0
2
4
6
8
step

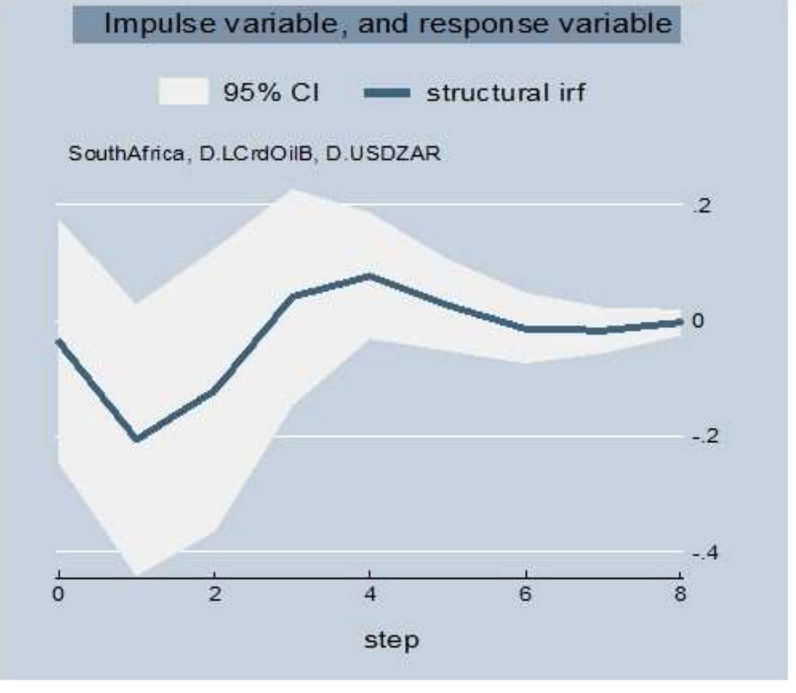

Impulse variable, and response variable
95% CI
structural irf
SARABIA, D.LCrd OilB, D.USDSAR
.002
0
-.002
-.004
0
2
4
6
8
step


Impulse variable, and response variable
95% CI
structural irf
EMIRATES, D.LCrdOilB, D.USDAED
.0002
0
-.0002
-.0004
0
2
4
6
8
step

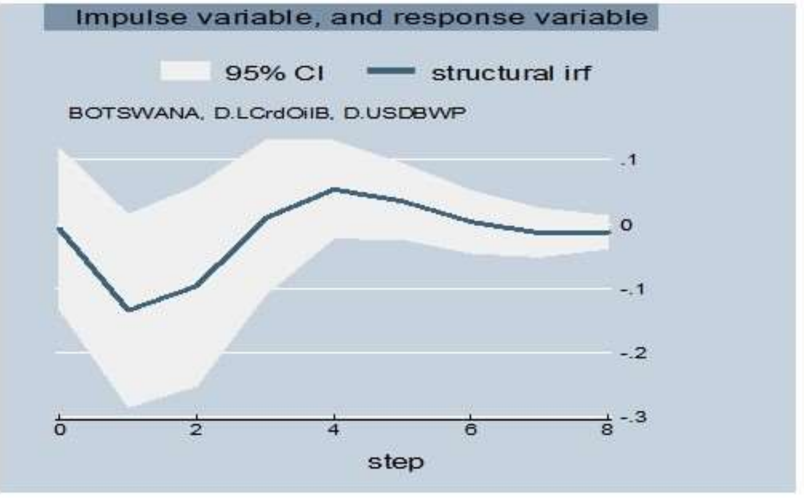

Impulse variable, and response variable
95% CI
structural irf
Kuwait, D.LCrdOilB, D.USDKWD
.05
0
-.05
-.1
0
2
4
6
8
step

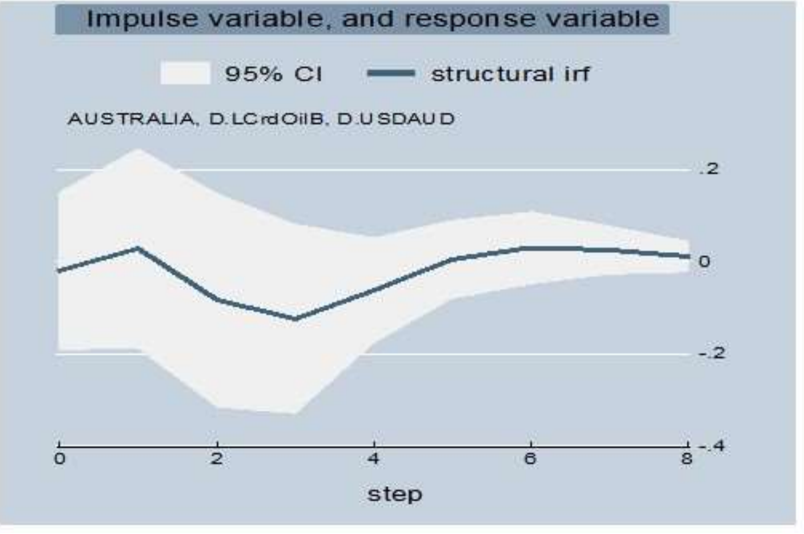


Impulse variable, and response variable
95% CI
structural irf
NORWAY, D.LCrdOilB, D.USDNOK
0
-.2
-.4
0
2
4
6
8
step



Impulse variable, and response variable
95% CI
structural irf
SouthAfrica, D.LCrdOilB, D.USDZAR
.2
0
-.2
-.4
0
2
4
6
8
step





These results confirm that changes in crude oil price have significant effects on exchange rate volatility for oil exporting countries with exception Norway krone. Both marginal effects as estimated form OLS and the dynamic responses from SVAR, evidence suggests that exchange rate volatility is influenced by crude oil price. However, some relationships are accompanied by a lot of noise, as they depict large uncertainty around the central path and low adjusted r-square in the regressions.

5. Conclusion and Implications

This study revealed some important pieces of evidence about the relationship between exchange rate volatility and crude oil prices. Firstly, evidence produced from this analysis showed that the price of crude oil plays a significant role in the stability of most currencies, especially in oil-exporting countries. The results showed that a decline in the price of crude oil not only increases the level of currency volatility, but it also increases the variance in the variation of volatility. SVAR impulse responses show that a positive crude oil price shock significantly reduces currency's exchange rate volatility for oil exporting countries. Although the analysis did not identify those other factors that might explain non-significant results for some countries, it nevertheless showed that the decline in the price of crude induces heightened exchange rate volatility, while a positive oil price shock lowers the volatility. It is very important to understand the main drivers of exchange rate volatility over time, because it prevents knee-jerk reactions from policymakers. For this reason, policymakers should take care when responding to depreciation and currency volatility, because volatility breeds more instability before calmer periods are realised, especially in some oil producing countries. The results show that, for most currencies in the sample, the level of volatility significantly increased when crude oil price declined to below 100 US$ per barrel. This evidence consistent with the estimated dynamic responses of exchange rate volatility.

However, the analysis also showed that in some advanced countries, such as Norway (which is an oil producing country), the exchange rate volatility barely responded to the price of crude oil. For this, it is possible that other factors such as lower inflation, strong housing market, foreign reserve levels and oil revenues management might be at play for this outcome. In all, exchange rates in emerging markets and developing economies are highly vulnerable to crude oil price shocks. Often a sudden change in the direction of the crude oil price causes explosive exchange rate volatility which affects the sustainability of fiscal and external sectors.

References

Amisano, G., & Gianini, C. (1997). From Var Models to Structural VAR Models. (2nd Ed.), *Topics in structural VAR econometrics* (pp. 1-28). Heidelberg, Germany: Springer Verlag.

Auclair, G., Fouejieu, A., Lukonga, I., Quayyum, S., Shbaikat, G., Sommer, M., . . . Versailles, B. (2016). *Learning to live with cheaper oil: Policy adjustment in oil-exporting countries of the Middle East and Central Asia*. Washington, DC: International Monetary Fund, Middle East and Central Asia Department.

Calderón, C., & Kubota, M. (2009). *Does higher openness cause more real exchange rate volatility?* (Policy Research Working Paper No. 4896). Retrieved from: https://elibrary.worldbank.org/doi/-/10.1596/1813-9450-4896

Cohen, J. (1988*). Statistical power analysis for the behavioural sciences*. Hillsdale, United States of America: Lawrence Earlbaum Associates.

Devereux, M. B, & Engel, C. (2003). Monetary policy in the open economy revisited: Price setting and exchange rate flexibility. *Review of Economic Studies*, *70*(4), 765-783.

Dizioli, A., Guajardo, J., Klyuev, V., Mano, M., & Mehdi, R. (2016). *Spillovers from China's growth slowdown and rebalancing to the ASEAN-5 economies* (IMF Working Paper No. 16/170). Retrieved from: https://www.imf.org/en/Publications/WP/Issues/2016/12/31/Spillovers-from-Chinas-GrowthSlowdown-and-Rebalancing-to-the-ASEAN-5-Economies-44179

European Central Bank. (2017). China's economic growth and rebalancing and the implications for the global and euro area economies. *European Central Bank Economic Bulletin*, pp. 32-52.

Flood, R. P., & Rose, A. K. (1999). Understanding exchange rate volatility without the contrivance of macroeconomics. *The Economic Journal*, *109*(459), 660-672.

Hussain, A. B., & Nora, M. Y. (2013). Evaluating the mechanism of oil Price shocks and fiscal policy responses in the Malaysian economy. Paper Presented at the *IOP Conference Series: Earth and Environmental Science*. Retrieved from http://iop-science.iop.org/article/10.1088/1755-1315/16/1/012010/pdf

Irena, M., & Andrius, B. (2013). Fundamental exchange rate forecasting models. Advantages and drawbacks. *KSI Transaction on Knowledge Society*, *6*(3), 9-17.

MacDonald, R. (2007). *Exchange rate economics: Theories and evidence*. New York, United States of America: Routledge.

Ouliaris, S., Pagan, A. R., & Restrepo, J. (2016). *Quantitative macroeconomic modeling with structural vector autoregressions: An EViews implementation*. Irvine, United States of America: EViewes Publishers.

Ratti, R. A., & Vespignani, J. L. (2016). Oil prices and global factor macroeconomic variables. *Energy Economics*, *59*(1) 198-212.

Rentschler, J. E. (2013, August 18). Oil Price volatility – its risk on economic growth and development. Retrieved from http://blogs.world-bank.org/developmenttalk

Rogoff, K. (1999). Perspectives on exchange rate volatility. *International capital flows* (pp. 441-453). Chicago, United States of America: University of Chicago Press.

Sørensen, J. B. (2002). The use and misuse of the coefficient of variation in organizational demography research. *Sociological Methods and Researc*h, *30* (4), 475-491.

York, R., & Zhan, Z. (2009). *Fiscal vulnerability and sustainability in oil-producing Sub-Saharan African countries* (IMF Working Paper No. 09/174). Retrieved from: https://www.imf.org/en/Publications/WP/Issues/2016/12/31 /FiscalVulnerabilityand-Sustainability-in-Oil-Producing Sub-Saharan AfricanCountries-23184

Annexure

Table A1: Countries Included in the Study's Sample

Major Crude Oil Exporting Countries	Other Minerals Exporting Countries
Saudi Arabia	South Africa
Russia	Namibia
Canada	Botswana
United Arab Emirates	Australia
Kuwait	
Nigeria	
Angola	
Norway	
United States	
Mexico	