DISSERTATION THESIS:

Relationship and causality between oil prices and US exchange rates

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Msc in banking and finance
The relationship between oil prices and exchange rates has been a topic of great academic debate and research interest during the last decades. There is plenty of empirical evidence for a long-run relationship between the oil price and US dollar exchange rates, while it seems that causalities change over time and run in both directions. In this light, the aim of this study was to investigate the long-run relationship between crude oil prices and real trade-weighted US dollar exchange rate index for a time period of 30 years (1988-2018), as well as to examine the direction of the respective causalities, by considering a cointegration method. According to research results, it was found that crude oil prices and real trade-weighted US dollar exchange rate are negatively correlated, and causality runs from oil prices to the US dollar exchange rate. It was also demonstrated that the two variables are cointegrated, thus, they hold a long-run equilibrium relationship.

Keywords: oil prices, exchange rates, causality, cointegration.
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CHAPTER 1

INTRODUCTION

The relationship between oil prices and exchange rates has been a topic of great academic debate and research interest during the last decades, given the fact that oil is a commodity of major importance for the global economy and its price is denominated in US dollars. Although this relationship has significantly changed over time, due to the respective developments in the world oil markets and the global economy, previous work by Krugman (1980), Caprio & Clark (1981) and Golub (1984) triggered a research interest regarding the short- and long-run links between oil prices and US dollar against other currencies of both oil-importing and oil-exporting countries.

In turn, this interest led to the formation of a thorough theoretical framework that later inspired relative empirical work on this matter, mostly based on three general transmission channels, i.e. the trade channel, the portfolio channel and the wealth effect channel (Beckmann et al, 2017). The empirical literature concerning the relationship between US dollar exchange rates and crude oil prices is mainly focused on causal relationship of these two variables both in the short- and long-run, as well as on the magnitude and the direction of this link. The underlying idea of the long-run modelling is that there is stable long-run equilibrium and short-run deviations from the equilibrium (Coudert et al, 2008).

Several studies have examined the long-run relationship between oil prices and US dollar exchange rates by using various econometric techniques. The bottom line of these
studies is that, usually, there is a long-run relationship between oil prices and exchange rates, although the causality is not clear. With the use of cointegration methods, it has been largely documented that oil prices and US dollar exchange rates are cointegrated, while there is a one-way causality that runs from oil prices to exchange rates (Amano & van Norden, 1998; Chen & Chen, 2007; Bénassy-Quéré et al, 2007; Coudert et al, 2008; Beckmann & Czudaj, 2013), although there is also evidence for a bidirectional relationship (Robero, 2012; Fratzcher et al, 2014).

In this light, the aim of this empirical study is to investigate the short-run and long-run relationship between crude oil prices and US dollar exchange rates, so as to test for cointegration dynamics, long-term equilibrium links and causality patterns. In order to do so, time series analysis was performed with the use of monthly data (average values) of crude oil prices and real trade-weighted US dollar exchange rate index for a time period of 30 years (November 1988 to October 2018). This study applies a Granger Causality method and tests for cointegration with the use of Engle-Granger and Johansen techniques.

This thesis is structured as follows: the following chapter 2 presents the theoretical background of the relationship between oil prices and exchange rates, focusing on the respective transmission channels, and overviews the relevant research literature on this matter, by presenting the empirical methods and findings of previous studies. Chapter 3 presents the research methodology, including the data sample, the methods for testing the causal relationships and the cointegration techniques applied. In Chapter 4, research findings are presented according to Granger causality tests, and Engle-Granger and Johansen cointegration tests. The last chapter (Chapter 5) discusses the research findings, pointing also out the study limitations.
CHAPTER 2

LITERATURE REVIEW

2.1 THEORETICAL BACKGROUND

2.1.1 Historical evolution

Given the fact that oil is a commodity of major importance for the world economy and that its price is denominated in US dollars, policymakers, academics and researchers have frequently discussed the relationship between crude oil prices and exchange rates during the last years, focusing particularly in the idea than an appreciation of the US dollar usually triggers a decrease in oil prices (De Schryder & Peersman, 2015). Starting from the 1970s when the first oil price shock took place in 1973, the changes of the oil prices has begun to be a matter of great concern around the world. Given the adverse effects of oil price shocks in the world markets caused major awareness towards its relationships with other macroeconomic variables, including exchange rates. Krugman (1980), Caprio & Clark (1981) and Golub (1983) work triggered a great research interest regarding the links between oil prices and US dollar against other currencies, leading to the formation of theoretical framework that later inspired relative empirical work on this matter.

The relationship between oil prices and US dollar exchange rates has significantly changed over time, given the respective development in the world oil markets and the global economy (Castro Rozo & Jiménez-Rodríguez, 2018). Before 1990, this relationship was predominantly negative, as this period is characterized by troubles in
some major oil-producing countries due to the Kippur war, the Iranian Revolution and the Iran-Iraq war. The subsequent relatively stable oil prices were disrupted by the Gulf war in 1990 and later on this decade several significant developments took place in the world oil market, including the increase of oil production in Iraq, the reduction in oil demand in Asia and the increase of total oil inventories due to warm weather conditions (Castro Rozo & Jiménez-Rodríguez, 2018). In 1999-2000 oil prices almost tripled given a strong world demand and oil production cutbacks in OPEC countries, and between 2000 and 2003 there is also an upward trend, due to the increased oil demand in the Asian countries and the fact that oil started by be heavily used as a strong financial asset.

From 2003 onwards, there is a relatively stable relationship between oil prices and US dollar exchange rates, given the economic growth in Asia, although this period is disrupted by the global economic crisis in 2008. It has been shown that in times of crisis, dependence of oil prices on exchange rates can be rather weak, although clear conclusion cannot be made (Reboredo & Rivera-Castro, 2013). After the global financial crisis, there is evidence that global supply has increased, especially in the US, while the global oil demand is rather weak, providing a renewed macroeconomic framework for studying the relationship between oil prices and exchange rates (Reboredo, 2012). In either case, there is clear evidence that these two variables are closely linked, although this link changes over time, taking into account the macroeconomic conditions and the relative transmission mechanisms.

2.1.2 Transmission channels
The link between exchange rates and crude oil prices has been theoretically explained by three general transmission mechanisms, i.e. the trade channel, the portfolio channel and the wealth effect channel (Beckmann et al, 2017). The trade transmission mechanism, firstly proposed by Amano & van Norden (1998), suggests that real oil prices reflect terms of trade shocks. In particular, if the non-tradable sector of one country is more energy intensive in relation to the tradable one, then its output price increases relative to the respective one of the second country, implying that the currency of the first country will face a real appreciation due to higher inflation (Buetzer et al, 2016). If the price of the commodities of the tradable sector is not fixed, the nominal exchange rate is affected, as it is linked with inflation. In the case of oil prices, if there
is an increase then currencies of countries which are highly dependent on oil in their tradable sectors will be depreciated due to higher inflation. Amano & van Norder (1998) used monthly data of US exchange rates and oil prices from 1972 to 1993 and applied cointegration tests and error-correction models, finding that the two variables are cointegrated, as well as that oil prices affect exchange rates, although in the long-run, a rise in oil prices will cause dollar appreciation. Overall, the trade transmission mechanism explains that one-direction causality from oil prices towards exchange rates holds over different time horizons and can be differentiated in the short- and long-run.

The portfolio and wealth channel, firstly introduced by Krugman (1983) and Golub (1983), suggests that a rise in oil prices will cause a wealth effect transfer from oil-importing countries to oil-exporting ones, which has an impact on exchange rates, although the magnitude of this impact depends on the portfolio preferences of oil-exporting countries in the short-run, and on their import preferences in the long-run. The underlying idea of the portfolio transmission mechanism is that oil-exporting countries experience a wealth transfer in the case of oil prices increases. Krugman (1983) and Golub (1983) found that oil-exporting countries, that is to say OPEC ones, display a preference for US dollar-dominated assets and, as such, when oil prices rise, then their income is also increased. In the short-run, oil-exporting countries use their increased income to buy more US dollar-dominated assets, causing US dollar appreciation. In the long-run, this higher income is transferred into higher expenditures and, therefore, US dollar is depreciated.

Consequently, the basic difference between the wealth and the portfolio channel is that the first one explains the relationship between oil prices and exchange rates in the short-run, while the second one have long-run impacts. In the latter case, when oil prices rise, currencies of the oil-exporting countries are expected to appreciate and currencies of the oil-importing countries are expected to depreciate, as wealth is transferred to the first ones. As Beckmann et al (2017) explain, the short- and long-run effects are dependent on two major factors, first, the level of dependence of US on oil imports relative to the country’s share of exports to oil-producing countries, and second, oil-exporting countries’ preferences for US dollar-dominated assets.

Breitenfellner & Cuaresma (2008) suggest that the negative causal relationship between the external value of the US dollar and crude oil prices can be explained by five
transmission mechanisms, which are generally based on the aforementioned theories. First, the purchasing power channel explains that oil-exporting countries try to stabilize this power of their US dollar export revenues in terms of their imports and, consequently, the respective pricing behavior takes into account relative changes in the US exchange rate. Oil-exporting countries have an incentive to increase oil export prices in the case of a US dollar depreciation. Second, the local price channel suggests that US dollar exchange rates’ fluctuations cause deviations from equilibrium in the market for oil. Therefore, a dollar depreciation means that oil becomes cheaper in non-dollar countries, thereby increasing respective demand which in turn lead to adjustments in the oil prices. Third, the investment channel explains that a US dollar depreciation cause a reduction of the returns for dollar-denominated financial assets in foreign currencies and, hence, oil attractiveness is increased for foreign investors, both for purely investing incentives and its use as a hedge against inflations rises. Fourth, the monetary policy channel suggests that in the case of oil-producing countries, whose currencies are pegged to the US dollar, a US dollar depreciation causes a monetary easing and, as lower interest rates involve a liquidity rise, demand for oil also increases. Lastly, the currency market channel is based on the notion that foreign exchange markets are more efficient that oil markets and, thus, the demand and supply of oil are affected by developments in the real economy.

Several studies have used all these aforementioned theories in order to test for the causal relationship between US dollar exchanges rates and oil prices. For example, Cheng (2008) applied the purchasing power, the local price, the investment and the monetary channels, and found that the causality between these two variables goes from US exchange rates to oil prices, and the relationship between them is negative both in the short- and long-run. In addition, Krichene (2005) found the same causality by using the purchasing power and local price channels, indicating that US exchange rates and oil prices are cointegrated in the long-run, having a negative relationship. It should be, lastly, noted that all the transmission mechanisms that have been theoretically developed can be significantly affected by various factors, as there are common variables that drive both US exchange rates and oil prices. The most important among them are inflation, GDP growth, interest rates, stock prices and uncertainty in the currency markets (Beckmann & Czudaj, 2013). For example, it has been suggested that exchange rates and oil prices are interrelated as they are both affected of GDP and
interest rates, as well as that an increase in GDP causes an increase in the price of oil (Lardic & Mignon, 2008).

2.2 EMPIRICAL LITERATURE

2.2.1 Empirical methods
The empirical literature concerning the relationship between US dollar exchange rates and crude oil prices is mainly focused on causal relationship of these two variables both in the short- and long-run, as well as on the magnitude and the direction of this link. Therefore, the empirical methods applied by researchers are dominated by respective methodologies that focus on the long-run and short-run analysis. In the short-run modelling, the main questions refer to the volatility effects between oil prices and exchange rates as well as to the respective short-run causalities. Accordingly, in the long-run modelling, the main assumption is that oil prices and exchange rates are cointegrated, that is to say that there is a co-movement between them (Coudert et al, 2008).

The underlying idea of this long-run co-movement is that there is stable long-run equilibrium and short-run deviations from the equilibrium, which tend to be corrected over time. If US exchange rates and oil prices are cointegrated in the long-run, they could not be cointegrated in the short-run, while the long-run coefficient signifies the intensity of this relationship. In accordance, the error correction mechanism is also used in order to define which variable reacts to deviations from the long-run equilibrium, as well as the speed of correction and the variable responsible for this (Habib et al, 2016). When applying the relative modelling methodologies, the underlying question focuses on the causality between oil prices and US dollar exchange rates, although this causality has been historically inconclusive (Brahmasrene et al, 2014). This can be explained by various methodological issues, including the exchange rate measure, the time-varying patterns, the data frequency, the oil dependence of the countries and the time period of the analysis (Ferraro et al, 2015).

In general terms, the relative empirical literature uses time series analysis and the empirical methods used include the following (Beckmann et al, 2017): (1) Granger causality analysis, in order to determine if past oil prices (exchange rates) contain
information value for the prediction of the current value of exchange rates (oil prices), (2) Copula method, by which tail dependence between oil prices and exchange rates is analyzed, (3) Wavelet approach, which is used in order to define correlations between the two variables in different time scales, and (4) CARCH, by which the volatility spillovers between oil prices and exchange rates are analyzed. In this case of Granger causality analysis, which is the most popular one, cointegration tests or VAR models are used, so as to determine the long-run relationship between exchange rates and oil prices, as well as the respective deviations in the short-run (cointegration), and to examine the short-run response of oil prices (exchange rates) shocks to exchange rates (oil prices) (VAR models). The two most popular cointegration methods include the Engle-Granger methodology, in which the causality is predetermined, and the Johansen methodology, in which causality is not predetermined and multiple long-run relationships can be derived. It should be noted that the first empirical method (cointegration analysis) refers to the long-run relationships between oil prices and US dollar exchange rates, while the three following ones provide evidence for the short-run (Beckmann et al, 2016).

2.2.2 Empirical findings

2.2.2.a Impact of oil prices on exchange rates

Many studies have focused on the short- and long-run relationship between exchange rates and oil prices. In general terms, the vast majority has provided evidence that there is a negative relationship between these two variables. A strand of literature has proven that oil prices affect exchange rates, meaning that the later react to changes in oil prices. Using the wealth effect mechanism, both Golub (1983) and Krugman (1983) demonstrated an oil price increase influence on exchange rates. In particular, Krugman (1980) used data on three countries (US, Germany, OPEC) and found that an increase in oil prices leads to a dollar appreciation in the short-run, but in the long-run, this turns into dollar depreciation. In terms of trade channels, other researchers have also found that oil prices have a negative effect on exchange rates. For example, Backus & Crucini (2000) verified that oil accounts for much of the variation in terms of trade, although its quantitative role varies significantly over time, and thus, exchange rates react to changes in oil prices. Cashin et al (2004) draw similar conclusions, and Habib et al
(2016) identified three structural shocks of the global oil market that had a significant impact on exchange rates in 43 advanced and emerging countries. The authors revealed that oil-exporting countries tend to experience currency appreciation pressures after these oil demand shocks, which are mainly offset by foreign exchange reserves accumulation.

Bodenstein et al (2011) also examined the effects of endogenously determined oil price fluctuations in a two-country model and found that, under incomplete financial markets, an oil shock that lead to an oil price increase causes the oil importer’s exchange rate to depreciate. That is to say an increase in oil prices reduces US dollar reserves in oil-importing countries and leads to account imbalances and portfolio reallocations. Akram (2004) examined the non-linear relationship between oil prices and the Norwegian exchange rate and found that changes in low oil price have a strong impact on the exchange rate. The authors also point out that non-linear models outperform random walk models of forecasting, as a non-linear relationship leads to a well-specified exchange rate model that has a strong predictive power, taking into account changes in oil prices. Bénassy-Quéré et al (2007) used a cointegration analysis and demonstrated that changes in real oil prices have a strong impact on China’s currency, taking into account the country’s energy-intensive growth, while Lizardo & Mollick (2010) found evidence for improved exchange rates forecasts for several bilateral currencies and time periods when including changes in oil prices. Lastly, Huang & Guo (2007) found that real oil price leads long-run exchange rate to appreciate in China, a finding that is constant with the ones of Amano & van Norden (1998), who confirmed that oil prices and exchange rates are cointegrated, while causality runs from oil prices to exchange rates.

2.2.2.2 Impact of exchange rates on oil prices
Although the negative relationship between oil prices and exchange rates is almost undeniable, another strand of literature provide robust evidence that oil prices react to changes in exchange rates, and not vice versa. Coudert & Mignon (2016) assessed the relationship between real oil prices and US dollar between 1974 and 2015, finding that the two variables hold a negative relationship over the whole period, as well as that oil prices depends on the evolution of the dollar. Accordingly, it can be suggested that oil price changes due to the increased attractiveness of oil as an alternative asset against the fall in the price of US assets and US dollar depreciation. Breitenfellner & Cuaresma
(2008) came to similar conclusions, when investigating the impact of changes in the US dollar/euro exchange rate of crude oil prices, finding that taking into account information on exchange rates and its determinant, significantly improves oil price forecasting. Blomberg & Harris (1995) argued that a US dollar appreciation increases oil prices in terms of a domestic currency, due to the fact that crude oil is a dollar-denominated international commodity. In addition, Yousefi & Wirjanto (2004) examined the crude oil price formation in order to understand oil price reactions of OPEC countries to changes in the US dollar exchange rates, and verified that causality between these two variables runs from exchange rates into oil prices, pointing also out that there is a cross-regional dimension of the crude oil market.

Several other researchers have tried to examine the predictability of exchange rates for oil prices changes. For example, Alquist et al (2011) argued that specific bilateral exchange rates are useful for predicting oil prices, demonstrating particularly that the Australian exchange rate has a significant predictive power for forecasting changes in nominal oil prices for several time periods. Drchal (2016) applied time-varied models and also provided evidence that exchange rates may be strong predictive variables of oil spot prices, although their predictive value differentiates for different time periods. That is to say that no safe conclusions can be made about the informational value of exchange rates for oil prices, as different studies have come to mixed findings, given also the different empirical methods applied as well as the wide variety of data used. This assumption is also supported by Zhang et al (2008), who examined the forecasting accuracy of US dollar exchange rate fluctuations on the oil price volatility. The authors indicated that the influence of the US dollar exchange rate on international crude oil markets may be significant in the long-run, however, its short-term impact may be quite limited. In other words, it could be suggested that the US dollar influence on oil prices is relatively partial. Lastly, Beckmann & Czudaj (2013) ascertained that the causality between exchange rates and oil prices is greatly affected by the econometric method used as well as by the choice of the exchange rate measure, although they demonstrated that for certain time periods, the time-varying causality mainly runs from nominal exchange rates to nominal oil prices.
2.2.2.c Cointegration findings

As previously mentioned, the long-run relationship between the oil prices and exchange rates has been a topic of academic debate and has gained great research interest over the years. This relationship has been analyzed for several set of countries and regions, and with the use of different spans and forms of data, including effective and bilateral exchange rates, and nominal and real oil prices (Beckmann et al., 2017). In addition, these studies have used different empirical methodologies, with the most popular ones being cointegration analyses with the application of Engle-Granger and Johansen methods, as well as time-varying models. The bottom line of these studies is that, usually, there is a long-run relationship between oil prices and exchange rates, although the causality is not clear. Besides, although there is a broad consensus that this relationship is negative, there is also evidence that for certain time periods this relationship may be positive. Taking into account that this study applies the cointegration analysis in order to test for long-term links between the variables under examination, this section overviews the findings of studies that have also applied similar methodologies.

One of the most cited studies on this matter is the one of Amano & van Norden (1998), who studied thoroughly the relationship between the US real price of oil and the US real exchange rate with a cointegration technique. According to their findings, oil prices and exchange rates are cointegrated, that is to say they hold a long-run relationship, while there is a one-way causality that stems from oil prices to exchange rates, a finding that can be attributed to an “adverse effect” due to the larger share of US oil exports to OPEC compared to the respective imports share. Zhang et al. (2008) examined the relationship between US dollar exchange rate and crude oil price using cointegration techniques and VAR models, and found that there is a significant long-run equilibrium cointegration relationship between the two variables, as well as that the US dollar depreciation for the years under investigation is a key factor for the increase of the international crude oil prices. In this study, it was also revealed that the causality drives from the exchange rate to the oil price in the long-run, although in the short-run the respective influence is quite insignificant, an assumption that should be taken into account by oil market analysts and trade researchers.

Robero (2012) analyzed co-movements between oil prices and exchange rates for different regions and found that there is, indeed, a long-run relationship, although this
seems to be stronger for oil-exporting countries than for oil-importing ones. In this study it was also demonstrated that an increase in oil prices and a depreciation against the US dollar is characterized by a bidirectional causality, and after the 2008 financial crisis, the negative interdependence of the two variables is intensified. In a latter study, Reboredo & Rivera-Castro (2013) applied a wavelet model and found that before the crisis, there was no significant interdependence between oil prices and exchange rates. Bénassy-Quéré et al (2007) applied cointegration and causality techniques in order to test for the long-run relationship between the real oil price and the real price of dollar over the 1974-2004 period, suggesting that there is a cointegrated link between them, as a 10% rise in the oil price coincides with a 4.3% appreciation of the dollar in the long-run in China. As regards causality, the aforementioned findings indicate that the causality runs from oil prices to the exchange rates, although it should be mentioned that these findings should be regarded in caution, as during the time period under investigation China has been both an oil importer and exporter.

In addition, Rautava (2004) also used a cointegration methodology in order to examine the impact of oil prices in the exchange rates in the Russian economy and revealed that the two variables are cointegrated in the long-run, as oil prices and the real exchange rate come to a long-run equilibrium. Similar results are obtained by Beckmann & Czudaj (2013), who argued that real exchange rates and oil prices have a negative long-run relationship, and that changes in oil prices trigger exchange rates trough price differentials, although there are differences between oil-importers and oil-exporters. Chen & Chen (2007) used a monthly panel of G7 countries during 1972-2005 and established a long-run relationship between exchange rates and real oil prices, as the variables were found cointegrated, and revealed an one-way causal relationship, as it was shown that real oil prices may have been the dominant source of real exchange rate fluctuations, suggesting that oil prices have a significant relative forecasting power.

Coudert et al (2008) also performed a cointegration and causality methodology and indicated that oil prices and the US effective exchange rate are cointegrated, while the causality runs from oil prices to the exchange rates, a relationship transmitted through the US net foreign asset position. Accordingly, Clostermann & Schnatz (2000) found that real oil prices have a significant impact on real exchange rate movements in the long-run, verifying the one-way causality. On the other hand, Fratzcher et al (2014) did not confirmed the aforementioned assumption, as they provided evidence for a
bidirectional causality between the US dollar and oil prices since the early 2000s, although both variables have been significantly affected by changes in equity market returns. All in all, most studies support a cointegrated long-term relationship between oil prices and the US dollar exchange rate, with the causality running mostly from the first variable to the second one, although the respective findings are inclusive. It should be, lastly, noted that several researchers have applied other time-varying methodologies in order to test for this long-term relationship. For example, recently, Castro & Jiménez-Rodríguez (2018) considered a Time-Varying Parameter VAR model and indicated a US dollar depreciation after an oil price shock in the short-run for any period of time, although the long-run pattern of US exchange rate’s responses is diverse.
CHAPTER 3

METHODOLOGY

3.1 DATA

The aim of the following empirical study is to investigate the relationship between the price levels of crude oil and US dollar exchange rates through econometric methods. In this light, this study intends to determine whether there is a short-run or long-run equilibrium relationship between the price levels of crude oil and US dollar exchange rates.

The data sample selected refers to variables under examination, including the price levels of crude oil (OIL) and real trade-weighted US dollar exchange rate index (USD). The time period of our data spans from November 1988 to October 2018, it is monthly and refers to average values. All data were collected from the Yahoo Finance database. The choice of the data set was constrained by the availability of data.

3.2 CAUSAL RELATIONSHIP TESTING

For the examination of existence of causal relationship between the price levels of crude oil (OIL) and real trade-weighted US dollar exchange rate index (USD), Granger Causality method will be used.

The kind of causal relationship may vary as changes in a variable may precede or follow or changes of another variable. The examination of this relationship is the purpose of analyzing causality known as Granger causality.

To clarify the procedure of assessing Granger causality, the following models considered:

\[ Y_t = \sum_{i=1}^{m} a_i Y_{t-i} + \sum_{i=1}^{m} b_i X_{t-i} + u_t \]  \hspace{1cm} (1)

\[ X_t = \sum_{i=1}^{m} c_i X_{t-i} + \sum_{i=1}^{m} d_i Y_{t-i} + \epsilon_t \]  \hspace{1cm} (2)
Based on the above models, the following cases are distinguished:

1. The coefficients $b_i$ of the variables $X_{t-i}$ in (1) are statistically significant, while the coefficients $c_i$ of $Y_{t-i}$ in (2) are statistically different from zero. In this case there is Granger causality from $X$ to $Y$.

2. The coefficients $b_i$ of the variables $X_{t-i}$ in (1) are not statistically significant, while the coefficients $c_i$ of $Y_{t-i}$ in (2) are statistically significant. In this case there is Granger causality from $Y$ to $X$.

3. The coefficients $b_i$ variables $X_{t-i}$ in (1) and $c_i$ coefficients of $Y_{t-i}$ in (2) are statistically different from zero. In this case there is bidirectional Granger causality.

4. The coefficients $b_i$ of the variables $X_{t-i}$ in (1) and $c_i$ coefficients of $Y_{t-i}$ in (2) are not statistically different from zero. In this case there is Granger independence.

Consequently, the estimation of Granger causality examines the null hypothesis that variable does not causes another variable by examining the statistical significance of the estimated coefficients.

### 3.3 LONG-RUN RELATIONSHIP TESTING

#### 3.3.1 Engle-Granger cointegration

To address the problems arising from the effort to estimate long-term relationships between non-stationary series, the methodology of cointegration was developed. The concept of cointegration was introduced by Granger (1981) and mainly developed further by Engle and Granger (1987) and Johansen (1988, 1991, 1995).

Cointegration analysis refers to nonstationary variables entrained together, either upstream or downstream with respect to time that share a common trend. This common path causes linear relations between these variables, for long periods, specifying equilibrium relationships between them and the results arising from each regression may not be fictitious. More generally, cointegration is a technical assessment of long-
term parameters or balance parameters in a relationship where the variables are non-stationary.

In the case of simple bivariate model and according to Engle and Granger (1987), two time series \( Y_t \) and \( X_t \), are cointegrated of class \((d, b)\), denoted by \( CI(d, b) \), where \( 0 \leq b \leq d \), if,

(a) The two time series are integrated of \( d \) class, and

(b) There is a linear combination of the two time series \( \beta_1 Y_t + \beta_2 X_t \), which is stationary series in order of integration \((d - b)\).

More specifically if two series \( Y_t \) and \( X_t \), which are first class integrated \((\{Y_t, X_t\} \sim I(1))\) and its regression model is given by the equation \( Y_t = \beta_0 + \beta_1 X_t + u_t \) give a linear combination of \( \hat{u}_t = Y_t - \hat{\beta}_0 - \hat{\beta}_1 X_t \) which is stationary, ie \( \hat{u}_t \sim I(0) \), then these two series are cointegrated presented as \( \{Y_t, X_t\} \sim CI(1,1) \), while the equation \( Y_t = \beta_0 + \beta_1 X_t + u_t \) is called cointegrating equation. Also in \( \hat{u}_t = Y_t - \hat{\beta}_0 - \hat{\beta}_1 X_t \) the coefficients vector \( \begin{bmatrix} 1, -\beta_0, -\beta_1 \end{bmatrix} \) is called cointegration vector, while the slope parameter \( \beta_1 \) is called cointegrating parameter. For the case of cointegration between two variables, it has been proven that there is only one vector of cointegration, i.e. the linear combination of the two series is unique. Finally, the stochastic error term \( u_t \) is called disequilibrium error and reflects the range of the imbalance between the variables \( Y_t \) and \( X_t \).

Engle and Granger (1987) developed further the work of Granger (1981, 1986) and suggested a simple test first to determine the existence of cointegration relationships, called Engle-Granger test (EG). More specifically, suppose that the existence of cointegration between two series, \( Y_t \) and \( X_t \), must be investigated. Following the approach of Engle & Granger (1987), the integration order of each variable should be determined, using the methodology of unit roots. Then, there are three possible cases:
(a) If both variables are stationary (for example \( \{Y_t, X_t\} \sim I(0) \)) is not necessary to continue because one can simply apply the classic regression analysis to estimate the relationship between them.

(b) If the variables are of a different class of integration (for example \( Y_t \sim I(0) \) and \( X_t \sim I(1) \)) one can conclude that the two variables are not cointegrated.

(c) If both variables are integrated of the same order (for example, \( \{Y_t, X_t\} \sim I(1) \)), they may also be cointegrated. So, one can continue and estimate with the OLS long run relationship of the form \( Y_t = \beta_0 + \beta_1 X_t + u_t \) and take the residuals.

To see if \( Y_t \) and \( X_t \) are cointegrated one should check the stationarity of the residuals. Residuals are deviations from the long-run equilibrium and if form stationary series, \( \hat{u}_t \sim I(0) \), then \( Y_t \) and \( X_t \) are cointegrated, i.e. there is a stationary linear combination between them. In particular, to test the stationarity of residuals one can apply control the DF or ADF test as follows:

\[
\Delta \hat{u}_t = \beta \hat{u}_{t-1} + \sum_{i=1}^{k} \gamma_i \hat{u}_{t-i} + \epsilon_t \text{ and test for }
\]

H0: \( \beta = 0 \), non stationarity

H0: \( \beta < 0 \), stationarity

Rejection of the null hypothesis implies that the residuals are of a stationary series, and therefore the variables are cointegrated.

It is noted that equation \( \Delta \hat{u}_t = \beta \hat{u}_{t-1} + \sum_{i=1}^{k} \gamma_i \hat{u}_{t-i} + \epsilon_t \) does not contain fixed term, because by definition the residuals generated by the method of OLS are distributed around zero. Also, the estimate of \( \beta \) coefficient is biased downwards because by default the method OLS tends to produce stationary residuals, and therefore the critical values \( \tau \) of the ADF test is not suitable to be used. Engle & Granger (1987), using Monte Carlo simulations, built appropriate critical values which are more negative than those of the ADF test. Engle & Yoo (1987) improved further these critical values for the case where one
applies the EG test to investigate the existence of cointegration between more than two variables, while MacKinnon (1991) proposed a revised critical values, which are those used hitherto.

The EG test is easy to understand and to implement but it has some significant drawbacks. First, when assessing the long-term relationship between the variables $Y_t$ and $X_t$, it is for the researcher to decide which variable will be the dependent and which the independent one. For example, in the case two variables $Y_t$ and $X_t$, the test can be assessed either by using the equation $(Y_t = \beta_0 + \beta_1 X_t + u_{t,1})$ or by using the equation $(X_t = \beta_0 + \beta_1 Y_t + u_{t,2})$. It has been shown that as the sample tends to infinity the cointegration tests in the residuals $u_{t,1}$ and $u_{t,2}$ are equivalent. However, in practice, large samples are rarely available and it is likely the one regression indicates the existence of cointegration while the second does not. This problem becomes bigger when the cointegration test comprises more than two variables.

Secondly, when in the cointegrating regression there are more than two variables, then there may be more than one cointegrating vector and the approach of Engle & Granger (1987) cannot inform about the exact number of cointegrating vectors. That is, it is impossible without external information to determine the long term equilibrium relationship (Enders, 1995). These problems are effectively treated by other cointegration methodologies as the Johansen (1988, 1991 and 1995) cointegration method.

### 3.3.2 Johansen cointegration

The concept of cointegration refers to the process of linking the relationships between integral non-staggered series and the long-term equilibrium. Consequently, the existence of a long-term equilibrium relation between two variables requires I (1) to prove and their linear combination follows I (0).

Breafly, the concept of Johansen cointegration is based on a (VAR) model that is:

$$Y_t = \Phi_1 Y_{t-1} + \ldots + \Phi_k Y_{t-k} + U_t, \quad t=1,2,\ldots,T$$
Where $Y_t$ is the $n \times 1$ vector of I (1) variables and $U_t$ is the white noise vector of the residuals.

Rewriting the equation in other terms, the equation becomes:

$$\Delta Y_t = \Pi_1 Y_{t-1} + \Pi_2 \Delta Y_{t-1} + \ldots + \Pi_k \Delta Y_{t-k+1} + U_t$$

where $\Pi_1 = -I + \sum_{i=1}^{k} \Phi_i$ and $\Pi_j = -\sum_{i=j}^{k} \Phi_i$ for $j=2,\ldots,k$.

The vector we are interested in checking is $\Pi_1$, which shows us the long-term relationship between the variables in $Y_t$. The degree of the matrix $(r)$ matrix contains important information about the cointegration behavior between the variables. If the matrix matrix level $\Pi_1$ is zero, then there is no cointegrating relation between the I (1) variables. The reduced degree ($r < n$) of the matrix $\Pi_1$ assumes that there are $r$ cointegrating vectors between non-stagnant variables. Finally, the exactly identified degree ($r = n$) of the matrix $\Pi_1$ assumes that all variables are stationary to start together.

It should be noted that if a single degree is found during the test, then the calculated vector must be $[1, -1]$ to satisfy the condition under consideration. In order to delimit the degree of the matrix $\Pi_1$ matrix, we use the trace test and the maximum eigenvalue of Johansen (1991) and check for long-term cointegration vector in cases where there is a unique cointegration vector.

Usually the matrix has a reduced degree that is $r \leq (n-1)$ and then we have:

$$\Pi_1 = \alpha \beta'$$

where $\alpha$ is a matrix $n \times r$ and $\beta$ is a matrix $r \times n$.

Thus, $\beta' \chi_{r-1}$ is the matrix of the coefficients of cointegration and $\alpha$ represents the matrix of the terms of the residue correction. The degree of matrix $\Pi_1$ and the number of cointegration relationships are determined using the two most popular LR probabilities, namely the trace statistic ($\lambda_{trace}$) and the maximum eigenvalue ($\lambda_{max}$), whose test statistics are as follows:

$$\lambda_{trace} = -T \sum_{i=r+1}^{n} \log(1 - \hat{\lambda}_i)$$
$\lambda_{\text{max}} = -T \log(1 - \hat{\lambda}_{r+1})$

where $\lambda_i$ is the greater eigenvalue of the matrix $\Pi_i$ matrix and the tests are made according to the null hypothesis that $r = 0$ and $r = 1$.

### 3.4 SHORT-RUN DYNAMICS TESTING

As previously mentioned, if two variables $Y_t$ and $X_t$ are cointegrated, then there is a long-term relationship or equilibrium relationship between them. However, in the short-run these variables can be found in a disequilibrium with the disequilibrium error (the stochastic term) reflecting the range of this disequilibrium. According to the representative theorem of Granger (Granger, 1986, Engle & Granger, 1987), this dynamic short-term relationship can be formulated in an error correction model (Error Correction Model - ECM) which essentially connects the long and short-term behavior of variables. ECM originally introduced in the Sargan (1964) and was later extended by Engle & Granger (1987). For the case of the model $Y_t = \beta_0 + \beta_1 X_t + \epsilon_t$ where $Y_t$ and $X_t$ are cointegrated, the ECM is represented as:

$$
\Delta Y_t = a_0 + \sum_{i=1}^{k} \beta_i \Delta Y_{t-i} + \sum_{i=1}^{p} \gamma_i \Delta X_{t-i} + \lambda \hat{u}_{t-1} + \epsilon_t
$$

Where $k$ and $p$ denote the number of lags that are added to the model, $\hat{u}_t$ is the error term and $\epsilon_t$ is white noise. The term $\lambda \hat{u}_{t-1}$ is called error correction term (ECT) and integrates the information from the long period, while the parameter $\lambda$ is called adjustment coefficient, because its value indicates the speed at which the equilibrium value of $Y_t$ is restored after a possible exogenous disturbance (shock). The adjustment coefficient $\lambda$ takes values between zero and the unit, indicating that only a part of the disequilibrium error in the behavior of $Y_t$ is corrected in the next period. Therefore, the ECM of $\Delta Y_t = a_0 + \sum_{i=1}^{k} \beta_i \Delta Y_{t-i} + \sum_{i=1}^{p} \gamma_i \Delta X_{t-i} + \lambda \hat{u}_{t-1} + \epsilon_t$ integrates into a model information and the long and the short run, and states that the changes of $Y_t$ are explained by its past changes, by past changes of $X_t$ and by the long-term disequilibrium error of the previous period.
ECM is considered very important and popular for several reasons (Asteriou & Hall, 2007). First, it is a model that measures the speed of adjustment towards equilibrium between two consecutive periods, which has a very good fit in the exercise of economic policy. Secondly, it incorporates only stationary variables, thus avoiding the problem of spurious regression. Third and most important, for the variables which are cointegrated, there is an adjustment mechanism that prevents the disequilibrium error term relative to become ever greater. Finally, it is also crucial to note that not only the cointegration implies the existence of an ECM, but also the opposite. This is the essence of representative theorem of Granger.
CHAPTER 4

RESEARCH FINDINGS

4.1 DESCRIPTIVE FINDINGS

In this section, the basic properties of the indices-variables are presented in a descriptive manner. First, Figures 1 and 2 present the overtime trend of the real price of crude oil and the real trade-weighted US dollar exchange rate index.

Figure 1: Crude oil price trend
The following table presents the descriptive statistics of the research variables. More specifically, mean, median, minimum, maximum, standard deviation, skewness and kurtosis are presented.

<table>
<thead>
<tr>
<th></th>
<th>OIL</th>
<th>USD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>46.237</td>
<td>93.903</td>
</tr>
<tr>
<td>Median</td>
<td>31.385</td>
<td>93.121</td>
</tr>
<tr>
<td>Maximum</td>
<td>132.830</td>
<td>112.813</td>
</tr>
<tr>
<td>Minimum</td>
<td>10.410</td>
<td>80.519</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>31.838</td>
<td>7.556</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.821</td>
<td>0.527</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.397</td>
<td>2.511</td>
</tr>
</tbody>
</table>

As it is shown above, the mean value of crude oil price is equal to 46.237. Also, the mean value of real trade-weighted US dollar exchange rate index is equal to 93.903. Focusing on descriptive statistics related to the distribution of the data such as skewness and kurtosis, it is noticed that both variables OIL and USD show significant positive (right) asymmetry as skewness is positive and mean is greater than median. In order to have symmetrical distribution skewness, these values should be zero or at least close to
zero, fact that does not stand in any case. Furthermore, we observe that kurtosis is lower than 3 for both variables OIL and USD and the distribution of these variables is leptokurtic.

Interpreting the correlation matrix arising, it is observed that there is a negative and low correlation of OIL and USD \( (r=0.172, p=0.035) \), which means that as crude oil price increases real trade-weighted US dollar exchange rate index decreases and vice versa.

<table>
<thead>
<tr>
<th></th>
<th>OIL</th>
<th>USD</th>
</tr>
</thead>
<tbody>
<tr>
<td>OIL</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>USD</td>
<td>-0.172 (0.035)</td>
<td>1</td>
</tr>
</tbody>
</table>

Numbers in parenthesis are p-values

4.2 GRANGER CAUSALITY TESTS

In order to test for causal relationships between crude oil prices and real trade-weighted US dollar exchange rate index, the following equation system is applied by using two lags based on the AIC criterion:

\[
OIL_t = a_1 OIL_{t-1} + a_2 OIL_{t-2} + b_1 USD_{t-1} + b_2 USD_{t-2} + u_t
\]

\[
USD_t = c_1 USD_{t-1} + c_2 USD_{t-2} + d_1 OIL_{t-1} + d_2 OIL_{t-2} + \epsilon_t
\]

The hypotheses tested in this part of the study are:

1. OIL does not Granger Cause USD
2. USD does not Granger Cause OIL

Interpreting the estimated results of the Granger Causality test, we initially observe that there is a causal relationship of crude oil price levels to real trade-weighted US dollar exchange rate index \( (p<0.001) \). On the other hand, the existence of causal relationship of USD to OIL does not hold as \( p=0.397 \). The results of the causality test are made clear, with a general conclusion that there is a one way causality relationship of crude oil price to real trade-weighted US dollar exchange rate index, while there is no reverse
causality. Consequently, variations in the crude oil price precede changes in the real trade-weighted US dollar exchange rate index.

Table 3: Granger causality test results

<table>
<thead>
<tr>
<th></th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>OIL does not Granger Cause USD</td>
<td>10.240</td>
<td>0.000</td>
</tr>
<tr>
<td>USD does not Granger Cause OIL</td>
<td>0.929</td>
<td>0.397</td>
</tr>
</tbody>
</table>

4.3 ENGLE-GRANGER COINTEGRATION TEST

Before testing for cointegration, the econometric methodology needs to check out for the stationarity for each individual time series, considering that most index data are non-stationary, i.e. they tend to exhibit a deterministic and/or stochastic trend (Nelson & Plosser 1982). A series is expected to be stationary if the mean and variance are time – invariant. At this point, we test the stationary of the variables used in order to proceed to the cointegration test through Engle-Granger cointegration procedure, whereas before this application the theoretical background of the used unit root test is summarized.

From the aferomentioned empirical results, it becomes clear that a very important component of econometric analysis is the application of unit root tests, in order to examine if there is stationarity in first differences I(1) in the applied variables. Unfortunately, the majority of unit root tests considered insufficient and it is likely to lead to controversial conclusions, given their limited power. For this reason, it is usual to apply various econometric unit root tests, of which the most important is Augmented Dickey-Fuller (ADF test).

In this test, the null hypothesis presents the existence of unit root (a = 0), against the alternative hypothesis of the existence of stationarity (a <0). Test statistic is calculated using the conventional t-ratio for the given significance level and the critical value is calculated by exacting MacKinnon critical values for Dickey-Fuller test.

The following tables present the unit root tests through ADF method for all the variables used, with trend in levels and first differences.
The null and alternative hypotheses for the tests may be written as $H_0: a = 0$ and $H_1: a < 0$.

So under the null hypothesis, there is a unit root, while under the alternative one, there is no unit root.

**Table 4: ADF unit root test results**

<table>
<thead>
<tr>
<th></th>
<th>Level</th>
<th>1st Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>OIL</td>
<td>28.797 (0.092)</td>
<td>44.885 (0.001)</td>
</tr>
<tr>
<td>USD</td>
<td>20.782 (0.410)</td>
<td>72.042 (0.000)</td>
</tr>
</tbody>
</table>

Numbers in parenthesis are p-values

Interpreting our results and comparing the exported values with the corresponding critical values for ADF for a significance level of 5%, and p-values for 0.05, we outline that the existence of unit root at level is accepted in both cases for the variables OIL and USD. Thus, the variables of our research are not stationary in level. Instead, performing the same test in first differences we observe that our data are stationary as well as the presented p-value is less than the significance level of $a = 5\%$. So we can clearly conclude that our variables are I (1).

The Engle-Granger cointegration test is based on the simple idea that if there is a cointegration relationship, the OLS estimates of the regression $Y_t = a + bX_t + e_t$ are reasonable so the residuals $e_t = Y_t - a - bX_t$ should be I (0). So an ADF test in the residuals for the regression below should show that there is not unit root. The regression tested is the following:

$\Delta \hat{\varepsilon}_t = a\hat{\varepsilon}_{t-1} + \sum_{j=1}^{p} \gamma_{ij}\Delta \hat{\varepsilon}_{y-j} + u_t$

Continuing our study, we proceed to the unit root test for the estimated residuals of the regression applied above. The ADF regression equation is:

$\Delta \hat{\varepsilon}_t = a\hat{\varepsilon}_{t-1} + \sum_{j=1}^{p} \gamma_{ij}\Delta \hat{\varepsilon}_{y-j} + u_t$

The results obtained are as follows:

**Table 5: EG cointegration test results**

<table>
<thead>
<tr>
<th></th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residuals</td>
<td>49.121 (0.000)</td>
</tr>
</tbody>
</table>

Numbers in parenthesis are p-values
As it is noticed, the residuals appear to be I(0). Thus the null hypothesis of non-stationarity for significance level of 1% is rejected. This result indicates that crude oil price levels and real trade-weighted US dollar exchange rate index are cointegrated and thus there is a long-term, or equilibrium relationship between them.

### 4.4 JOHANSEN COINTEGRATION TEST

In order to perform the Johansen cointegration test, the trace and maximum eigenvalue criteria are used at a statistical significance level of 0.05. The results of the cointegration test are listed below.

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Trace statistic</th>
<th>Critical Value (5%)</th>
<th>p</th>
<th>Max eigenvalue statistic</th>
<th>Critical Value (5%)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>19.604</td>
<td>15.494</td>
<td>0.011</td>
<td>15.959</td>
<td>14.264</td>
<td>0.026</td>
</tr>
<tr>
<td>At most one</td>
<td>3.645</td>
<td>3.841</td>
<td>0.056</td>
<td>3.645</td>
<td>3.841</td>
<td>0.056</td>
</tr>
</tbody>
</table>

By applying the Johansen's cointegration test, it is noted that the assumption of no cointegration relationship is rejected and the assumption of the existence of one cointegration relationship is accepted, therefore, crude oil price levels and real trade-weighted US dollar exchange rate index have a long-term relationship. We proceed to investigate the nature of the relationship between the two variables in the short run by using the Error Correction Mechanism.

### 4.5 ERROR CORRECTION MECHANISM

As previously mentioned, the method of Engle-Granger cointegration is a way that one can estimate the long-run equilibrium relationship between two or more variables. Engel and Granger have shown that if two variables Y and X are cointegrated, then there is a long-term equilibrium relationship between these variables, although these variables may be in disequilibrium in the short-run. This short-run relationship between two variables can be formulated in a model called error correction model (ECM). The error of equilibrium (disequilibrium) can be used to combine the short-run to long-run
period. The method used for this combination is called the error correction mechanism (ECM).

To estimate an error correction model using the method of least squares (OLS) we should count the cointegration vector. The specificity of the error correction model forces the long-run behavior of endogenous variables to converge to the cointegration relationship while arranges the short-run dynamics.

According to Engle and Granger, the Error Correction Model can be specified as follows. Also, we present the results obtained for ECM in table 6:

\[ \Delta \text{OIL}_t = \gamma_1 + p_1 Z_{t-1} + a_1 \text{USD}_{t-1} + b_1 \Delta \text{OIL}_{t-1} + e_{1t} \]

\[ \Delta \text{USD}_t = \gamma_2 + p_2 Z_{t-1} + a_2 \Delta \text{OIL}_{t-1} + b_2 \Delta \text{USD}_{t-1} + e_{2t} \]

Engle (1987) exceptionally explained the way that the results are interpreted, indicating that \( \Delta \) denotes the first difference operator, and \( Z_{t-1} \) denotes the error from the linear regression between OIL and USD. The two random error terms are denoted by \( e_{1t} \) and \( e_{2t} \). The error correction mechanism is represented by the coefficients of \( p \), which measures how quickly current prices correct last period deviation and restore to their long-term equilibrium. If \( p_1 \) is significant, then current USD will adjust to last period deviation from equilibrium. Suppose \( Z_{t-1} \) is positive, which means OIL is too high, as \( p \) is expected to be negative; the term \( p_1 Z_{t-1} \) is also negative. Therefore, \( \Delta \text{OIL}_t \) will be negative to restore the equilibrium. The lead–lag relationships are represented by the coefficients of \( a \). If \( a_1 \) is significant but \( a_2 \) is insignificant, it is concluded that there is a unidirectional causality from USD to OIL. An inverse causality can be found if \( a_1 \) is insignificant but \( a_2 \) is significant. If both coefficients are jointly insignificant, then there is no short-run relationship between OIL and USD.

Table 7: ECM results

<table>
<thead>
<tr>
<th></th>
<th>D(OIL)</th>
<th>D(USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error correction</td>
<td>-0.231</td>
<td>7.903</td>
</tr>
<tr>
<td></td>
<td>(0.044)</td>
<td>(0.950)</td>
</tr>
</tbody>
</table>
By interpreting the results of the ECM, it is observed that coefficient $a_1$ is insignificant and thus it can be argued that the historical changes in USD cannot predict the movement of OIL. Also, it is noticed that the coefficient $a_2$ is significant and thus it is argued that historical changes in OIL can predict the changes in USD and thus do contain information about USD in the next period.

The error correction coefficients $p_1$ is significant and negative and $p_2$ is significant and positive. In the first case, it is noticed that if USD is high compared to the OIL levels then will decrease in the next period eliminating any disequilibrium. In the second case it is noticed that high levels of OIL lead to high levels of USD. Also it is observed that coefficients $b_1$ and $b_2$ for OIL and USD are significant and, thus, it can be argued that OIL and USD can be forecasted by their historical levels.

<table>
<thead>
<tr>
<th></th>
<th>[-5.205]</th>
<th>[ 8.313]</th>
</tr>
</thead>
<tbody>
<tr>
<td>D(OIL(-1))</td>
<td>-0.235</td>
<td>-4.705</td>
</tr>
<tr>
<td></td>
<td>(0.078)</td>
<td>(1.682)</td>
</tr>
<tr>
<td></td>
<td>[-2.992]</td>
<td>[-2.796]</td>
</tr>
<tr>
<td>D(USD(-1))</td>
<td>-0.007</td>
<td>-0.043</td>
</tr>
<tr>
<td></td>
<td>(0.004)</td>
<td>(0.093)</td>
</tr>
<tr>
<td></td>
<td>[-1.628]</td>
<td>[-0.471]</td>
</tr>
<tr>
<td>$C$</td>
<td>-0.264</td>
<td>-1.505</td>
</tr>
<tr>
<td></td>
<td>(0.399)</td>
<td>(8.541)</td>
</tr>
<tr>
<td></td>
<td>[-0.661]</td>
<td>[-0.176]</td>
</tr>
</tbody>
</table>

Standard errors in ( ) & t-statistics in [ ]
CHAPTER 5

DISCUSSION AND CONCLUSIONS

5.1 DISCUSSION OF FINDINGS

The relationship between oil prices and exchange rates has been a topic of research interest since the 1970s, since oil and US dollar are two important financial assets and the latter is typically used as the invoicing currency in the international crude oil trading. There is plenty of empirical evidence for a long-run relationship between the oil price and US dollar exchange rates, while it seems that causalities change over time and run in both directions. In this light, the aim of this study was to investigate the long-run relationship between crude oil prices and real trade-weighted US dollar exchange rate index for a time period of 30 years (1988-2018), so as to identify causal links between these two variables, as well as to examine the direction of the respective causalities.

According to the research results, first, it was found that crude oil prices and real trade-weighted US dollar exchange rate are negatively correlated, as it has been well-documented in the relevant research literature (Krugman, 1980; Caprio & Clark, 1981; Golub, 1983; Amano & van Norden, 1998; Breitenfellner & Cuaresma, 2008). Second, it was demonstrated that the causality runs from oil prices to the US dollar exchange rate, a finding that agrees with previous studies. Indeed, it has been found that an oil price increase influence exchange rates via the wealth effect mechanism (Golub, 1983; Krugman, 1983; Bodenstein et al, 2011) or through the “adverse effect” (Amano & van Norden, 1998) and the investment channel (Coudert et al, 2008; Habib et al, 2016). Previous studies have supported a one-way causality from oil prices to US dollar exchange rates (Bénassy-Quéré et al, 2007; Chen & Chen, 2007; Beckmann & Czudaj, 2013). There is also evidence for improved exchange rates forecasts when incorporating oil prices (Akram, 2004; Huang & Guo, 2007; Lizardo & Mollick, 2010).

Third, both Engle-Granger and Johansen cointegration tests proved that crude oil prices and real trade-weighted US dollar exchange rate index are cointegrated, thus, they hold
a long-run equilibrium relationship. A long-run relationship between oil prices and exchange rates has been well documented in the relevant research literature, as it has been largely found that the two variables are cointegrated (Amano & van Norden, 1998; Rautava, 2004; Bénassy-Quéré et al, 2007; Chen & Chen, 2007; Coudert et al, 2008; Zhang et al, 2008; Robero, 2012; Beckmann & Czudaj, 2013). Indeed, most studies support a cointegrated long-term relationship between oil prices and the US dollar exchange rate, with the causality running mostly from the first variable to the second one, a finding that this study also confirms. Lastly, this study revealed that deviations from the equilibrium relationship between oil prices and US dollar exchange rates in the short-run are restored, meaning that there are also short-run links between the two variables and deviations are corrected, a correction triggered by oil prices towards US dollar exchange rates. Indeed, previous studies have supported the idea of a long-run co-movement and short-run deviations from the equilibrium point between the variables under examination which tend to be corrected over time (Coudert et al, 2008; Habib et al, 2016).

5.2 CONCLUSIONS AND LIMITATIONS

This study contributes to better understand the dynamic long-run relationship between the US effective exchange rates and crude oil prices by considering a cointegration analysis using data for a 30-year time period. The negative sign patterns of this relationship found in this analysis is consistent with most of economic theory, which establishes a depreciation after an increase in oil prices. In addition, the negative correlation between oil prices and US dollar exchange rates can be ascribed to several transmission mechanisms, including the investment, monetary, trade, portfolio and wealth channels. Moreover, this study established a long-run relationship between the variables under examination, while causality runs from oil prices to exchange rates, a finding which is consistent with past research that has largely demonstrated that oil price changes affect the US dollar in the long-run.

Thus, this research acknowledges the contribution to existing knowledge and theory regarding the links between oil prices and exchange rates, although it should be mentioned that there are also diversified findings on this matter, particularly regarding the direction of the causality and short-run deviations from the equilibrium.
Accordingly, this research has a number of limitations that should be mentioned. In particular, the study is limited by the frequency and type of data (monthly average prices and aggregate exchange rate index), and thus no distinction was possible for oil-exporting and oil-importing countries. Furthermore, no time-varying technique was used in order to test for dynamic equilibrium relationships between the two variables under examination, while no transmission mechanism was possible to identify given the research framework and type of data used. Lastly, the long-run linkages between exchange rates and oil prices were investigated only via cointegration methods.

Although there is strong evidence that oil prices and exchange rates are related over the long-run as well as for various short-run linkages and spillovers between the two markets, the respective causalities represent an ongoing question for future research. In addition, there is also empirical evidence suggesting time-varying relationships, that is to say that past linkages do not necessarily hold in the future. It can be, thus, suggested that exchange rates’ movements are not an absolute measure for predicting and understanding oil price movements, and vice versa, as each variable contains useful information for respective forecasts that changers over time. Moreover, the relationship between the two variables has become even more volatile during the last years, given the changes in the monetary policy and the “financialization” of the oil market. In this light, future research should take into account the time-varying dynamics influencing the relationship between exchange rates and oil prices, and address the sample choices and the need for a “richer” data environment in order to apply more advanced and dynamic econometric techniques. In addition, the transmission mechanisms should be also taken into account, while making distinctions between oil supply and demand factors is also important from a theoretical point of view.
REFERENCES


