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The Effect of Oil Prices on Floating Exchange Rates

by

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Abstract

This thesis contributes to the existing literature by examining the effect of oil prices on floating exchange rates of oil dependent countries. I conduct empirical tests on monthly data of 32 currencies over a timeframe of 15 years from 2003 to 2017 and 13 currencies over a timeframe of 25 years from 1993 to 2017. The analysis, therefore, includes a large sample that has the drawback of a shorter sample, and a longer sample with fewer currencies which has not been the focus of previous research. Data is estimated using the VECM as some variables are co-integrated.

Empirical results show that in the shorter sample, exchange rates are affected by the price of oil a third of the sample, while the short-term interest rate affects exchange rates in 37.5% of the sample. In the long-run, there is evidence of a relationship between oil prices and exchange rates in only 10% of the sample. In the longer sample, results indicate that oil prices have a direct effect on exchange rates in more than 50% of the sample in the short-run, while interest rates have no effect. And in the long-run, only 15% of the models show a long-run relationship with the price of oil.

Key Words: VECM, VAR, oil prices, exchange rates, oil dependent countries, short-run causality, long-run causality, Granger, floating currencies, co-integration, ADF

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List of Abbreviations

ADF – Augmented Dickey Fuller

AIC - Akaike's Information Criterion

CIA – Central Intelligence Agency

HQ – Hannan–Quinn criterion

IMF – International Monetary Fund

SBIC – Schwarz's Bayesian Information Criterion

SDR – Special Drawing Rights

USD – United States Dollar

VAR – Vector Autoregressive

VECM – Vector Error Correction Model

WTI - West Texas Intermediate

Contents

1. Introduction

Crude oil continues to be one of the basic and mostly used fuel commodity in the world. Even though oil trade as a percentage of GDP has started to decline since the 1980's among developed countries, crude oil is still counted as one of the main energy sources worldwide. The price of oil is determined daily in the world market (Baumeister and Kilian, 2014), and like all commodities, crude oil prices are sensitive to supply and demand shocks (Kilian 2009). By being such a necessary commodity, significant changes in oil prices do in fact have a big influence on the global economy (Kilian, 2009). There are several crude oil prices traded internationally, the most traded include the Brent price of crude oil and the West Texas Intermediate (WTI).

In theory, many researchers find that oil price shocks should have a direct effect on exchange rates. Empirically, however, there seems to be some conflicting findings; and due to these discrepancies, one set of literature finds that commodity prices do not affect exchange rates, others find some effect in part of the sample, while another set of literature finds that fuel prices, in general, do affect exchange rates.

There are several researches on how exchange rates affect oil prices and vice versa, many of which include research on developing countries, developed countries, emerging economies, countries with floating and pegged currencies and oil dependent countries. This thesis particularly addresses the effect of oil prices on floating currencies of oil dependent countries, both importers and exporters, since there continues to be limited research focused on floating countries. A sample of 32 floating currencies are modeled over a sample period of 15 years from 2003 to 2017, using monthly data. Another set of 13 floating currencies are modeled over a sample period of 25 years from 1993 to 2017, using monthly data. By analyzing these two sets of data, the results will include a large sample of currencies that have the drawback of a shorter timeframe, and a smaller sample of currencies with a longer timeframe, which has not been conducted in any of the previous literature. I mainly follow the techniques in Habib and Kalamova (2007), Wand and Wu (2012), and Habib, Bützer and Stracca (2016), most of which use either the Vector Autoregressive Model (VAR), Vector Error Correction Model (VECM), cross-sectional or panel regressions to model data related to crude oil. After conducting the Augmented Dickey Fuller (ADF) test to test for stationarity and the Johansen's co-integration test, results indicate that the variables are both non-stationary and co-integrated; I, therefore, estimate the models using the VECM. Accordingly, the presence of long-run causality is determined by analyzing the co-integration vector(s), and the presence of short-run causality is also measured using the Wald test.

1.1. Research Purpose

The difference in results in previous research can be attributed to the different types of models used, the macro-economic variables taken into consideration, the country specific variables, the price of oil used and the frequency of the data. Most previous research focus on emerging or developed economies, oil importers and exporters, commodity countries, or a specific country. Therefore, this thesis will contribute to the current literature in several ways:

1. Most previous literature use only one price of oil to estimate the model(s), I shall estimate the model using the US crude oil imported acquisition cost by refiners nominated in Special Drawing Rights (SDR) and in United States Dollar (USD) as a robustness check.
2. I will also examine only oil dependent countries with floating currency regimes, which has not been the main focus of previous research before.
3. I will also model a large amount of currencies over a period of 15 and 25 years, as all research use only one timeframe, that is either very short or very long, hence no comparison of timeframes using similar models ensue.

That said, the research question of this thesis is "What is the effect of oil prices on exchange rates in oil dependent economies with floating regimes?"

1.2. Outline of Thesis

The rest of the thesis is organized as follows: In Section 2, I discuss the various literature and present the highlights of their main findings and make note of the contradicting results and motivations on the topic. In Section 3, I explain how I choose the countries I include in the analysis and how I define and choose the global and the country specific variables. A discussion of the methodology and the empirical tests are then elaborated upon in Section 4 followed by the results of these tests in Section 5. Section 5 will also include the results on the robustness check. Finally, Section 6 includes some concluding remarks, where a comparison of the results to previous literature ensues.

2. Literature Review

From a theoretical perspective, oil prices should directly affect exchange rates and vice versa, since an increase in oil prices directly affects various macro-economic variables that include country income and current account balances, which in turn affects asset market equilibrium (Golub 1983). Furthermore, crude oil is mainly used as a raw material that is inputted into production of necessities, so significant changes in oil prices should affect production costs thereby affecting macroeconomic variables including exchange rates (Maslyuk, Rotaru and Dokumentov, 2017). However, Baumeister and Kilian (2014) argue that since the price of oil is determined in the world market it would be illogical that oil prices would have an additional or other independent effect on exchange rates.

The above theoretical arguments are supported by their respective empirical findings. I therefore discuss the two opposing view points in this section: (1) the finding that fuel commodity prices, in general, do have some effect on exchange rates and (2) the finding that oil prices do not affect exchange rates.

2.1. Oil Prices affect Exchange Rates

The first set of literature finds a predominant relationship between commodity prices (mainly oil) and the exchange rates of many countries.

Bloomberg and Harris (1995) provide empirical evidence that exchange rates do in fact affect oil prices and there exists a negative correlation between commodity prices and the US dollar. More recently, this was confirmed by Kim and Jung (2018) where in a sample of 9 countries over a timeframe of 19 years, a negative long-run relationship is found between oil prices and exchange rates in all countries except Japan. They also find that there is a negative inverse relationship between the US interest rates and the WTI price of crude oil. However, when Kim and Jung (2018) look at correlations between exchange rates and oil prices they find that some currencies have a positive correlation, some have a negative correlation, and some have no correlation; and in times of financial crises, the price of oil is highly correlated with exchange rates. Furthermore, Kim and Jung (2018) model their data using GARCH, copula dependencies and Granger-Causality tests. Despite the long timeframe in their analysis, they use a relatively small sample of pegged and floating currencies that are oil dependent, which is not sufficient to determine a trend, particularly on floating currencies.

Basher and Sadorsky (2006) conduct empirical tests on a sample of 21 emerging economies and analyze their results according to different frequencies of the same time frame. They find a relationship between exchange rates and oil prices in weekly data in all their sample. However, daily data of the same sample yielded statistically insignificant results, while results of monthly data are statistically significant in 50% of the sample. Basher and Sadorsky (2006) focus their research on emerging economies, some of which include countries with floating exchange rates while others are importers and exporters of crude oil; however, they do not focus on a combination of both aspects.

Furthermore, Chen and Chen (2007) examine the relationship between the exchange rates of the G7 countries and crude oil prices over a period of 32 years by modeling monthly data using pooled panel regressions, and find that oil prices are a major factor in exchange rate fluctuations. They model their data using three different prices of oil which include the UAE price of oil, Brent price of oil and the West Texas Intermediate (WTI). Their research again focuses on a small sample of currencies with a longer time frame.

Sadorsky (2000) investigates the relationship between fuel commodities and exchange rates, and models the sample using linear causality. She finds that commodity prices and exchange rates are co-integrated, so the variables are modeled using VECM, as with the case with this thesis. However, the results are not consistent with Wang and Wu (2012) since unlike Sadorsky (2000) whose sample is 10 years from 1987 to 1997, Wang and Wu's (2012) sample is from 2003 to 2011, so Wang and Wu's (2012) timeframe includes the period before and after the global financial crisis. Wang and Wu (2012) find that, like Sadorsky (2000), there is a linear causality relationship before the financial crisis, but after the financial crises they find a bi-directional and non- linear causality relationship between oil prices and exchange rates; and that not all the series are co-integrated. Moreover, Wang and Wu's (2012) research mainly only focuses on the US and the timeframe and currencies modeled are both limited. It is worth noting that the results of Sadorsky (2000) are consistent with those of Bloomberg and Harris (1995).

Moreover, Amano and Van Norden (1998) also use the VAR and VECM to model their sample of three currencies that include Japan, Germany and the US and reach the conclusion that deviations in oil prices significantly affect exchange rates but not vice versa. However, the sample is quite limited in the number of economies taken into consideration, which requires more in-depth research with a larger and more recent sample.

Finally, Basher, Haug and Sadorsky (2012) also conduct empirical analysis on a sample of 22 emerging economies using monthly data and follow Kilian (2009) in their approach by using the VAR model. Their results show that oil prices are somewhat affected by exchange rate fluctuations.

2.2. Oil Prices do not affect exchange rates

Empirical results of another set of literature find an insignificant effect of how exchange rates react to changes in oil prices; however, the findings are not consistent.

Iwayemi and Fowowe (2011) find that the in the case of oil importing economies, there is little if no relationship between the price of oil and most macroeconomic variables, including exchange rates. They conduct their study on Nigeria, of which oil constitutes to 95% of its total exports, using linear Granger causality tests. They find that exports is the only variable that reacts to oil price shocks and shows a leverage effect (Iwayemi and Fowowe, 2011), as negative shocks affect exports more than positive shocks. It is worth noting that Nigeria has a managed arrangement of its currency (International Monetary Fund, 2016). Moreover, these findings are only based on one country, and therefore, a significant trend cannot be determined. However, taking their findings into consideration I include various macroeconomic variables in the model which are elaborated on in the Section 3.

Furthermore, Habib and Kalamova (2007) conduct a study on Russia, Saudi Arabia and Norway and find that the Russian Ruble is the only currency that can be called an oil currency, as it is the only currency of the three that follows a stochastic trend with oil. They find that the Saudi Riyal and the Norwegian Krone do not react to oil prices despite having a pegged currency and a floating currency to the USD respectively; which may be attributed to an accumulation of foreign reserves for the Norwegian Krone (Habib and Kalamova, 2007). The finding that foreign reserves play an important role to subdue exchange rate fluctuations was later confirmed by Habib, Bützer and Stracca (2016). Because of this finding, I include foreign reserves as a country specific variable in the model. Moreover, Habib and Kalamova (2007) follow the model proposed by Cashin, Céspedes, and Sahay (2004) that of a small open economy. Cashin, Céspedes, and Sahay (2004) model 44 commodities with 58 currencies and find a relationship in a third of the sample over a period of 32 years; however, they model exchange rates with non-energy commodities, and do not distinguish their results based on floating and pegged currencies.

More recently, Habib, Bützer and Stracca (2016) model a sample of 43 countries with floating and pegged currencies over a period of 27 years and find no relationship between oil price shocks and exchange rates; and find that crude oil prices are not an important factor in exchange rate implications. Their findings are in line with Baumeister and Kilian (2014) who state that there should be no evidence of a relationship between US exchange rates and oil prices in the long run, since both rates are determined in the world market. Habib, Bützer and Stracca (2016) model their data using panel regressions, of both floating and pegged currencies; their timeframe is close to the timeframe used in this thesis and many of the variables they use are included as well.

3. Data

3.1. Research Approach

The hypothesis of this thesis is to discover the effect of oil prices on the floating currencies of oil dependent countries, both importers and exporters by modeling the data using the VECM. Table 1 lists the currencies that have a floating arrangement and free-float currencies as retrieved from the Annual Report on Exchange Arrangements and Exchange Restrictions 2016, from the International Monetary Fund (IMF). The floating arrangement is mostly determined by the market but there is some interference from central banks to prevent major exchange rate fluctuations (IMF, 2016). Free-floating currencies, on the other hand, have very minimal government intervention, thus the classification by the IMF. It is worth noting that all the currencies of the countries mentioned in Table 1, except for the Euro, the Australian Dollar and the Canadian Dollar have a floating arrangement.

Table 1: List of Countries with Floating Currencies as of October 2016.

Floating Arrangement				**Free Floating**	
Afghanistan	Indonesia	Norway	Switzerland	Australia	Malta
Albania	Japan	Paraguay	Tanzania	Austria	Netherlands
Argentina	Kazakhstan	Peru	Thailand	Belgium	Portugal
Armenia	Kenya	Philippines	Turkey	Canada	Slovak Rep.
Brazil	Korea	Poland	Uganda	Cyprus	Spain
Chile	Madagascar	Romania	Ukraine	Estonia	
Colombia	Malawi	Russia	United Kingdom	Finland	
Georgia	Mauritius	Serbia	United States	France	
Ghana	Mexico	Seychelles	Uruguay	Ireland	
Guatemala	Moldova	Sierra Leone	Zambia	Italy	
Hungary	Mongolia	Somalia		Latvia	
Iceland	Mozambique	South Africa		Lithuania	
India	New Zealand	Sweden		Luxembourg	

Furthermore, the Central Intelligence Agency (CIA) classifies oil dependent countries according to a country's level of import and export of oil (Cia.gov, 2018). The list of the main countries that import and export crude oil are presented in Tables A1 and A2 in Appendix A, respectively.

Taking Tables 1, A1 and A2 into consideration, I arrive at Table 2 which lists the countries that have a floating arrangement or a free float currency and are oil dependent (whether importers or exporters), along with their currency name, symbol and the date each country moved towards a floating regime.

Table 2: Floating Currencies, Symbols and Date of Float

#	Country	Currency	Date of Float
1	Albania	Albanian LEK (ALL)	1992[i]
2	Argentina	Argentine Peso (ARS)	2002[ii]
3	Australia	Australian Dollar (AUD)	1983[iii]
4	Brazil	Brazilian Real (BRL)	1999[iv]
5	Canada	Canadian Dollar (CAD)	1970[v]
6	Chile	Chilean Peso (CLP)	2000[vi]
7	Colombia	Colombian Peso (CPO)	1999[vii]
8	Georgia	Georgian Lari (GEL)	1997[viii]
9	Ghana	Ghanaian Cedi (GHS)	1983[ix]
10	Guatemala	Guatemalan Quetzal (GTQ)	1996[x]
11	Hungary	Hungarian Forint (HUF)	2008[xi]
12	India	Indian Rupee (INR)	1993[xii]
13	Indonesia	Indonesian Rupiah (IDR)	1997[xiii]
14	Japan	Japanese Yen (JPY)	1973[xiv]
15	Kazakhstan	Kazakhstani Tenge (KZT)	2015[xv]
16	Kenya	Kenyan Shilling (KES)	1993[xvi]
17	Mexico	Mexican Peso (MXN)	1995[xvii]
18	Moldova	Moldovan Leu (MDL)	1993[xviii]
19	Mongolia	Mongolian Tughrik (MNT)	1993[xix]
20	New Zealand	New Zealand Dollar (NZD)	1985[xx]
21	Norway	Norwegian Krone (NOK)	1992[xxi]
22	Peru	Peruvian Sol (PEN)	Aug. 1990[xxii]
23	Philippines	Philippine Piso (PHP)	1970[xxiii]
24	Poland	Polish Zloty (PLN)	1991[xxiv]
25	Romania	Romanian Leu (RON)	1992[xxv]
26	Russia	Russian Ruble (RUB)	1999[xxvi]
27	Serbia	Serbian Dinar (RSD)	2006[xxvii]
28	South Africa	South African Rand (ZAR)	1994[xxviii]
29	South Korea	South Korean Won (KRW)	Dec. 1997[xxix]
30	Sweden	Swedish Krone (SEK)	1992[xxx]
31	Switzerland	Swiss Franc (CHF)	2015[xxxi]
32	Thailand	Thai Baht (THB)	1997[xxxii]
33	Turkey	Turkish Lira (TRY)	2002[xxxiii]

34	Ukraine	Ukrainian Hryvnia (UAH)	1992
35	United Kingdom	Great British Pound (GBP)	1992[xxxiv]
36	Uruguay	Uruguayan Peso (UYU)	2002[xxxv]
37	Zambia	Zambian Kwacha (ZMW)	1991[xxxvi]
38	Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Lithuania, Netherlands, Portugal, Slovak Rep. and Spain	Euro	Each country adopted the Euro at a different date.

Six currencies are eliminated from the analysis, which include the Serbian Dinar, the Swiss Franc, the Kazakhstani Tenge and the Hungarian Forint since there is not enough data on their exchange rate to conduct conclusive tests, as the floating regime has been in effect for less than 15 years. The Philippine Piso (PHP) is also eliminated since the country specific variable "GDP" is integrated to order 2, and if included, the VECM will yield distorted results. The Euro is also eliminated from the analysis as it will be quite difficult to collect variables specific to only those 13 countries, who adopted the Euro in different years, and some overlap may occur with other EU countries included in the analysis.

Empirical tests are therefore conducted on a total of 32 currencies for 15 years from 2003 to 2017 using monthly data. The same empirical tests are also conducted on 13 currencies dating back 25 years from 1993 to 2017, also using monthly data; in this sample, Ghana and Moldova are excluded from the analysis since exchange rate data is not available from 1993 to 1998. By including both timeframes on the same set of countries, the analysis will include a relatively large sample of currencies that have the drawback of a shorter sample, and a longer sample with fewer currencies.

Data is modeled using the VECM, which is a restricted VAR model. VAR modelling tends to estimate a model from various perspectives and therefore explain a model in a more comprehensive way than a univariate time series regression (Brooks, 2014), since the variables enter the model as endogenous variables, thus making all the equations procured in the system identified. The VECM is mainly used when two or more variables are co-integrated; and it is apparent from the literature that exchange rate and crude oil models usually have co-integrated variables; this will be later confirmed in Section 4. Furthermore, VAR modelling, in general, is a widely used econometric tool for modelling several variables; and is considered one of the most used in modeling crude oil.

3.2. Choice of Variables

The nine variables inputted into the model are chosen with careful consideration based on the numerous literature on the topic and include a mix of global and country specific variables.

3.2.1. Global Variables

Global Economic Activity: World Steel Production is used as a measure of global real economic activity, different to Kilian (2009) and Habib, Bützer and Stracca (2016). Kilian (2009) proposed the use of dry cargo single voyage bulk cargo freight figures that are manually collected from Drewry Shipping Consultants Ltd. The reason I choose to deviate from Kilian's (2009) proposed index, despite its popularity among researchers, is because the index uses equal weights for both commodities and routes which may be a source of bias across time, as both commodities and routes tend to fluctuate across time (Ravazzolo and Vespignan, 2015). Kilian's (2009) index also uses equal weights for different commodity shipping prices which is unrealistic since commodity prices tend to fluctuate over time (Ravazzolo and Vespignan, 2015).

To account for the drawbacks of Kilian's (2009) proposed index, Ravazzolo and Vespignan (2015) propose using world steel production as a measure of global economic activity, as it accounts for the weighting problem in Kilian's (2009) proposed index, as the weights for each country are updated monthly. Furthermore, world steel production does not need to be deflated unlike Kilian's (2009) index as steel production is a real variable (Ravazzolo and Vespignan, 2015). When Ravazzolo and Vespignan (2015) tested steel production they found that like Kilian's (2009) framework, it provides reasonably accurate forecasts for world GDP, and is therefore considered a suitable index for measuring real economic activity. Data is available from the World Steel Association for 24 out of 32 countries included in the analysis; and is retrieved from Bloomberg. I also download the US steel production data, which is used if a country's corresponding values are integrated to order 0 and can not be inputted into the VECM without distorting the results.

Oil Prices: There are various indices to choose the price of crude oil from, two of the most popular ones are the West Texas Intermediate (WTI) and the Brent price of crude oil (Brent). The literature tends to use either one of the above prices. Kilian (2009), deviates from the majority and uses the refiner acquisition cost of imported crude oil, nominated in USD per barrel and deflates it using the US consumer price index. Habib, Bützer and Stracca (2016), also use the same price of oil as

Kilian (2009) but nominate it in Special Drawing Rights (SDR) per barrel to account for aspects regarding endogeniety that may be a result of reverse causality. The SDR is an international reserve asset, created by the IMF, whose value is determined by five currencies including the USD, the Euro, the Chinese Renminbi, the Japanese Yen and the British pound (IMF, 2018).

I follow Kilian (2009) and Habib, Bützer and Stracca (2016) and use the US crude oil imported acquisition cost by refiners nominated in Special Drawing Rights (SDR) per barrel as the oil price. As a robustness check, I estimate the models in both samples a second time with the deflated oil prices nominated in USD per barrel to check if the exchange rate of the USD to SDR can yield different results. The US refiner acquisition cost of imported crude oil (nominated in USD) is retrieved from the International Energy Agency (IEA). The exchange rate of the USD to the SDR is available from the IMF via Bloomberg, so the price of crude oil in SDR is therefore calculated and inputted in the model as log values.

3.2.2. Country Specific Variables

Exchange Rates: The dependent variable in the models are the exchange rates of the USD to the above-mentioned currencies in Table 2, which are retrieved from Bloomberg and inputted into the model as log values.

Interest Rates and inflation: According to An, Kim and You (2016) exchange rate flexibility may be a major influence for deviations in interest rates and inflation rates. Herwartz and Roestel (2009) also find in a study conducted on the G7 countries that exchange rates of countries with floating currencies tend to be affected by international inflation and interest rates. Akram (2009) also found empirical evidence that commodity prices are affected by interest rates and Habib, Bützer and Stracca's (2016) also include both variables in their model.

As with Habib, Bützer and Stracca (2016) the money market rates are used as the interest rates and are available for most countries from the IMF; and are retrieved from Bloomberg. Money market rates are used because they are short term and highly liquid (range from overnight rates to monthly rates) and are also considered a measure of liquidity. The US 3-month LIBOR rate is also retrieved for countries with data limitation in their money market rates or if their money market rates are I(0), and could not be inputted in the VECM.

The Consumer Price Index (CPI) is also retrieved for all countries from Bloomberg and Thomson Reuters Eikon as a measure of inflation; the US CPI is also downloaded for the same reason as the US 3-month LIBOR rate and world steel production.

Stock Market: The local stock market index for each country is also included among the variables since Basher, Haug and Sadorsky (2012) find a significant relationship between oil prices, exchange rates and the local stock market. Local stock market monthly prices are retrieved from Bloomberg and converted to log values. Some countries have either missing data or do not have public records of their local stock market, so the prices of the S&P 500 index are retrieved and used to avoid running some models with missing data.

Gross Domestic Product (GDP): GDP is also another macroeconomic variable to include as it is included in Habib, Bützer and Stracca (2016), where data is available from Bloomberg. As GDP is only available annually, I initially follow Habib, Bützer and Stracca (2016) and interpolate the data using the cubic spline method to convert annual data to monthly figures. However, when unit root tests are conducted on the interpolated value, results show that most of the countries' GDP became I(2), which would distort results if the VECM is used. I, therefore, proceed with the replacement method, which contains only one unit root.

Oil Trade Balance: I also follow Habib, Bützer and Stracca (2016) in including oil rents as a percentage of GDP as a macro-economic variable, which is only available annually from the World Bank; annual data is converted to monthly figures using the replacement method as with GDP.

Foreign Reserves: Previous empirical studies have not used foreign reserves as a country specific variable besides Habib, Bützer and Stracca (2016) and Habib and Kalamova (2007) who found that currencies of oil exporting countries are not affected by changes in oil shocks because the central banks accumulate foreign reserves. Monthly foreign reserves are retrieved from the IMF via Bloomberg and are converted to log values before entering the model.

Dummy Variables: Two dummy variables are also added; one that takes the value of 1 before the global financial crisis in 2008 and takes the value of 0 after the financial crisis; this is in accordance with Wang and Wu (2012). The second dummy variable follows the price of oil and takes a value of 1 in periods where oil prices drop significantly and the value of 0 otherwise.

3.2.3. Summary of Variables

To sum up, raw data fed into the VECM include the log figures of exchange rates, oil prices, stock markets and foreign reserves; in addition to the actual value of inflation, interest rates, GDP and oil trade balance. The variable symbols, corresponding to each of the above variables, are illustrated in Table 3 below.

Table 3: Variable Symbols and Modifications

Variable Name	Symbol in Equation	Modification
Global Economic Activity	GEA	None
Oil Prices	OIL	Log values
Exchange Rate	CURR	Log values
Interest Rate	IR	None
Inflation	CPI	None
Stock Market	SM	Log values
Gross Domestic Product	GDP	None
Oil Trade Balance	OGDP	None
Foreign Reserves	FR	Log values
Dummy Variable 1 – Financial Crisis	D1	None
Dummy Variable 2 – Oil prices	D2	None

Moreover, due to some missing data corresponding to some variables in several countries and to avoid running the models with missing data, I use corresponding US variables instead. Table 4 lists the countries where US variables are used instead of the country specific variables due to missing data.

Table 4: Countries with Data Limitation

Variable	Sample 1: 2003-2017 Countries with Data Limitation	Sample 2: 1993-2017 Countries with Data Limitation
Inflation	Mongolia	None
Interest Rate	Kenya, Zambia and Mongolia, Albania, Norway, India	Romania, Peru, Ukraine
Stock Market	Albania, Georgia, Guatemala, Ghana and Moldova	Norway, Romania, New Zealand

4. Methodology

This section initially includes an overview of the VAR methodology, followed by the series of tests conducted on the raw data to identify whether the VAR is the most effective econometric model to use. These tests include: The Augmented Dickey Fuller (ADF) test that tests for stationarity, and the Johansen's test of co-integration. I also elaborate on determining the lag length of the model to test for co-integration, since results of the Johansen's test are sensitive to lag length. Based on the results of the Johansen's test, if one or more of the variables are co-integrated, the VECM is used to model the data as it accounts for co-integrated variables, unlike the VAR model. Figure B1 in Appendix B is a visual representation of the methodology used in this thesis.

4.1. The VAR Methodology

The hypothesis of this thesis is whether oil prices affect exchange rates of floating currencies of oil dependent countries in both the long and short timeframe under investigation. The VAR methodology is one of the most popular econometric models used to model exchange rates and oil prices. Brooks (2014) defines a VAR model as a systems regression model that is a combination of a univariate time series and simultaneous equation. Variables in a VAR enter the model as endogenous variables, and, alternatively, each variable is expressed in terms of the other remaining variables' lagged values, its own lagged values and an error term (Brooks, 2014). Estimating the model in this way gives it "a very rich structure" that can explain the variables in a more comprehensive way than any univariate time series regression (Brooks, 2014). Brooks (2014) affirms that to estimate a VAR model, a list of variables can be hypothesized to affect each other.

The econometric representation of an unrestricted VAR (*k*) usually takes the following form:

$$y_t = \alpha + \beta_1 y_{t-1} + \beta_2 y_{t-2} + \ldots\ldots\ldots + \beta_K y_{t-K} + u_t \qquad \text{(equation 1)}$$

where

- *k* refers to the number of lags, a VAR(*k*) model is referred to a VAR model of order *k*.
- y_t is the vector of each endogenous variables at time t. In this thesis, y_t has nine elements that include the global economic activity (*GEA*), the price of oil (*OIL*), the exchange rate (*CURR*), the interest rate (*IR*), inflation (*CPI*), the stock market (*SM*), the gross domestic product (*GDP*), the oil trade balance (*OGDP*), and foreign reserves (*FR*).

- α is an *n x 1* vector of constants
- β_i is the *n x n* coefficient matrix for each of the *k* lags
- u_t is the white noise error term and is assumed to be i.i.d. ~ $(0,\sigma^2)$

4.2. Tests of Non-Stationarity

For the VAR model to work, it is important to ensure that all variables are stationary, or in other words, integrated to order 0, to avoid spurious regressions. In the case a variable is non-stationary, log returns are used on price series and can be applied on oil prices, exchange rates, foreign reserves and the stock market. Differencing can also be used to convert non-stationary variables to stationary variables and can be applied on the remaining variables: global economic activity, GDP, oil trade balance, interest rates and inflation. However, Brooks (2004) mentions that in case of the presence of a unit root in the time series, using differencing to induce stationarity is not preferred since there tends to be some information loss in the long run between the different variables, and recommends the use of the VECM if there is presence of co-integration.

The ADF test is used to test for non-stationarity; the null hypothesis is that the data contains a unit root, meaning the data is non-stationary; under the alterative hypothesis the data does not contain a unit root, and is therefore, stationary (Brooks, 2014). If the test statistic of the ADF test is greater than the critical value, the null hypothesis is rejected concluding that the data is stationary. Results of the ADF test conducted on the raw data indicate that five variables: GDP, oil trade balance, interest rates, global economic activity and inflation are non-stationary for most countries.

Table 5 lists the countries that have some stationary variables and therefore rejected the ADF test on the 5% level. In case of co-integration among the variables and the model is estimated using the VECM, corresponding I(1) US variables are used instead of the country's original variable that is I(0). It is worth noting, however, that in the second sample from 1993 to 2017, the US variable 'global economic activity' (GEA) is I(0); so instead of including GEA as an endogenous variable in the regression, I include the country's GEA variable in the model as an exogenous variable, like the dummy variables. Countries in the sample from 1993 to 2017, whose GEA variable is I(0) include Canada, Japan, New Zealand, Poland, and Sweden.

Table 5: Summary of Augmented Dickey Fuller Test

Variables that are I(0)	**Sample 1: 2003-2017 Countries that reject the ADF**	**Sample 1: 1993-2017 Countries that reject the ADF**
Global Economic Activity	Argentina, Brazil, Canada Chile, Colombia, Mexico, Peru, Russia, Uruguay	Canada, Japan, New Zealand, Poland, and Sweden
Interest Rates	Brazil, Chile, Georgia, Indonesia, Peru, Russia, Turkey, Ukraine, Uruguay	None
Inflation	Albania, Brazil, Canada, Mexico, Norway, Thailand, Turkey, Ukraine, Uruguay,	Albania, Australia, Canada, Norway, Peru, Romania

4.3. Determining Lag Length

Since some variables in the model are not stationary, Brooks (2014) states that co-integration tests must be conducted to check the long-run relationship of the variables, but before proceeding with test of co-integration, the lag length of each model should to be determined.

There is more than one approach to determine lag length, however, I only discuss information criteria as it is more widely used among researchers and more recommended. Information criteria considers two terms, one that is a function of the residual sum of squares (RSS) and a penalty term for losing degrees of freedom (Brooks, 2004). Therefore, increasing the number of lags in a model will have two opposing effects: one that will decrease the RSS yet increase the penalty term (Asteriou and Hall, 2011). It is particularly important to choose the number of lags that will decrease the RSS and outweigh the penalty term, thus decreasing the value of the information criteria (Brooks, 2014).

There are three types of information criteria: Akaike's information criterion (AIC), Schwarz's Bayesian information criterion (SBIC), and Hannan–Quinn criterion (HQ). Brooks (2014) mentions that SBIC has a stiffer penalty term than AIC, and HQ is in between; he also mentions that even though SBIC is consistent it is inefficient, and the opposite holds true for AIC. AIC also tends to deliver a large model as the number of lags increase, yet not one criteria is preferred over another. I follow Habib and Kalamova (2007) and Wang and Wu (2012) where the number of lags is chosen based on the AIC, since increasing the lag structure helps eliminate heteroscedasticity in the model, but also results in serial autocorrelation if the number of lags is increased beyond the optimum. So, the idea is to find the most suitable number of lags that eliminates heteroscedasticity and residual autocorrelation in the model, in addition to limiting the lost numbers of degrees of freedom; I limit the number of lags to 12, as the data's frequency is monthly.

4.4. Testing for Co-integration

The Johansen's test specifies the amount of co-integrating vectors for the non-stationary variables included in the regression based on the number of lags (Azhagaiah and Banumathy, 2015). If there is evidence of co-integration between the variables, the model is estimated using the VECM instead of the VAR model. The Johansen's test determines the long-run relationship of the variables, which is denoted by the co-integrating vector (Π). The co-integrating vector, Π, is an *n* x *n* matrix, and is determined by examining the rank, *r*, of the matrix through its eigenvalues (Brooks, 2004). Given the large number of variables in the model, results of the Johansen's test may indicate more than one co-integrating relationship, and therefore more than one co-integrating vector that measures the long-run equilibrium between the varaibles.

The Johansen's test has two test statistics: the *trace statistic* denoted by λ_{trace} and the *maximal eigenvalue statistic*, denoted by λ_{max}. Both tests are based on examining the rank of the Π matrix. The trace statistic's can be formulated as follows:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{g} \ln(1 - \hat{\lambda}_i) \qquad \text{(equation 2)}$$

where r is the number of cointegrating vectors under H_0, T is the number of observations after considering the number lags and $\hat{\lambda}_i$ is the estimated eigen values from the Π matrix (Brooks, 2004). The null hypothesis of the trace test measures whether the number of cointegrating vectors is less than or equal to r (Asteriou and Hall, 2011), while the alternative hypothesis is that the number of cointegrating vectors is greater than r (Brooks, 2014). So, if $\hat{\lambda}_i = 0$, then $\lambda_{trace} = 0$ and the null hypothesis is not rejected, implying no cointegration between the variables. On the other hand, if $\hat{\lambda}_i$ is large, then $\ln(1 - \hat{\lambda}_i)$ will be more negative resulting in a larger test statistic; if the test statistic is larger than the critical value, the null hypothesis is rejected concluding that 'r' cointegrating vectors are in the regression.

The *maximal eigenvalue statistic*, λ_{max}, is formulated as follows:

$$\lambda_{max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}) \qquad \text{(equation 3)}$$

The null hypothesis tests the rank of $\Pi = r$ which implies that there are 'r' cointegrating vectors; if the null hypothesis is rejected, there are (r+1) cointegrating vectors (Asteriou and Hall, 2011). If Π's rank is equal to zero, this means that $\hat{\lambda}_i=0$, and with ln(1)=0, the test statistic is therefore 0, implying that Π's rank is not significantly different from zero (Brooks, 2014), and therefore the variables are not co-integrated.

Results of the Johansen's test indicate the presence of at least one co-integration relationship between the variables in all models in both samples, implying that the models should be estimated using the VECM. The step-by-step approach to estimate the VECM is visually illustrated in Figure B2 in Appendix B.

4.5. The Vector Error Correction Model (VECM)

As mentioned earlier, the VECM is a restricted VAR model, where some variables are co-integrated and some of the data is non-stationary. The VECM captures the short-run and long-run relationships between the variables by considering the lagged levels of cointegrated variables and differenced equations (Brooks, 2014). The long-run relationship from the dependent variable to the rest of the variables is captured when the model is in equilibrium, by the cointegrating vector 'Π' (Asteriou and Hall, 2011). The short run relationship from each individual variable on the RHS to the dependent variable is captured by the first differenced term.

There are several resulting system equations when the VECM is estimated, each equation alternatively takes one variable as the dependent variable, and the remaining variables as independent variables. According to the hypothesis of the thesis, I only investigate one system equation where the exchange rate (CURR) is the dependent variable as indicated in equation 5 below. Ideally, raw data fed into the VECM should be non-stationary and integrated to the same order, preferably I(1), to spot stationary co-integrated relationships between the variables. Furthermore, when the data is first differenced the variables and the error term become I(0) and any trend in the variables is eliminated thus avoiding spurious regressions; otherwise results can be largely affected (Asteriou and Hall, 2011). In practice, however, having all variables I(1) is rarely the case. To account for this in the thesis, variables that are integrated to order 2 are eliminated from the sample, as with the case of the Philippines, whose GDP is integrated to order 2. As for variables that are I(0), which is the case with some countries' data on global economic activity, interest rates and inflation, I use their corresponding US values which are integrated to order 1. Asteriou and Hall (2011) also state that I(0) variables can enter the models as exogenous variables; this is applied with the 'global economic activity' (GEA) variable in the longer sample, as the corresponding US value is also I(0). The dummy variables also enter the model as exogenous variables since they influence the model's results. By estimating the VECM each variable in the regression is now first differenced, and therefore stationary, and can be estimated using OLS. Brooks (2014) illustrates the VECM as follows:

$$\Delta y_t = \Pi\, y_{t-\kappa} + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} \ldots\ldots\ldots + \Gamma_{\kappa-1} \Delta y_{t-(\kappa-1)} + u_t \qquad u_t \text{ is iid} \sim (0,\sigma^2) \qquad \text{(equation 4)}$$

where

- t represents the time frame of each month in the sample(s)
- $\Pi = (\Sigma^k{}_{i=1}\ \beta_i) - I_g$, and $\Gamma_i = (\Sigma^i{}_{j=1}\ \beta_j) - I_g$
- The model has *g* different variables that are first differenced on the LHS and *k-1* lags of the differenced form of the dependent variables on the RHS (Brooks, 2014).
- Π is the co-integrating vector and is also know as the speed of adjustment toward long-run equilibrium. It captures the long-run relationship from the dependent variable to the rest of the variables. To determine the presence of a long-run relationship in the model the null hypothesis is that no long-run causality exists from the independent variables in the cointegration equation to the dependent variable.
- Γ_i is the coefficient matrix attached to each differenced term that captures the short-run relationship between each of the independent variables to the dependent variable. The short-run causality is tested using the Wald test (discussed below).

The model examined in the thesis, with the exchange rates as the dependent variable can be represented as follows:

$$\Delta CURR_t = \Pi\,(CURR_{t-k} + OIL_{t-k} + \ldots\ldots + GEA_{t-k}) + \Gamma_1 \Delta OIL_{t-1} + \ldots..+ \Gamma_{k-1}\Delta OIL_{t-(k-1)} + \Gamma_1 \Delta GEA_{t-1} + \ldots\ldots + \Gamma_{k-1}\Delta GEA_{t-(k-1)} + \Gamma_1 \Delta IR_{t,i} + \ldots\ldots\ \Gamma_{k-1}\Delta IR_{t-(k-1)} + \Gamma_1 \Delta FR_t + \ldots\ldots\ \Gamma_{k-1}\Delta FR_{t-(k-1)} + \Gamma_1 \Delta OGDP_t + \ldots\ldots\ \Gamma_{k-1}\Delta OGP_{t-(k-1)} + \Gamma_1 \Delta GDP_t + \ldots\ldots\ \Gamma_{k-1}\Delta GDP_{t-(k-1)} + \Gamma_1 \Delta SM_t + \ldots..\ \Gamma_{k-1}\Delta SM_{t-(k-1)} + \Gamma_1 \Delta CPI_t + \ldots\ldots\ \Gamma_{k-1}\Delta CPI_{t-(k-1)} + u_t \qquad \text{(equation 5)}$$

The nine variables in the equation include the global economic activity (*GEA*), the price of oil (*OIL*), the exchange rate (*CURR*), the interest rate (*IR*), inflation (*CPI*), the stock market (*SM*), gross domestic product (*GDP*), the oil trade balance (*OGDP*), and foreign reserves (*FR*).

4.5. The Wald Test

After estimating the model in such a way, the Wald test is used to capture the short run causality from each of the independent variables to the dependent variable, denoted by Γ_i. The Wald test is an approach that estimates the unrestricted model to arrive at the likelihood ratio and involves setting some restrictions on the coefficients of each variable under the null hypothesis (Azhagaiah and Banumathy, 2015). To capture the short-run causality, the coefficients of each independent variable's lags are normalized to zero and if the results of the Wald test are significant then the null hypothesis cannot be rejected, concluding that there is no short-run causality from that specific variable to the dependent variable. The step-by step interpretation of the coefficients is further interpreted using an example on the United Kingdom in Section 5.

4.6. Diagnostic Checks

There are also several diagnostic checks that must be considered to ensure that the corresponding models yield correct results. These diagnostic checks include interpreting the R-squared and the p-value of the model to ensure the data fits the model well (high R-squared and low p-value). Tests of heteroscedasticity, serial autocorrelation and normality of the residuals are also conducted. Heteroscedasticity is tested by running the Breuch-Pagan-Godfrey test; the null hypothesis of the test is that the model is homoscedastic, so the test should yield a p-value larger than 5% to conclude the model is homoscedastic. Serial autocorrelation of the residuals is tested by running the Breusch-Godfrey Serial Correlation LM Test, based on the number of lags of each model. The null hypothesis is that the errors are not autocorrelated up to lag *p*, so the test should yield a p-value larger than 5% to conclude the residuals are not autocorrelated. Residuals should also be normally distributed, and this is tested using the Jarque Bera test, where, under the null hypothesis, residuals are normally distributed. In many of the models estimated, the null hypothesis is rejected; however, like Hoxha (2010) and Habib and Kalamova (2007), I do not reject these models and do not exclude them from the analysis.

5. Empirical Results

I start this section by explaining how I interpret the short-run and long-run causality of all the models by taking an example on the UK's model. I then report the results of each of the two samples in table format due to space issues, followed by an in-depth analysis of both samples. The results and analysis of the robustness check are then elaborated upon, followed by a detailed comparison between both findings.

5.1. Model Interpretation and Analysis – An Example

I take a detailed example on the United Kingdom (UK) from the shorter sample (2003 to 2017) to illustrate how I interpret the results of each model in both samples to arrive at the conclusion whether long-run causality exists from the exchange rate to the independent variables, in addition to the presence of short run causality from each of the independent variables to the exchange rate.

The dependent variable in this model is the log price of the exchange rate of the USD to the Great British Pound (GBP), denoted by LOGGBP in equation 6. After conducting the tests elaborated upon in Section 4, I arrive at the estimated model for the UK that contains one lag and three co-integrating equations:

D(LOGGBP) = C(1)*(LOGGBP(-1) + 0.181173475117*OGDP(-1) - 0.163399202073*FR(-1) + 0.0284232559017*IR(-1) - 9.42826091006e-05*GEA(-1) + 8.57415281159e-05*GDP(-1) - 0.029162948444*CPI(-1) + 0.256144694234) + C(2)*(OIL(-1) - 0.667106189708*OGDP(-1) - 0.942461829114*FR(-1) - 0.0541865601305*IR(-1) - 0.000830479086937*GEA(-1) + 0.000168035648962*GDP(-1) - 0.04450655842*CPI(-1) + 0.967020899812) + C(3)*(SM(-1) + 0.351350644201*OGDP(-1) - 0.0270190227552*FR(-1) + 0.0357604372881*IR(-1) - 0.000158992018812*GEA(-1) - 0.000271525095626*GDP(-1) - 0.0568463779322*CPI(-1) - 2.99617042848) + C(4)*D(LOGGBP(-1)) + C(5)*D(OIL(-1)) + C(6)*D(SM(-1)) + C(7)*D(OGDP(-1)) + C(8)*D(FR(-1)) + C(9)*D(IR(-1)) + C(10)*D(GEA(-1)) + C(11)*D(GDP(-1)) + C(12)*D(CPI(-1)) + C(13) + C(14)*D2 + C(15)*D1

(equation 6)

Where

- LOGGBP is the log exchange rate of the USD to the GBP and is denoted in equation 5 by $CURR_t$.

- C(1), C(2), and C(3) are the cointegrating vectors, Π, that capture the long run causality. In this model there are three co-integrating equations, therefore, three different long-run relationships exist between the variables. However, I only analyze the co-integrating equations that contain the exchange rate (LOGGBP), which is C(1) in this case. By analyzing C(1), the speed of adjustment towards long-run equilibrium is captured.
- C(4), C(5), ……., C(12) are the Γ_i coefficients of the cointegrating equation attached to each of the first differenced independent variables. In this model, there is only one lag, so one coefficient is normalized to 0, when conducting the Wald test.
- The first differenced variables are denoted in equation 6 in the following manner D(LOGGBP(-1)), D(OIL(-1)), D(SM(-1)), D(OGDP(-1)), D(FR(-1)), D(IR(-1)), D(GEA(-1)), D(GDP(-1)) and D(CPI(-1)), where, for instance, D(OIL(-1)) is the ΔOIL_{t-1} denoted in equation 5.
- C(13) is the intercept
- C(14) and C(15) are the coefficients of the dummy variables (D1 and D2) that are included in the model as exogenous variables.
- The rest of the variables' abbreviations are the same as specified in equation 5 above.

Long-run causality: The cointegrating vector that contains the dependent variable is analyzed to determine the presence of long-run causality; in this case it is the C(1) coefficient only. C(1) is the co-integrating vector (Π) for the following cointegrating equation:

(LOGGBP(-1) + 0.181173475117*OGDP(-1) - 0.163399202073*FR(-1) + 0.0284232559017*IR(-1) - 9.42826091006e-05*GEA(-1) + 8.57415281159e-05*GDP(-1) - 0.029162948444*CPI(-1) + 0.256144694234). (equation 7)

If C(1)'s value is negative and significant then long run causality exists from the exchange rate to the remaining variables and the model reverts to equilibrium in the long-run. If the value of the C(1) coefficient is positive, there is deviation from long-run equilibrium and no long run-causality exists from the exchange rate to the remaining variables (Asteriou and Hall, 2011). The values of the UK coefficients are presented in the Table 6.

Table 6: Coefficient Values and Significance for the UK Model

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	**-0.021371**	**0.037517**	**-0.569636**	**0.5697**
C(2)	-0.003434	0.011411	-0.300984	0.7638
C(3)	-0.008424	0.024261	-0.347217	0.7289
C(4)	-0.019557	0.086235	-0.226785	0.8209
C(5)	-0.060620	0.025369	-2.389510	0.0180
C(6)	-0.106527	0.059854	-1.779795	0.0770
C(7)	0.003745	0.019786	0.189296	0.8501
C(8)	-0.033494	0.062134	-0.539060	0.5906
C(9)	-0.000971	0.003121	-0.311095	0.7561
C(10)	-5.66E-06	9.37E-06	-0.604676	0.5462
C(11)	-7.91E-06	1.33E-05	-0.592664	0.5542
C(12)	0.008257	0.003259	2.533946	0.0122
C(13)	-0.000365	0.002611	-0.139859	0.8889
C(14)	0.003193	0.002825	1.130019	0.2601
C(15)	0.001333	0.006578	0.202719	0.8396

Based on the table above, C(1) is both negative and insignificant as the p-value is larger than 5%; the null hypothesis, that no long run-causality exists from the independent variables in the cointegration equation to the exchange rate, cannot be rejected. It can be therefore concluded that no long-run causality exists from the six independent variables in the co-integration equation to the exchange rate. In other words, these six variables don't influence the exchange rate in the long-run.

Short-run causality: To test for short-run causality, the coefficients of each lagged variable is normalized to 0 using the Wald Test. For instance, to test if short-run causality exists from the price of oil to the exchange rate, C(5) is normalized to 0, since there is only one lag. The null hypothesis of the Wald test will therefore be C(5)=0. The result of the Wald test based on the Chi-square statistic yields a p-value of 1.69%, thus concluding that there is short-run causality from the price of oil to the exchange rate. The same is done for all coefficients from C(4) to C(12). Results of the Walt test for the rest of the variables indicate that short run causality exists from the price of oil and inflation to the exchange rate of the GBP.

5.2. VECM Results: Sample from 2003 to 2017

The above methodology, tests and analysis are conducted on the shorter sample from 2003 to 2017 on 32 countries. Of the 32 models estimated, 16 models (50% of the sample) are considered models with good fit, since each model passed the diagnostic checks at the 5% level. These 16 models' lags and number of cointegrated equations are summarized in Table A3 in Appendix A. The remaining 16 (problematic) models did not meet one or more of the diagnostic checks at the 5% level; the models of these 16 countries are summarized in Table A4 in Appendix A, along with the type of error(s). Following the literature, some of the problematic models can be considered models with good fit if heteroscedasticity and serial autocorrelation are rejected at the 1% level, and if their respective models are rejected at the 10% level instead of the 5% level. These models include those of Albania, Georgia, India, and Kenya. I follow Azhagaiah and Banumathy (2015), Habib and Kalamova (2007), Iwayemi and Fowowe (2011) and Sadorsky (2000) in adding these models to the models of good fit, therefore having a total of 20 models with good fit which represent 62.5% of the sample and 12 problematic models that represent 37.5% of the sample.

Results of the long-run causality of models with good fit are presented in Table 7. All the estimated models have more than one co-integration equation, thus more than one co-integrating vector (Π) is present. However, all models in both samples have only one co-integrating equation that contains the dependent variable (CURR), which is the cointegrating equation associated with the C(1) coefficient. Therefore the C(1) is the only co-integrating vector analyzed for long-run causality from the exchange rate to the remaining variables.

Short-run causality results are reported in Table 8. The abbreviations of variables in the short-run causality tables include the price of oil (*OIL*), global economic activity (*GEA*), the interest rate (*IR*), foreign reserves (*FR*), the oil trade balance (*OGDP*), the gross domestic product (*GDP*), the stock market (*SM*), and inflation (*CPI*). Furthermore, the presence of short-run causality between the exchange rate and the independent variables is denoted by a (Y), and no presence of short-run causality is denoted by an (N).

Table 7: Long-Run Causality Results: Models with Good-Fit (2003 to 2017)

Country	Sign of C(1) Coefficient	Power of the test	Conclusion
Albania	Negative	Significant	Long-run causality exists from the exchange rate to the price of oil, stock market, oil trade balance, foreign reserves and the interest rate.
Brazil	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Canada	Negative	Significant	Long-run causality exists from the exchange rate to oil trade balance, the interest rate, global economic activity, GDP and inflation.
Chile	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Georgia	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Ghana	Negative	Significant	Long-run causality exists from the exchange rate to GDP and inflation.
Guatemala	Negative	Significant	Long-run causality exists from the exchange rate to the stock market, oil trade balance, foreign reserves, the interest rate, global economic activity, GDP and inflation.
India	Negative	Significant	Long-run causality exists from the exchange rate to the foreign reserves, the interest rate, global economic activity, GDP and inflation.
Kenya	Negative	Significant	Long-run causality exists from the exchange rate to the interest rate, GDP and inflation.
Mexico	Negative	Significant	Long-run causality exists from the exchange rate to global economic activity, GDP and inflation.
Moldova	Negative	Significant	Long-run causality exists from the exchange rate to oil trade balance, the interest rate, global economic activity, GDP and inflation.
New Zealand	Negative	Significant	Long-run causality exists from the exchange rate to foreign reserves, the interest rate, global economic activity, GDP and inflation.
Norway	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Poland	Negative	Significant	Long-run causality exists from the exchange rate to oil trade balance, foreign reserves, the interest rate, global economic activity, GDP and inflation.

South Africa	Negative	Significant	Long-run causality exists from the exchange rate to the interest rate, global economic activity, GDP and inflation.
Sweden	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Turkey	Negative	Significant	Long-run causality exists from the exchange rate to foreign reserves the interest rate, global economic activity, GDP and inflation.
United Kingdom	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Uruguay	Negative	Significant	Long-run causality exists from the exchange rate to global economic activity, GDP and inflation.
Zambia	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.

Table 8: Short-Run Causality Results: Models with Good-Fit (2003 to 2017)

Country	OIL	GEA	IR	FR	OGDP	GDP	SM	CPI
Albania	Y	NA	Y	N	N	N	N	N
	There is short-run causality from the price of oil and the interest rate to the exchange rate.							
Brazil	Y	Y	N	N	N	N	N	N
	There is short-run causality from the price of oil and global economic activity to the exchange rate.							
Canada	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							
Chile	Y	N	Y	N	N	N	N	N
	There is short-run causality from the price of oil and the interest rate to the exchange rate.							
Georgia	N	N	Y	N	N	Y	N	N
	There is short-run causality from the interest rate and GDP to the exchange rate.							
Ghana	N	N	N	N	N	Y	N	N
	There is short-run causality from GDP to the exchange rate.							
Guatemala	N	N	N	N	N	Y	Y	N
	There is short-run causality from GDP and the stock market to the exchange rate.							
India	N	Y	Y	N	N	Y	N	N
	There is short-run causality from global economic activity, the interest rate and GDP to the exchange rate.							

Kenya	N	NA	Y	N	NA	N	N	N
	There is short-run causality from the interest rate to the exchange rate.							
Mexico	N	N	N	N	N	N	N	Y
	There is short-run causality from inflation to the exchange rate.							
Moldova	Y	N	N	N	N	N	N	N
	There is short-run causality from the price of oil to the exchange rate.							
New Zealand	Y	N	N	N	Y	N	N	N
	There is short-run causality from the price of oil and oil trade balance to the exchange rate.							
Norway	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							
Poland	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							
South Africa	Y	N	N	N	N	N	Y	N
	There is short-run causality from the price of oil and the stock market index to the exchange rate.							
Sweden	N	Y	Y	N	N	N	N	N
	There is short-run causality running from global economic activity and the interest rate to the exchange rate.							
Turkey	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							
United Kingdom	Y	N	N	N	N	N	N	Y
	There is short-run causality from the price of oil and inflation to the exchange rate.							
Uruguay	N	N	Y	N	N	N	N	N
	There is short-run causality from the interest rate to the exchange rate.							
Zambia	N	NA	Y	Y	NA	N	Y	N
	There is short-run causality from the interest rate, foreign reserves and the stock market index to the exchange rate.							

The empirical results of the long-run causality and short-run causality for the remaining 12 problematic models are reported in Tables 9 and 10 respectively. Results of these models should be considered with caution as they may be counterintuitive since their respective models contain one or more error that does not pass the diagnostic checks at the 1%, 5% nor the 10% level, as illustrated in Table A4 in Appendix A.

Table 9: Long-Run Causality Results: Problematic Models (1993 to 2017)

Country	**Sign of Cointegrating vector C(1)**	**Power of the test**	**Conclusion**
Argentina	Negative	Significant	Long-run causality exists from the exchange rate to the price of oil, stock market, oil trade balance, foreign reserves, the interest rate, global economic activity and GDP.
Australia	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Columbia	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Indonesia	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Japan	Negative	Significant	Long-run causality exists from the exchange rate to oil trade balance, foreign reserves, the interest rate, global economic activity, inflation and GDP.
Korea	Negative	Significant	Long-run causality exists from the exchange rate to the global economic activity and GDP.
Mongolia	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Peru	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Russia	Positive	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Romania	Negative	Significant	Long-run causality exists from the exchange rate to the interest rate, global economic activity and GDP.
Thailand	Negative	Significant	Long-run causality exists from the exchange rate to the oil price, interest rate, GDP and inflation.
Ukraine	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.

Table 10: Short-Run Causality Results: Problematic Models (2003 to 2017)

Country	OIL	GEA	IR	FR	OGDP	GDP	SM	CPI
Argentina	N	N	Y	Y	N	N	N	N
	There is short-run causality from the interest rate and foreign reserves to the exchange rate.							
Australia	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							
Colombia	N	Y	N	N	N	Y	N	N
	There is short-run causality from global economic activity and GDP to the exchange rate.							
Indonesia	N	N	Y	N	N	N	Y	N
	There is short-run causality from the interest rate and the stock market index to the exchange rate.							
Japan	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							
Korea	Y	N	N	N	N	Y	Y	N
	There is short-run causality from the price of oil, GDP and the stock market index to the exchange rate.							
Mongolia	Y	NA	Y	Y	Y	Y	N	N
	There is short-run causality from the price of oil, the interest rate, foreign reserves, oil trade balance and GDP to the exchange rate.							
Peru	N	Y	N	Y	N	Y	N	N
	There is short-run causality from global economic activity, foreign reserves and GDP to the exchange rate.							
Romania	Y	N	Y	Y	N	N	N	Y
	There is short-run causality from the price of oil, the interest rate, foreign reserves and inflation to the exchange rate.							
Russia	N	N	N	N	N	N	N	Y
	There is short-run causality from inflation to the exchange rate.							
Thailand	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							
Ukraine	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							

5.3. VECM Results: Sample from 1993 to 2017

The same empirical tests are conducted on the longer sample on 13 countries. Of the 13 models estimated, only 30% of the models (four of 13) are considered models with good fit, since they meet all the diagnostic checks at the 5% level. These models' number of lags and number of cointegrating equations are reported in Table A5 in Appendix A. The remaining nine problematic models' number of lags and number of cointegrating equations are reported in Table A6 in Appendix A, along with the type of error(s). As with the previous sample, Australia, Norway and Sweden are included among models with good fit as heteroscedasticity and serial autocorrelation are rejected at the 1% level instead of the 5% level. Taking this into account the number of models with good fit therefore increases to seven models out of 13, which represents 54% of the sample; and six models are now considered problematic representing 46% of the sample.

Table 11 summarizes the results of the long-run causality of models with good fit, while short-run causality results are reported in Table 12.

Table 11: Long-Run Causality Results: Models with Good-Fit (1993 to 2017)

Country	Sign of Cointegrating vector C(1)	Power of the test	Conclusion
Australia	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Japan	Negative	Significant	Long-run causality exists from the exchange rate to the stock market index, oil trade balance, foreign reserves, interest rate, GDP and inflation
Norway	Negative	Significant	Long-run causality exists from the exchange rate to oil trade balance, the interest rate, global economic activity, inflation and GDP.
Poland	Negative	Significant	Long-run causality exists from the exchange rate to GDP and inflation.
Sweden	Positive	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
United Kingdom	Negative	Significant	Long-run causality exists from the exchange rate to oil trade balance, foreign reserves, interest rate, global economic activity, GDP and inflation.
Ukraine	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.

Table 12: Short-Run Causality Results: Models with Good-Fit (1993 to 2017)

Country	OIL	GEA	IR	FR	OGDP	GDP	SM	CPI
Australia	Y	N	N	N	N	N	N	N
	There is short-run causality running from the price of oil to the exchange rate.							
Japan	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							
Norway	Y	N	Y	N	N	N	N	N
	There is short-run causality running from the oil price and interest rate to the exchange rate.							
Poland	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							
Sweden	Y	N	N	N	N	N	Y	N
	There is short-run causality running from the price of oil and stock market to the exchange rate.							
United Kingdom	Y	N	N	N	N	N	Y	Y
	There is short-run causality running from the price of oil, the stock market and inflation to the exchange rate.							
Ukraine	N	N	N	Y	N	N	N	N
	There is short-run causality running from foreign reserves to the exchange rate.							

The long-run causality results for the six problematic models are reported in Table 13, while the short-run causality results are presented in Table 14. And as with the first sample, these results should be read with caution.

Table 13: Long-Run Causality Results: Problematic Models (1993 to 2017)

Country	Sign of Cointegrating vector C(1)	Power of the test	Conclusion
Albania	Negative	Significant	Long-run causality exists from the exchange rate to the price of oil, stock market, oil trade balance, the interest rate, GDP and inflation
Canada	Negative	Significant	Long-run causality exists from the exchange rate to the price of oil, stock market and oil trade balance.
India	Negative	Significant	Long-run causality exists from the exchange rate to oil trade balance, foreign reserves, the interest rate, global economic activity, GDP and inflation
New Zealand	Negative	Significant	Long-run causality exists from the exchange rate to stock market, oil trade balance, the interest rate, foreign reserves, GDP and inflation
Peru	Negative	Significant	Long-run causality exists from the exchange rate to foreign reserves, global economic activity, GDP and inflation.
Romania	Positive	Insignificant	No Long-run causality exists from the exchange rate to the other variables.

Table 14: Short-Run Causality Results: Problematic Models (1993 to 2017)

Country	OIL	GEA	IR	FR	OGDP	GDP	SM	CPI
Albania	Y	N	N	N	N	N	N	N
	There is short-run causality from the price of oil to the exchange rate.							
Canada	Y	N	N	N	N	N	N	N
	There is short-run causality from the price of oil to the exchange rate.							
India	N	Y	N	N	N	Y	N	N
	There is short-run causality from global economic activity and GDP to the exchange rate.							
New Zealand	Y	N	N	N	N	N	N	N
	There is short-run causality from the price of oil to the exchange rate.							
Peru	N	Y	N	Y	N	N	N	N
	There is short-run causality from global economic activity and foreign reserves to the exchange rate.							
Romania	N	Y	N	N	N	N	N	N
	There is short-run causality from global economic activity to the exchange rate.							

5.4. Result Analysis

Despite distinguishing between models with good fit and problematic models, problematic models that do not pass the diagnostic checks at the 1%, 5% or the 10% level are still included in the analysis. This is in accordance with the models of Habib and Kalamova (2007) that had heteroscedasticity and serial autocorrelation, and when four quarters of the data were removed, heteroscedasticity and any residual autocorrelation was eliminated, and their initial results did not change. Therefore, both sets of models are taken into consideration, but problematic models should nevertheless be regarded with caution, especially those models that are rejected at the 10% level or have heteroscedasticity or serial autocorrelation that cannot be rejected at the 1% level. Analysis of the models with good fit and problematic models are analyzed separately and holistically for each sample. Furthermore, when comparing my results with the literature, I compare my findings to results retrieved from a large sample.

5.4.1. Sample 1: 2003 to 2017

Models with good fit: From the 20 models with good fit, 65% of the sample (13 of 20 models) show long-run causality from the exchange rates to the remaining variables, meaning that in the long run, all or some of the independent variables have a significant effect on exchange rates. These 13 models show no long-run causality from the exchange rates to the price of oil, except in Albania. Short-run causality, on the other hand, exists from oil prices to the exchange rates in 35% of the sample (seven of 20 models). Of the eight independent variables in the model (excluding the dummies) the price of oil and the interest rates are the two variables that mostly affect exchange rates in the short-run; interest rates affect 40% of the models (eight of 20 models). It is important to note that seven out of the eight countries whose exchange rates are affected by the interest rates, have the 3-month US LIBOR rate as their interest rate.

Problematic models: From the 12 problematic models that should be carefully considered, 42% (five of 12 models) show long-run causality from exchange rates to the remaining variables. Long-run causality exists from the exchange rate to the price of oil in only two models. Short-run causality results, on the other hand, show that only 25% of the sample (three of 12 models) have short run-causality from the price of oil to the exchange rates. Interest rates and foreign reserves are the two variables that mostly affect the exchange rates as the results are significant in a third of the sample. Consistent with the models with good fit, three out of the four models have the 3-month US LIBOR rate as their short-term interest rate.

Holistic Perspective: All-inclusive, empirical results show evidence of a long-run relationship between the exchange rates and the price of oil in 10% of the sample (three of 32 models), which is in line with the results of Baumeister and Kilian (2014). Furthermore, 10 models have short-run causality from the price of oil to the exchange rate which is approximately a third of the sample (31.25%) and is mostly consistent with Habib and Kalamova (2007), who find a relationship with oil prices in the short-run in a third of their sample as well. Moreover, exchange rates of 12 models are more likely affected by the short-term interest rates, which constitutes to 37.5% of the sample and 10 of those models have the US 3-month LIBOR rate as their interest rate. This implies that the US LIBOR rate does influence exchange rates, which is in accordance with Akram (2009), Herwartz and Roestel (2009) and An, Kim and You (2016) who find that floating currencies are affected by US interest rates.

5.4.2. Sample 2: 1993 to 2017

Models with good fit: As discussed above, seven out of the 13 models are considered models with good fit which constitute to 54% of the sample. Of these seven models, 31% of the sample (four of 13 models) have long run causality from the exchange rate to the rest of the variables, but not to the price of oil. Moreover, 31% of the sample show short-run causality from the price of oil to the exchange rates. And unlike the shorter sample, there is no short-run causality from the interest rates to the exchange rates, except in Norway's model. There is also short-run causality from foreign reserves to the exchange rate in only two countries.

Problematic models: Of the six problematic models 80% (Five of the six) show long-run causality from the exchange rate to the rest of the variables and only a third of those models (two of six models) show a long-run relationship between the price of oil and the exchange rates. Additionally, there is short-run causality from the price of oil to the exchange rates in 50% of the sample (three of six models). Furthermore, no short-run causality from the interest rates to the exchange rates is found.

Holistic Perspective: Almost 70% of the sample (nine of 13 models) show long-run causality from the exchange rate to the rest of the variables. And only two models show long-run causality from the exchange rates to the oil price which represent 15% of the sample; this is in line with the shorter sample and can be considered similar to the results of Baumeister and Kilian (2014). On the other hand, 54% of the models (seven of 13) show short-run causality from oil prices to the exchange rates, which is considerably larger than the shorter sample, and is line with Basher and Sadorsky (2006).

5.4.3. Conclusion

Looking at Table 15 below, the main difference between the results of both samples is with the short-run causality from the exchange rate to the interest rates, which is significant in 37.5% of the shorter sample compared to 8% in the longer sample. On the other hand, both samples show similar results regarding the long-run relationship with the price of oil, where there is very little or no effect between oil prices and the exchange rate in the long-run in both samples.

Table 15: Summary of Overall Findings in Both Samples

	2003 to 2017	**1993 to 2017**
# of good models	20 of 32 models (62.5%)	7 of 13 models (54%)
# of problematic models	12 of 32 models (37.5%)	6 of 13 models (46%)
Long-run causality (all variables)	18 of 32 models (56.5%)	9 of 13 models (70%)
Long-run causality (oil price)	3 of 32 models (10%)	2 of 13 models (15%)
Short-run causality (oil price)	10 of 32 models (31.25%)	7 of 13 models (54%)
Short-run causality (interest rates)	12 of 32 models (37.5%)	1 of 13 models (8%)

5.5. Robustness Check

As a robustness check, empirical tests are repeated using the price of the refiner acquisition cost of imported crude oil nominated in USD (instead of SDR), which is deflated using the US CPI. The results are presented in Appendix C, and as with the original sample, both models with good fit and problematic models are taken into consideration in the analysis and are analyzed separately and holistically.

5.5.1. Sample 1: 2003-2017

Results of the Johansen's test and the diagnostic checks of the regression are reported in Tables C1 (models of good fit) and C2 (problematic models) in Appendix C. The results indicate several discrepancies from the original sample. Initially, not the same countries reported in Tables 9 and

10 are considered models of good fit; and the number of lags and cointegrated equations are considerably different as well. The models of Albania, Chile, Indonesia, Japan, Mongolia and Peru are considered models of good fit, since they passed the diagnostic checks of heteroscedasticity or serial autocorrelation at the 1% level, or their models were not rejected at the 10% level. Also, the number of good models remained at 20 and contained four different countries that the original results reported in Section 5.4.1.

Models with good fit: Long-run causality results are reported in Table C3 in Appendix C. Results indicate that long-run causality exists from the exchange rate to the rest of the variables in 45% of the sample (nine of 20 models), contrary to 64% in the original tests. Furthermore, 25% of the sample (five of 20 models) show long-run causality from the exchange rates to the price of oil, which again is different than the original results of only one country having a long-run relationship with the price of oil. Short-run causality results, presented in Table C4 in Appendix C, indicate that 15% of the samples' (three of 20 models) exchange rates are affected by oil prices, contrary to 35% in the original results. However, results of both samples are consistent regarding interest rates, in terms that it is the most variable that affect the exchange rate, as 45% of the sample show short-run causality from interest rates to the exchange rate.

Problematic models: Results of the long-run causality of the 12 problematic models, illustrated in Table C5 in Appendix C, show that 50% of the sample (six of 12 models) have long-run causality from the exchange rate to the remaining variables, compared to 42% in the original sample. Furthermore, only two models show a long-run relationship with the price of oil, which is the same as the original results, and represent 17% of the sample. Short run-causality results, presented in Table C6 in Appendix C, show only one model with a short-run relationship between the exchange rate and the price of oil; this represents 8.3% of the sample, compared to three models, that represent 25% of the sample, in the original results.

Holistic Perspective: Overall, 47% of the sample (15 of 32 models) have long-run causality from the exchange rates to the rest of the variables, and only 22% (seven of 32 models) have a long run relationship between the price of oil and the exchange rates, compared to 10% in the original sample. Results of long-run causality are not in line with any of the literature but is closer to the results of Cashin, Céspedes, and Sahay (2004) than Baumeister and Kilian (2014). Short-run causality results show that only 12.5% of the samples' (four of 32 models) exchange rates are affected by the price of oil, compared to 31.25% in the original sample, which is considered close to the results Habib, Bützer and Stracca (2016). Furthermore, unlike the original results, no predominant relationship was found with interest rates.

5.5.2. Sample 2: 1993-2017

Models of good fit: Results of the Johansen's test and diagnostic checks of the models are reported in Tables C7 (models of good fit) and C8 (problematic models) in Appendix C. Following the same method as previous samples, there are a total of seven models of good fit, like the original results, however, the countries are not the same as the results reported in Section 5.4. As reported in Table C9 in Appendix C, of the seven models, 29% (two of seven) show long-run causality from exchange rates to the remaining variables, compared to 31% in the original results, and 14% of the sample (one of seven models) show a long-run relationship with the price of oil, compared to none in the original sample. Short-run causality results, reported in Table C10 in Appendix C, show that 29% (two of seven models) are affected by oil prices, compared to 31% in the original results.

Problematic models: Results of long-run causality are reported in Table C11, which show that 50% of the sample (three of six models) show long-run causality from the exchange rates to the oil prices, compared to the 80% in the original sample; and like the original results, two models show long-run relationship with the price of oil. Short-run causality, reported in Table C12 in Appendix C, shows no relationship between the price of oil and the exchange rates; the stock market index influences the exchange rate in a third of the sample, which is inconsistent with the original results.

Holistic Perspective: All-inclusive, 23% of the sample (three of 13 models) show long-run causality from the price of oil to the exchange rates, which similar to the shorter sample, and is close to the results of Cashin, Céspedes, and Sahay (2004) than any of the literature. Furthermore, only 8% (one model) shows short-run causality from the exchange rate to the price of oil, which is consistent with Habib, Bützer and Stracca (2016). Furthermore, consistent with the original sample, there is no short-run causality from interest rates to the exchange rates and the same holds true for foreign reserves.

5.5.3. Conclusion

Table 16 below summarizes the discrepancies between the results when the two prices of oil are used. It is apparent from the table and the above findings that using the deflated US crude oil imported acquisition cost by refiners nominated in USD yields different results when the same price of oil is nominated in SDR. The most prominent differences in the shorter sample are in the short-run and long run causality with the price of oil. In the longer sample, the main difference is seen in the short run causality from the price of oil to the exchange rates and in the long-run causality from the exchange rates to all the variables. The difference in results is partly explained by Habib, Bützer and Stracca (2016) that the use of oil prices nominated in USD do not necessarily account for endogeniety which can be attributed to reverse causality. I believe repeating the tests with other crude oil prices like Brent and WTI would also add to the findings to further compare findings to determine a trend.

Table 16: Comparison of Results of using different oil prices

	Oil Price (SDR)	**Oil Price (USD)**
2003 to 2017		
# of good models	20 of 32 models (62.5%)	20 of 32 models (62.5%)
# of problematic models	12 of 32 models (37.5%)	12 of 32 models (37.5%)
Long-run causality (all variables)	18 of 32 models (56.5%)	15 of 32 models (47%)
Long-run causality (oil price)	3 of 32 models (10%)	7 of 32 models (22%)
Short-run causality (oil price)	10 of 32 models (31.25%)	4 of 32 models (12.5%)
1993 to 2017		
# of good models	7 of 13 models (54%)	7 of 13 models (54%)
# of problematic models	6 of 13 models (46%)	6 of 13 models (46%)
Long-run causality (all variables)	9 of 13 models (70%)	5 of 13 models (38.5%)
Long-run causality (oil price)	2 of 13 models (15%)	3 of 13 models (23%)
Short-run causality (oil price)	7 of 13 models (54%)	2 of 13 models (15.4%)

6. Conclusion

Due to the presence of non-stationary variables, the Johansen's test for co-integration is conducted and the presence of at least one co-integrating relationship between the variables in all the models is found. This implies that there is a long-term relationship between the exchange rates and at least one of the variables, in addition to the presence of short-run causality between the variables as well. To capture the long-run and short-run relationship between the variables in the presence of co-integration, data is modeled using the VECM.

The main findings of the thesis can be briefly summarized as follows: Empirical results indicate that, in the short-run, the price of oil affects the exchange rates in almost a third of the shorter sample from 2003 to 2017, similar to the findings of Habib and Kalamova (2007). In the longer sample from 1993 to 2017, the price of oil affects exchange rates in 54% of the sample, which is consistent with the findings of Basher and Sadorsky (2006).

In the long-run, there is empirical evidence of a relationship between the exchange rates and the price of oil in 10% of the shorter sample, and 15% of the longer sample. These results are can be considered close to the findings of Habib, Bützer, and Stracca (2016) and Baumeister and Kilian (2014).

Furthermore, in the shorter sample, a relationship exists between the short-term US interest rates and some countries' exchange rates in 37.5% of the sample, which is in line with An, Kim and You (2016), Akram (2009) and Herwartz and Roestel (2009). However, in the longer sample, there is no evidence that interest rates influence exchange rates. Additionally, country specific interest rates do not affect exchange rates in either of the samples, but the US interest rates do influence exchange rates in the shorter sample. Furthermore, unlike in Habib, Bützer, and Stracca (2016) and Basher, Haug and Sadorsky (2012), there is no relationship between the foreign reserves and stock market respectively in either sample. From the robustness check conducted, it is apparent that results may change based on the price of crude oil used.

On a final note, empirical results of this thesis indicate that oil prices do affect exchange rates in a significant part of the sample, however, the results are not consistent with one set of literature. It is apparent from the literature and the findings of this thesis that results differ as the variables in the model change, as the data frequency changes (Wang and Wu, 2012), as the length of the time frame being analyzed changes, and as the model used to estimate the data changes. However, an additional set of tests can still be conducted using panel pooled regressions as with Habib, Bützer, and Stracca (2016) since this will give a more holistic view and may further confirm that the use of different models does affect the results of empirical tests. Furthermore, remodeling the data using other prices of oil like West Texas Intermediate (WTI) or the Brent price of crude oil, like in Chen and Chan (2007), may also act as an additional robustness check.

Appendix A: Tables

Table A1: Crude Oil Importing Countries – Barrels /day

Country	Barrels/day	Country	Barrels/day	Country	Barrels/day
United States	7,850,000	Philippines	215,800	Sri Lanka	36,480
China	6,167,000	Israel	215,600	Iran	33,710
India	3,789,000	Malaysia	194,400	Dominican Republic	27,440
Japan	3,181,000	Pakistan	166,000	Bangladesh	26,160
Korea, South	2,942,000	Chile	163,000	Tunisia	23,600
Germany	1,837,000	Lithuania	160,800	Jamaica	19,160
Spain	1,285,000	Austria	148,400	Bosnia	18,940
Italy	1,231,000	Romania	145,500	Senegal	18,060
France	1,096,000	Kazakhstan	145,800	Guatemala	17,220
Netherlands	1,090,000	Morocco	129,800	Russia	15,110
Canada	892,500	Bulgaria	122,800	Papua New Guinea	14,880
Taiwan	858,700	Hungary	120,400	Nicaragua	14,180
Singapore	831,300	Slovakia	115,600	Ghana	13,860
Thailand	830,500	New Zealand	109,200	Kenya	11,870
UK	808,800	Czechia	105,800	Zambia	11,200
Belgium	639,500	Cuba	101,500	Korea, North	10,640
Indonesia	507,900	Peru	83,660	Norway	10,630
Turkey	506,300	Syria	83,140	Argentina	10,180
Poland	490,300	Denmark	77,950	Ukraine	7,840
Greece	477,400	Cote d'Ivoire	65,540	Oman	6,970
Belarus	450,200	Ireland	65,390	Algeria	5,880
South Africa	434,500	Jordan	63,220	Albania	1,000
Sweden	393,900	Egypt	60,940	Uzbekistan	380
Brazil	350,100	Trinidad and Tobago	58,460	Georgia	200
Australia	339,500	Switzerland	58,400	Brunei	160
Portugal	270,600	Croatia	47,200	Kyrgyzstan	100
Bahrain	223,900	Serbia	45,790	Burma	29
Finland	220,400	Cameroon	39,120	Moldova	20
		Uruguay	37,900		

Source: https://www.cia.gov/library/publications/the-world-factbook/rankorder/2243rank.html

Table A2: Crude Oil Exporting Countries - Barrels/Day

Country	Barrels/day	Country	Barrels/day	Country	Barrels/day
Saudi Arabia	7,273,000	Egypt	197,700	Mauritania	6,750
Russia	5,116,000	Vietnam	183,600	Netherlands	6,335
Iraq	2,792,000	South Sudan	155,200	Philippines	4,942
UAE	2,684,000	Sudan	152,100	Poland	4,520
Canada	2,671,000	Brunei	119,500	Greece	3,082
Nigeria	2,279,000	Chad	105,000	Belize	3,000
Nepal	2,016,000	Ghana	99,890	Burma	2,814
Angola	1,700,000	Denmark	78,370	Germany	1,987
Kuwait	1,656,000	Timor-Leste	74,230	Ukraine	1,336
Venezuela	1,514,000	Cameroon	64,290	Lithuania	1,238
Norway	1,395,000	Turkmenistan	62,880	Romania	1,049
Iran	1,342,000	Yemen	49,590	Hungary	1,042
Kazakhstan	1,292,000	Tunisia	46,370	Georgia	1,002
Qatar	1,255,000	Argentina	38,600	Barbados	765
Mexico	1,224,000	Cote d'Ivoire	34,720	Czechia	519
Algeria	798,900	Trinidad and Tobago	32,620	Pakistan	493
Oman	745,800	China	32,000	Switzerland	319
Azerbaijan	721,600	Belarus	31,770	Bangladesh	313
Colombia	681,900	New Zealand	30,560	El Salvador	220
United Kingdom	636,200	Uzbekistan	27,000	Macedonia	142
United States	590,900	Congo,	20,000	Slovakia	130
Brazil	518,800	Albania	19,100	Tajikistan	79
Ecuador	400,700	Papua New Guinea	17,400		
Libya	383,500	Svalbard	16,070		
Malaysia	310,900	Peru	15,560		
Indonesia	289,300	Mongolia	14,360		
Equatorial Guinea	278,000	Thailand	12,200		
Congo, Republic of the	254,400	Italy	11,610		
Australia	213,600	Singapore	11,460		
Gabon	202,000	Guatemala	7,407		

Source: https://www.cia.gov/library/publications/the-world-factbook/rankorder/2242rank.html

Table A3: Summary of Models with Good Fit (2003 to 2017)

Country	Number of Lags	Number of Cointegrated equations
Brazil	2	5
Canada	2	4
Chile	2	2
Ghana	11	6
Guatemala	2	2
Mexico	2	5
Moldova	2	4
New Zealand	1	4
Norway	2	7
Poland	2	3
South Africa	2	5
Sweden	2	2
Turkey	2	4
United Kingdom	1	3
Uruguay	2	5
Zambia	2	2

Table A4: Summary of Problematic Models (2003 to 2017)

Country	Lags	Cointegrated equations	Problem at the 5% level
Albania	2	3	Heteroscedasticity at a p-value of 1.76%
Argentina	2	2	Heteroscedasticity at a p-value of 0%
Australia	1	5	Heteroscedasticity at a p-value of 0% and a high p-value of 9.6%
Columbia	11	7	Serial Autocorrelation at a p-value of 0%
Georgia	2	2	Heteroscedasticity at a p-value of 2.07%
India	2	4	Serial Autocorrelation at a p-value of 2.42%
Indonesia	2	4	Heteroscedasticity at a p-value of 0%
Japan	2	3	High p-value of 11%
Kenya	2	4	Serial autocorrelation at a p-value of 3.21%
Korea	10	7	Serial Autocorrelation at a p-value of 0%
Mongolia	11	7	Serial Autocorrelation at a p-value of 0%
Peru	9	8	High p-value of 11% and serial Autocorrelation of 0%.
Russia	11	7	Serial Autocorrelation at a p-value of 0%
Romania	12	6	Serial Autocorrelation at a p-value of 0%
Thailand	2	4	High p-value of 11.45%
Ukraine	11	7	Serial Autocorrelation at a p-value of 0%

Table A5: Summary of Models with Good Fit (1993 to 2017)

Country	Number of Lags	Number of Cointegrated equations
Japan	3	2
Poland	2	5
United Kingdom	2	3
Ukraine	2	2

Table A6: Summary of Models with Good Fit (1993 to 2017)

Country	Lags	Cointegrated equations	Problem at the 5% level
Albania	2	2	Heteroscedasticity at a p-value of 0%
Australia	2	3	Heteroscedasticity at a p-value of 3%
Canada	2	2	Heteroscedasticity at a p-value of 0% and serial autocorrelation at a p-value of 2.92%
India	2	3	Heteroscedasticity at a p-value of 0%
New Zealand	1	2	Heteroscedasticity at a p-value of 0% and serial autocorrelation at a p-value of 0%
Norway	2	4	Serial auto-correlation at a p-value of 3.97%
Peru	2	4	Heteroscedasticity at 0%
Romania	2	3	Heteroscedasticity at a p-value of 0%
Sweden	2	1	Heteroscedasticity at a p-value of 3.39%

Appendix B: Figures

Figure B1: Methodology

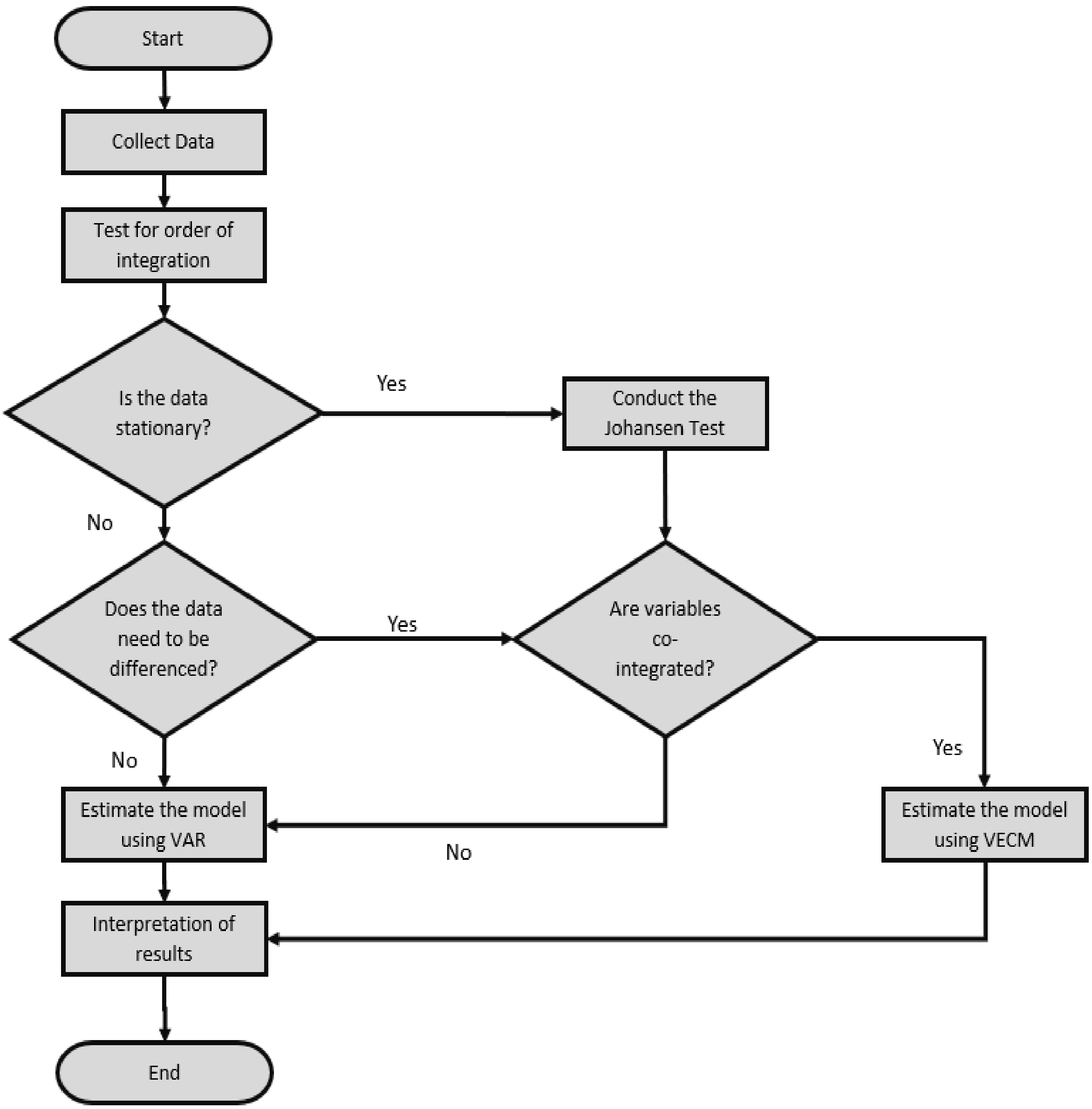
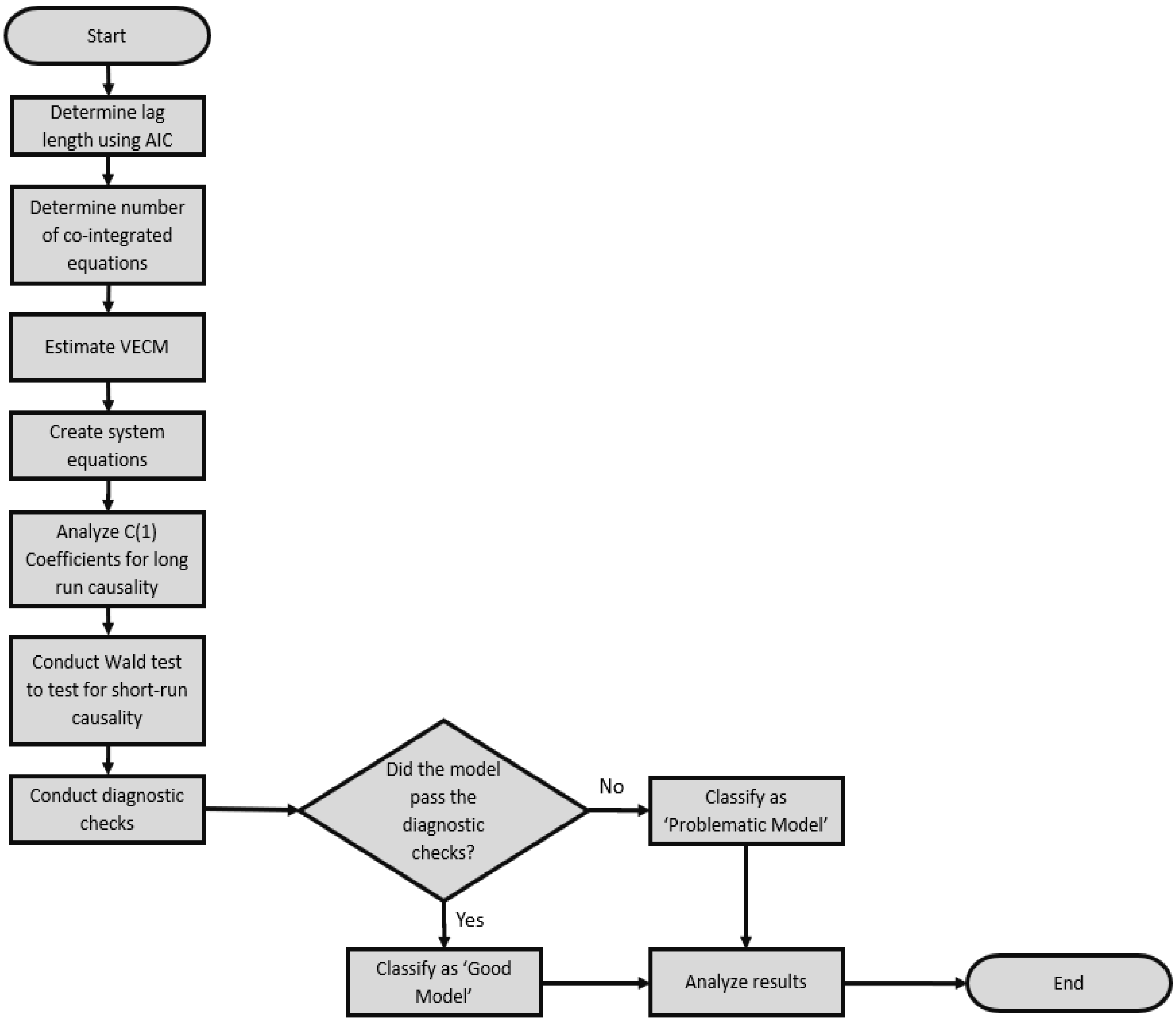


Figure B2: VECM Estimation



Appendix C: Robustness Check Results

Table C1: Summary of Models with Good Fit (2003 to 2017)

Country	Number of Lags	Number of Cointegrated equations
Brazil	2	2
Georgia	8	4
Guatemala	2	2
India	2	4
Kenya	3	4
Moldova	7	5
New Zealand	1	2
Norway	1	4
Poland	3	3
Sweden	2	1
Turkey	8	7
United Kingdom	1	2
Uruguay	3	3
Zambia	2	1

Table C2: Summary of Problematic Models (2003 to 2017)

Country	Lags	Cointegrated equations	Problem
Albania	2	1	Heteroscedasticity at a p-value of 1.47%
Argentina	1	5	Heteroscedasticity at a p-value of 0%
Australia	10	5	High p-value of 7% and Serial autocorrelation at a p-value of 0%
Canada	2	2	High p-value of 14%
Chile	2	2	Heteroscedasticity at a p-value of 2.45%
Colombia	2	1	High p-value at 30% and Heteroscedasticity at a p-value of 0.15%
Ghana	10	6	High p-value at 36.7% and Serial Autocorrelation at a p-value of 0%
Indonesia	2	4	Heteroscedasticity at a p-value of 1.63%
Japan	2	1	High p-value of 6.4%
Korea	9	8	Serial auto-correlation at a p-value of 0%
Mexico	3	2	High p-value of 11%
Mongolia	3	1	Serial auto-correlation at a p-value of 1.86%
Peru	6	6	Serial auto-correlation at a p-value of 1.6%
Romania	1	2	High p-value of 5.27% and Heteroscedasticity at a p-value of 0%
Russia	9	7	Serial auto-correlation at a p-value of 0 %
South Africa	2	4	High p-value of 12%
Thailand	9	8	Serial auto-correlation at a p-value of 0%
Ukraine	2	4	Heteroscedasticity at a p-value of 0%

Table C3: Long-Run Causality Results: Models with Good Fit (2003 to2017)

Country	Sign of C(1) Coefficient	Power of the test	Conclusion
Albania	Negative	Significant	Long-run causality exists from the exchange rate to the price of oil, interest rate, foreign reserves, oil trade balance, stock market, GDP and inflation.
Brazil	Positive	Significant	No Long-run causality exists from the exchange rate to the other variables.
Chile	Negative	Significant	Long-run causality exists from the exchange rate to the price of oil, the interest rate, global economic activity, oil trade balance, the stock market, GDP and inflation.
Georgia	Positive	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Guatemala	Negative	Significant	Long-run causality exists from the exchange rate to the price of oil, foreign reserves, the interest rate, global economic activity, oil trade balance, GDP and inflation.
India	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Indonesia	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Japan	Negative	Significant	Long-run causality exists from the exchange rate to the price of oil, foreign reserves, the interest rate, global economic activity, oil trade balance, the stock market and GDP.
Kenya	Negative	Significant	Long-run causality exists from the exchange rate to the interest rate, global economic activity, GDP and inflation.
Moldova	Negative	Significant	Long-run causality exists from the exchange rate to foreign reserves, global economic activity, the interest rate and GDP.
Mongolia	Positive	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Norway	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
New Zealand	Negative	Significant	Long-run causality exists from the exchange rate to the price of oil, oil trade balance, foreign

			reserves, the interest rate, global economic activity, GDP and inflation.
Peru	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Poland	Negative	Significant	Long-run causality exists from the exchange rate to oil trade balance, foreign reserves, the interest rate, global economic activity, GDP and inflation.
Sweden	Positive	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Turkey	Positive	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
United Kingdom	Positive	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Uruguay	Negative	Significant	Long-run causality exists from the exchange rate to foreign reserves, the interest rate, global economic activity, GDP and inflation.
Zambia	Positive	Significant	No Long-run causality exists from the exchange rate to the other variables.

Table C4: Short-run Causality Results: Models with Good Fit (2003 to 2017)

Country	**OIL**	**GEA**	**IR**	**FR**	**OGDP**	**GDP**	**SM**	**CPI**
Albania	N	N	Y	N	N	N	N	N
	There is short-run causality from the interest rate to the exchange rate.							
Brazil	Y	Y	N	N	N	N	N	Y
	There is short-run causality from oil prices, global economic activity and inflation to the exchange rate.							
Chile	N	N	Y	N	N	N	N	N
	There is short-run causality from the interest rate to the exchange rate.							
Georgia	N	N	Y	N	N	N	N	N
	There is short-run causality from the interest rate to the exchange rate.							
Guatemala	Y	N	N	N	N	N	Y	N
	There is short-run causality from oil prices and the stock market index to the exchange rate.							
India	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							
Indonesia	N	N	Y	N	N	N	N	N
	There is short-run causality from the interest rate to the exchange rate.							
Japan	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							

Kenya	N	N	Y	N	N	N	N	N
	There is short-run causality from the interest rate to the exchange rate.							
Moldova	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							
Mongolia	N	N	N	N	N	Y	N	N
	There is short-run causality from GDP to the exchange rate.							
New Zealand	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							
Norway	Y	N	N	N	N	N	N	N
	There is short-run causality from oil prices to the exchange rate.							
Peru	N	N	Y	Y	N	N	N	N
	There is short-run causality from the interest rate and foreign reserves to the exchange rate.							
Poland	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							
Sweden	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							
Turkey	N	N	Y	N	N	N	N	Y
	There is short-run causality from the interest rate and inflation to the exchange rate.							
United Kingdom	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							
Uruguay	N	N	Y	N	N	N	N	N
	There is short-run causality from the interest rate to the exchange rate.							
Zambia	N	N	Y	N	N	N	Y	N
	There is short-run causality from the interest rate and the stock market index to the exchange rate.							

Table C5: Long-Run Causality Results: Problematic Models (2003 to2017)

Country	Sign of C(1) Coefficient	Power of the test	Conclusion
Argentina	Negative	Significant	Long-run causality exists from the exchange rate to the interest rate, global economic activity, GDP and inflation.
Australia	Negative	Significant	Long-run causality exists from the exchange rate to the interest rate, global economic activity, oil trade balance and GDP.
Canada	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Colombia	Negative	Significant	Long-run causality exists from the exchange rate to the price of oil, interest rate, foreign reserves, oil trade balance, global economic activity, the stock market, GDP and inflation.
Ghana	Positive	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Korea	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Mexico	Negative	Significant	Long-run causality exists from the exchange rate to the interest rate, foreign reserves, oil trade balance, global economic activity, GDP and inflation.
Romania	Negative	Significant	Long-run causality exists from the exchange rate to the price of oil, interest rate, foreign reserves, oil trade balance, global economic activity and GDP.
Russia	Positive	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
South Africa	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Thailand	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Ukraine	Negative	Significant	Long-run causality exists from the exchange rate to the interest rate, foreign reserves, global economic activity, GDP and inflation.

Table C6: Short-run Causality Results: Problematic Models (2003 – 2017)

Country	OIL	GEA	IR	FR	OGDP	GDP	SM	CPI
Argentina	N	N	N	N	N	N	N	Y
	There is short-run causality from the inflation rate to the exchange rate.							
Australia	N	N	N	N	N	Y	N	N
	There is short-run causality from GDP to the exchange rate.							
Canada	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							
Colombia	N	Y	N	N	N	Y	N	N
	There is short-run causality from the global economic activity and GDP to the exchange rate.							
Ghana	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							
Korea	N	N	N	Y	N	N	N	N
	There is short-run causality running from foreign reserves to the exchange rate.							
Mexico	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							
Romania	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							
Russia	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							
South Africa	N	N	N	N	N	N	Y	N
	There is short-run causality running from the stock market index to the exchange rate.							
Thailand	N	N	Y	N	N	N	Y	Y
	There is short-run causality from the interest rate, foreign reserves and inflation rate to the exchange rate.							
Ukraine	Y	N	N	Y	N	N	N	Y
	There is short-run causality from the price of oil, foreign reserves and the inflation rate to the exchange rate.							

Table C7: Summary of Models with Good Fit (1993 to 2017)

Country	Number of Lags	Number of Cointegrated equations
Japan	3	2
Norway	1	2
Poland	2	4
Sweden	2	1

Table C8: Summary of Problematic Models (1993 to 2017)

Country	Lags	Cointegrated equations	Problem
Albania	2	2	Heteroscedasticity at a p-value of 0%
Australia	2	3	Heteroscedasticity at a p-value of 1.24%
Canada	2	2	High p-value at 9.19% and Heteroscedasticity at a p-value of 1.14%.
India	12	4	Serial autocorrelation at a p-value of 4.39%
New Zealand	1	1	Heteroscedasticity at a p-value of 0%
Peru	2	4	Heteroscedasticity at 0%
Romania	2	2	Heteroscedasticity at a p-value of 0%
United Kingdom	2	2	High p-value at 18.9%
Ukraine	2	2	High p-value at 13%

Table C9: Long-Run Causality Results: Models with Good Fit (1993 to 2017)

Country	Sign of C(1) Coefficient	Power of the test	Conclusion
Australia	Positive	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Canada	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
India	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Japan	Negative	Significant	Long-run causality exists from the exchange rate to the oil prices, foreign reserves, the interest rate, oil trade balance, GDP and inflation.
Norway	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Poland	Negative	Significant	Long-run causality exists from the exchange rate to foreign reserves, interest rate, GDP and inflation.
Sweden	Positive	Insignificant	No Long-run causality exists from the exchange rate to the other variables.

Table C10: Short-run Causality Results: Models with Good Fit (1993 to 2017)

Country	OIL	GEA	IR	FR	OGDP	GDP	SM	CPI
Australia	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							
Canada	Y	N	N	N	N	N	N	N
	There is short-run causality from oil prices to the exchange rate.							
India	N	N	N	N	N	Y	N	Y
	There is short-run causality from GDP and inflation to the exchange rate.							
Japan	N	N	N	Y	N	N	N	N
	There is short-run causality from foreign reserves to the exchange rate.							
Norway	Y	N	Y	N	N	N	N	N
	There is short-run causality from the price of oil and the interest rate to the exchange rate.							
Poland	N	N	N	Y	N	N	N	N
	There is short-run causality from foreign reserves to the exchange rate.							
Sweden	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							

Table C11: Long-Run Causality Results: Problematic Models (1993 to 2017)

Country	Sign of C(1) Coefficient	Power of the test	Conclusion
Albania	Negative	Significant	Long-run causality exists from the exchange rate to the price of oil, the interest rate, the stock market index, oil trade balance, GDP and inflation.
New Zealand	Negative	Significant	Long-run causality exists from the exchange rate to the price of oil, foreign reserves, the interest rate, the stock market index, oil trade balance, GDP and inflation.
Peru	Negative	Significant	Long-run causality exists from the exchange rate to foreign reserves, the interest rate, global economic activity, GDP and inflation.
Romania	Positive	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
United Kingdom	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.
Ukraine	Negative	Insignificant	No Long-run causality exists from the exchange rate to the other variables.

Table C12: Short-run Causality Results: Problematic Models (1993 to 2017)

Country	OIL	GEA	IR	FR	OGDP	GDP	SM	CPI
Albania	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							
New Zealand	N	N	N	N	N	N	Y	N
	There is short-run causality from the stock market index to the exchange rate.							
Peru	N	N	N	N	Y	N	N	N
	There is short-run causality from oil trade balance to the exchange rate.							
Romania	N	Y	N	N	N	N	Y	N
	There is short-run causality from the global economic activity and the stock market index to the exchange rate.							
United Kingdom	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							
Ukraine	N	N	N	N	N	N	N	N
	There is no short-run causality from the independent variables to the exchange rate.							

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