# The relationship between the oil price and the U.S. dollar

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**Abstract**

*The relationship between the oil price and the real exchange rate of the U.S. dollar is a topic of great interest and wide discussion in economic literature. This paper is aimed at analyzing this relationship. The currencies that were used for the study are the U.S. dollar, British pound, Swiss franc, Swedish Krona, Japanese Yen, and Canadian dollar. In order to actualize this analysis, we developed and used a model based on a monetary approach to exchange rates; the model includes such variables as real money balances, real GDP of countries, differences between domestic and foreign interest rates, and the real price of oil. Monthly time series data from 1995 to 2015 was used to make an econometric analysis of the topic. Before testing the model, the data was tested to be stationary and the data series found to be in order of integration. An error correction model was used and the determinants of the exchange rate were estimated. The results of the final model showed that an increase in oil price, caused a minor appreciation of dollar against the currencies included in the work.*

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## 1. Introduction

Change in oil price is one of the major cause of economic downturns, trade deficits, high and unpredictable inflation, and consequently, high level of investment uncertainty in the economy (Reboredo 2012). USD oscillations cause big disruptions in the real economy and financial markets. The volatility of the USD, impacts both oil exporting and oil importing countries. If the U.S. Dollar weakens against the oil-importing country's currency, the country's purchasing power goes up. However, when the USD is getting stronger, importing countries can experience an oil shock, which may lead to inflationary pressure in the economy as oil refined products are the main source of energy production and goods transportation (Rasmussen and Roitman 2011). Oil traders are not only concerned with oil movements, but with movements of the U.S. Dollar. Main speculation and hedging activities arise when there is a rise or a drop in any of those two. Hence, the modelling of currency and oil markets co-movements is a topic of great interest for traders, investors and policymakers as it has a lot of important features for portfolio management and policy design (Reboredo 2012).

Correlation between the oil market and currency market was well established but was not much discussed before the 1970's. In the 1980's, Krugman (1980) and Golub (1983), have noticed this link and made it a wide topic of discussion. An oil exporting country may experience its currency appreciation when the oil price is higher and may experience its currency depreciation when the oil price is lower. However, oil importers may experience domestic currency depreciation, when the oil price goes up and

vice versa for exporters. When the USD depreciates against foreign currency, the purchasing power of the foreign country increases and the foreigners start to demand more oil. Higher demand for crude oil causes its price to increase which results in the same medium-run equilibrium in oil trade (Bloomberg and Harris 1995).

A thorough understanding of how much impact, the change in oil price has on exchange rates, will help to make valuable predictions, which can be of great importance for policymakers. Wieland and Wolters (2011), provided a detailed analysis why it is important to initiate forecasts for policymaking. They argued that forecasts are used to project the potential outcomes of a policy and measure its effectiveness in achieving the policymakers' targets.

The aim of this research is to examine the magnitude of the impact of oil price on the U.S. currency against British pound (GBP), Swiss franc (CHF), Japanese Yen (YEN) and Swedish Krona (SWE).

## 2. Literature Review

This part will be divided into two sections. Section I will contain a review of related literature, which examined the links between oil price and the U.S. exchange rate in particular. Section III will not be focusing on oil. In fact, it will focus on modelling of the exchange rate in general. It is important to present a brief outlook of the works that are based on modeling and forecasting exchange rates. Authors are looking for the best way to model exchange rate movements, and some of the approaches will be used further in this work for the analysis of the main topic.

Section I

Throop (1993), has examined the sources of fluctuations in exchange rates of USD against other currencies. The study has identified three types of factors that were empirically important for the stability of exchange rates. These three factors were; the real price of oil, productivity growth and governments' budget deficits. She found that due to oil price increase, the dollar will depreciate in the short run but will become stronger in the long run.

Amano and van Norden (1998), explored the ability of real oil prices to explain American real effective exchange rate, which is the weighted average of dollar to an index of a basket of other major currencies that are adjusted for the inflation effects. They believed that their model is more advanced than the ones presented by Krugman (1980) and Golub (1983), due to the improvements in econometric methods. Amano and van Norden (1998), have found significant evidence of the presence of a long-term relationship between the real exchange rate and oil prices. They also concluded that, the causality runs from oil prices to the real exchange rate and not vice versa. Because of the fact that the U.S. is one of the major oil importers, their results showed that the higher energy prices lead to an appreciation of the USD in the long run. Amano mentioned that in 1991, the U.S. was importing 20.2% of oil from OPEC, while OPEC was importing more than 25% of the U.S. exports. Therefore, the increase in oil price will increase American Balance of Payments. Hence, higher oil prices are beneficial for American GDP and exchange rate.

The analysis of Amano and van Norden (1998) was similar to the works done by Krugman (1980) and Golub (1983), who believed that the effect of a positive oil shock on the U.S. exchange rate is ambiguous. Amano and van Norden (1998) and Golub (1983), showed that from the perspective of OPEC, the U.S. does not purchase the majority of OPEC's exports. However, OPEC buys a big share of American imports leading to the fact that higher oil prices will lead to the transfer of wealth and improvement of the U.S. trade balance.

Krugman (1980) and Golub (1983) developed models that showed the links between oil price and dollar exchange rate, dividing the world into three areas: America, Germany and OPEC. Krugman (1980), found that the impact of oil price increase is different in the short run and in the long run. He used a dynamic partial equilibrium framework to show how the oil-producing countries use their dollar revenue from oil exports. His model reflects that the direction of the effect of increase in the price of oil depends on a comparison of the balance of payments of oil exporting and oil importing countries. His approach is focused on "real" factors – how much of OPEC's increased income will be spent on the U.S. goods. Since OPEC countries will spend their extra incomes from export only after a time lag, the increase in the price of oil will not boost the exports of industrial countries instantaneously. So, there is no deterioration of American or German current account, although, their capital accounts will improve. OPEC countries will

invest their extra incomes in dollars and marks. The magnitude of the effect of the increase in oil price on dollar will be determined by the proportion of invested assets in dollar by OPEC and the share of the U.S. in current account deficit with other countries.

Golub (1983), was more concentrated on studying wealth transfers and their impact on portfolio equilibrium as a result of the oil price change. He had the same three-area analysis as Krugman (1980). He concluded that the increase in oil price, would cause stronger dollar if OPEC propensity to hold dollars were high. As a result, the impact of the higher oil price on exchange rate would depend on the relocation of wealth. If OPEC will keep dollars, it will keep the exchange constant. However, if they would prefer to keep their financial assets in marks, they need to sell dollars in order to obtain marks. It will cause dollar depreciation against German mark due to the changes in demand and supply foreign exchange market.

Amano and van Norden (1995), have documented a robust relationship between the real price of oil and real effective exchange rates for Japan, Germany and the U.S. Their results suggested that the price of oil may have been one of the main sources of persistent real exchange rate shocks and that energy prices have had important implications on exchange rate sustainability. Before the explanation of their results, it is worth mentioning that, during their work, they have found that: there was significant evidence that both the real effective US exchange rates and the oil price contained a unit root. Also, the oil price had Granger causality with the exchange rate but not vice versa. Lastly, a stable dynamic model with the usage of lagged real oil prices, was significantly better in forecasting out-of-sample than a random-walk model. Therefore, the results that were obtained by Amano and Norden (1995) were as follows: the U.S. real exchange rate was co-integrated with the real price of oil, suggesting that the real price of oil was one of the dominant sources of persistent oil shocks over the post-Bretton Woods period. The causality tests showed that oil prices determined the exchange rate but the exchange rate did not have any effect on oil prices. They made a single-equation error correcting model with the real price of oil and real effective exchange rates. It was stable, and it captured much of in-and out-of-sample movement in the exchange rate in dynamic simulations. The tests showed that the error correcting model had a good out-of-sample predictive ability, for both the size and sign of changes in the real effective exchange rate.

Some of the researchers even tried to make forecasts of future exchange rates based on oil prices. Such economists as Ferraro, Rogoff and Rossi (2015), showed the existence of a short-term correlation on the basis of daily frequencies of oil and exchange rate. Their results were a bit paradoxical, as they showed that there was a little systematic relation between the changes in oil prices and exchange rate on a monthly and quarterly basis. On the contrary, the very short-term relationships between oil and exchange rates were robust enough to make predictions.

However, Kilian and Vigfusson (2015), made a very valuable argument. They mentioned that even such proficient macroeconomic news announcers as Bloomberg and Wall Street Journal do not always predict the exchange rate fluctuations due to the changes in oil prices on a daily basis. The reason for this is that, there is a nonlinear relationship between the oil price and the dollar exchange rate. Kilian said that there were debates found in economic literature about whether unexpected oil price shocks cause recessions. He was assuming a small country model that is highly dependent on oil import. His work is saying that after analysing oil price shocks and their effects on the real sector and exchange rate, it is impossible to make a certain scenario of how a certain country's economy will react to a certain oil price shock of a certain magnitude.

Findlay and Rodriguez (1977) looked at the increase in the price of oil as an increase in import bill of a country. They tried to apply an imported intermediate input in Keynesian model. Their work was written in 1977 after a sharp increase in the price of oil and they were analysing this impact on oil-importing countries in terms of exchange rate. They saw oil as an imported intermediate input in Mundell-Fleming Model. Mundell-Fleming Model could be seen as a close relative of IS-LM model, which is a mathematical representation of the Keynesian model. The key difference is that IS-LM model assumes that the economy is closed, whereas Mundell-Fleming uses the assumptions of an open economy, where the capital is perfectly mobile and the exchange rates are flexible (Feenstra and Taylor 2012).

So, Findlay and Rodriguez assumed that if a country comes across an increase in one of the main costs of production of tradable goods in the economy, the overall price level in the economy will go up (Findlay and Rodriguez, 1977). This results in the real exchange appreciation caused by a higher price

level in the economy. The real exchange rate between two currencies is the product of the nominal exchange rate and the ratio of prices between the two countries (Feenstra and Taylor 2012). According to Mundell-Fleming model, higher real exchange rate makes the country's tradable goods less competitive internationally. Therefore, their net exports will decrease to a certain point.

Section II

Campbell and Clarida (1987), Meese and Rogoff (1983) found that even general predictions about the co-movements of real interest rates and real exchange rates are rejected by the data. They had a number of reasons that were rejecting the idea that it is possible to explain exchange rate movements using conventional exchange rate models.

However, MacDonald and Taylor (1994) showed that there is a long-run relationship between the variables that are used in the monetary model of exchange rates. They also concluded that the monetary model is far more effective than a random walk model in out-of-sample forecasting. Gardeazabal and Regulez (1992), studied monetary policy of exchange rates and used co-integration to test and predict the exchange rate. Yet, the data was rejecting some of the parameters imposed by the approach. The evidence that monetary model is much better for explaining the deviations in exchange rates is still uncertain.

Some of the researchers started to analyze exchange rates, using purchasing power parity (PPP) condition, and the ability of the exchange rate to adjust under this condition. Grossman and Rogoff (1997) found some evidence in favour of PPP condition when they used sufficiently long spans of data. It was a much-unexpected result, because over a long period of time, one would expect a gradual shift in the industrial structure of a country's productivity growth due to advances in technology, development and other factors that may alter real equilibrium exchange rates.

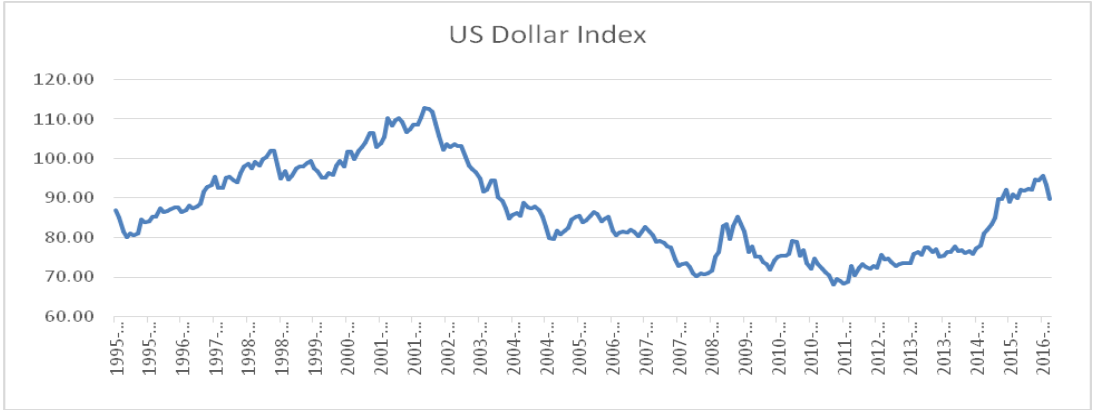
The main goal of the work of Rossi (2013) was to answer a question; "Does anything forecasts exchange rates, and if so, which variables?" It was believed that exchange rate is a very difficult trend to forecast using economic models. Meese and Rogoff (1983) found that it is better to use a random walk model for making economic forecasts. There was such a phenomenon as Messe-Rogoff puzzle. This has been a very arguable topic since 1983 when Richard Messe and Kenneth Rogoff concluded that a random walk model is the most applicable model for forecasting exchange rates. Their findings implied the fact that, international economics and finances have been very underdeveloped and the companies that were spending on analytics of the exchange rate in order to make the right financial decision were wasting their money. Rossi (2013), said that the predictability of exchange rate depends on forecast horizon, sample period, model and forecast evaluation method. She concluded that some other models such as Taylor-rule forecasting model exhibit some predictive ability for the short run periods, and monetary model reveal some predictive ability for the longer periods of time, but neither approach found empirical support for superior exchange rate forecasting ability of a predictor for all courtiers, time periods and models.

**3.** Data

**3.1.** The US dollar index trend

**Figure 1. The U.S. dollar index**

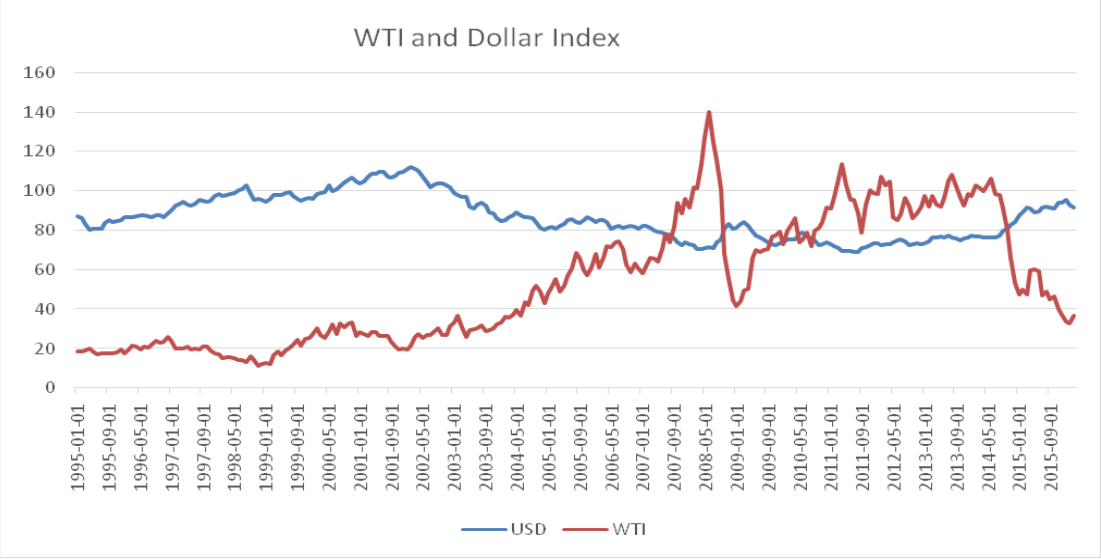
**Table 1. The U.S. dollar index descriptive statistics**



| | 1995-2003 | 2004-2008 | 2009-2016 |
|---|---|---|---|
| Mean | 96.5578 | 80.8930 | 78.0934 |
| Median | 96.9991 | 81.6969 | 76.2304 |
| Standard Deviation | 8.066227 | 4.988595 | 6.930620 |

The graph above shows the fluctuations of DXY Exchange Rate, which is the index of dollar performance with the base year 1973 against a weighted basket of currencies that includes Euro, Yen, Great British Pound, Canadian dollar, Swiss Franc and Swedish Krona. The U.S. currency has been rising since mid-1995 and falling since mid-2001. It is possible to see that mean and median of dollar index were relatively high with a standard deviation of 8 in the period 1995-2003. Then the U.S. dollar had a negative trend against the basket of currencies. It is both seen from the graph and the chart. Although, the U.S. dollar has appreciated by almost 20% due to the booming results of the U.S. economy in the period 2007-2008, it has fallen back after the financial crisis of 2008. Later, it was a volatile period without a certain trend. Since 2014 it was a steady yearly appreciation of the USD. However, the U.S. currency started falling again at the end of 2015. Separate graphs that show the exchange rate deviations of Japanese yen, Great British pound, Canadian dollar, Swiss franc and Swedish krona against the U.S. dollar are included in Appendix 1.

**Figure 2. West Texas Intermediate crude oil spot price and the U.S. dollar index**




After the 2008 crisis, the volume (total sum of credits) and the scale (the number of borrowing countries) of the financial help from the International Monetary Fund and the World Bank grew. Thus, the total volume of borrowings from the World Bank grew by 20%, from $127.068 billion in 2008 to $152.513billion in 2015 (WorldBank, 2017). The volume of total financial help from the IMF also increased (International Monetary Fund, 2017).

### 3.2. Comparison of the oil price and dollar index

On the graph above, it is possible to see that with an increase in the price of oil, the U.S. dollar index has been falling since 2001. The USD experienced a very moderate volatility in the periods, when oil prices were changing significantly. To compare, it is possible to take standard deviations of WTI oil price and the dollar index. In the period 1995-2003 oil price was not rising significantly and its standard deviation was $5.7593 per barrel. During the same period, the U.S. dollar experienced the highest volatility among the periods examined in this study. It had a volatility of 8.066277 points. When the oil price picked up at almost $140, the dollar index was at the lowest point in the period between 1995-2016. When the oil prices experienced a sharp fall in 2008, the U.S. dollar has appreciated. Also, it is possible to see that at the most current period, the oil prices are lower than in post-2007 period, but the value of dollar against the major

currencies is relatively high. It could therefore be seen as illogical, as the USD is a major key in the oil sector trade. According to empirical works of Amano and van Norden (1998), Throop (1993) and Findlay and Rodriguez (1977), the relation between oil price and the USD should be positive. However, the current period implies oil price decrease and dollar appreciation, and this is atypical for some of the previous papers.

**4.** Methodology

To analyze the relationship between oil prices and exchange rates, the same model that was used by Kaushik, Nag and Upadhyaya (2014), was applied to test oil price effects on Indian Rupee. This model is based on monetary approach to exchange rate determination Frenkel (1976). This approach highlights the fact that the foreign exchange market is a monetary phenomenon, where monies are traded for monies. Another important issue in this approach is 'purchasing power parity' condition (PPP) which holds true: goods-market arbitrage will adjust exchange rate to equalize prices in different countries (Boughton 1989).It is important to mention the domestic money supply as it determines the price level for domestic country. Therefore, relative supplies of money, determine the exchange rate. The increase in domestic money supply relative to foreign money stock will cause a depreciation of domestic currency. The model also assumes that uncovered interest parity (UIP) condition holds true. Uncovered Interest Parity condition assumes that the difference in interest rates between two countries is equal to the expected change in exchange rates between these two countries (Backus and Frenkel 1985). Also, the model assumes that the expectations must be rational (Boughton 1989).

This paper used the model based on Frenkel (1985) and Ahking (1989) flexible-price monetary model, which was further developed by Kaushik, Nag and Upadhyaya (2014), by the inclusion of the price of oil to estimate its impact on real exchange rate.

We performed the correlation analysis of the influence of the index of gender equality and the index of climate change according to the UN on the oil prices and USD parity (United Nations Development Programme, 2017), (UN, 2017). Correlation of the gender equality index and the oil price index constituted 98.54%, and correlation of the climate change and oil prices index constituted 99.63%. Correlation of the index of gender equality and USD parity constituted 99.31%, correlation of the index of climate change and USD parity constituted 99.26.

The results of the performed analysis show that oil price and USD parity are predetermined by the influence of non-monetary indicators – such as gender equality and climate change. We also determined that protectionism, and fighting the manipulation of the exchange rate, accompany the growth of oil prices and USD exchange rate.

**Equation 1.**

$$logRER = c_0 + c_1 \log(m) + c_2 \log(m^*) + c_3 \log(y) + c_4 \log(y^*) + c_5(i - i^*) + c_6 \log(RPOIL) + u$$

In Equation 1, RER, the real exchange rate is defined as the product of nominal exchange rate and the ratio of foreign price index to domestic price index; m stands for the real domestic money supply; y is real GDP; irepresents the interest rate and RPOIL is the real price of oil. The asterisk * stands for foreign country. United Kingdom, Canada, Switzerland, Sweden and Japan are seen as foreign countries and are denoted as *.

It is possible to make some predictions regarding the equation. If there is an increase in domestic money supply and other variables remain constant, the price level in the domestic country grows. According to purchasing power parity, all prices should be equalized in real terms. Therefore, domestic exchange rate will depreciate. The U.S. dollar will be weaker against other currencies. Conversely, an increase in foreign market supply, holding other factors constant, will cause a proportional rise in prices for foreign goods. That will result to a proportional long-run appreciation of domestic currency against the currencies in countries, where the money base was increased (Feenstra and Taylor 2012).

**5. Estimation and empirical results**

In order for our models to be valid, we need to ensure that we do not get spurious results which may happen if our models contain non-stationary variables. We can test for non-stationarity by using either the augmented Dickey-Fuller test or the Phillips Perron test. Each has its own advantages and disadvantages: Phillips Perron test is more robust to heteroskedasticity, and doesn't need the lag length specified, but the augmented Dickey-Fuller test may be more powerful (Greene 2003). The equation augmented Dickey-Fuller test (for variable$X_t$) is performed by estimating the following equation:

**Equation 2.**

$$\Delta X_t = \alpha + \rho_t + \beta X_{t-1} + \sum_{i=1}^{n} \lambda_i \Delta X_{t-1} + \varepsilon_t$$

Where Δ is the first difference operator, t is a time trend, and $\varepsilon_t$ is a stationary random error term. The null hypothesis of the test is$H_0$: β =0 which corresponds to the situation that $X_t$ has a unit root and is therefore non-stationary. If the test is significant, then we can reject this null hypothesis and conclude that $X_t$ is stationary (Greene 2003).For the Phillips Perron test we estimate a similar equation but without any lagged difference terms:

**Equation 3.**

$$\Delta X_t = \beta X_{t-1} + \epsilon_t$$

The null hypothesis is the same as for the augmented Dickey-Fuller test, but the test statistics is calculated in a slightly different way, which makes it robust to heteroskedasticity and serial-correlation.

The augmented Dickey-Fuller (ADF) and Phillips Perron (PP) test statistics for each variable in both levels and first differences (FD), are shown in table 3, with stars indicating the level of significance of each value. The ADF and PP statistics are significant for all of the first differenced variables at the 5% level, except for lgjapan_m3 (the log of Yen money supply) which is significant at the 10% level. For a small number of the variables, one or other of the ADF and PP test statistics are also significant in the levels.

Since we want to estimate the coefficients of equation 1, which is expressed in the non-stationary levels of the log transformed variables, we will need to estimate an error correcting model which uses the stationary, first differenced versions of the variables.

**6. Discussion**

The US bilateral trade deficits, unsustainablebail-outofGreece, UK Brexit, Indiademonetization, and other phenomena in the modern world economy, also potentially influence the growth of oil prices and the USD parity. Due to the multitude of indicators and factors that potentially influence oil prices and the USD parity, only the most vivid of them are studied in this research, which is a certain limitation. Expansion of the list of the studied factors and conduct of a large-scale factor analysis of oil prices and USD parity are a perspective direction for further scientific research in this sphere.

**7. Conclusions**

This paper estimates the effect of oil price change on the real exchange of the U.S. dollar. In order to see the effect, the monetary approach to the exchange rate was applied. The variables included in the model are; the price of oil, domestic real money balances, foreign money balances, domestic and foreign output, long run interest differences. The U.S. real exchange rate was a dependent variable. The currencies that were tested against the U.S. dollar were seen as foreign, and they included British Pound, Japanese Yen, Canadian Dollar, Swiss Franc, and Swedish Krona. Monthly time series data from 1995 to 2015 was used. Before the model estimation, the time series properties of the data were diagnosed, using the standard unit root test and co-integration test. The data was found to be stationary and the hypothesis of no co-integration was rejected. Hence, an error correction model was written and tested. The results showed that foreign money supply is an important determinant for the exchange rate of YEN/USD, foreign output was a significant determinant for the exchange CHF/USD, the difference in long run

interest rates was shown to be statistically significant for CHF/USD, SEK/USD, and YEN/USD. The oil price though seems to be statistically significant for SHF/USD, SEK/USD, GBP/USD, CAN/USD but not for YEN/USD. As a result, the increase in price of oil causes a minor appreciation of the U.S. dollar against most of the currencies analysed in this paper.

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Appendix 1.

**Figure 1. Exchange rate Swiss Franc/ U.S. Dollar**

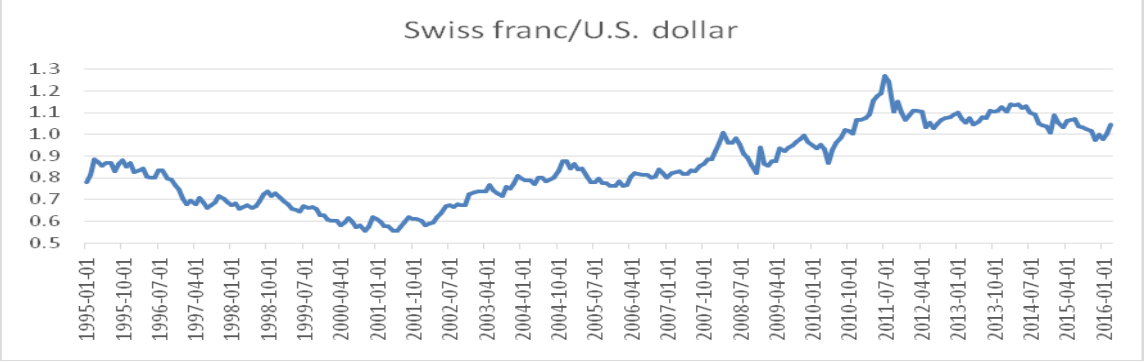


**Figure 2. Exchange rate Japanese Yen/ U.S. Dollar**

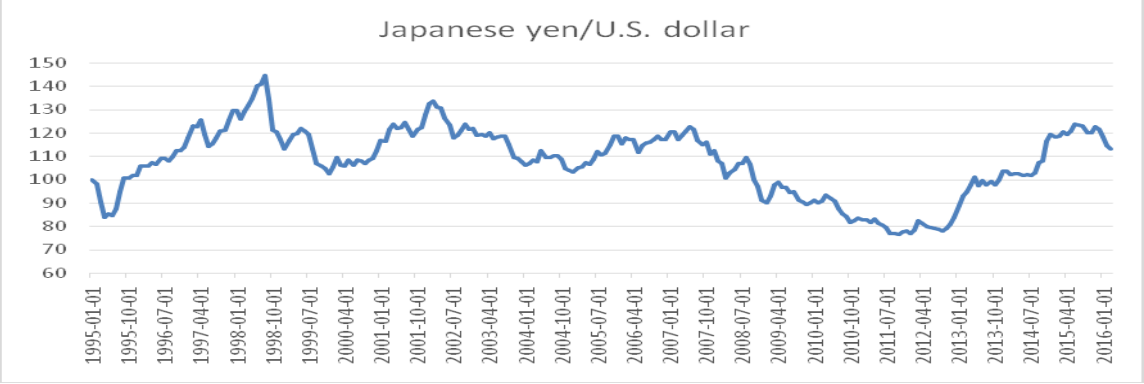

**Figure 3. Exchange rate British Pound/ U.S. Dollar**

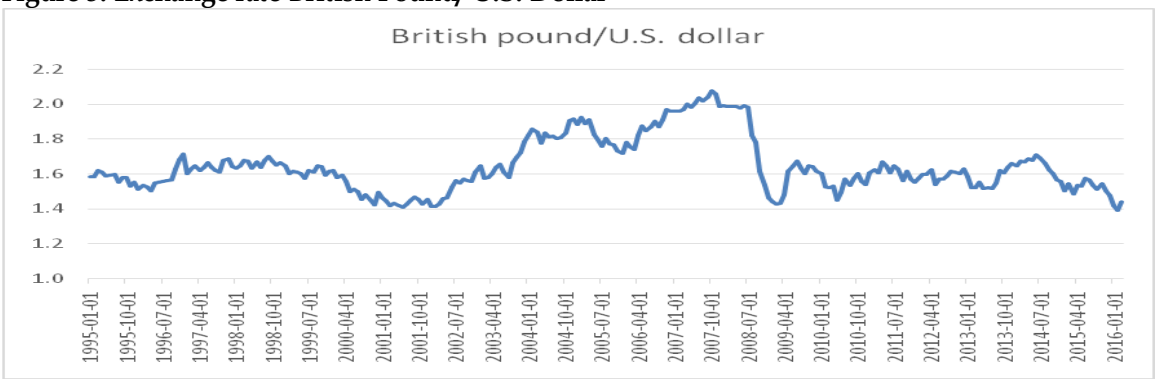


**Figure 4. Exchange rate Swedish Krona/ U.S. Dollar**

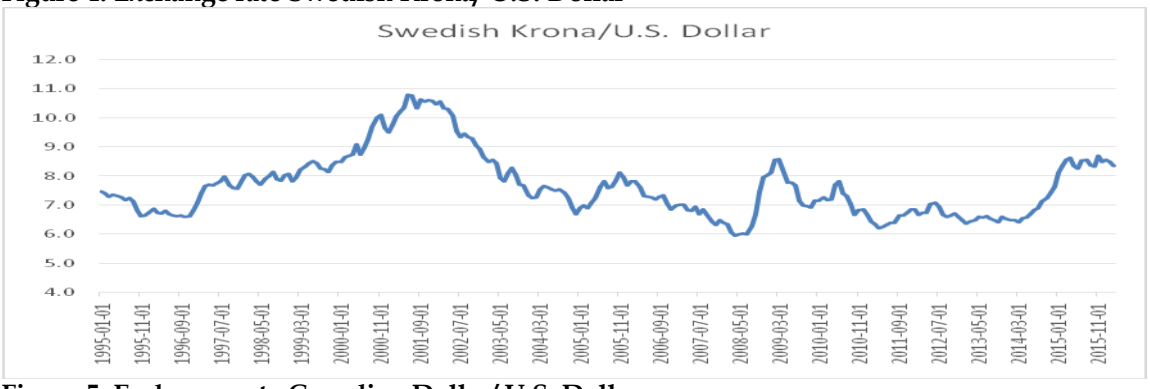


**Figure 5. Exchange rate Canadian Dollar/ U.S. Dollar**