Exchange Rate Forecasting models: Does UIP hold against Random Walk and Carry Trade?

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Abstract

This paper examines the accuracy of the exchange rate forecasting models for OECD countries and their currencies.

In this thesis, the performance of structural exchange rate models, as UIP model compared against the Random Walk model. previous studies presented that no single model beats the Random Walk. In this paper we see that the results are ambiguous and vary between both UIP model and Random Walk model during the pre-crisis and post-crisis periods. In addition, the obtained results from the Diebold-Mariano test reveal that during the pre-crisis period the UIP model produces significantly less forecasting errors for the CLP/USD, HUF/USD and KRW/USD currency pairs while the Random Walk model produces lower forecasting errors for the ILS/USD, JPY/USD, CZK/USD, PLN/USD, NZD/USD and ISK/USD during the pre-crisis period. Hence, better forecasting accuracy. During the pre-crisis period the UIP model is no worse than the Random Walk in predicting for the CAD/USD, TRY/USD, NOK/USD, SEK/USD and CHF/USD currency pairs.

During the post-crisis period, the results indicate that UIP model is superior for the JPY/USD, MXN/USD, TRY/USD and NZD/USD currency pairs and produces less forecasting errors. The Random Walk also produces less forecasting errors for the AUD/USD and PLN/USD currency pairs. Furthermore, the Null Hypothesis cannot be rejected for the EUR/USD, HUF/USD, SEK/USD, CHF/USD, KRW/USD, CZK/USD and ISK/USD thereby implying that both the UIP model and the Random Walk model are equally good in forecasting these currency pairs.

In addition, the UIP model has been compared to the Carry Trade strategy during the pre and post-crisis periods to examine whether the Carry Trade strategy succeeds to earn an average excess return during the periods where UIP model does not hold. However, during the pre-crisis and post-crisis periods the Carry Trade obtained results show average excess returns in the periods whether the UIP model have negative statistically significant beta coefficients or it's statistically insignificant.

Keywords: Exchange rate, Comparison, Forecast, UIP, Random Walk, Diebold Mariano

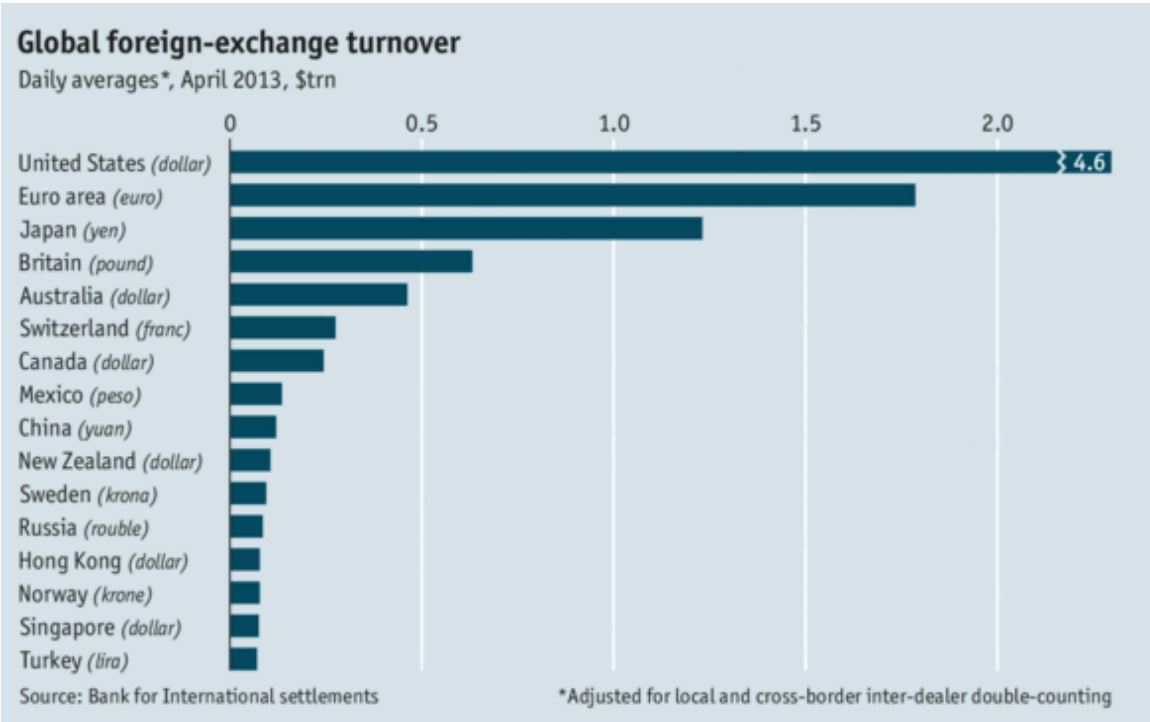
Content

List of Figures and Tables:

1. Introduction

The foreign exchange market is the most and greatest liquid market on the globe. Figure 1 illustrates that the Bank of International Settlements' daily average turnover of the foreign exchange market in April 2013 was 5.3 trillion USD compared to 4 trillion USD on the last survey of 2010 and 3.3 trillion USD in 2007. The Bank of International Settlements BSI conducts the survey every three years with the resulting evidence of the BSI capturing the increase in global foreign exchange turnover within a timeline of the past 9 years. The result shows that the traded currencies have been increased after the world crisis of 2008 as it went from 3.3 USD trillion in 2007 to 4 USD trillion in 2010.

Figure 1: the global foreign exchange turnover.



Source: Bank for International Settlements

There are many debates between empirical research groups on exchange rate prediction models. Part of these groups claim that the foreign exchange rate markets is efficient. Therefore, the changes in exchange rates are better explained by the random walk model. Another part of these groups supports an alternative method. To them, the market fundamentals should be the driving determinants of the exchange rate. Mussa (1979) claims in his empirical study foundation that the exchange rate cannot be predicted by following the random walk model. In (1983) Meese and Rogoff drew the same conclusion after testing the structural prediction models and the covered interest rate parity against random walk model. The interest rate parity assumes that the interest rate differential between two countries should be equal to the expected change in exchange rate. Flood and Rose (2002) claimed that uncovered interest rate parity does well in time of crisis with no distinction between the short and long run. Furthermore, Chinn and Meredith (2004) and Chaboud and Wright (2005) generated results in favor of the uncovered interest rate parity but they disagree on whether it works well in the long or short-term period.

Through the last few years, some of attention has been given to a phenomenon called carry trade. The International Monetary Fund (IMF) defines carry trade as: *"A leveraged transaction in which borrowed funds are used to take a position in which the expected return exceeds the cost of the borrowed funds"*.

The carry trade strategy basically means that the investor goes long and buys currencies from countries with high interest rate and then goes short and sells those currencies with low interest rate. The definition of carry trade strategy is conditioned upon the violation of the uncovered interest rate parity that claims that high interest rate currencies should depreciate against low interest rate currencies. To spot the carry trade phenomenon, the high interest rate currencies must appreciate or not depreciate more than the interest rate difference against the low interest rate currencies. If the currency depreciated value higher than the interest rate deferential, the strategy is not successful. Plantin and Shin (2007) claimed that the carry trade is a self-enforcing arbitrage strategy, therefore an increasing pressure to buy (sell) on the high (low) yielding interest rate currency will cause a strengthening (weakening) of the exchange rate and hence the market inefficiency increases.

The Diebold – Mariano test (1995) has been used to compare the differences in accuracy between the currency exchange rate models. The Diebold- Mariano test aims to discover which of the compared models produces less errors and thus is more accuracy. The obtained results from currency exchange rate forecasting UIP model will be compared to the Random Walk using Mean Absolut Errors (MEA) and Root Mean Square Errors (RMSE). The compared results in Diebold-Mariano test will assess the statistical robustness of the used currency exchange rate forecasting models.

The next section reviews the cutting edge of academic literature on the most used monetary and currency exchange rate forecasting models.

2. Literature Review

2.1. Random Walk model

The Random Walk's method introduced first by Pearson (1905). The main concept of his paper shows that future stock price movements cannot be predicted by their historical movements. Therefore, the stock price of period "t" is the stock price of period "t-1" added to the error term. Later in this paper, the UIP model will be compared with The Random Walk model with respect to their forecasting accuracy and do the Random Walk model produces less errors comparing to the UIP model and hence, higher predictive power.

From a historical point of view on exchange rate forecasting models we see that many researchers tried to compete with Random Walk model but none of the models performed well enough compared to the model Random Walk. According to Meese and Rogoff (1983), the tested models did not perform significantly better than the Random Walk model. Also, taking into consideration the certainty that the models used the obtained values as explanatory variables which, imply that you can better flip the coin then proceed the research using another model to continue forecasting the exchange rate movements. In other words, the market fundamental based model failed to outperform the random walk model in the part of "*out of sample*". The results of Mees also were supported by test Diebold & Mariano (1995), the test performed to forecast the exchange rates using a 3-month forward rates, Diebold found that random walk model generated substantial significant results compared to the forward relative to forward contracts.

In (2003) Kilian and Taylor's paper, they explained the reason why such a basic and naïve Random Walk model is difficult to beat. They represented in their paper that forecasting using linear model is a mistake and therefore, the predictive power has been failed. This may happen as a result of non-linear data. However, the exchange rates with the underlying fundamentals such as the relative prices, works the best only for longer horizons. This is the reason why Kilian and Taylor moved to use longer horizons. The use of longer horizons two to three years is not attractive for most investors because it is a general modeled with long horizon forecasting.

2.2. The Purchasing power parity (PPP)

Purchasing Power Parity is the conversion rate of currency that adjusts and eliminates price level differences between countries through the equalization of the different currencies purchasing power. This implies that price level between countries is expressed in their currencies and should to be equal. Taylor and Sarno (1998) described the purchasing power parity and imply that changes in the nominal exchange rate should be equal to underlying changes of the domestic price levels, which means that the real exchange rate is constant. Purchasing power parity states that the home currency spot exchange rate "S" is equal to the domestic aggregate price level "p" over foreign aggregate price level "p*". This implies the law of one price which states that a good is equally expensive in each country when converted to a common currency. The most prominent example of the economic law is the "Big Mac" index, which provides a close examination of exchange rate valuation. The purchasing power parity states the law of one price to a basket of goods. Using the PPP value for the exchange rate is determined based on the change in two countries relative price levels. Studies such as Frankel (1996) showed that due to the failure of the law of one price, the purchasing power parity as a prediction model has been rejected.

2.3. Taylor Rule Model

Taylor (1993) gives us a rule based on the inflation rate differences, the central bank could set the nominal interest rate. When inflation rate exceeds the level they prefer, the central bank will raise the nominal interest rate. Taylor's formed model could be able to forecast short time horizons the same as purchasing power parity.

2.4. Covered interest rate parity

The covered interest rate parity occurs when interest rate differential between domestic and foreign currencies is offset by the forward exchange rate of those currencies. Simply, the return on domestic interest rate's borrowed amount equals the return when the interest rate's borrowed amount in a foreign currency. When the foreign interest rate is higher than the domestic interest rate, the interest rate differential between both of them is compensated by a lower forward exchange rate.

Frenkel and Levich (1975) showed in their academic paper a deviation from the covered interest parity condition occurred. Frenkel and Levich concluded that the CIP condition held for a certain period during the examined test “from January 1962 until November 1967”. Also, Taylor (1986) examined in his paper whether a profit could be made by borrowing in one currency and lending in the other one, in this case the US dollar. Taylor found data that support the CIP condition. However, from 144 observations in his data, he found only one arbitrage opportunity occurred.
Concluding on the mentioned academic papers above on covered interest parity, there is a deviation from CIP condition and thus trading strategies shouldn’t expect to earn a significant excess amount of return.

2.5. Uncovered interest parity

Uncovered interest parity situation assumes that the interest rate differential between the foreign and the domestic countries should to be equal to the expected change in exchange rate. According to the UIP model, an increase in the interest rate differential should be compensated by currency depreciation or in other words, the future exchange rate depreciation expected to compensate a positive interest rate differential. However, if UIP holds, there is no profit arbitrage opportunity could be made due to the high yield currency is expected to depreciate by the amount that equal to the two countries interest rate differential. If UIP condition does not hold, this means that the capital markets are not efficient and gain form an arbitrage could be made.
The UIP condition has been studied and tested by many researchers. Even though some researchers have been loosely supported the UIP model, the majority of researchers have empirically rejected the validity of UIP which implied that $\alpha = 0$ and $\beta = 1$.

Many earlier studies such as Hodrick, L.P. (1987) and Froot, K.A., Thaler, R.H. (1990) have supported the violation and rejection of UIP. An empirical paper by Huisman and Koedijk (1998) examined the UIP condition using panel approach, the result support the claim that UIP condition does not hold in all periods. Concluding that the rejection of UIP condition is not severe as is commonly found but still does not hold in all periods. Another paper support the previous claim is King (1998) paper, the paper examined the validity of UIP between New Zealand and four of its key trading partner. The UIP did not held for all periods even After capital control removal. The same conclusion has been drawn also by Sarno (2005) test results, which UIP does not hold for all time horizons. P. Isard (2006) concluded on UIP validity that is strongly challenged by the empirical results, at least at short-time horizons, he also claims that the variation may exist due to the risk premium. A. Mehl and L. Cappiello (2007) estimated the UIP model for long horizons in mature economy and emerging market, the supported results were in favor of UIP in mature currencies. However, the results were against of emerging market currencies.

Flood and Rose (1994) also Jurek (2007) got the same opposite results to UIP condition even though the results only valid for extreme periods. Later test has been done by Flood and Rose (2002), examined the uncovered interest parity model during the financial crisis and shows the influence of this financial crisis on UIP model. The supported results indicate that the currencies with high interest rate depreciate during the financial crisis which is a sign of UIP prediction validity but this depreciation of the currency was not large enough to compensate the entire differential of the interest rate.

If UIP condition holds then the possibility of carry trade profitability will be zero. After looking into Flood and Rose (2002)'s results we find that UIP does hold only in extreme periods, the possibility of carry trade strategy may occur as results of UIP weakness.

2.6. Carry Trade

Due to the failure of uncovered interest parity model in the most papers mentioned before, some of the attention has been given to a phenomenon called carry trade. The International Monetary Fund (IMF) defines carry trade as follows:

"A leveraged transaction in which borrowed funds are used to take a position in which the expected return exceeds the cost of the borrowed funds[1]".

The main concept behind the carry trade strategy is borrowing in currencies "funding currencies" with low interest rates and investing in high interest rates currencies "target currencies". However, the investors generate profits in case of currency appreciation during the life of the investment.

According to Galati and Melvin (2004), there was an increase in volume of foreign exchange trading between the years 2001 and 2004. Galati explained in his paper that this increase by an extended period of exchange rate appreciation of high interest rate currencies lead the investors to gain, is the situation called carry trade. Galati stated that the period of low or flat

[1] International Monetary Funds (IMF) Carry Trade Strategy definition. (2007b, 102)

bond yield might have been a reason of growing trend of investing in FX market during that period where in that market currencies such as US dollar and Swiss Frank with low interest rates acting as a funding currencies, while currencies with a high interest rates acting as a target currencies such as Australian dollar.

Dunis and Miao (2007) used the carry trade strategy in the periods January 1999 and to March 2005 for nine major currency. Dunis results on carry trade strategy were positive and well performed in many aspects such as returns, risk adjusted returns and the maximum of potential loss but the strategy does not perform well is case of market where the volatility considered to be high. Furthermore, Dunis and Miao concluded that the interest rate differential between currency pairs is not fully compensated by either the depreciation or the appreciation of the given exchange rate.

Galati an McGuire (2007) considered the carry trade as main role of the exchange rate relocation, Galati and Melvin (2004) mentioned that the large institutional investors such as commodity traders and hedge funds are the big players, for that reason there is a pressure on sold and bought currencies because the big investors hold a big and large positions. In cases where those big investors hold on carry trade position, this will weaken the currency with low interest rate and gives strength to the currency with high interest rate. Therefore, the large investors movement could affect the currency if they decide to take or reverse their positions.

An interesting research has been done by Burnside et al. (2008), he considered the diversifications opportunities among different currency pairs. Burnside used a 23 currency pairs of an equally weighted portfolio. The results on these weighted portfolios showed a huge decrease in volatility and increase in sharp ratio as consequence. Briere and Drut (2009) done the same research of Burnside (2008) using the currency pairs equally weighted portfolio with added two portfolios with high and low interest rate differential. The test result shows a huge deviation from UIP model for the high interest rate differential currency pair portfolios, but the result also shows the impact of the financial crisis on carry trade strategy. In financial crisis period the currency pairs with high interest rate differential generate a lower sharp ratios comparing the results with the period with no crisis, the result generates a higher sharp ratios, which is the same conclusion of Dunis and Miao (2007).

Menkhoff et al. (2011) claimed that the carry trade strategy high returns are generated to compensate for the time varying risk. In high volatility period, the result shows a lower return of the currencies with high interest rate and positive higher return of the currencies with low interest rate.

Gyntelberg and schrimpf (2011) examined the performance of carry trade during the financial distress period. They conclude that during the financial distress, the return on carry trade continued to generate attractive return for extended periods, but there were a significant downside risks has been involved. In contrast, the carry trade strategy yielding small gains most of the time but exposing the investors to a large risk.

Mancini and Ronaldo (2012) examined the impact of liquidity risk on the carry trade strategy. Mancini found that the currencies with high interest rate produce a positive betas which have more exposure to liquidity risk than the currencies with low interest rate that produce a negative betas and therefore are less exposure to liquidity risk. The results consist with Gyntelberg (2011) results in extending where the investor exposed to higher risk.

2.7. Diebold & Mariano

In (1995) Diebold&Mariano introduced a technique to evaluate the results and measure the accuracy between exchange rate forecasting models. Their method could be used on multiple forecasting periods. Add to that, Diebold's method can measure the errors between two exchange rate forecasting models and evaluate which of these models produces more or less errors. The knowledge has been generated by Diebold's method leads to more confidence when choosing between exchange rate forecasting models.

Diebold's test can generate an over-sized results while increases the forecasting time horizons. The noted issue has been addressed by Harvey, Leybourne and Newbold (1997) who advised the usage of an approximately unbiased estimator of the variance of the mean loss differential, under the condition that the forecast accuracy is measured in terms of mean-squared prediction error also, assuming a zero autocorrelation at order *h* and beyond these errors. Diebold (1995) used a standard unit normal distribution. However, Harvey advised the usage of comparison Diebold & Mariano statistics test with thecritical value of *t*-test instead. Furthermore, Mariano (2007) admitted that the given advice helped to solve the issues and to improve the generated test results.

Back in (1996) West concluded on Diebold's method that when the test does not relay on regression estimation, the test will provide a suitable prediction results. Furthermore, West and McCraken (1998) claimed that if the indicators do not relay on the estimated parameters, the Diebold & Mariano results could be applied, but this should not be the case in the opposite situation.

The proposed method by Diebold&Mariano (1995) was widely successful, the method was used for the empirical finance issues and in currency exchange rate predictability by quite many researchers such as; Mark (1995) examined a test to compare Diebold&Mariano method to random walk model with respect to the predictive ability of estimated regression. Mark concluded that forecasts point based on fundamental outperform random walk model in the long-run. Also, White (2000) involved the work by West (1996) and Diebold&Mariano (1995) in developing a method called “ Reality check Bootstrap” to deal with data snooping issues.

The Diebold&Mariano method is proven to be effective in dealing with a number of applications in economics and finance.

As of now, most of the literatures on currency exchange rate models have been covered. The next chapter will cover the methodology and the econometric procedure in general to be used in the paper.

3. Data and methodology

In this section, the used data will be discussed as well as the methodology for the empirical research. Firstly, describing the data and its specification. Later, discussing the major used models included in the research. Finally, describing the tests used for the models accuracy and their robustness.

The used data will be divided into two periods in this analysis. The first period covers all the years after the Bretton Woods collapse until the beginning of the Global Financial Crisis in 2008. In the empirical research, this period is called pre-crisis period. The selected starting date is associated with the fixed currencies regime where all currencies were fixed to the U.S. dollar. Therefore, forecasting of exchange rates while the dominating currency system is fixed exchange rates will produce ineffective results. As a result of that, the starting point selected on March 1973 when officially Bretton Woods's system collapsed and all currencies included in this empirical research were freely floating (P. M. Garber, 1993). The second period covers data after the beginning of the Global Financial Crisis and covers all the years until July 2014, in the thesis this period is specified as the post-crisis period.

There are several reasons for dividing the analysis into two periods. First, the purpose of dividing the analysis into two periods is to examine the predictive power of the used forecasting models. In such a way, the test can examine, whether UIP and Random Walk models produce accurate forecasts results in the pre-crisis period and in the post-crisis period. As a result of that, the test results and model's predictability can be compared during different periods. In addition, crisis period is ambiguous that has an effect on the forecasts. Dividing into two periods might capture these differences. Finally, during the Global Financial Crisis there were certain policies and movements implemented (changes in monetary policy, quantitative easing, etc.) that might have an effect on the currency future exchange rate. Therefore, the effect of the model might have different predictive power than during the pre-crisis period. As a result of this, the data divided into two different periods to examine the predictive power of the selected models.

In addition, the estimated UIP model results during the pre-crisis and post-crisis periods will be compared to the Carry Trade strategy during the same period to examine whether the Carry Trade strategy succeed to generate an average excess return during the periods where UIP model does not hold.

3.1. Data

The empirical research covers only the OECD countries and their currencies. In this paper, We select only the OECD countries currencies because for emerging markets, the future currencies exchange rates might be less predictable due to omitted factors such as unstable environment, economics, politics etc. These factors might not be captured in the regressions and might have an effect on currencies in these economies leading to inaccurate forecasts. While selecting only the OECD countries, the test can examine the effect of the selected model on the exchange rate forecasts for the developed currencies, which might be more predictable and might produce statistically significant results. Since in the list of the OECD countries there are many economies that use Euro, the total number of analyzed currencies is decreased from 34[2] to 20[3].

The used data set in the empirical research was obtained from Thomson Reuters Database. This database covers data for all relevant currencies during the analyzed period. Considering all the OECD currencies relatively to one U.S. dollar with a monthly data used. All the included currencies are of countries, which in 2014 were in the list of OECD. Similarly, all the countries that before 2014 used national currencies while in 2014 adopted the Euro in the analysis are considered as using the Euro and thus, their national currencies are dropped from the analysis. Since the data as of March 1973 is unavailable for every currency, We use the earliest available data for every currency. In such a way, 38 different regressions obtained with different examined periods for every currency.

Every currency in the pre-crisis period has a different number of observations. The list of currency pairs with their official codes is provided in *Appendix 1.* GBP/USD exchange rate has the longest available data and covers the period from March 1973 until September 2008. AUD/USD, CAD/USD, EUR/USD, CHF/USD, DKK/USD, HUF/USD, JPY/USD, KRW/USD, MXN/USD, NOK/USD, NZD/USD, SEK/USD, TRY/USD have an available data that starts in January 1994 and ends in September 2008. The exchange rates between PLN/USD and CZK/USD cover the years from January 1995 until September 2008 while ILS/USD has data available since November 1999 and CLP/USD since December 1999 whereas ISD/USD since June 1997. The post-crisis period covers a significantly lower

[2] The OECD countries are Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom and the United States.

[3] Australia, Canada, Chile, Czech Republic, Denmark, Hungary, Iceland, Israel, Japan, Korea, Mexico, New Zealand, Norway, Poland, Sweden, Switzerland, Turkey, United Kingdom, the United States and the Euro zone with the euro.

number of observations. Most of the currencies for the post-crisis period have data starting since 2008 and until July 2014.

In addition, the empirical research requires interest rate for every country. Since the LIBOR is unavailable for the required period for the all selected currencies therefore, we used 1-month interest rate for every currency. This data is also obtained from the Thomson Reuters database.

3.2. Methodology

3.2.1. Pre-crisis period

Pre-crisis period covers all available data for the 20 OECD currencies. In other words, the obtained data set after March 1973 until September 2008 for every currency. Due to unavailability of data for every currency since March 1973, every regression has a different number of observations. Therefore, we choose to divide the available period for every currency into two equal periods and use the first one in the following equation that summarizes the UIP model and the carry trade Strategy implemented in the empirical research as follow:

3.2.1.1. The uncovered interest rate parity:

$$\Delta s_{t+1}^{UIP} = \alpha + \beta(i_t - i_t^*) + \epsilon_t \qquad (1)$$

Where, Δs_{t+1}^{UIP} is the change in the exchange rate from period *t* to period *t +1*, $i_t - i_t^*$ is the difference between one-month interest rate in the domestic country's interest rate (i.e. one of the OECD currencies except of the United States) and in the United States. α and β are coefficients whereas ϵ_t is the error term. UIP model holds when α equal to zero whereas β equal to 1. In such a case, we expect that an increase in the interest rate differential leads to depreciation in the exchange rate of the foreign currency by an equal amount.

The basic specification provided in equation 1 has been used for all currencies.

3.2.1.2. The carry trade strategy:

Carry trade strategy consists of borrowing currencies with low interest rate and lending currencies with high interest rate. Assuming that all OECD currencies are the domestic currencies and their interest rates are i_t. The USD in this paper is the foreign currency and it's interest rate i_t^*. S_t is the currency exchange rate expressed as OECD currency "domestic" per one USD "foreign currency". Consider the following strategy. Borrow the domestic currency at the domestic interest rate i_t, convert the domestic currency at the exchange rate into $\frac{1}{S_t}$ foreign currency unit (FCU), then invest these (FCUs) at the foreign interest rate i_t^*. At the time *t+1,* the investor will convert the (FCUs) into the domestic currency at exchange rate S_{t+1} .

If the carry trade is done by borrowing and lending in the money market, the payoff of the domestic currency to the carry trade without transaction costs is[4]:

$$S_{t+1}^{C} = \left[(1 + i_t^*)\frac{S_{t+1}}{S_t} - (1 + i_t)\right] \mathrm{y}_t \tag{2}$$

Where:

$$\mathrm{y}_t = \begin{cases} +1 & if \quad i_t^* > i_t \\ -1 & if \quad i_t > i_t^* \end{cases} \tag{3}$$

The Carry Trade strategy is a zero-net investment strategy. Therefore, in equation (3) we normalize the amount of the currency, we bet on that absolute value of y_t to one.

The econometric rejection of the UIP model outcome implies by being in the situation where an investor benefits from high interest rate currency appreciation. According to the UIP model there should not be excess return. Therefore, the expectation of S_{t+1}^{C} should be equal to zero. In other words, if UIP condition holds, the $E\left(S_{t+1}^{C}\right) = 0$.

For UIP model, first part of the data, the estimation specification of the UIP gives particular coefficients, i.e. α and β. According to the UIP model, the change in the two countries interest rate should determine the future exchange rate. Therefore, the major hypothesis here is to examine the predictive power of the obtained coefficients. These estimated coefficients

[4] The Carry Trade used strategy Based on A. Craig Burnside et al. (2008). The Carry Trade Strategy is earlier most used by variety of researchers. See also Galati and Melvin (2004).

are further used for the forecasting of the OECD countries exchange rates relative to the U.S. dollar for the out-of-sample data. The second part of the data varies for every currency depending on the total number of observations that is available. In other words, α and β obtained from the first part of data and use them to forecast the future exchange rate of the respective currencies for the second part of the data.

In addition, we test and evaluate whether the selected currencies are homoskedastic. Also, whether there is no autocorrelation. The heteroskedasticity could have a negative effect on the coefficients either upwards or downwards. This leads to biased results and irrelevant conclusion. Therefore, was very necessary to correct for it. Currencies are corrected for heteroskedasticity. Such currencies for UIP model are AUD/USD, ILS/USD, TRY/USD, NZD/USD, White's test in the Eviews statistical package has been used. Also, Newey-West's specification has been used to correct for autocorrelation and heteroskedasticity if any currency has both.

Another theory states that exchange rates are unpredictable and follow the random walk model (Meese & Rogoff, 1983). Thus, in addition to the UIP model and to the carry trade strategy, we include Random Walk model to compare it with the UIP model. Similar to the UIP model, we divide the available data into two periods and apply similar procedure to UIP. According to the Random Walk model, the expected change in exchange rate should be equal to 0. Therefore, equation (4) summarizes the Random Walk model that is estimated in the empirical research:

3.2.1.3. Random Walk

$$\Delta s_{t+1}^{RW} = 0 \tag{4}$$

3.2.2. Post-crisis period

Post-crisis period covers the data from September 2008 until November 2014. The methodology for the post-crisis period is similar to the pre-crisis period. Therefore, dividing the available data period for every currency into two equal parts. Using the first part I estimate equation (1) for the UIP model to obtain α and β coefficients that are used to forecast the out-of-sample monthly exchange rates for the respective currencies, i.e. the second part of the data, the regressions include substantially lower number of observations, as the data for the most recent months is unavailable.

Similar to the pre-crisis period, evaluating the heteroskedaticity and autocorrelation of the data. The following currencies are corrected for UIP model's heteroskedasticity using White's test: AUD/USD, CLP/USD, DKK/USD, HUF/USD, ILS/USD, MXN /USD.

In addition, using Random Walk model and estimating equation (4) as for the pre-crisis period. The procedure is similar to pre-crisis period, though, the number of observations is substantially lower.

3.2.3. Forecasting accuracy

Using the above described UIP and Random Walk models give particular forecasting errors. Two different measurements have been used to evaluate the accuracy of the forecasts.

The first accuracy measure is the Mean Absolute Error [MAE]. Equation (5) shows how this measure is calculated:

$$MAE = \frac{1}{T}\sum_{i=1}^{T}\left|\Delta s_{t+1}^{F} - \Delta s_{t+1}\right| \tag{5}$$

where, $\Delta s_{t+1}^{F} - \Delta s_{t+1}$ is the difference between the forecasted changes in exchange rate Δs_{t+1}^{F} and the actual change in exchange rate Δs_{t+1} whereas *T* is the number of observations. In other words, it is the difference between forecasted exchange rate and the actual one after taking absolute value and dividing it by the number of observations.

The second accuracy measure is the Root Mean Square Error [RMSE] that is summarized in equation (6):

$$RMSE = \sqrt{\sum_{i=1}^{T}(\Delta s_{t+1}^{F} - \Delta s_{t+1})^{2}} \tag{6}$$

This is the square root of the squared difference between the forecasted exchange rate and the actual one. The lower the forecasting errors and thus, the number obtained from equation (5) and equation (6), the more accurate the forecasts are of the respective model. In particular, applying equation (5) and equation (6) for both UIP and Random Walk models. Similar measures are applied to both examined periods, i.e. pre-crisis and post-crisis.

3.2.4. Diebold-Mariano

To compare the accuracy of the currency exchange rate forecasting models, Diebold&Mariano test has been preformed (Diebold&Mariano, 1995). With this test we intend to measure, which of the models are more accurate in predicting exchange rates for the selected currencies. In other words, this statistic test is used to evaluate, whether the UIP model produces statistically significantly more accurate forecasts results compared with the Random Walk model. This test uses above-mentioned forecasting errors to measure the accuracy of the model. Specifically, in addition to the major hypothesis stated above, the hypothesis regarding Diebold&Mariano is as following:

UIP model against Random Walk model:

$$H_0: E\left[L\left(\epsilon_{t+h|t}^{UIP}\right)\right] = E\left[L\left(\epsilon_{t+h|t}^{RW}\right)\right]$$

$$H_1: E[L\left(\epsilon_{t+h|t}^{UIP}\right)] \neq E[L\left(\epsilon_{t+h|t}^{RW}\right)]$$

$L\left(\epsilon_{t+h|t}^{UIP}\right)$ and $L\left(\epsilon_{t+h|t}^{RW}\right)$ represent loss functions of UIP model and Random Walk forecasting models respectively. This can also be written as:

$$H_0: E[d_t] = 0$$

$$H_1: E[d_t] \neq 0$$

For UIP model against RW d_t is equal to:

$$d_t = L\left(\epsilon_{t+h|t}^{UIP}\right) - L(\epsilon_{t+h|t}^{RW}) \tag{7}$$

Equation (8) obtained to calculate "d squared" while equation (9) calculate "d absolute" for the DM test statistics:

$$d_{squared,t} = (\hat{\epsilon}_t^{UIP})^2 - (\hat{\epsilon}_t^{RW})^2 \tag{8}$$

$$d_{absolute,t} = \left|\hat{\epsilon}_t^{UIP}\right| - |\hat{\epsilon}_t^{RW}| \tag{9}$$

Where $\hat{\epsilon}_t^{UIP}$and $\hat{\epsilon}_t^{RW}$are UIP and Random Walk estimated forecasting errors, respectively. Equation (8) is the difference between the squared errors of UIP and Random Walk models, respectively while, equation (9) is the difference between the absolute errors of UIP and Random Walk models, respectively.

The DM statistic is summarized in equation (10).

$$DM = \frac{d_t}{SE(d_t)} \tag{10}$$

Where $d_t$is obtained from equation (8) and equation (9) whereas $SE(d_t)$ is the standard error of the calculatedd_t. I calculate DM statistic for both $d_{squared,t}$ and $d_{absolute,t}$. Then comparing the results to determine, which model has higher predictive power?.

Overall, this section describes the major data as well as the methodology used for the empirical research. Therefore, using the above described models and methodology we intend to evaluate UIP model forecasting during pre-crisis and post-crisis periods. Also, anticipating UIP model to produce statistically significantly more accurate forecasts results compared with Random Walk.

4. Empirical research

This part discusses the results of the empirical research. Firstly, I concentrate on the pre-crisis period and later I discuss the results of the after-crisis period. The last part of the chapter includes the robustness checks of the selected models.

4.1. Descriptive statistics

Table 1 shows the descriptive statistics of the main variables including large differences in the 1-month rates between the different currencies for the OECD countries exchange rates before the world crisis of 2008. The mean of month rate differs from 0.001 for the British pound up to 0.049 for Turkish Lira. Looking at the monthly std. Deviation varies from 0.014 for the Canadian dollar and goes up to 0.058 for the Turkish Lira.

Table 1 “ pre-crisis”

This table shows the descriptive statistics for OECD countries for pre-crisis period. The variable is the change in the exchange rate relative to U.S. dollar.

The change in exchange rate pre-crisis relative to the USD				
	Mean	Std. Dev	Min	Max
GBP	0.001	0.032	-0.131	0.079
EUR	0.003	0.026	-0.073	0.065
AUD	0.003	0.029	-0.064	0.082
CAD	0.002	0.014	-0.033	0.032
CLP	0.003	0.028	-0.057	0.070
DKK	0.002	0.028	-0.072	0.066
HUF	0.012	0.022	-0.073	0.064
ILS	0.001	0.020	-0.036	0.040
JPY	0.001	0.040	-0.166	0.098
MXN	0.012	0.053	-0.136	0.359
TRY	0.049	0.058	-0.138	0.312
NZD	0.003	0.029	-0.065	0.078
NOK	0.002	0.025	-0.050	0.057
KRW	0.005	0.053	-0.109	0.358
SEK	0.002	0.027	-0.059	0.065
CHF	0.002	0.040	-0.099	0.061
CZK	0.003	0.032	-0.066	0.090
PLN	0.006	0.027	-0.079	0.074
ISK	0.001	0.026	-0.023	0.072

Table 2 shows the descriptive statistics of the main variables including large differences of the currencies for the OECD countries exchange rates after the world crisis of 2008. The mean of month rate varies from -0.009 for the Japanese Yen and up to 0.045 for Norwegian krone. The monthly standard deviation varies from 0.034 for the Japanese yen and the Israeli Shekel and goes up to 0.076 for the Icelandic Krone.

More in depth data will be included in *Appendix 2*.

Table 2 " post-crisis "

This table shows the descriptive statistics for OECD countries for post-crisis period. The variable is the change in the exchange rate relative to U.S. dollar.

The change in exchange rate post-crisis relative to the USD				
	Mean	Std. Dev	Min	Max
GBP	0.002	0.039	-0.100	0.110
EUR	0.000	0.043	-0.098	0.093
AUD	0.007	0.055	-0.107	0.152
CAD	-0.003	0.038	-0.093	0.115
CLP	-0.003	0.044	-0.057	0.178
DKK	0.000	0.043	-0.099	0.090
HUF	0.004	0.067	-0.107	0.194
ILS	-0.001	0.034	-0.069	0.077
JPY	-0.009	0.034	-0.065	0.082
MXN	0.003	0.043	-0.093	0.150
TRY	0.010	0.052	-0.060	0.192
NZD	-0.005	0.060	-0.133	0.152
NOK	0.045	0.051	-0.015	0.119
KRW	-0.001	0.058	-0.134	0.132
SEK	-0.000	0.053	-0.110	0.106
CHF	-0.008	0.043	-0.128	0.090
CZK	-0.000	0.054	-0.100	0.133
PLN	0.005	0.065	-0.102	0.168
ISK	0.009	0.076	-0.198	0.276

4.2. Uncovered Interest Rate Parity

Firstly, we regress the exchange rate between the OECD countries' currencies and U.S. dollar on the interest rate differential. Thus, estimating equation (2) to determine the relevant coefficients $\propto$ and β. The results of the regressions are provided in Table (3) and Table (4).

Table 3

This table shows OLS estimates for OECD countries. The dependent variable is the change in the exchange rate relative to USD while the independent variable is the difference between US 1-month interest rate and respective countries interest rates. Where necessary, the estimates are corrected for heteroskedasticity using White's test. Panel A shows the results using the pre-crisis period whereas Panel B includes the results for the post-crisis period. The currency codes are provided in *Appendix 1.* The number in the parenthesis is the standard error, significance at 10%, 5% and 1% are showed by *, ** and ***, respectively.

Panel A "The estimated coefficient pre-crisis"

	GBP	EUR	AUD	CAD	CLP	DKK	HUF	ILS	JPY	MXN
Beta	-0.139**	-0.383**	-0.621**	-0.151	0.026	-0.492**	0.026	-0.290**	-0.603*	0.034
	(0.054)	(0.181)	(0.246)	(0.129)	(0.215)	(0.211)	(0.034)	(0.128)	(0.344)	(0.041)
Alpha	0.001	0.001	0.006**	0.001	0.003	-0.001	0.008	0.015**	-0.027	0.005
	(0.002)	(0.003)	(0.003)	(0.002)	(0.007)	(0.003)	(0.006)	(0.007)	(0.017)	(0.011)
Observations	213	88	88	88	52	88	88	53	88	88
Adj. R-square	0.026	0.039	0.029	0.004	-0.020	0.049	-0.005	0.074	0.023	-0.003

Panel B "The estimated coefficient post-crisis"

	GBP	EUR	AUD	CAD	CLP	DKK	HUF	ILS	JPY	MXN
Beta	1.827	1.355	3.199***	2.678*	0.393	0.372	0.045	0.792	2.270	1.430*
	(1.095)	(1.147)	(1.159)	(1.323)	(0.443)	(0.922)	(0.704)	(0.729)	(2.618)	(0.723)
Alpha	-0.009	-0.009	-0.135***	-0.018*	-0.014	-0.004	0.001	-0.015	-0.006	-0.075**
	(0.008)	(0.011)	(0.047)	(0.010)	(0.010)	(0.012)	(0.042)	(0.011)	(0.007)	(0.035)
Observations	35	35	35	35	35	35	35	35	33	34
Adj. R-square	0.164	0.012	0.163	0.084	0.021	-0.018	-0.030	0.013	-0.008	0.162

The results in Panel A of Table 3 indicate that the estimated coefficient is negative and statistically significant for the GBP/USD exchange rate. This indicates that the interest rate differential between U.S. and U.K. leads to an expected appreciation of the British pound relative to the U.S. dollar. Therefore, a 10% increase in difference between the United Kingdom and the United States interest rates lead to an expected depreciation of the USD relative to the GBP by approximately 1.4%, which means that the currency pair GBP per USD increases. As a result, an investor could earn an expected capital gain by investing in British pound. The results contradict with the theory as the UIP model states that the estimated coefficient should be positive and equal to 1.

Similar conclusions can be drawn for the EUR/USD, AUD/USD, DKK/USD and ILS/USD currency pairs. The coefficients are negative and statistically significant at 5%. This results that an investor expected to invest in Euro, Australian dollar, Danish krone and Israeli shekel whereas selling the U.S. dollar. The results also do not support the academic theory. In addition, the JPY/USD exchange rate estimated beta coefficient is only marginally significant, though, has a negative sign as well. However, the estimated coefficients have no statistical power for the CAD/USD, CLP/USD, HUF/USD and MXN/USD. This results that the change in the interest rate differential between the U.S. and the relative countries does not affect the future exchange rate during the pre-crisis period.

Panel B illustrates the estimated coefficients of the respective currencies for the post-crisis period. It shows that the statistical significance for all currencies disappears. An exception is for the AUD/USD exchange rate. The coefficient is above 1 and highly statistically significant. As a result, an increase in the interest rate differential between U.S. and Australia by 1% leads to an expected deprecation of the Australian dollar by approximately 3% which has a strong economic significance. Thus, an investor expected to buy or invest in the U.S. dollar and sell the Australian dollar to generate a capital gain.

On the other hand, the estimated coefficients become marginally significant for the CAD/USD and MXN/USD exchange rates. The coefficients are positive and results that an investor earns an expected capital gain by investing in the U.S. dollar and selling the Canadian dollar as well as selling the Mexican peso.

Table (4), Panel A illustrates the estimated coefficients of the remaining currencies during the pre-crisis period. The results indicate similar pattern as in Table (3). An increase in the interest differential between the U.S. dollar and the Swedish Krona as well as the Swiss Franc interest rates lead to an expected appreciation of these currencies relative to the U.S. dollar. As a result, an investor prefers to buy and to invest in Swedish krone as well as Swiss franc and sell U.S. dollar. An exception for the TRY/USD exchange rate. The coefficient is positive and highly statistically significant indicating that an investor expects to sell the Turkish lira and invest in the U.S. dollar.

The statistical power of the estimated coefficients decreases during the post-crisis period. As the results illustrate, the estimated beta is positive and high statistically significant for the NZD/USD, SEK/USD and PLN/USD exchange rates. In other words, an increase in the interest rate differential between U.S. and Australia by 1% leads to an expected deprecation of the given domestic currencies by approximately 2.6%, 2% and 3.8% respectively, which have a strong economic significance for both the NZD/USD and PLN/USD. This results that an investor expects invest in the U.S. dollar and sell the given domestic currencies in the post-crisis period.

Table 4

This table shows OLS estimates for OECD countries. The dependent variable is the change in the exchange rate while the independent variable is the difference between US 1-month interest rate and respective countries interest rates. Where necessary, the estimates are corrected for heteroskedasticity using White''s test. Panel A shows the results using the pre-crisis period whereas Panel B includes the results for the post-crisis period. The currency codes are provided in *Appendix 1*. The number in the parenthesis is the standard error, significance at 10%, 5% and 1% are showed by *, ** and ***, respectively.

Panel A "The estimated coefficient pre-crisis"

	TRY	NZD	NOK	KRW	SEK	CHF	CZK	PLN	ISK
Beta	0.059***	-0.120	-0.163	0.077	-0.350***	-0.369**	0.007	-0.040	-0.029
	(0.022)	(0.164)	(0.175)	(0.214)	(0.129)	(0.233)	(0.103)	(0.081)	(0.048)
Alpha	0.003	0.005	0.003	0.002	0.002	-0.010	0.003	0.012	0.003
	(0.014)	(0.005)	(0.003)	(0.008)	(0.003)	(0.008)	(0.005)	(0.012)	(0.004)
Observations	88	88	88	88	88	88	83	82	68
Adj. R-square	0.345	-0.006	-0.002	-0.006	0.068	0.017	-0.012	-0.010	0.027

Panel B "The estimated coefficient post-crisis"

	TRY	NZD	NOK	KRW	SEK	CHF	CZK	PLN	ISK
Beta	0.460	2.622***	-	2.573	2.049**	-9.704	1.318	3.899***	0.363
	(0.369)	(0.841)		(1.615)	(0.821)	(6.613)	(1.618)	(1.369)	(0.483)
Alpha	-0.029	-0.081***	-	-0.059	-0.023*	-0.021*	-0.023	-0.123**	-0.023
	(0.028)	(0.026)		(0.038)	(0.012)	(0.012)	(0.026)	(0.046)	(0.033)
Observations	28	34	-	34	34	34	34	34	33
Adj. R-square	0.081	0.209	-	0.045	0.137	0.034	0.054	0.177	0.015

4.3. Carry Trade

In this chapter Tables (5) and (6) provided below shows the Carry Trade Strategy average excess returns during the pre-crisis and the post-crisis periods. Furthermore, the results of the carry trade strategy average excess returns will be compared to the beta coefficients of the UIP model. According to the UIP model, there should not be an excess return from the Carry Trade strategy. In other words, the expected returns on such strategy equal to zero.

Table 5

This table shows Carry Trade strategy average excess returns for OECD countries. The all currencies are relative to USD. Panel A shows the results using the pre-crisis period whereas Panel B includes the results for the post-crisis period. The currency codes are provided in *Appendix 1.* The significance level at 10%, 5% and 1% are showed by *, ** and *** respectively.

Panel A "pre-crisis average excess returns"

	GBP	EUR	AUD	CAD	CLP	DKK	HUF	ILS	JPY	MXN
Average returns	0.002	0.008**	0.001	0.006***	0.021***	0.009**	1.896**	0.046***	0.048***	0.203***

Panel B "post-crisis average excess returns"

	GBP	EUR	AUD	CAD	CLP	DKK	HUF	ILS	JPY	MXN
Average returns	0.003	0.005	0.045***	0.008	0.029***	0.012	0.725	0.017**	-0.007	0.051***

The pre-crisis results in panel A of Table (5) indicate that the average excess returns are positive and statically significant at 1%, 5% and 10% for the EUR/USD, CAD/USD, CLP/USD, DKK/USD, HUF/USD, ILS/USD, JPY/USD and MXN/USD currency pairs. This indicates that, there is an expected average excess returns expected to be made for these currency pairs during the pre-crisis period. The U.S. dollar “foreign currency” expected to appreciate relatively against the domestic currencies. As a result, an investor expected to take a long position on the U.S. dollar to generate an excess return.
Furthermore, we compare the Carry Trade results of Table (5) panel A to the UIP results of Table (3) panel A. We find that the beta coefficients of the UIP model for the currency pairs EUR/USD, CAD/USD, DKK/USD, ILS/USD and JPY/USD are negative and statistically significant, the negative beta coefficient in such regression implies a rejection of the UIP model. However, the results of Table (5) panel A for the same currency pairs are positive and statistically significant. As a results of that, the investor who takes a long position and invest in the foreign currency pair “U.S. dollar” expect to gain an excess returns in case of dollar appreciation. For the currency pairs CLP/USD, HUF/USD and MXN/USD in Table (3) panel A, the estimated beta coefficients have no statistical power. However, the carry trade results show a positive and significant average excess returns for the same currency pairs. The same conclusion could be drawn, the investors expected to gain an average excess return in case of U.S. dollar appreciation. The currency pairs GBP/USD and AUD/USD in Table (5) panel A are insignificant and have no statistical power for currencies movement during the pre-crisis period.

Table (5) panel B shows an average excess returns of the carry trade strategy during post-crisis period. The average returns are positive and statistically significant for the currency pairs AUD/USD, CLP/USD, ILS/USD and MXN/USD. This implies that the investors expected to gain from the U.S dollar appreciation an average excess return in case borrowing the domestic currencies and investing in the foreign currency “U.S. dollar”. The result of UIP model Table (3) panel B shows that the UIP beta coefficients for the currency pairs CLP/USD and ILS/USD are positive and statistically insignificant in other words, there is no statistical power for those currencies. The same currency pairs CLP/USD and ILS/USD result in Table (5) panel B on carry trade strategy shows a positive average returns and statistically significant. The same conclusion could be drawn as before, the investors gain average excess returns on these two currency pairs during the post-crisis period. However, the results of the currency pairs AUD/USD and MXN/USD are ambiguous during the post-crisis period, they are both positive and statistically significant for the UIP model and the Carry Trade strategy. The currency pairs GBP/USD, EUR/USD, CAD/USD, DKK/USD and JPY/USD in Table (5) panel B are insignificant and have no statistical power for currency pairs movement during the post-crisis period.

The pre-crisis results for the remaining currency pairs in panel A of Table (6) shows that the average excess returns are positive and statically significant at 1%, 5% and 10% for the TRY/USD, NZD/USD, KRW/USD, CHF/USD, CZK/USD, PLN/USD and ISK/USD currency pairs. This indicates that there is an expected average excess returns could be made for these currency pairs during the pre-crisis period. The U.S. dollar expected to appreciate against the domestic currencies or at least not depreciate. As a result, an investor expects to take a long position on the foreign currency to make an excess profit on their capital investments.

Furthermore, comparing the Carry Trade results of Table (6) panel A to the UIP results of Table (4) panel A during the pre-crisis. The beta coefficients of the UIP model currency pair CHF/USD is negative and statistically significant. The same as we interpreted before, the negative beta coefficient in such regression implies a rejection of the UIP. However, the Carry Trade results of Table (6) panel A for the CHF/USD currency pair is positive and statistically significant at 1% significant level. As a result of that, the investor who takes a long position on the CHF currency expected to gain an excess return. For the currency pairs NZD/USD, KRW/USD, CZK/USD, PLN/USD and ISK/USD in Table (4) panel A, the estimated beta coefficients have no statistical power. Again, the results indeed in favor of the Carry Trade show a positive and significant average excess returns for the same currency pairs. The same conclusion could be drawn, the investors expect to gain an average excess profit in case of U.S. dollar appreciation.

The results of TRY/USD currency pair is ambiguous during the pre-crisis period, the TRY/USD for both Carry Trade strategy and UIP model is positive and statistically significant. The currency pairs NOK/USD and SEK/USD in Table (6) panel A are insignificant and have no statistical power for currencies movement.

Table 6

This table shows Carry Trade strategy average excess returns for OECD countries remaining currencies. The all currencies are relative to USD. Panel A shows the results using the pre-crisis period whereas Panel B includes the results for the post-crisis period. The currency codes are provided in *Appendix 1.* The significance level at 10%, 5% and 1% are showed by *, ** and *** respectively.

Panel A "pre-crisis average excess returns"									
	TRY	**NZD**	**NOK**	**KRW**	**SEK**	**CHF**	**CZK**	**PLN**	**ISK**
Average returns	0.724***	0.012***	0.001	0.045***	0.003	0.034***	0.045***	0.138***	0.058***

Panel B "post-crisis average excess returns"									
	TRY	**NZD**	**NOK**	**KRW**	**SEK**	**CHF**	**CZK**	**PLN**	**ISK**
Average returns	0.074***	0.032***	-	0.022**	0.011	-0.005	0.016*	0.025**	0.078***

The results of the post-crisis period in panel b of Table (6) illustrate the average excess returns on carry trade strategy of the remaining currency pairs. The results are positive and statically significant for the TRY/USD, NZD/USD, KRW/USD, CZK/USD, PLN/USD and ISK/USD exchange rates. This means that there is an average excess returns could be made for these currency pairs during the post-crisis period. The U.S. dollar expected to not depreciate against the domestic currencies also, in case of U.S. dollar appreciation the gain is even larger. This results an excess profit from being long on the foreign currency. Furthermore, comparing the Carry Trade during the post-crisis results of Table (6) panel B to those of the UIP in Table (4) panel B. The average return on carry trade strategy for the following currency pairs TRY/USD, KRW/USD, CZK and ISK/USD outperform the UIP model given results. The result of the currency pairs NZD/USD and the PLN/USD are ambiguous during the post-crisis period, the TRY/USD and PLN/USD for both Carry Trade strategy and UIP model are positive and statistically significant. The currency pairs SEK/USD and CHF/USD in Table (6) panel B are insignificant and have no statistical power for currencies movement.

Furthermore, We use the estimated coefficients (irrespective of their significance) for the forecasts of future exchange rates for both UIP and the Random Walk models using Eviews statistical package. Then, evaluating the forecast accuracy using equation (5) and equation (6) and calculate MAE and RMSE. The results are provided in Table (7) and Table (8).

Table 7

This table illustrates the estimates of the forecasting accuracy for the respective OECD countries' currencies for the pre-crisis and post-crisis periods. MAE is Mean Absolute Error while RMSE is Root Mean Squared Error. The estimated measurements correspond with the period of the forecasted exchange rate for every currency. Panel A shows MAE and RMSE of the UIP model for the pre-crisis period whereas Panel B shows MAE and RMSE of the Random Walk model for the pre-crisis period. Panel C shows MAE and RMSE of the UIP model for the post-crisis period whereas Panel D shows MAE and RMSE of the Random Walk model for the post-crisis period.

Panel A "UIP model during pre-crisis period"										
	GBP	**EUR**	**AUD**	**CAD**	**CLP**	**DKK**	**HUF**	**ILS**	**JPY**	**MXN**
MAE	0.019	0.020	0.024	0.019	0.024	0.020	0.031	0.022	0.022	0.016
RMSE	0.027	0.026	0.031	0.023	0.029	0.026	0.036	0.029	0.027	0.019
Panel B "RW model during pre-crisis period"										
	GBP	**EUR**	**AUD**	**CAD**	**CLP**	**DKK**	**HUF**	**ILS**	**JPY**	**MXN**
MAE	0.019	0.020	0.024	0.019	0.024	0.020	0.031	0.017	0.020	0.018
RMSE	0.026	0.026	0.030	0.023	0.029	0.026	0.037	0.024	0.025	0.022
Panel C "UIP model during post-crisis period"										
	GBP	**EUR**	**AUD**	**CAD**	**CLP**	**DKK**	**HUF**	**ILS**	**JPY**	**MXN**
MAE	0.018	0.019	0.047	0.017	0.026	0.021	0.033	0.016	0.022	0.028
RMSE	0.022	0.027	0.056	0.022	0.038	0.028	0.049	0.019	0.030	0.043
Panel D "RW model during post-crisis period"										
	GBP	**EUR**	**AUD**	**CAD**	**CLP**	**DKK**	**HUF**	**ILS**	**JPY**	**MXN**
MAE	0.018	0.018	0.027	0.016	0.025	0.018	0.033	0.017	0.023	0.026
RMSE	0.023	0.025	0.037	0.023	0.038	0.025	0.049	0.020	0.030	0.040

As the results indicate, both models, UIP and Random Walk models, produced a very similar MAE and RMSE. With the robustness check I will evaluate, whether this difference is statistically significant and whether the Random Walk model is producing more accurate forecasts

Table 8

This table illustrates the estimates of the forecasting accuracy for the respective OECD countries' currencies for the pre-crisis and post-crisis periods. MAE is Mean Absolute Error while RMSE is Root Mean Squared Error. The estimated measurements correspond with the period of the forecasted exchange rate for every currency. Panel A shows MAE and RMSE of the UIP model for the pre-crisis period whereas Panel B shows MAE and RMSE of the Random Walk model for the pre-crisis period. Panel C shows MAE and RMSE of the UIP model for the post-crisis period whereas Panel D shows MAE and RMSE of the Random Walk model for the post-crisis period.

Panel A "UIP model during pre-crisis period"									
	TRY	**NZD**	**NOK**	**KRW**	**SEK**	**CHF**	**CZK**	**PLN**	**ISK**
MAE	0.037	0.026	0.024	0.016	0.024	0.022	0.029	0.030	0.029
RMSE	0.049	0.033	0.030	0.022	0.030	0.027	0.036	0.037	0.037
Panel B "RW model during pre-crisis period"									
	TRY	**NZD**	**NOK**	**KRW**	**SEK**	**CHF**	**CZK**	**PLN**	**ISK**
MAE	0.058	0.027	0.024	0.017	0.024	0.022	0.028	0.028	0.029
RMSE	0.067	0.033	0.030	0.023	0.030	0.028	0.036	0.035	0.037
Panel C "UIP model during post-crisis period"									
	TRY	**NZD**	**NOK**	**KRW**	**SEK**	**CHF**	**CZK**	**PLN**	**ISK**
MAE	0.029	0.032	-	0.023	0.021	0.021	0.027	0.043	0.023
RMSE	0.038	0.042	-	0.029	0.027	0.036	0.038	0.054	0.027
Panel D "RW model during post-crisis period"									
	TRY	**NZD**	**NOK**	**KRW**	**SEK**	**CHF**	**CZK**	**PLN**	**ISK**
MAE	0.025	0.027	-	0.019	0.020	0.022	0.024	0.030	0.021
RMSE	0.033	0.038	-	0.027	0.026	0.036	0.033	0.042	0.028

4.4. Diebold & Mariano

To evaluate which model produces more accurate results, we calculate the absolute and the squared DM-Statistic as discussed in the previous chapter. The results of the regressions for the pre-crisis period are illustrated as follows:

UIP model against Random Walk model:

Table 9

This table illustrates Diebold Mariano estimates for the respective OECD currencies for the pre-crisis and post-crisis periods. The showed numbers illustrate squared errors. Panel A and Panel B illustrates the DM squared and absolute difference between squared and absolute UIP and Random Walk errors for the pre-crisis, respectively. Panel C and Panel D illustrates the DM squared and absolute difference between squared and absolute UIP and Random Walk errors for the post-crisis, respectively. Significance at 10%, 5% and 1% are showed by *, ** and ***, respectively.

Panel A "DM squared per-crisis"										
	GBP	**EUR**	**AUD**	**CAD**	**CLP**	**DKK**	**HUF**	**ILS**	**JPY**	**MXN**
DM-Statistic	1.176	-0.472	0.0255	-0.809	-2.437**	-0.318	-4.649***	3.528***	1.731*	1.389
p-value	0.239	0.637	0.798	0.418	0.015	0.749	3.34E-06	0.001	0.083	0.165
Panel B "DM absolute pre-crisis"										
	GBP	**EUR**	**AUD**	**CAD**	**CLP**	**DKK**	**HUF**	**ILS**	**JPY**	**MXN**
DM- Statistic	0.511	0.056	-0.181	-1.896*	-2.022**	0.136	-4.989***	3.808***	2.035**	0.788
p-value	0.609	0.955	0.857	0.058	0.043	0.892	6.05E-07	0.001	0.042	0.431
Panel C "DM squared post-crisis"										
	GBP	**EUR**	**AUD**	**CAD**	**CLP**	**DKK**	**HUF**	**ILS**	**JPY**	**MXN**
DM- Statistic	-0.382	1.016	4.036***	-0.752	-0.679	0.384	0.277	-1.117	-2.703***	-7.289***
p-value	0.703	0.309	5.43E-05	0.452	0.496	0.701	0.781	0.264	0.007	3.12E-13
Panel D "DM absolute post-crisis"										
	GBP	**EUR**	**AUD**	**CAD**	**CLP**	**DKK**	**HUF**	**ILS**	**JPY**	**MXN**
DM- Statistic	-0.226	0.203	4.547***	0.642	-0.325	-0.372	0.314	-1.199	-2.884***	-8.726***
p-value	0.821	0.003	5.45E-06	0.521	0.745	0.709	0.754	0.231	0.004	2.63E-18

The pre-crisis results in Table (9) Panel A and Panel B illustrates the DM- test Statistic for both squared and absolute loss functions respectively. During the pre-crisis period, the CLP/USD and HUF/USD currency pairs are negative and statistically significant at 5% and 1% respectively for both squared and absolute loss functions. For these specific currency pairs, the UIP model has lower forecasting errors and better forecasting accuracy. In other words, the UIP model out performs the Random Walk model during the pre-crisis period. Furthermore, the currency pairs ILS/USD and JPY/USD are positive and statically significant. The conclusion that could be drawn is that the UIP model produces a higher forecasting errors than the Random Walk model. Hence, the Random Walk outperforms the UIP model for these specific currency pairs during this specific pre-crisis period.

Apart form the CAD/USD absolute loss function that is statistically significant at 10% significant level, the remaining positive DM- Statistic currency pairs in Table (9) panel A and B are statistically insignificant, resulting that we cannot reject the null hypothesis. Therefore, both UIP model and Random Walk model are equally good in forecasting these currency exchange rates. The same conclusion holds for the currency pairs with negative DM-Statistic, the results insignificantly differ from zero. Hence, the UIP model is not worse than the Random Walk in predicting these exchange rate currencies.

Panel C and D in Table (9) shows the DM-test Statistic results during the post-crisis period for both squared and absolute DM-Statistic respectively. The AUD/USD exchange currency shows a positive and highly significant result for both squared and absolute DM-Statistics, though, the Random Walk model produces less errors than UIP and better forecasting accuracy. Furthermore, for the JPY/USD and MXN/USD currency pairs, the DM-Statistic of both are negative and statistically significant at 1% significant level which indicates that the Random Walk model have more errors and therefore, the UIP model produces better forecasting accuracy. For the remaining currency pairs, in case of positive and insignificant currency pairs such as EUR/USD and HUF/USD DM-Statistic results, we cannot reject the null hypothesis thus, both UIP model and Random Walk model are equally good in forecasting these currency pairs.

The same conclusion could be drawn for the currency pairs with negative DM-Statistic, the results insignificantly differ from zero. Therefore, Random Walk model is not better than UIP in predicting these currency pairs during this period.

Table 10

This table illustrates Diebold Mariano estimates for the respective OECD currencies for the pre-crisis and post-crisis periods. The showed numbers illustrate squared errors. Panel A and Panel B illustrates the DM squared and absolute difference between squared and absolute UIP and Random Walk errors for the pre-crisis, respectively. Panel C and Panel D illustrates the DM squared and absolute difference between squared and absolute UIP and Random Walk errors for the post-crisis, respectively. Significance at 10%, 5% and 1% are showed by *, ** and ***, respectively.

Panel A "DM squared per-crisis"									
	TRY	**NZD**	**NOK**	**KRW**	**SEK**	**CHF**	**CZK**	**PLN**	**ISK**
D- Statistic	1.227	1.657*	-0.827	-3.201***	-0.021	-0.903	4.376***	4.562***	1.687*
p-value	0.219	0.097	0.408	0.001	0.983	0.366	1.21E-05	5.06E-06	0.091
Panel B "DM absolute pre-crisis"									
	TRY	**NZD**	**NOK**	**KRW**	**SEK**	**CHF**	**CZK**	**PLN**	**ISK**
D- Statistic	1.136	2.313**	-0.931	-2.654***	-0.361	-0.654	3.541***	4.179***	1.805*
p-value	0.256	0.021	0.352	0.008	0.717	0.513	0.001	2.92E-05	0.071
Panel C "DM squared post-crisis"									
	TRY	**NZD**	**NOK**	**KRW**	**SEK**	**CHF**	**CZK**	**PLN**	**ISK**
D- Statistic	-1.694*	-0.001**	-	0.793	0.372	-0.198	2.429**	1.727*	-0.195
p-value	0.091	0.024	-	0.427	0.709	0.843	0.015	0.084	0.845
Panel D "DM absolute post-crisis"									
	TRY	**NZD**	**NOK**	**KRW**	**SEK**	**CHF**	**CZK**	**PLN**	**ISK**
D- Statistic	-2.595***	-0.008*	-	2.106**	1.039	-1.006	1.138	2.375**	0.528
p-value	0.009	0.085	-	0.035	0.298	0.314	0.255	0.017	0.597

The results in Table (10) Panel A and Panel B shows the DM- test Statistic for both squared and absolute DM-Statistics respectively. During the pre-crisis period, the KRW/USD currency pair is negative and statistically significant at 1% significant level for both squared and absolute DM-statistic. The KRW/USD currency pair result shows that the UIP has lower forecasting errors and better forecasting accuracy. Therefore, the UIP model outperforms the Random Walk model during the pre-crisis period. Furthermore, CZK/USD, PLN/USD, NZD/USD and ISK/USD are positive and statically significant at significant level 1%, 1%, 10% and 10% respectively. The conclusion could be drawn is that, the UIP model produces a higher forecasting errors than Random Walk model. Indeed, the Random Walk outperforms the UIP model for these specific currency pairs during this specific pre-crisis period.

TRY/USD currency pair in Table (10) panel A and B is positive and statistically insignificant, resulting that we cannot reject the null hypothesis. Therefore, both UIP model and Random Walk model are equally good in forecasting these currency exchange rates. The same conclusion holds for the currency pairs with negative DM-Statistic NOK/USD, SEK/USD and CHF/USD, the results insignificantly differ from zero. Therefore, UIP model is not worse than Random Walk in predicting these exchange rate currencies.

Panel C and D in Table (10) illustrates the DM-test Statistic during the post-crisis period for both squared and absolute DM-Statistic respectively. The PLN/USD currency pair is positive and significant for both squared and absolute DM-Statistics, though, the Random Walk model produces less errors than the UIP model and thus, a better forecasting accuracy. Furthermore, for the TRY/USD and NZD/USD currency pairs, the DM-Statistic for both are negative and statistically significant which indicates that the Random Walk model have more errors therefore, the UIP model produces better forecasting accuracy. For remaining currency pair, the SEK/USD is positive and insignificant currency pair, as results we cannot reject the null hypothesis thus, both UIP model and Random Walk model are equally good in forecasting these currency pairs. The CHF/USD exchange rate is negative and statistically insignificant, the results insignificantly differ from zero. Therefore, Random Walk model is not better than UIP in predicting these currency pairs. The same conclusion could be drawn for KRW/USD, CZK/USD and ISK/USD currency pairs, for these currency pairs the forecasting models are equally weighted in forecasting accuracy.

5. Conclusions

After analyzing the academic literature, it is visible that there are two major models used when forecasting exchange rates i.e. the UIP model and the Random Walk model. In addition, due to the failure of the UIP model the carry trade strategy implemented to gain from the high interest rate currency appreciation.

Various academics analyzed the performance of these models during different periods and for different currencies. In my thesis I aimed to compare the Uncovered Interest Rate Parity model as well as Carry Trade strategy during the pre-crisis period, i.e. before the Global Financial Crisis that started in September 2008, and post-crisis period, i.e. after September 2008 to discover if there are excess returns could be made in time where the UIP model does not hold. In addition, I incorporated Random Walk model to compare it with the UIP model during the two different periods for various OECD currencies to examine the forecasting accuracy for these two forecasting models by using Diebold&Mariano statistic test.

The UIP obtained results are ambiguous. During the pre-crisis period the estimated coefficients are negative and high statistically significant for the GBP/USD, EUR/USD, AUD/USD, DKK/USD/ ILS/USD, SEK/USD and CHF/USD exchange rates and marginally significant for the JPY/USD exchange rate. On the other hand, for the TRY/USD exchange rate the results correspond with the theory as the increase in the interest rate differential leads to the depreciation of the TRY relative to USD.

The post-crisis period results reveal much different pattern, the coefficients are positive and highly statistically significant for the AUD/USD, NZD/USD, SEK/USD and PLN/USD whereas positive and only marginally significant for the CAD/USD and MXN/USD exchange rates. For the remaining currencies the UIP model does not produce statistically significant forecasts resulting that interest rate differential has no statistical power in explaining the future exchange rate between these currencies and U.S. dollar.

The Carry Trade obtained results shows an average excess returns in the periods whether the UIP model have negative statistically significant beta coefficients or it’s statistically insignificant. During the pre-crisis period, the EUR/USD, CAD/USD, CLP/USD, HUF/USD, ILS/USD, JPY/USD, MXN/USD, NZD/USD, KRW/USD, CHF/USD, CZK/USD, PLN/USD and ISK/USD currency pairs are positive and statistically significant for the Carry Trade

Strategy, while the UIP model does not hold for the same currency pairs. However, the results were ambiguous for the TRY/USD currency pair, it is positive and statistically significant for both UIP model and the Carry Trade strategy.

During the post-crisis period, again the results show a sign of Carry trade strategy. The CLP/USD, ILS/USD, TRY/USD, KRW/USD, CZK/USD and ISK/USD currency pairs have a positive and statistically significant average excess profit on the carry trade strategy, while the UIP model does not hold for the same currency pairs. The results of AUD/USD, MXN/USD, NZD/USD and PLN/USD were ambiguous, the results were positive and statistically significant for both UIP and Carry Trade during the post-crisis period.

The carry trade strategy existence sign was way much better during the pre-crisis period than the post-crisis period. The results consist with the most of carry trade literature such as; Dunis and Miao (2007) also, Briere and Drut (2009).

In order to evaluate the forecasting accuracy, I calculate Diebold&Mariano Statistic. With this measure I intend to evaluate, whether the UIP model produces more accurate results as compared with the Random Walk model. The obtained results reveal that during the pre-crisis period the UIP model produces statistically significantly lower forecasting errors for CLP/USD, HUF/USD and KRW/USD. Therefore, the UIP model outperforms the Random Walk model only for these currency pairs during the pre-crisis period. On the other hand, the Random Walk model produces lower forecasting errors for the ILS/USD, JPY/USD, CZK/USD, PLN/USD, NZD/USD and ISK/USD during the pre-crisis period. . During the pre-crisis period the UIP model is not worse than Random Walk in predicting for the CAD/USD, TRY/USD, NOK/USD, SEK/USD and CHF/USD currency pairs.

During the post-crisis period, the UIP model outperforms the Random Walk model for the JPY/USD, MXN/USD, TRY/USD and NZD/USD exchange rate currencies and thus better forecasting accuracy for these currencies during the post-crisis. Furthermore, the DM-test statistics were positive and statistically significant for the AUD/USD and PLN/USD currency pairs. Hence, the Random Walk model produces less forecasting errors and better forecasting accuracy. Furthermore, the Null Hypothesis cannot be rejected for the EUR/USD, HUF/USD, SEK/USD, CHF/USD, KRW/USD, CZK/USD and ISK/USD thus, both UIP model and Random Walk model are equally good in forecasting these currency pairs.

5. Limitations and Suggestions

Some limitations of the thesis are worth discussing. Firstly, the results are subject to the currencies selected as well as to the analyzed period. As in my thesis I use only OECD currencies, the statistical power of the model might be different for the currencies that are not covered in this thesis. The model might work for other currencies that are not included in this thesis during one of these periods or during both of these periods. Also, the data for the Norwegian krone is very limited resulting that for this currency during the post-crisis period the data is unavailable. As a result of this, I could not compare the UIP for this currency during the both analyzed periods.

Several suggestions for the future research can be applicable. Firstly, the thesis includes only a limited number of observations for the post-crisis period. Including more observations might reveal different results that could support the major tested hypothesis and the results might reveal a different pattern. Also, incorporating more currencies in the empirical research might draw more robust statistical power of the model. As a result, the tested models might produce more accurate forecasts as compared one to another.

7. References

Abhyankar, A., Sarno, L. and Valente, G. (2005). Exchange Rates and Fundamentals: Evidence on the Economic Value of Predictability. Journal of International Economics, 66(2), pp. 325-348.

Baghestani, H. (2009). Evaluating Random Walk Forecasts of Exchange Rates. Studies in Economics and Finance, 26(3), pp. 171-181.

Brière, Marie and Drut, B. 2009. "The Revenge of Purchasing Power Parity on Carry Trades During Crises." CEB Working Paper No. 09/013 Feb.2009.

Burnside, C., Eichenbaum , M. and Rebelo, S. (2011). "Carry Trade and Momentum in Currency Markets".

Burnside, C., M. Eichenbaum and S. Rebelo, 2008, Carry trade: the gains of diversification, The Journal of Finance 45, 157-174 Journal of the European Economic Association 6, 581-588.

Chaboud, A. P. and Wright, J. H. (2005). Uncovered interest parity: it works, but not for long, Journal of International Economics, 66, 349-362.

Cheung, Y., Chinn, M. D. and Pascual, A. G. (2005). Exchange Rate Models of the Nineties: Are Any Fit to Survive? Journal or International Money and Finance, 24, pp. 1150-1175.

Chinn, Menzie D. and Meredith. (2004): "Monetary Policy and Long-Horizon Uncovered Interest Parity", International Monetary Fund Staff Papers, Volume 51, Number 3

Diebold, F. X. and Mariano, R. (1995). Comparing Predictive Accuracy. Journal of Business and Economic Statistics, 13, pp. 253-265.

Dunis, C.L. and J. Miao, 2007, Trading foreign exchange portfolios with volatility filters: the carry model revisited, Applied Financial Economics 17, 249-255.

Engel, C. and West, K. D. (2005). Exchange Rate Fundamentals. Journal of Political Economy, 113(3), pp. 485- 517.

Faust, J., Rogers, J.H. and J.H. Wright (2003) Exchange Rate Forecasting: the Errors We've Really Made. Journal of International Economics, Vol. 60 No. 1, pp. 35-59

Flood, R.and Rose, A.K.(2002). Uncovered interest rate parity in crisis. IMF Staff Pap 49, 252–266, 2002.

Flood, R.P. and A.K. Rose, (1994). Fixes of the forward discount puzzle, Review of Economics and Statistics 4, 748-752.

Frankel, J. and. Rose A. (1996), A Panel Project of Purchasing Power Parity: Mean reversion within and between countries, Journal of International Economics, 40 (1/2), 209-224

Frenkel, J.A. and R.M. Levich, 1975, Covered interest arbitrage: unexploited profits?, The

Journal of Political Economy 83, 325-338.

Froot, K. A. and Thaler ,R.H. (1990): "Anomalies: foreign exchange", Journal of Economic Perspectives, vol 4, pp 179–92.

Galati, Gabriele and Melvin. 2004. "Why has FX Trading Surged? Explaining the 2004 Triennial Survey". BIS Quarterly Review (Dec.), 67—74

Galati, Gabriele, Heath, A. and Patrick McGuire. 2007. "Evidence of Carry Trade Activity." BIS Quarterly Review, September 2007: 27-41.

Gyntelberg, J. and schrimpf , A. (2011) FX strategies in periods of distress. JEL classification: F31, G11, G15.

Hakkio, C. S. (1986). Does the Exchange Rate Follows a Random Walk? A Monte Carlo Study of Four Tests of Random Walk. Journal of International Money and Finance, 5(2), pp. 221-229.

Hansen, L. P., and Hodrick, R. J. 1980. "Forward Exchange Rates as Optimal Predictors of Future Spot Rates: An Econometric Analysis." Journal of Political Economy. "Referred in Mancini and Ranaldo 2012, 6".

Harvey, D., Leybourne, S. and Newbold, P. (1997). Testing the Equality of Prediction Mean Squared Errors. International Journal of Forecasting, 13(2), pp.281-291.

Hodrick, L.P.(1987): The empirical evidence on the efficiency of forward and futures foreign exchange markets. In: Fundamentals of Pure and Applied Economics. Chur Switzerland: Harwood Academic, 1987.

Huisman, R. Koedijk, K. Kool, C. and Nissen, F. Extreme support for uncovered interest parity, Journal of International Money and Finance, 17, (1998), 211-228.

Isard, P. Uncovered interest parity, IMF Working Paper, (2006). IMF Working Paper WP/06/96, pp. 1-14

Olmo, J. and Pilbeam, K. The profitability of carry trades (2008).

Jurek, J.W., 2007, Crash-neutral Currency Carry trades, Working paper, Princeton University.

Kilian L. & Taylor M. (2003), Why is it so difficult to beat the random walk forecast of exchange rates? Journal of International Economics 60, 85–107

King, A. Uncovered interest parity: New Zealand's post-deregulation experience, Applied Financial Economics, 8, (1998), 495-503.

Kllian, L. and Taylor, M. P. (2003). Why is it so difficult to beat random walk forecast of exchange rates? Journal of International Economics, 60(1), pp. 85-107.

MacDonald, R. and M.P. Taylor (1993) The Monetary Approach to the Exchange Rate: Rational Expectations, Long-Run Equilibrium, and Forecasting. Staff Papers – International Monetary Fund, Vol. 40, No. 1, pp. 89-107

Mariano, R, S. (2007). Testing Forecast Accuracy in a Companion to Economic Forecasting (eds M. P. Clements and D. F. Hendry), Blackwell Publishing Ltd, Malden, MA, USA.

Mark, N. C. (1995). Exchange Rates and Fundamentals: Evidence on Long-Horizon Predictability. The American Economic Review, 85(1), pp. 201-218.

Meese, R. A. and Rogoff, K. (1983). Empirical Exchange Rate Models of the Seventies: Do They Fit Our Sample? Journal of International Economics, 14(1-2), pp. 3-24.

Meh,A.l and Cappiello, L. Uncovered interest parity at distant horizons evidence on emerging economies & nonlinearities, Working Paper Series No 801, (2007), http://ssrn.com/abstract_id=1005122.

Menkhoff, Lukas, Sarno, Schmeling, M. and Schrimpf, A. 2011. "Carry Trades and Global Foreign Exchange Volatility." CEPR Discussion Paper No. DP8291.

Molodtsova, T., and D.H. Papell (2009), Out-of-Sample Exchange Rate Predictability with Taylor Rule

Mussa M. (1979) 'Empirical Regularities in the Behavior of Exchange Rates and Theories of the Foreign Exchange Rates', Carnegie-Rochester Conference Series on Public Policy,

Panda, C. and V. Narasimhan (2007) Forecasting Exchange Rate Better With Artificial Neural Network. Journal of Policy Modeling, Vol. 29, No. 2, pp. 227-236.

Pearson, K. (1905), Nature 72, 294, 342

Plantin, Guillaume and Shin, H. S. (2007). Carry Trades and Speculative Dynamics. Working paper, Princeton University

Sarno, L (2005): "Viewpoint: towards a solution to the puzzle in exchange rate economics: where do we stand?", Canadian Journal of Economics, vol 38, pp 673–708.

Schinasi, G.J., and P.A.V.B. Swamy (1987) The Out-of-Sample Forecasting Performance of Exchange Rate Models When Coefficients Are Allowed to Change. Journal of Internation Money and Finance, Vol. 8 No. 3, pp. 375-390

Taylor, M. & P., Sarno L. (1998), The behavior of real exchange rates during the post-Bretton Woods period, Journal of International Economics 46,281–312

Taylor, M.P., 1986, Covered Interest Parity: A High-frequency, High-quality Data Study, Economica 54, 429-438.

West, K. D. (1996). Asymptotic Inference about Predictive Ability. Econometrica, 64(5), pp. 1067-1084.

West, K. D. and McCraken, M. W. (1998). Regression-Based Test of Predictive Ability. International Economic Review, 39(4), pp. 817-840.

White, H. (2000). A Reality Check for Data Snooping. Econometrica, 68(5), pp. 1097-1126.

P. M. Garber, 1993. A Retrospective on the Bretton Woods System: Lessons for International Monetary Reform. Chapter 9: The Collapse of the Bretton Woods Fixed Exchange Rate System. National Bureau of Economic Research, 461-494.

ISO, 2014. On World Wide Web: http://www.iso.org/iso/home/standards/currency_codes.htm

Engel, C., Mark, N. C. and West, K. D. (August, 2007). Exchange Rate Models Are Not As Bad As You Think. NBER Macroeconomics Annual 2007, Vol. 22

Backus et al. (July 2010). Monetary Policy and the uncovered Interest Rate Parity Puzzle. NBER Working Paper, No. 16218.

Bank for international settlement (BIS), (April, 2013). Global foreign exchange turnover. http://www.bis.org/publ/rpfx13.htm

8. Appendix

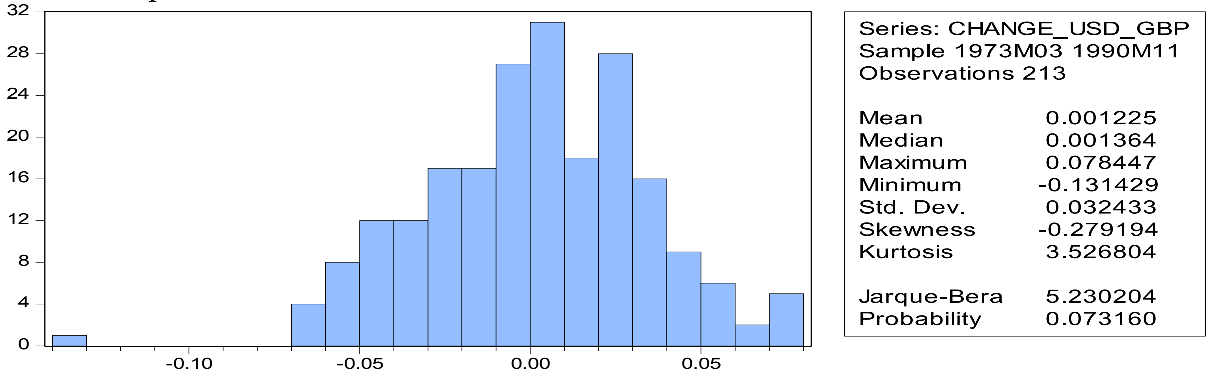
Appendix 1

The table illustrates ISO 4217 currency codes. All the data is retrieved from the ISO website

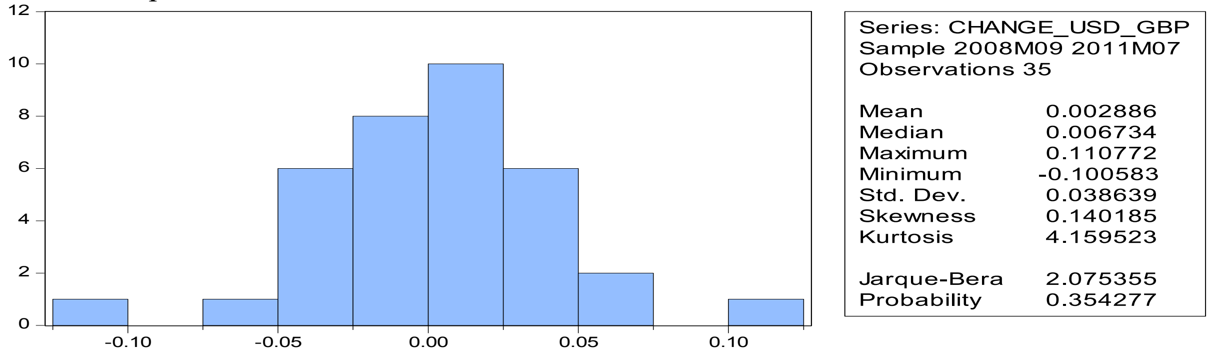
ISO 4217 code	Currency
AUD	Australian dollar
CAD	Canadian dollar
CHF	Swiss franc
CLP	Chilean peso
CZK	Czech koruna
DKK	Danish krone
EUR	Euro
GBP	British pound
HUF	Hungarian forint
ILS	Israeli shekel
ISK	Icelandic krone
JPY	Japanese yen
KRW	South Korean won
MXN	Mexican peso
NOK	Norwegian krone
NZD	New Zealand dollar
PLN	Polish zloty
SEK	Swedish krona
TRY	Turkish lira

Appendix 2

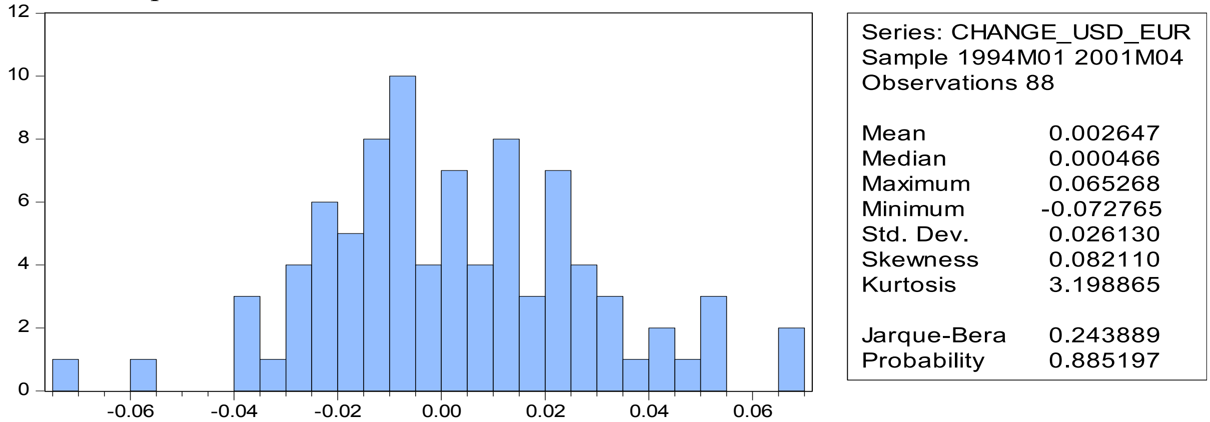
GBP/USD pre-crisis



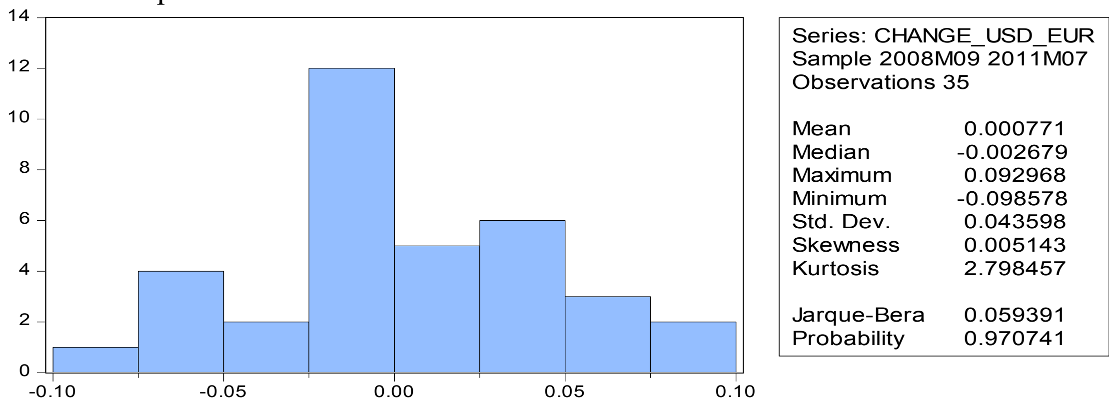
GBP/USD post-crisis



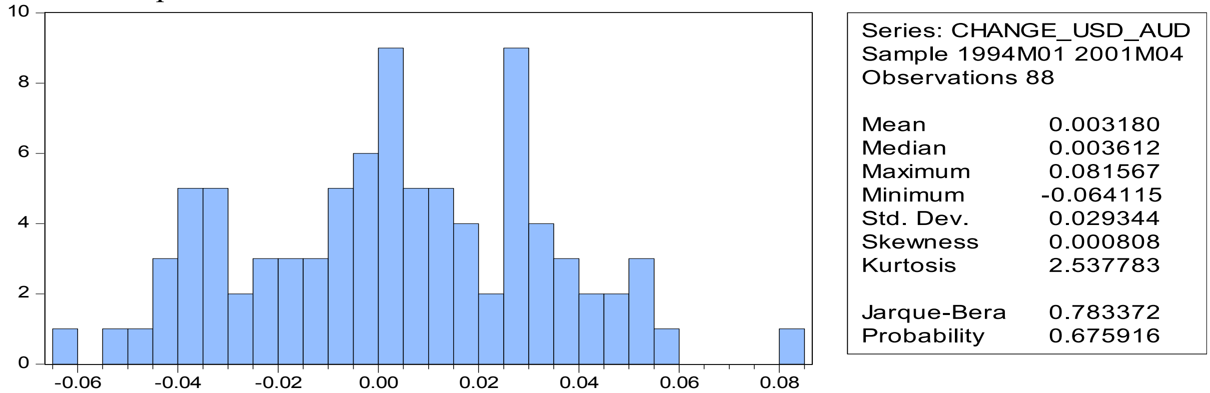
EUR/USD pre-crisis



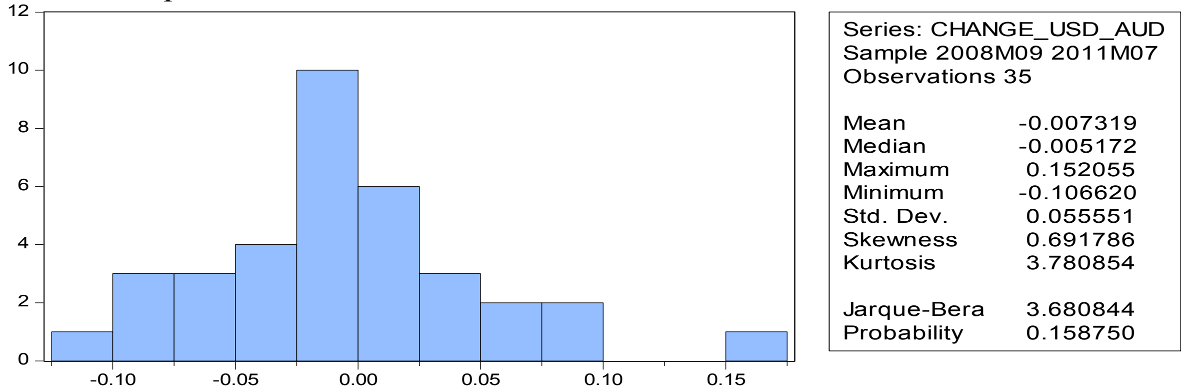
GBP/USD post-crisis



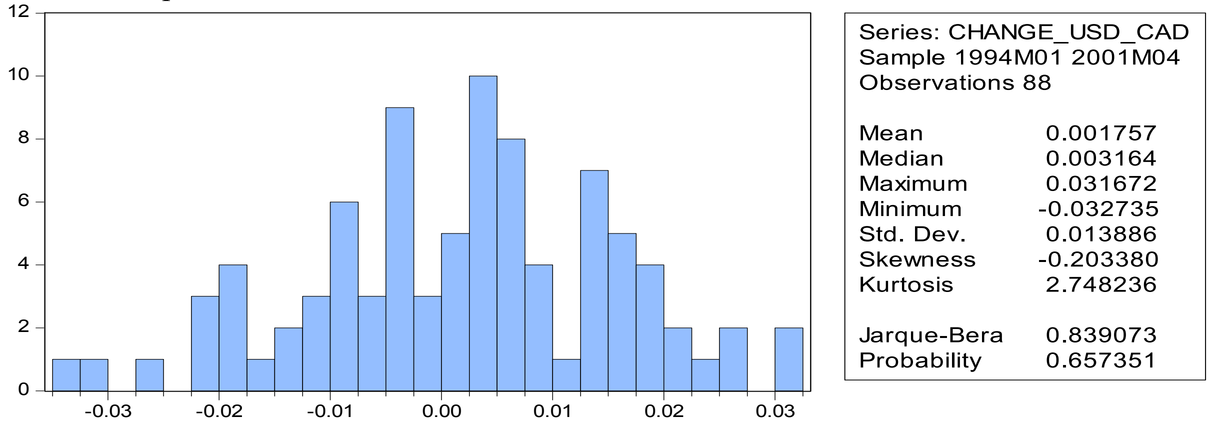
AUD/USD pre-crisis



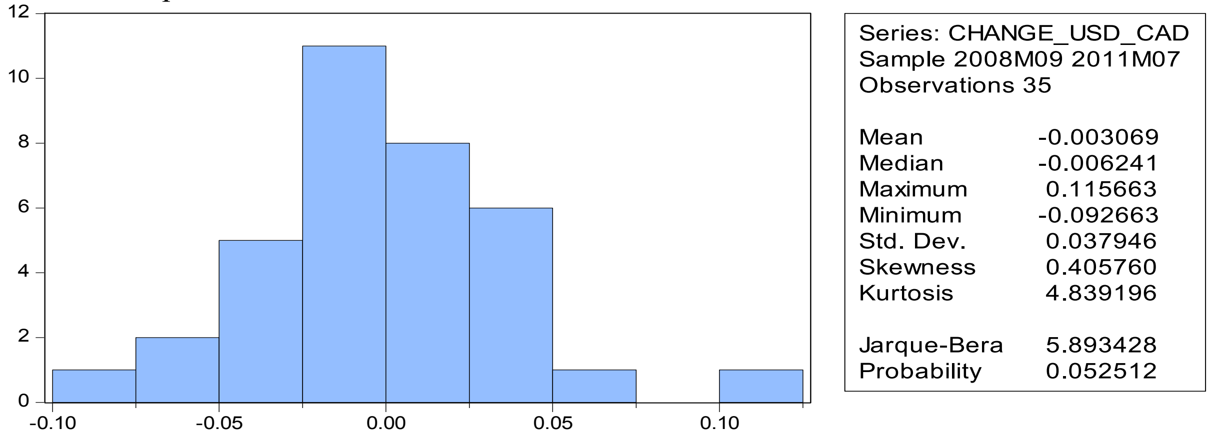
AUD/USD post-crisis



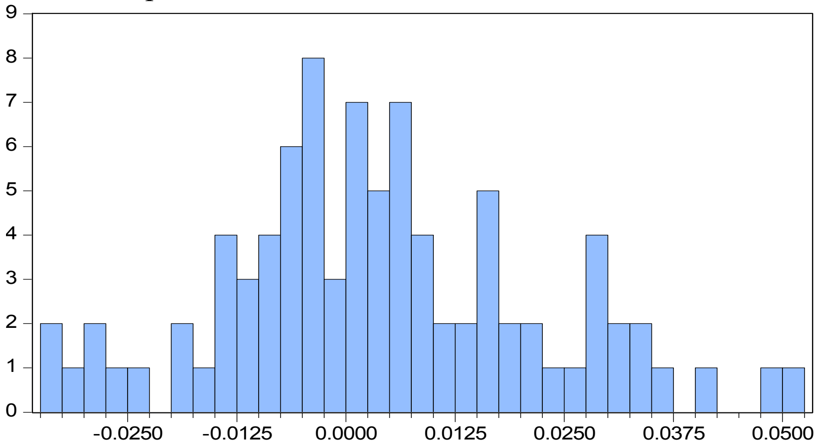
CAD/USD pre-crisis



CAD/USD post-crisis



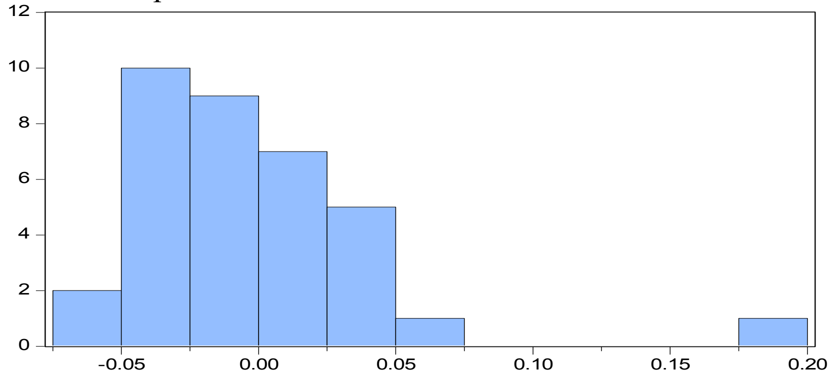
CLP/USD pre-crisis



Series: CHANGE_USD_CLP
Sample 1994M01 2001M04
Observations 88

Mean	0.003819
Median	0.001946
Maximum	0.051120
Minimum	-0.033349
Std. Dev.	0.018010
Skewness	0.257901
Kurtosis	2.958947
Jarque-Bera	0.981704
Probability	0.612105

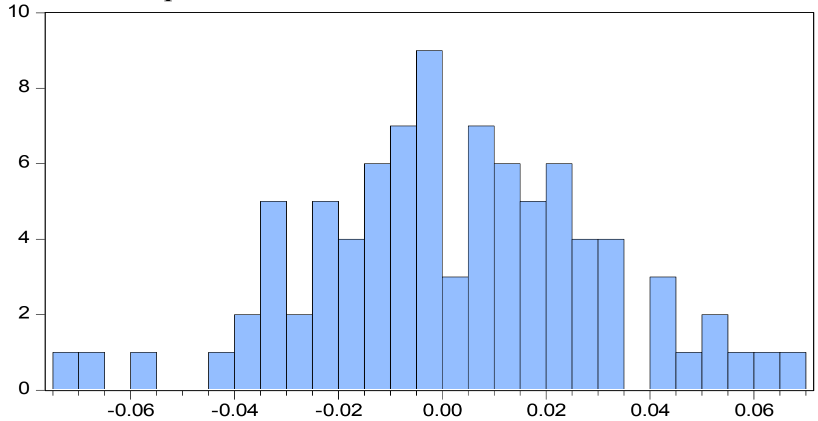
CLP/USD post-crisis



Series: CHANGE_USD_CLP
Sample 2008M09 2011M07
Observations 35

Mean	-0.003278
Median	-0.004418
Maximum	0.178594
Minimum	-0.057203
Std. Dev.	0.044610
Skewness	1.974150
Kurtosis	9.016693
Jarque-Bera	75.52660
Probability	0.000000

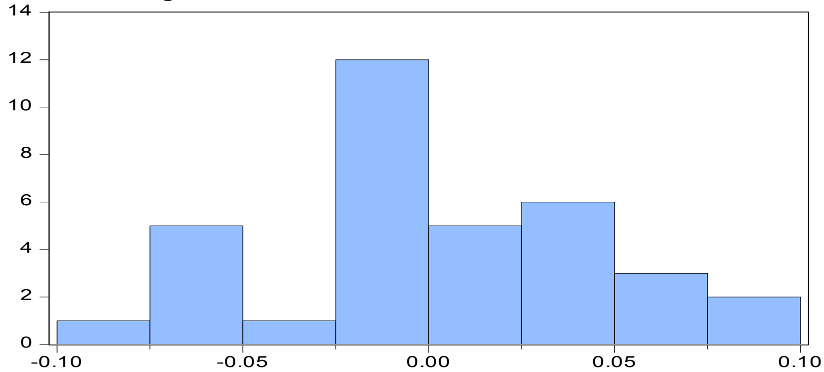
DKK/USD pre-crisis



Series: CHANGE_USD_DKK
Sample 1994M01 2001M04
Observations 88

Mean	0.002396
Median	-0.000332
Maximum	0.065756
Minimum	-0.071719
Std. Dev.	0.027459
Skewness	-0.109307
Kurtosis	3.220164
Jarque-Bera	0.352968
Probability	0.838212

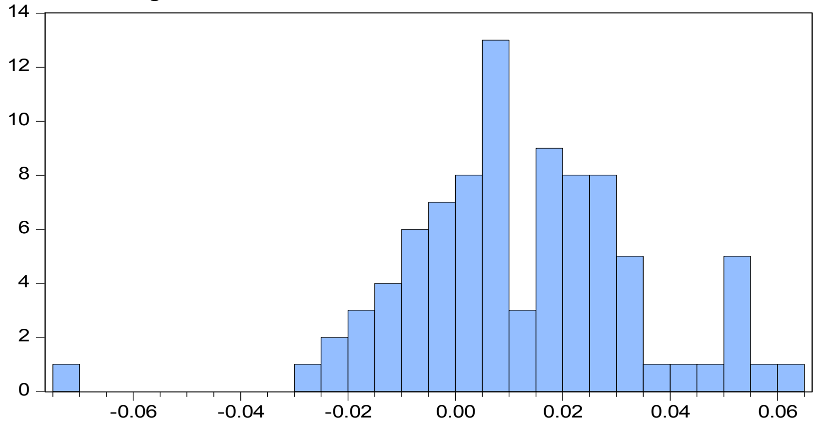
DKK/USD post-crisis



Series: CHANGE_USD_DKK
Sample 2008M09 2011M07
Observations 35

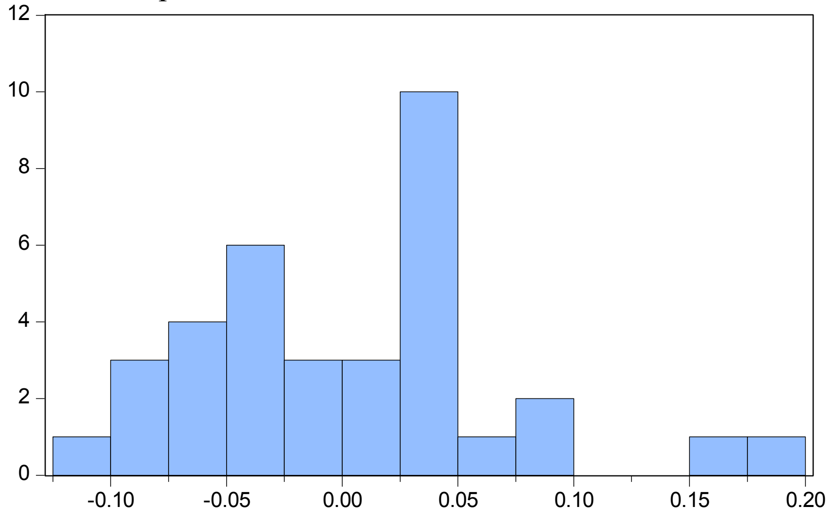
Mean	0.000747
Median	-0.002528
Maximum	0.090775
Minimum	-0.099349
Std. Dev.	0.043473
Skewness	-0.012044
Kurtosis	2.809061
Jarque-Bera	0.054014
Probability	0.973355

HUF/USD pre-crisis



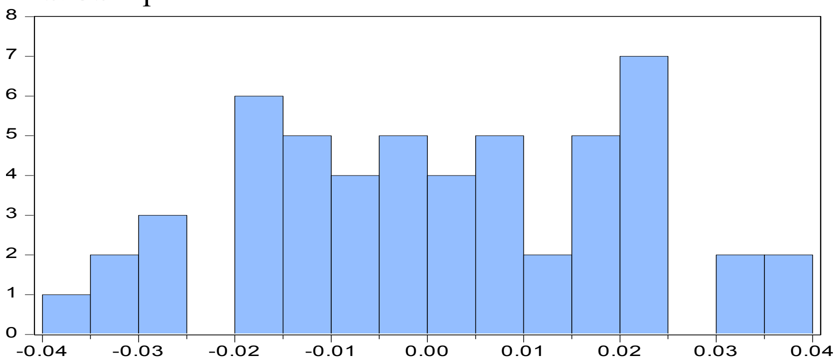
Series: CHANGE_USD_HUF	
Sample 1994M01 2001M04	
Observations 88	
Mean	0.012334
Median	0.009215
Maximum	0.063836
Minimum	-0.072879
Std. Dev.	0.021899
Skewness	-0.310725
Kurtosis	4.588893
Jarque-Bera	10.67287
Probability	0.004813

HUF/USD post-crisis



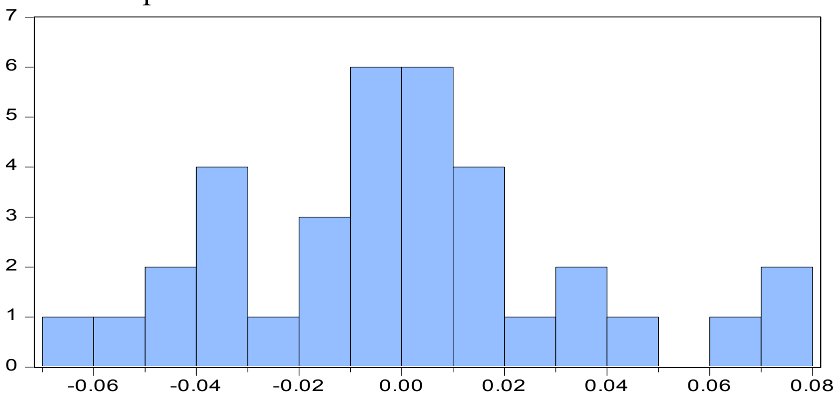
Series: CHANGE_USD_HUF	
Sample 2008M09 2011M07	
Observations 35	
Mean	0.004277
Median	0.001769
Maximum	0.193765
Minimum	-0.107347
Std. Dev.	0.067947
Skewness	0.786634
Kurtosis	3.675183
Jarque-Bera	4.274442
Probability	0.117982

ILS/USD pre-crisis



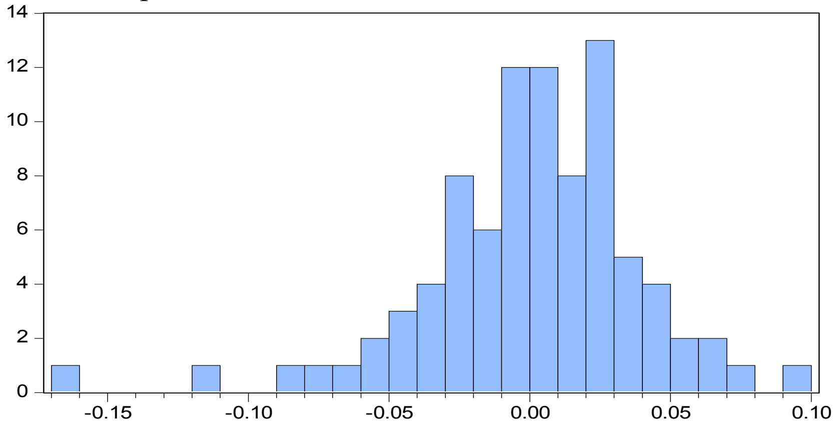
Series: CHANGE_USD_ILS	
Sample 1999M11 2004M03	
Observations 53	
Mean	0.001173
Median	0.000483
Maximum	0.039552
Minimum	-0.035939
Std. Dev.	0.019463
Skewness	0.016916
Kurtosis	2.162004
Jarque-Bera	1.553300
Probability	0.459944

ILS/USD post-crisis



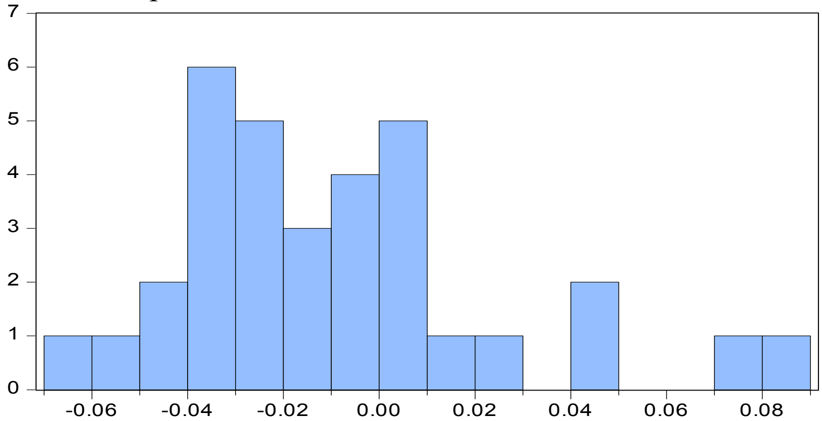
Series: CHANGE_USD_ILS	
Sample 2008M09 2011M07	
Observations 35	
Mean	-0.001476
Median	-0.001845
Maximum	0.076879
Minimum	-0.069649
Std. Dev.	0.033842
Skewness	0.431991
Kurtosis	3.164905
Jarque-Bera	1.128253
Probability	0.568857

JPY/USD pre-crisis



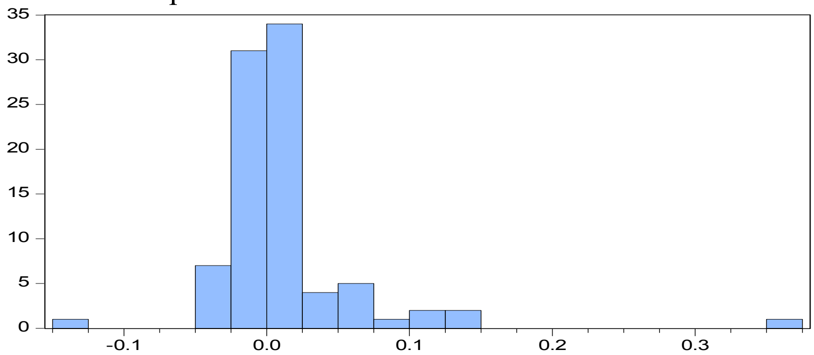
Series: CHANGE_USD_JPY	
Sample 1994M01 2001M04	
Observations 88	
Mean	0.000938
Median	0.001613
Maximum	0.098353
Minimum	-0.165821
Std. Dev.	0.039814
Skewness	-0.988252
Kurtosis	6.072437
Jarque-Bera	48.93692
Probability	0.000000

JPY/USD post-crisis



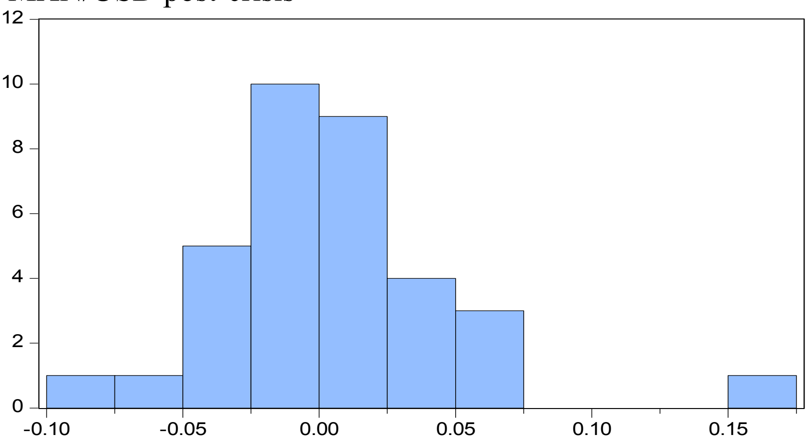
Series: CHANGE_USD_JPY	
Sample 2008M09 2011M05	
Observations 33	
Mean	-0.008812
Median	-0.015324
Maximum	0.082377
Minimum	-0.064810
Std. Dev.	0.034051
Skewness	0.965382
Kurtosis	3.656622
Jarque-Bera	5.718627
Probability	0.057308

MXN/USD pre-crisis



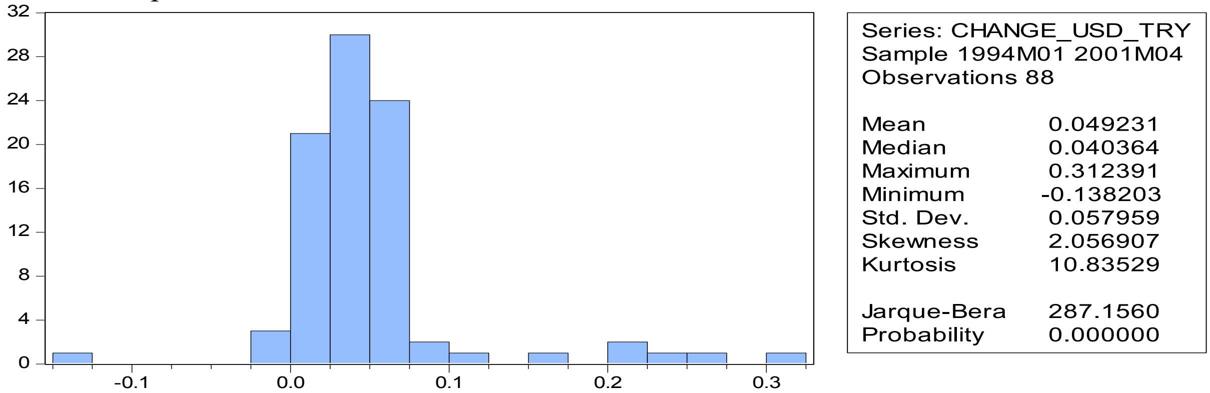
Series: CHANGE_USD_MXN	
Sample 1994M01 2001M04	
Observations 88	
Mean	0.012396
Median	0.001427
Maximum	0.358707
Minimum	-0.135748
Std. Dev.	0.052690
Skewness	3.405328
Kurtosis	23.43273
Jarque-Bera	1700.899
Probability	0.000000

MXN/USD post-crisis

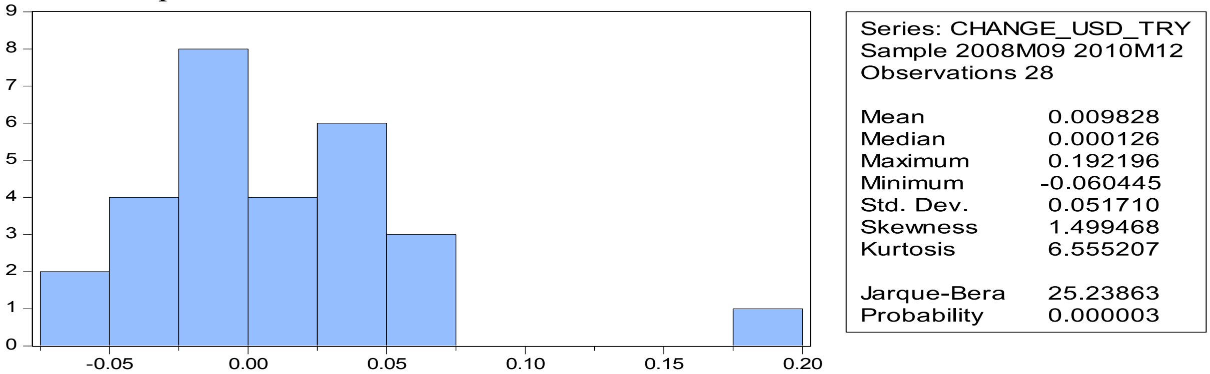


Series: CHANGE_USD_MXN	
Sample 2008M09 2011M06	
Observations 34	
Mean	0.003500
Median	-0.001409
Maximum	0.150674
Minimum	-0.092724
Std. Dev.	0.042866
Skewness	0.988468
Kurtosis	5.723845
Jarque-Bera	16.04744
Probability	0.000328

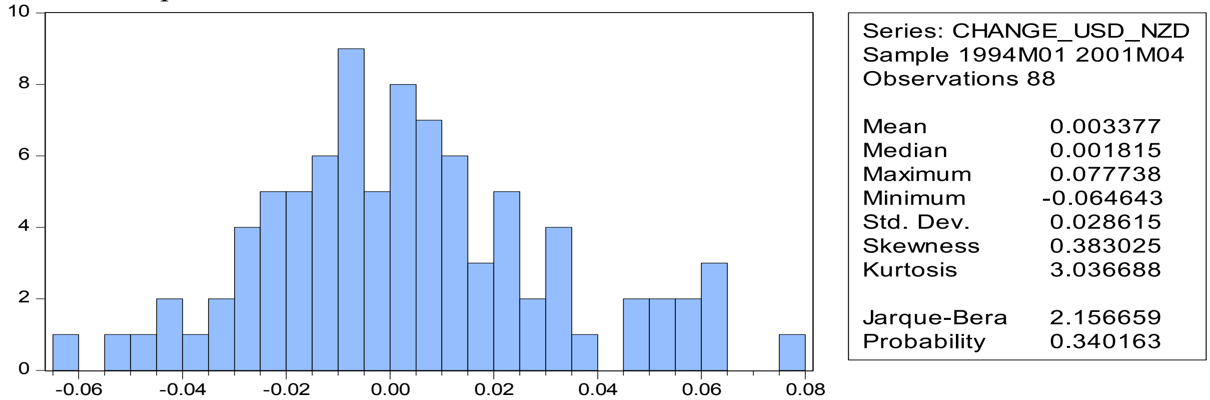
TRY/USD pre-crisis



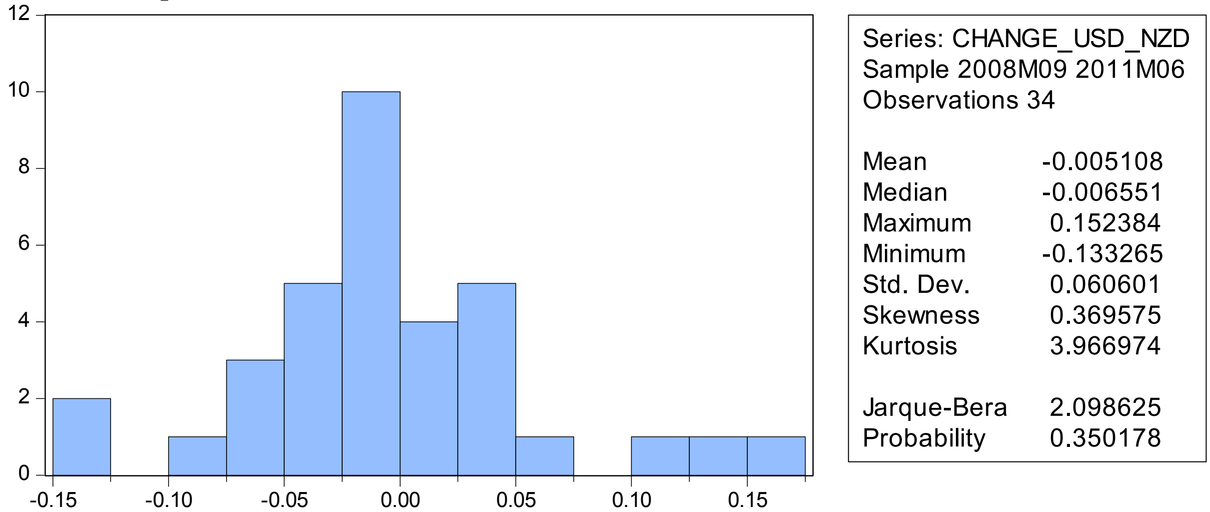
TRY/USD post-crisis



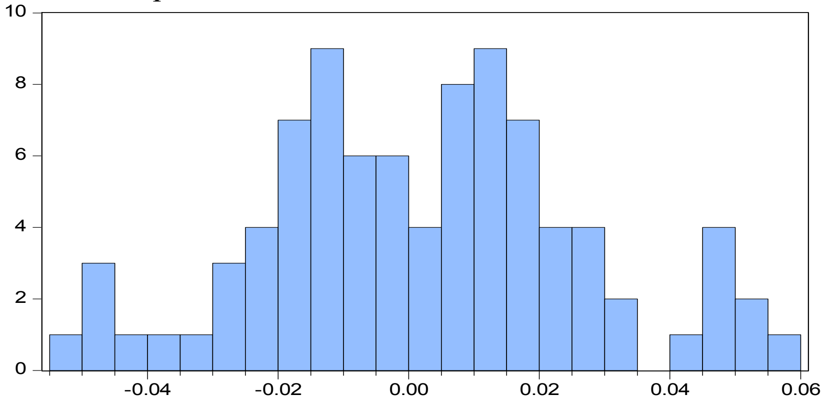
NZD/USD pre-crisis



NZD/USD post-crisis



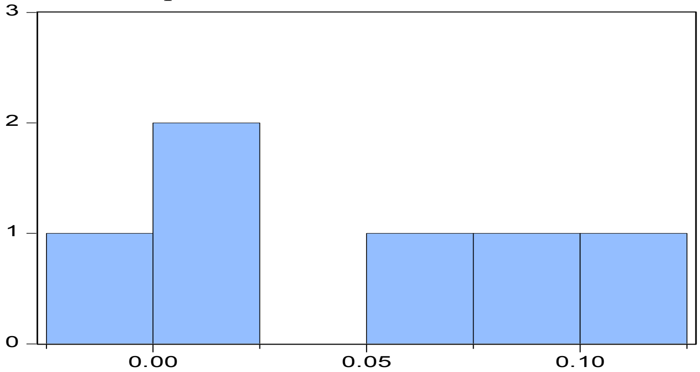
NOK/USD pre-crisis



Series: CHANGE_USD_NOK
Sample 1994M01 2001M04
Observations 88

Mean	0.002109
Median	0.003641
Maximum	0.057037
Minimum	-0.050665
Std. Dev.	0.024592
Skewness	0.040656
Kurtosis	2.759731
Jarque-Bera	0.235916
Probability	0.888733

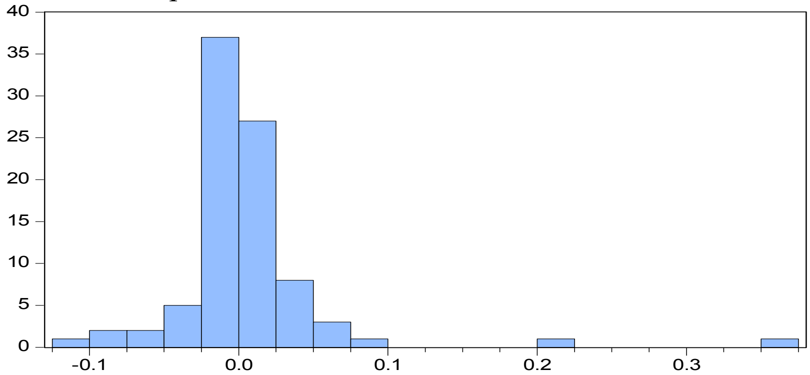
NOK/USD post-crisis



Series: CHANGE_USD_NOK
Sample 2008M09 2009M02
Observations 6

Mean	0.044907
Median	0.039178
Maximum	0.119090
Minimum	-0.014997
Std. Dev.	0.051210
Skewness	0.259669
Kurtosis	1.667956
Jarque-Bera	0.511013
Probability	0.774524

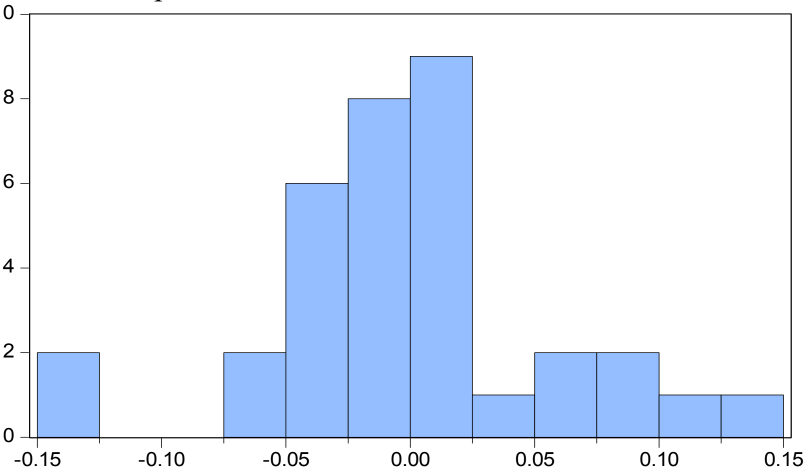
KRW/USD pre-crisis



Series: CHANGE_USD_KRW
Sample 1994M01 2001M04
Observations 88

Mean	0.005546
Median	-0.001305
Maximum	0.357940
Minimum	-0.109236
Std. Dev.	0.052766
Skewness	3.795606
Kurtosis	26.00911
Jarque-Bera	2152.500
Probability	0.000000

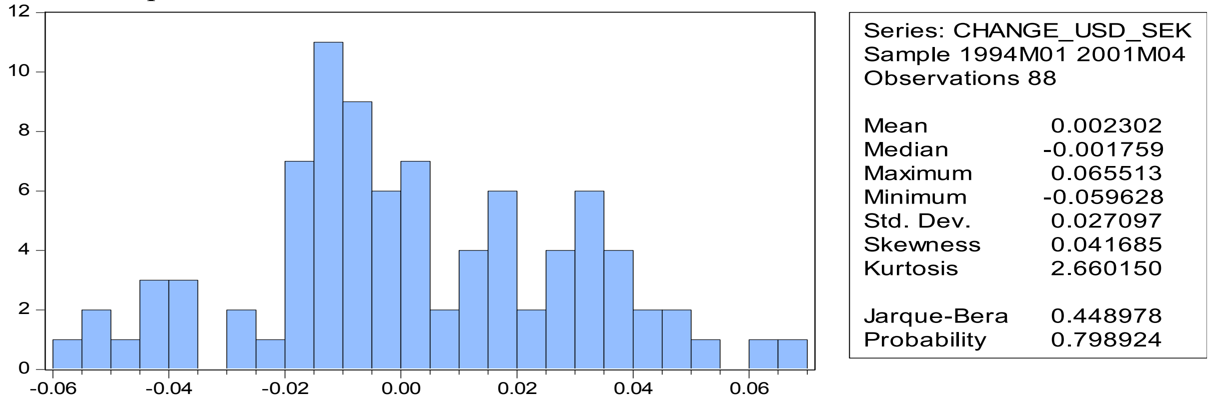
KRW/USD post-crisis



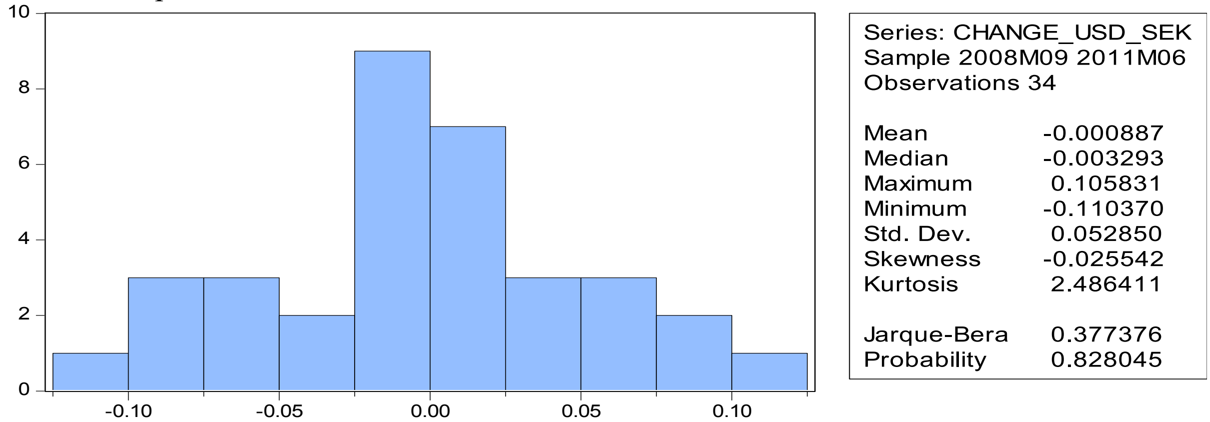
Series: CHANGE_USD_KRW
Sample 2008M09 2011M06
Observations 34

Mean	-0.001336
Median	-0.007235
Maximum	0.132055
Minimum	-0.134236
Std. Dev.	0.058356
Skewness	0.172276
Kurtosis	3.666122
Jarque-Bera	0.796783
Probability	0.671399

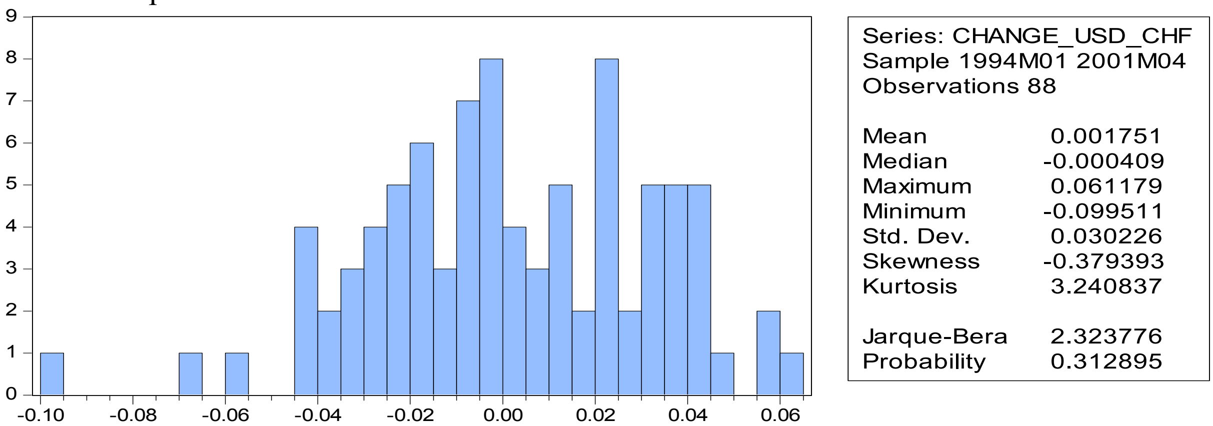
SEK/USD pre-crisis



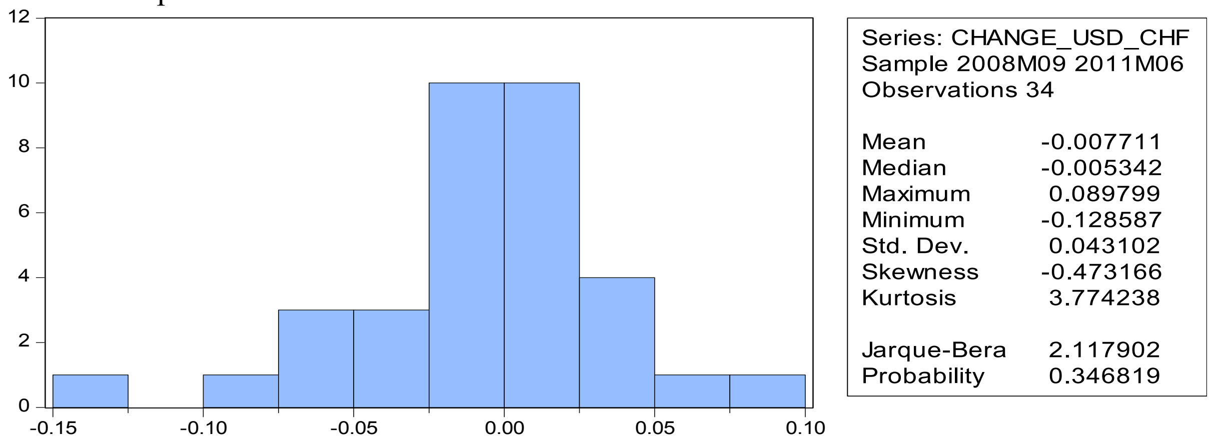
SEK/USD post-crisis



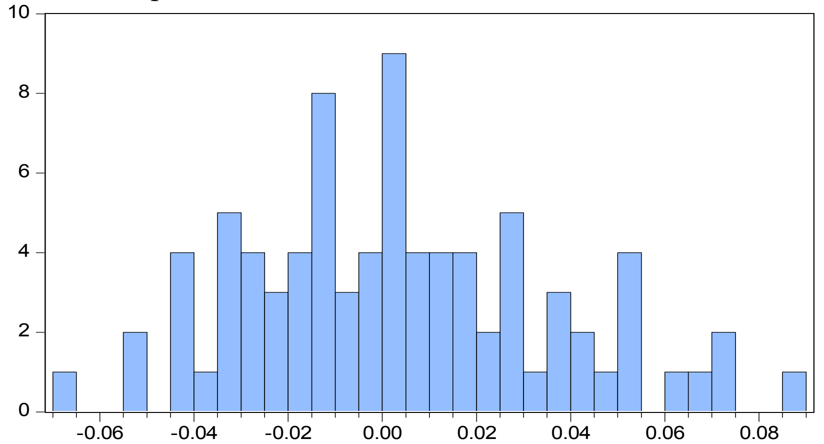
CHF/USD pre-crisis



CHF/USD post-crisis



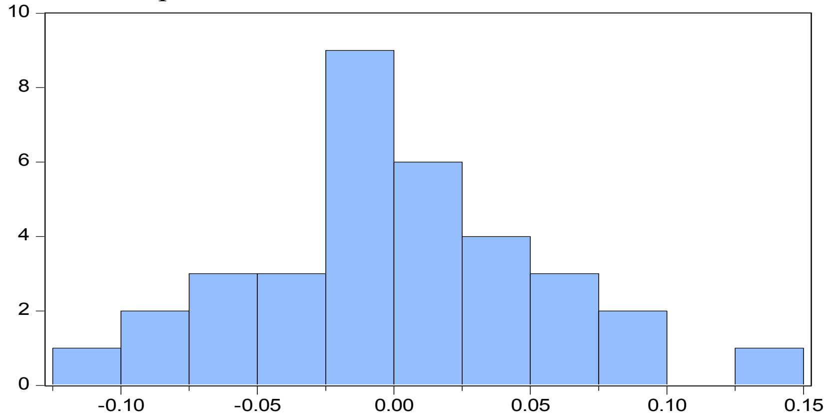
CZK/USD pre-crisis



Series: CHANGE_USD_CZK
Sample 1994M12 2001M10
Observations 83

Mean	0.003449
Median	0.000938
Maximum	0.089874
Minimum	-0.066552
Std. Dev.	0.032393
Skewness	0.400745
Kurtosis	2.803986
Jarque-Bera	2.354457
Probability	0.308132

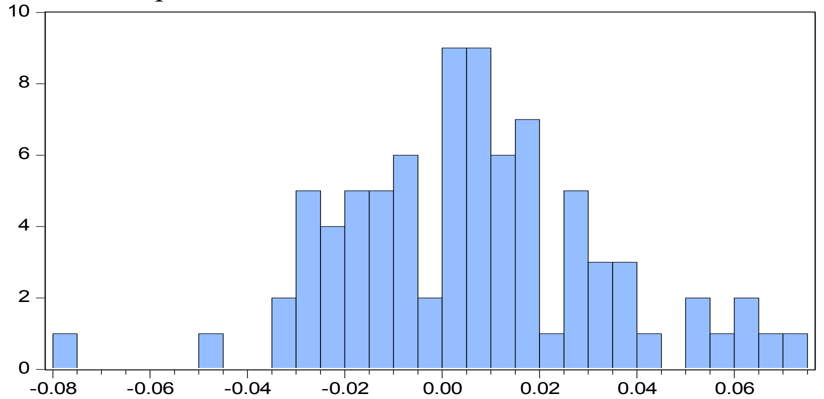
CZK/USD post-crisis



Series: CHANGE_USD_CZK
Sample 2008M09 2011M06
Observations 34

Mean	-0.000883
Median	-0.010036
Maximum	0.132800
Minimum	-0.100837
Std. Dev.	0.054488
Skewness	0.294421
Kurtosis	2.690866
Jarque-Bera	0.626588
Probability	0.731035

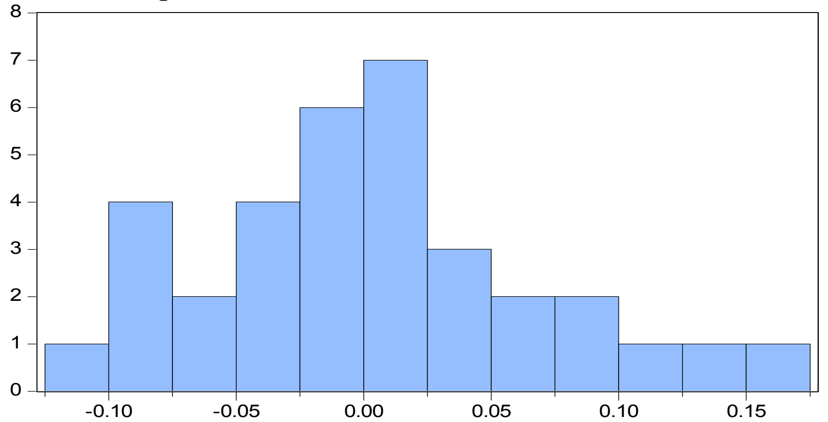
PLN/USD pre-crisis



Series: CHANGE_USD_PLN
Sample 1995M01 2001M11
Observations 82

Mean	0.006201
Median	0.005786
Maximum	0.073798
Minimum	-0.078506
Std. Dev.	0.026973
Skewness	0.112856
Kurtosis	3.632124
Jarque-Bera	1.539298
Probability	0.463176

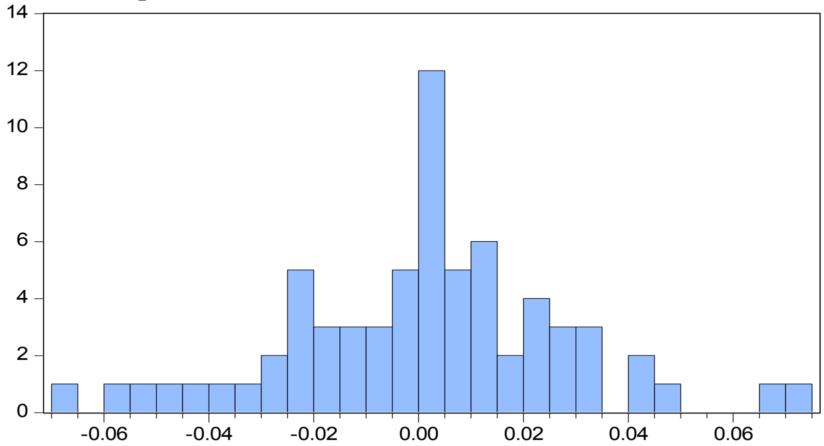
PLN/USD post-crisis



Series: CHANGE_USD_PLN
Sample 2008M09 2011M06
Observations 34

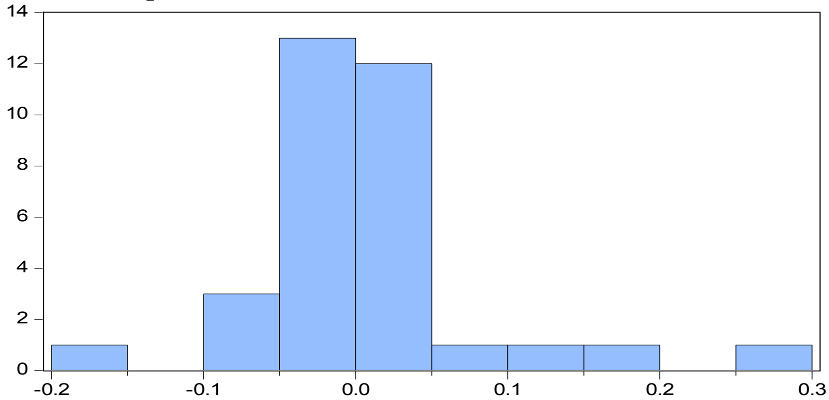
Mean	0.005088
Median	-0.000195
Maximum	0.168088
Minimum	-0.102256
Std. Dev.	0.065253
Skewness	0.525883
Kurtosis	2.920697
Jarque-Bera	1.576042
Probability	0.454744

ISK/USD pre-crisis



Series: CHANGE_USD_ISK	
Sample 1997M01 2003M01	
Observations 68	
Mean	0.001349
Median	0.002191
Maximum	0.072374
Minimum	-0.066216
Std. Dev.	0.026594
Skewness	-0.022917
Kurtosis	3.607482
Jarque-Bera	1.051548
Probability	0.591098

ISK/USD post-crisis



Series: CHANGE_USD_ISK	
Sample 2008M09 2011M05	
Observations 33	
Mean	0.009473
Median	-0.002732
Maximum	0.276506
Minimum	-0.197831
Std. Dev.	0.075878
Skewness	1.077670
Kurtosis	7.633428
Jarque-Bera	35.90695
Probability	0.000000