**Exchange Rate Forecasting Model Performance**

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**Abstract**

**In this research, the performance of fundamental exchange rate models, as UIRP and PPP, will be compared, in- and out-of-sample, with each other, with a Taylor Rule based model and with the famous Random Walk model. Former studies show that no single model beats the Random Walk. In this research we see that the Random Walk model still performs better than the PPP, UIRP and Taylor-based model according to their RMSE, MSE and MAE’s. However, the Diebold-Mariano statistic gives a different picture. All models perform better than the Random Walk model over the short and long term forecast horizon according to the Diebold-Mariano squared loss differential statistic.**

**JEL classification: C53, F31, F47**

**Keywords: exchange rate, comparison, forecast, PPP, UIRP, Taylor, Random Walk**

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1. **Introduction**

**The foreign exchange market is one of the biggest and most liquid financial markets in the world. Traders range from central banks, large commercial banks, currency speculators and retail investors, to all the companies which operate internationally. From this perspective, it was very useful to create models that could forecast exchange rate movements, especially after the termination of the Bretton Woods system in the seventies. If the model works, it could save or earn a lot of money for an institution or company.**

**The risk that relates to the trading in currencies, also known as exchange rate risk or currency risk, can in theory disappear with a correct model. A European company that sells cars in the US can, with a correct model, forecast the exchange rate movement and therefore eliminate the exchange rate risk. The same holds for an investor that invests in foreign assets. He will be losing money when the domestic currency depreciates. Besides this, a correct model in the hands of a currency trader will make him rich.**

 **Carry strategy is a well know strategy on which currency trading is based. It basically means that you go long in (buy) currencies from countries with a high interest rate, and you short (sell) currencies with a low interest rate. This should give you a positive return on the investment. *Gourinchas & Tornell (2004)* explain that in theory, the interest rate differential will gradually mean-revert. Investors know this, and when the differential is there, they trade on it and eventually the premium disappears. This can be seen in the following figure. *Figure 1.1* gives an example of the movement of the UK Pound to US Dollar exchange rate, according to the UIRP- model. This mean-reverting movement, is the movement where carry traders make use of. In some way, they make use of the inefficiencies of the market.** 

***Figure 1.1: Movement of exchange rate according to UIRP for carry trading***

**The model that is used to test this trade is the well known Uncovered Interest Rate Parity Model. Later in this research, this model will be fully described.**

**A lot of other models have been created to forecast the exchange rate movements. In this research the focus lays on 3 of the fundamental models: The Purchasing Power Parity model and the earlier mentioned Uncovered Interest Rate Parity model will be compared with the Taylor Rule Based model. *Molodtsova & Papell (2009)* argue that this model based on Taylor fundamentals provides significantly more evidence on predictability. *Taylor (1993)* stated the ‘Taylor Rule’, which basically means that the central bank changes the short run interest rate in reaction to changes in inflation and output gap. Based on this rule, a new model was created to forecast the exchange rates. This research shows if this model (still) performs best, and adds the Euro currency into this model.**

**In this research, it is tried to see, with an out-of-sample methodology, whether one of the fundamental exchange rate forecasting models, and especially if the Taylor Rule model, can significantly perform better then the simple Random Walk. A short term and long term forecast horizon will be used. With short term is meant a horizon of 1 month and 3 months (quarterly). The long term will be 12 months. (For the Taylor Rule, only quarterly data is available, so comparison of the short term forecasting performance will be done in quarterly terms).**

*Pindyck & Rubinfeld (1998)* describe in their book the two main methods of forecasting techniques: Static and Dynamic Forecasting. In this research, static forecasting is used with the help of Eviews. Dynamic Forecasting forecasts multiple periods (n-step) ahead by using the previously forecasted period. Static Forecasting uses the actual data to forecast one period ahead. This is also called rolling forecasting. **This rolling method is used to re-estimate the parameters of the different kinds of models for the 1 month, 3 month and 12 month forecast horizons. With the help of the Root Mean Squared Error (RMSE) the performance ability of the different models will be compared. A high error suggests a bad ability to forecast the exchange rate movement. A Diebold-Mariano *(Diebold & Mariano, 1995)* statistic is used to** assess whether the differences between the forecasts are significant.

This research works with direct exchange rates (direct quotes), so the domestic price of foreign currency. Foreign variables will be indicated with a \*. An appreciation of the foreign currency causes an increase in the direct quote. A decline in the Yen, Euro or UK Pound per US Dollar exchange rate implies an appreciation of the Yen, Euro or Pound or a depreciation of the US dollar.

The next chapter gives a review of the literature written about this subject. In chapter 3 there will be a description of the data. Chapter 4 will explain the used methodology and chapter 5 will present the empirical results. Finally this research will end with the conclusion.

1. **Literature Review**

***2.1 Random Walk***

The concept of ‘Random Walk’ was first described by *Pearson (1905).* The paper describes that future stock price movements cannot be predicted by their past movements or trends. So the price at time *t* will be the price at time *t-1* plus a noise term ***ε****.* In this paper, all the models described later, will be compared, with respect to their forecasting ability, with the concept of ‘Random Walk’.

**When we look back into the history of exchange rate forecasting models, we see that every model did not perform really well compared to the Random Walk. According to** *Meese and Rogoff (1983)*, the models discussed did not significantly perform better than the ‘Random Walk model’, despite of the fact that the models use realized values as explanatory variables. This basically means that you can better flip a coin then using one of the models to forecast the exchange rate movements.

*Kilian & Taylor (2003)* give a reason why the naive Random Walk model is so hard to beat. Theydescribed in their paper that the concept of the linear forecasting models is wrong, and thus fail in their predictive ability. This would be due to the non-linearity in the data. Linking exchange rates with underlying fundamentals (relative prices etc.) is not working in the short term, but only in longer horizons. That is why the authors switched to longer horizons of 2 to 3 years. However, this forecast of 2 to 3 years is quite general, and doesn’t give much reason to implement it for short term forecasts. No single investor is waiting for a general forecasting model with an excessively long term horizon.

*2.2 Fundamental Models*The Purchasing Power Parity (PPP) hypothesis states that prices expressed in home currency should be equal (in every currency). A strict Purchasing Power Parity implies that changes in the nominal exchange rate should be equal to those of the national price levels, which means that the real exchange rate is constant (*Taylor & Sarno (1998))*. The law of one price is an essential part of the PPP. This means that the relation S = P / P\* holds for all goods. S stands for the spot exchange rate and P stands for the domestic aggregate prive level (P\* stands for the foreign aggregate price level). Many studies reject the PPP as an exchange rate forecaster due to the failure of the law of one price (e.g. Frankel (1990))

*Meredith & Chinn (1998),* describe that the Uncovered Interest Rate Parity Model as an exchange forecasting model is rejected in most studies. The UIRP uses interest rates to forecast exchange rates. They say it fails because the interest rates used to construct this model are short term interest rates. Short term interest rates deviations come from risk premium shocks. This leads to deviations from the UIRP. If you incorporate long term interest rates, the movements in exchange rates are more driven by fundamentals. Still the UIRP model does not perform better than the Random Walk according to *Cheung, Chinn & Pascual (2005).*

*2.3 Taylor Rule Models*

In 2007, *Molodtsova & Papell* compared the fundamental exchange rate models with a Taylor Rule based model. *Taylor (1993)* formed a rule which basically describes that the central bank sets the nominal interest rate based on the inflation gap, the output gap and the real interest rate: the central bank raises the nominal interest rate, if inflation exceeds the desired level and also when the actual output is bigger than the potential output. The model they formed, could forecast exchange rates over short term horizons, but so could the fundamental models like the Purchasing Power Parity Model and the Uncovered Interest Rate Parity Model. This is in strong contradiction with previous research, like those of *Meese & Rogoff (1983), Cheung, Chinn & Pascual (2005)* and *Engel, Mark and West (2006)*. This research adds significant value to the existing literature, because no single research on forecasting models based on the Taylor Rule is done with the Euro currency.

*2.4 Other Models*

There are also other models to forecast exchange rates, such as Monetary models (one that assumes sticky prices and one that assumes flexible prices)and Portfolio-Balance models.

*2.4.1 Monetary Model*

There are also other models to forecast exchange rates, such as Monetary modelsand Portfolio Balance models**.** The Monetary models try to explain movements in the exchange rate with the help of the money supply. While doing this, it assumes that non-monetary assets are (perfect) substitutes. There is a difference between Monetary models that assume sticky prices and models that assume flexible prices. *Frenkel (1976)* created the flexible-price Monetary model. He assumed that prices adjust immediately in the money market. This means that domestic capital is a perfect substitute for foreign capital (The yields are the same). *Dornbusch (1976)* had a different view on this topic. He assumed prices adjust gradually. This means that the Purchasing Power Parity would hold only in the long run, so foreign and domestic capital are not perfect substitutes. According to *MacDonald and Taylor* (1992), the Monetary model performs poorly on estimating exchange rates. Also *Cao Yong & Ong Wee Ling (1995)* see a better performance for the Purchasing Power Parity model compared to the Monetary model. *Chen & Mark (1996),* find however that the monetary models perform better than the fundamental models.

*2.4.2 Portfolio-Balance Model*

The Portfolio-Balance model is based on *Branson and Henderson (1985)****.*** It allows foreign and domestic capital to have different prices (so no perfect substitutes), because of a higher risk for certain bonds (*Keith Pilbeam, 2006)*. The required yield for riskier bonds is higher than for less riskier bonds (consistent with the asset pricing theory, a so called risk premium). According to the model, the risk component affects exchange rates in an extensive degree. *Cushman (2003)*.

In this research, the focus lays on the newer Taylor Rule model in comparions with the Fundamental models (PPP and UIRP). The Monetary and Portfolio Balance model will not be used.

*2.5 Conclusion*

A lot has been written on the topic exchange rate forecasting. There are different models that try to forecast the exchange rates. The majority of the models are based on Fundamental Models (PPP, UIRP) Monetary Models and Portfolio-Balance Models. Ever since the existing of forecasting models, it is hard to beat the naive Random Walk Model. However, forecasting models based on Taylor Rule fundamentals do better according to *Molodtsova & Papell (2007)*. Other research done on Taylor Rule models contradict to this finding (e.g. *Cheung, Chinn & Pascual, 2005)*. Because of this divergence of opinion, this research will try to show the performance of the Taylor Rule Model compared to Fundamental Models and the Random Walk model for the main currencies Euro, U.S. Dollar, U.K. Pound and Japanese Yen. There has been no research done so far on the Taylor Rule Model with the Euro as currency.

1. **Data**

*3.1 Used Dataset*

For this research, a dataset[[1]](#footnote-1) is used that contains monthly observations of the exchange rates, Consumer Price Index, short term interest rates (Euribor for Europe) and quarterly data of the output gap from the European Union, United States, Japan and United Kingdom. The data is downloaded from Datastream and the OECD.

This research uses direct quotes, so the exchange rates will be €/$, ￥/$ and ￡/$. The data runs from January 2000 (beginning of the Euro) up to April 2012 (most recent available data at the moment of research). The table below shows some descriptive statistic of the exchange rate data. In the chapter Appendix, all descriptive statistics are shown for each data series.

***Table 3.1: Descriptive Statistics Exchange Rates***

|  |  |  |  |
| --- | --- | --- | --- |
|  | ***€ / $*** | ***£ / $*** | ***¥ / $*** |
| **Mean** | 0.84 | 0.60 | 106.58 |
| **Maximum** | 1.18 | 0.71 | 133.88 |
| **Minimum** | 0.63 | 0.48 | 76.13 |
| **Skewness** | 0.83 | -0.14 | -0.55 |
| **Kurtosis** | 2.39 | 1.85 | 2.39 |
| **JB** | 0.01 | 0.01 | 0.00 |
| **Observations** | 148 | 148 | 148 |

The data of the exchange rate is, as shown above by the Jarque-Bera (JB) statistic, not normally distributed. This holds also for the CPI and interest rates, but not for the output gap. Further, there are no exceptional errors in the data such as missing data and extreme outliers.

*3.2 Unit Root*
To test whether the data series have a unit root, the Augmented Dickey-Fuller (ADF) test is used. The intuition behind the ADF test (Dickey & Fuller (1979) and Elliott, Rothenberg & Stock (1996)) is to see if the lagged level t-1 provides information for the prediction of t. Exchange rates normally have a trend. The ADF-test is firstly done with trend and intercept. If the trend is not significant, then only the intercept will be added to the regression. The more negative the ADF statistic is, the higher the probability is that you have to reject the null hypothesis of a unit root.

**Table 3.2: Unit Root Test Data Exchange Rates**

|  |  |  |
| --- | --- | --- |
| **Currency** | **ADF-Statistic** | **p-value** |
| **€ / $** | -1.169 | 0.687 |
| **£ / $** | -1.526 | 0.518 |
| **¥ / $** | -2.603 | 0.280 |

As shown in table 3.2, the data has a unit root. To correct for this, this research will make use of the first differences of the data. Table 3.3 shows the results for the Augmented Dickey-Fuller test for the data series in first differences.

**Table 3.3: Unit Root Test First Difference Data Exchange Rates**

|  |  |  |
| --- | --- | --- |
| **Currency** | **ADF-Statistic** | **p-value** |
| **€ / $** | -11.314 | 0.000\* |
| **£ / $** | -10.702 | 0.000\* |
| **¥ / $** | -12.405 | 0.000\* |

\* Significant at 99% confidence level

As you can see in Table 3.3, none of the data series of the first difference has a unit root. This is positive information. In none of the data series, the lagged level t-1provides information for t.

3.3 Conclusion

This chapter showed that the data of the exchange rates is not normally distributed. The data also contained a unit root. To correct for this, the first differences (*Table 3.3)* of the exchange rates are used to estimate the models discussed in the next chapter.

1. **Methodology**

**First, the models tested in this research will be described: The Random Walk model, Purchasing Power Parity model, the Uncovered Interest Rate Parity model and the Taylor Rule model.**

*4.1 Random Walk*

The Random Walk model is just a simple model that assumes that there is a 50% chance of the exchange rate going up, and a 50% chance of it going down. So implicitly, it says that the exchange rate of yesterday will be the same as the exchange rate today. Adding a constant and an error term implies in formula:

**Δ*st = α +* Δ*st-1 + ε***

Where the small letters s indicate natural logarithms and ∆ is the first difference..

If the constant term was not added, the R2-measure would be negative, which is not in line with this linear model. Hence, the alpha (*α*) is supposed to be zero in the regression.

*4.2 Purchasing Power Parity*

The Purchasing Power Parity forecasting approach is based on the theoretical Law of One Price, which states that identical goods in different countries should have identical prices.

This implies in formula:

**S = P / P\***

where *S* is the spot rate and P (P\*)is the domestic (foreign) aggregate price level.

According to the relative version of the PPP-theory the percentage change of the

exchange rate equals the difference in inflation rates between the two countries:

**∆s = ∆p - ∆p\***

The regression formula adds a constant and error term:

**Δst = α + β Δ(ψt-1) + ε**

The left hand term is the logarithm of the first difference of the exchange rates. This term is the term that will be estimated in every model. The equation has a constant α and ψ is the difference in the inflation rates (that is changes in the Consumer Price Index) of the home country (Euro Area, Japan, or United Kingdom) and the foreign country (US): *πt-1 – πt-1\**

The sign of the parameter β in the PPP-model is expected to be a positive. If the inflation differential increases, so for example the difference between the European and the U.S. inflation increases (and thus the Euro area inflation exceeds the US inflation), the Euro per US Dollar exchange rate is expected to rise. The Euro is expected to depreciate against the US Dollar. So the euro per dollar exchange rate increases. This can be explained by the economic rationality of supply and demand. If the inflation in Europe is rising, the Euro Area is not really attractive for investors to invest in: their money is becoming less valuable. The money therefore shifts to other parts of the world - which means less demand for the Euro and more demand for other currencies - for example the US Dollar. Hence, the currency of the Euro depreciates with respect to the US Dollar.



*Figure 4.1: Relationship currency movements (€ per $) and inflation rate differential (πea– πus)*

*Figure 4.1* shows the relation of the currency movements with the inflation rate differential (€ per $). In the period from the beginning of the existence of the Euro, until 2012, the average Euro per Dollar exchange rate decreased with 0.14% (standard deviation of 3.17%), with an average inflation rate differential of 0.79% (standard deviation of 1.56%). This is not really in line with the economic theory. An average inflation differential that is positive means that Euro area inflation exceeded US inflation on average (average Euro area inflation 3.34% and average US inflation 2.55%). This has to show in an increase in the (€ per $) in the exchange rate.

*Figure 4.2: Relationship currency movements (£ per $) and inflation rate differential (πuk – πus)*

*Figure 4.2* shows the same relationship, only then the relation of the currency movements and the inflation rate differential of the Pound with respect to the US Dollar. Remarkable is that here the opposite is happening then with the € per $. *Figure 4.2* shows an average exchange rate movement of 0.05% (standard deviation 2.79%) and an average inflation rate differential of -0.34% (this means UK inflation is lower than US inflation on average) (standard deviation of 1.63%). Again, this is the complete opposite of what theory is suggesting. A negative inflation rate differential has to show a negative exchange rate movement.

The only case, in which the theory is right, is in *Figure 4.3.* Here, the relationship between the Japanese Yen and U.S. Dollar exchange rate movement and the inflation rate differential between those countries is shown. An average inflation rate differential of
 -2.84% (standard deviation of 1.09%), because US inflation exceeds Japanese inflation by far, and an average exchange rate movement of -0.11% (standard deviation of 2.87%) confirm the economic PPP-theory. Later in this research, the usefulness of this model will be tested using the in-sample method. The p-value of the parameter has to be below 5% if this model can predict exchange rate movements (in-sample). For now, already a question mark can be assigned to this model.

*Figure 4.3: Relationship currency movements (¥ per $) and inflation rate differential (πjapan – πus)*

*4.3 Uncovered Interest Rate Parity*
This model assumes that a depreciation or appreciation of one currency to another can be neutralized by the interest rate differences. If for example the UK interest rate increases while US interest rates remain unchanged, then the British Pound should depreciate against the US Dollar, which means that the British Pound per US Dollar exchange rate increases. Thus, the sign of the parameter in the UIRP-model is expected to be positive. If the interest rate differential widens, so an increase in the difference between the two countries’ interest rate, the exchange rate will increase.

 According to the model, the expected change in the exchange rate is equal to nominal interest rate differential. The equation that we used for the forecasting is:

**Δst = α + β Δ(it-1-it-1\*) + ε**

Where Δst isthe logarithm of the first difference of the exchange rate is, α is the constant, *it* is the interest rate for the home country and *it*\* is the rate for the foreign country.

*Figure 4.4: Relationship currency movements (€ per $) and interest differential (iea – ius)*

*Figure 4.4* shows us the relationship between the currency movements (€ per $) and the interest rate differential. The average interest rate differential is 0.57% (standard deviation of 1.46%) with an average exchange rate change of -0.14% (standard deviation of 3.17%) This is not in line with the theory. If the European interest rate declines, this should mean that the Euro to Dollar exchange rate declines.

*Figure 4.5: Relationship currency movements (£ per $) and interest differential (iuk – ius)*

 However, when taking a look at the Pound/US Dollar exchange rate in relation with the interest rate differential (*Figure 4.5)* this relation is in line with the theory. An average interest differential of 1.90% (standard deviation of 1.31%) with an average exchange rate movement of 0.05% (standard deviation of 2.79%) speaks about a confirmation of the theory.

*Figure 4.6: Relationship currency movements (¥ per $) and interest differential (ijapan – ius)*

Also the relationship between the Japanese Yen to U.S. Dollar exchange rate and their interest rate differential is not in favor with the theory. An average exchange rate movement of 0.11% (standard deviation of 2.87%) and an average differential of -1.30% (standard deviation of 2.04%), is not the predicted positive relationship.

Again, just like with the Purchasing Power Parity, from the three currency relationships, only one is suitable with the theory. So again we can assign our question marks to this model.

*4.4 Taylor Rule Model*

*Taylor* *(1993)* introduced monetary rules that determine what interest rate the central bank should set based on the macro-economic fundamentals. The original formulation used the current inflation rate and the equilibrium or natural real interest rate, the inflation gap (difference between inflation and target inflation), the output gap (difference between actual GDP and potential GDP[[2]](#footnote-2)). .

The original formula that Taylor used was:

**it = α(πt-1 – πt-1T) + β(yt-1 – yt-1T)**

Where i is the interest rate, (πt – πtT) is the inflation gap, so thedifference between inflation and target inflation and (yt – ytT) the output gap (difference between actual GDP and potential GDP). The target inflation for the Euro Area, the US and UK is assumed to be 2% and for Japan assumed to be 1%

If Taylor Rules are specified for two countries or monetary areas, then the difference between them can be used to give an estimate of the exchange rate, if we assume that the UIRP theory holds. *Molodtsova and Papell* *(2009)* used this method (then assuming PPP theory to hold) to predict the exchange rate.

Home Taylor Rule:

**it = α(πt-1 – πt-1T) + β(yt-1 – yt-1T)**

Foreign Taylor Rule:

**it\*= α\*(πt-1 \*– πt-1T\*) + β\*(yt-1\*– yt-1T\*)**

We subtract the ‘foreign’ Taylor Rule from the ‘home’ Taylor Rule and assume UIRP:

**it - it\* = Δst**

**Δst = α(πt-1 – πt-1T) - α\*(πt-1 \*– πt-1T\*) + β(yt-1 – yt-1T) - β\*(yt-1\*– yt-1T\*)**

Adding a constant and an error term gives the formula that will be used for forecasting:

 **Δst = Ω + α(πt-1 – πt-1T) - α\*(πt-1 \*– πt-1T\*) + β(yt-1 – yt-1T) - β\*(yt-1\*– yt-1T\*) + ε**

The sign of the inflation-gap differential is expected to be positive. If the inflation gap differential increases, so for example the difference between the British and the US inflation gap (thus British inflation gap exceeds US inflation gap), the Pound per Dollar exchange rate increases and the pound is depreciating against the US dollar. This can be, as with the PPP-model, explained by the economic rationality of supply and demand. If the inflation in the UK is rising, it is not attractive for investors to invest in it: their money is becoming less valuable. The money therefore shifts to other parts of the world - which means less demand for the Pound and more demand for other currencies - for example the US Dollar. So, the pond per dollar exchange rate increases.

In a country with a negative output gap, it means that not all capacity is used, due to for example high unemployment. Hence, the country is not in a good situation. This can also be shown visually in the graph. In recessions and low economic growth, the output gap is often also negative or decreasing.

Often, a very low interest rate goes hand in hand with a highly negative output gap.[[3]](#footnote-3) In this Taylor rule model for the exchange rate, the foreign country output gap (i.e. the US output gap) is subtracted from the home output gap (i.e. the Japanese output gap) (since the exchange rate is defined as Japanese Yen per US Dollar). So if US’ output gap is lower than Japan’s, we have a positive output gap differential. The positive output gap differential will have a depreciating effect on the Japanese Yen and an appreciating effect on the US Dollar. This is because a smaller output gap comes with a smaller interest rate, and a smaller interest rate comes with an appreciating currency because UIRP holds. The relatively lower US interest rate relative to the Japanese interest rate is expected to come with an appreciating US Dollar and a depreciating Japanese Yen. (UIRP holds remember). The Yen / US Dollar exchange rate will increase. A positive sign is thus expected for the coefficient of the output gap differential. The output gaps and inflation rate gaps for the different currencies, which are relevant for the Taylor Rule are shown on the next pages.

*Figure 4.7: Japanese Output Gap*

*Figure 4.8: US Output Gap*

*Figure 4.9: U.K. Output Gap*

*Figure 4.10: Euro Area Output Gap*

 *Figure 4.11: Inflation Gap US, UK, Japan and Euro Area*

The inflation gap is calculated with a ‘symmetrical target’ inflation of 2% for the US, Euro Area and UK. For Japan, this target inflation is set on 1%. Symmetrical means that central banks are equally concerned about over- and undershooting. Most of the time central banks have an allowance of 1% above or below target. With a symmetrical target, the central bank tries to assure that the Gross Domestic Product does not deviate too much from its potential.

As the following graphs show, there is no clear pattern of a positive change in the exchange rate being associated with a positive output gap differential. This is not in line with what is expected by the Taylor model for the exchange rate. What is remarkable, is that the output gap differential between the home country (Euro Area, Japan and United Kingdom) and the foreign country (US), is moving from negative to positive somewhere from 2006. This is very clear in *Figure 4.11* and *Figure 4.13* and in a lesser degree in *Figure 4.12.* A positive output gap differential means that the output gap in for example the Euro area is higher than the US output gap. As mentioned before, a low output gap often indicates a low interest rate. If UIRP theory holds and when the interest rate in the Euro area is higher than the US interest rate (so a positive output gap differential), you expect a depreciating Euro against the US Dollar. This means that the € / $ exchange rate is rising. This theory tells us that from 2006, the exchange rates should rise, but the graphs 4.11. 4.12 and 4.13 do not show this relationship.

*Figure 4.12: Relationship currency movements (€ per $) and output gap differential (yea – yus)*

 *Figure 4.13: Relationship currency movements (£ per $) and output gap differential (yuk – yus)*

*Figure 4.14: Relationship currency movements (¥ per $) and output gap differential (yjapan – yus)*

*4.5 Error Comparison*

The forecast comparison off the accuracy of the different forecasting models will be done by the mean error (ME), the mean absolute error (MAE) and the root mean squared error (RMSE). This will be like the paper of *Meese and Rogoff, (1983).* The formula for the RMSE is:

$$RMSE=\sum\_{s=0}^{n} \sqrt{\frac{(F\left(s\right)- A(s))^{2}}{N}} $$

Here, F(s) is the forecasted and A(s) is the actual exchange rate. Expressing the formula in words, the difference between forecast and corresponding observed values are each squared and then averaged over the sample. Finally, the square root of the average is taken. Since the errors are squared before they are averaged, the RMSE gives a relatively high weight to large errors. This means the RMSE is most useful when large errors are particularly undesirable.

The formula of the MAE is:

$$MAE=\sum\_{s=0}^{n}\frac{⃒(F\left(s\right)- A(s))⃒}{N}$$

In words, the absolute difference between forecasted F(s) and actual A(s), divided by the sample size. This measurement is useful when the exchange rate distribution has fat tails.

And last, the formula of the ME is:

$$ME=\sum\_{s=0}^{n}\frac{(F\left(s\right)- A(s))}{N}$$

 This measurement is used, mainly to test the robustness of the model. By comparing MAE and ME, there will be seen if the model systematically over- or under predicts.

*4.6 Diebold-Mariano Statistic*
Next is to test the differences in the forecast accuracy of the forecasts. In this research the Diebold-Mariano statistic is used for this procedure which is defined as the ratio between the sample loss mean differential and an estimate of its standard error. The loss differential is here defined as the difference between both the squared and the absolute forecast error of the models and that of the ‘Random Walk’. The Diebold-Mariano statistic is the t-statistic derived by the regression of each loss differential on a constant with heteroscedastic and autocorrelation consistent (HAC) standard errors, as used by *Newey and West (1987).* As a matter of fact, all the regressions (with the in-sample testing procedure) will be done as described by *Newey and West (1987).* The statistic has an asymptotic standard normal distribution. Under the null hypothesis, the model with the lowest value of loss function has equal predictive ability with the alternative model. Under the alternative hypothesis, the model with the lowest value of loss function has superior predictive ability.

A quick way to compare forecasting performance of the models with the Random Walk is to compare the RMSE of the models with the errors of the Random Walk by means of ratio (*Cheung & Pasqual, 2005)*. If the ratio RMSEModel/RMSERandom Walk is smaller than 1, the model is better than the Random Walk.

*4.7 Conclusion*

The Random Walk, PPP-model, UIRP-model and Taylor Rule model will be compared on their forecast accuracy. In this chapter, the relation of the currency movements and the characteristics of the models are investigated. Besides this, the models’ features are excessively described. The forecasting performance will be measured with the help of the Diebold-Mariano Statistic and the ratio of the models’ RMSEs. The results are shown in the next chapter.  **5. Empirical Results**

**First of all, the regressions of all the forecasting models are compared with their p-values and R2 coefficients. This is also called the in-sample testing procedure. Then the errors of each of the models are compared with the out-of-sample procedure of rolling regressions. To make the research more robust, the Diebold-Mariano test statistic is also used to see if the model performs better than the ‘Random Walk’ model.**

 ***5.1 The Random Walk***

The regression formula used to estimate the Random Walk Model is:

**Δs*t = α +* Δ*st-1 + ε***

***Table 5.1: Regression Random Walk***

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***Exchange Rates*** | ***α*** | ***P-value*** | **Δ*st-1*** | ***P-value*** | **R2** |
| € / $ | **-0.0053** | **0.1752** | **0.9810** | **0.0000\*** | **0.9664** |
| £ / $ | **-0.0158** | **0.1133** | **0.9689** | **0.0000\*** | **0.9384** |
| **¥ / $** | **0.0440** | **0.5418** | **0.9902** | **0.0000\*** | **0.9602** |

**\**Significant at 99% confidence level***

**As table 5.1 suggests, the Random Walk model is doing good. Every single p-value from the explanatory variable Δ*st-1* lays below the 5% significance level. This basically means that the exchange rate of today can be forecasted by the exchange rate of yesterday.This can be seen also from the R2. The variable Δ*st-1* explains the Δ*st* for around 95%.**

***Table 5.2: Forecasting errors of the Random Walk Model***

|  |  |  |  |
| --- | --- | --- | --- |
| ***Exchange Rates*** | ***ME*** | ***MAE*** | ***RMSE*** |
| **€ / $** Month **Quarter** **Year** | **0.0019****0.0025****0.1031** | **0.0243****0.0549****0.0961** | **0.0225****0.0295****0.0312** |
| **£ / $** Month Quarter Year | **-0.0001****0.0000****0.0008** | **0.0211****0.0471****0.0474** | **0.0014****0.0001****0.0092** |
| **¥ / $** Month Quarter Year | **0.0015****0.0011****0.0017** | **0.02241****0.0503****0.0967** | **0.01861****0.0142****0.0201** |



***Figure 5.1: Random Walk Model (****€ / $)* ***forecasting (Monthly)***

**

***Figure 5.2: Random Walk Model (***€ */ $)* ***forecasting (Quarterly)***



***Figure 5.3: Random Walk Model (****€ / $)* ***forecasting (Yearly)***

**At this stage, looking at the forecasting figures, it is not yet clear how the Random Walk performs with respect to the other models. The forecasting figures look very random at first sight (as supposed to with the Random Walk). Figures 5.1, 5.2 and 5.3 look very messy but show this random feature. The Random Walk forecast has to be, according to the theory, accurate in predicting the change in exchange rates. You can see from the figures that the monthly Random Walk forecast is more accurate than for example the yearly. The Random Walk forecasting figures for the other two exchange rates give a similar image (see appendix). After presenting the performances of the individual models, there will be a comparison with the Random Walk models for which model performs best.**

***5.2 The Purchasing Power Parity***The regression formula used to estimate the Purchasing Power Parity Model is: **Δst = α + β (Δψt-1) + ε**

***Table 5.3: Regression PPP***

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***Exchange Rates*** | ***α*** | ***β*** | ***P-value α***  | ***P-value β*** | **R2** |
| € / $ | -0.0017 | 0.0176 | 0.4850 | 0.0005\* | 0.0514 |
| £ / $ | 0.0000 | 0.0115 | 0.9698 | 0.0966 | 0.0372 |
| **¥ / $** | -0.0018 | -0.0032 | 0.4281 | 0.5583 | 0.0035 |

***\* Significant at 99% confidence level***

**As the table shows, almost no single exchange rate can be predicted accurately in a significant way with the PPP-model. Only the** € / $ exchange rate can be predicted significantly with the help of the consumer price index. As described earlier in the chapter ‘Methodology’, the sign of the β has to be positive . For the only exchange rate the PPP can significantly predict, the sign of the parameter is positive. Hence, the Euro/ US Dollar exchange rate can be predicted by the PPP-model and in the direction as expected.



***Figure 5.4: Purchasing Power Parity Model (****€ / $)* ***forecasting (1,3,12 months)***



***Figure 5.5: Purchasing Power Parity Model (****£ / $)* ***forecasting (1,3,12 months)***



***Figure 5.6: Purchasing Power Parity Model (****¥ / $)* ***forecasting (1,3,12 months)***

**The figures above show the graphs of the forecasting errors of the PPP-model for one month, 3 month and 1 year forecasts of the researched exchange rates.**

***Table 5.4: Forecasting errors of the Purchasing Power Parity Model***

|  |  |  |  |
| --- | --- | --- | --- |
| ***Exchange Rates*** | ***ME*** | ***MAE*** | ***RMSE*** |
| **€ / $** Month **Quarter** **Year** | **0.0145****-0.0337****-0.0445** | **0.0349****0.0337****0.0445** | **0.1508**0.18160.1334 |
| **£ / $** Month Quarter Year | **0.0078****-0.0104****-0.0042** | **0.0324****0.0104****0.0042** | **0.0806****0.0056****0.0127** |
| **¥ / $** Month Quarter Year | **-0.0469****0.0064****0.0019** | **0.0673****0.0064****0.0019** | **0.4869****0.0348****0.0056** |

***5.3 The Uncovered Interest Rate Parity***

The regression formula used to estimate the Uncovered Interest Rate Parity Model is:
**Δst = α + β Δ(it-1-it-1\*) + ε**

***Table 5.5: Regression UIRP***

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***Exchange Rates*** | ***α*** | ***β*** | ***P-value α***  | ***P-value β*** | **R2** |
| **€ / $** | -0.0020 | 0.0011 | 0.4564 | 0.9125 | 0.0000 |
| **£ / $** | 0.0002 | -0.0030 | 0.9277 | 0.7636 | 0.0007 |
| **¥ / $** | -0.0017 | -0.0055 | 0.4703 | 0.4629 | 0.0033 |

**The Uncovered Interest Rate Parity Model is performing very badly. No single exchange rate prediction is significant and the R2 values are extremely low. The sign of the parameters of the** £ / $ and ¥ / $ is minus like expected, but the parameters are not significant

****

***Figure 5.7: Uncovered Interest Rate Parity Model (****€ / $)* ***forecasting (1,3,12 months)***



***Figure 5.8: Uncovered Interest Rate Parity Model (****£ / $)* ***forecasting (1,3,12 months)***



***Figure 5.9: Uncovered Interest Rate Parity Model (****¥ / $)* ***forecasting (1,3,12 months)***

***Table 5.6: Forecasting errors of the Uncovered Interest Rate Parity Model***

|  |  |  |  |
| --- | --- | --- | --- |
| ***Exchange Rates*** | ***ME***  | ***MAE*** | ***RMSE*** |
| € / $ Month Quarter **Year** | **-0.0315****0.0252****0.0018** | **0.0762****0.0252****0.0018** | **0.3274****0.1354****0.0053** |
| £ / $ Month Quarter **Year** | **-0.0098****0.0022****-0.0121** | **0.0532****0.0022****0.0121** | **0.1023****0.0120****0.0364** |
| ¥ / $ Month Quarter **Year** | **-0.0512****0.0092****-0.0038** | **0.1047****0.0092****0.0038** | **0.5319****0.0498****0.0114** |

 ***5.4 The Taylor Rule***

The regression formula used to estimate the Taylor Rule Model is:

**Δst = Ω + α(πt – πtT) - α\*(πt \*– πtT\*) + β(yt – ytT) - β\*(yt\*– ytT\*) + ε**

The Taylor Rule model is estimated on quarterly basis, because the data of the output gap was only quarterly available.

***Table 5.7: Regression Taylor Rule***

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***Exchange Rates*** | **Ω** **(p-value)** | **α** **(p-value)** | **α\*** **(p-value)** | **β****(p-value)** | **β\*****(p-value)** | **R2** |
| € / $ | -0.0173*(0.0155)\** | 0.0089(*0.0491)\** | 0.0087*(0.1440)* | -0.0059*(0.2779)* | -0.0018*(0.6473)* | 0.1031 |
| £ / $ | -0.0051*(0.5759)* | 0.0015*(0.8745)* | 0.0130*(0.0698)* | -0.0130*(0.0283)\** | -0.0051*(0.3704)* | 0.2017 |
| **¥ / $** | -0.0366*(0.2300)* | -0.0129*(0.2445)* | 0.0031*(0.6652)* | 0.0012*(0.7197)* | 0.0023*(0.2246)* | 0.0932 |

***\*significant at 95%-confidence level***

**Studying Table 5.7*,* the first thing that is remarkable is the relatively high R2-measurement, compared to the UIRP- and PPP-model. Only with** ¥ / $ exchange rate, the independent variables do not explain the dependent variable (exchange rate) that well. Further, the £ / $ and € / $ exchange rate have one independent variable that is significant at a 95%-confidence level, and the € / $ also has a significant constant. This is a good sign for the Taylor Rule model. The UIRP had no significant variable and the PPP only one with the € / $.

***Table 5.8: Forecasting errors of the Taylor Rule Model***

|  |  |  |  |
| --- | --- | --- | --- |
| ***Exchange Rates*** | ***ME***  | ***MAE*** | ***RMSE*** |
| € / $ Quarter Year | **0.0656****0.0250** | **0.1627****0.0341** | **0.5583****0.2047** |
| £ / $ Quarter Year | **-0.0756****-0.0051** | **0.1866****0.0465** | **0.5134****0.0405** |
| ¥ / $ Quarter Year | **0.1079****0.0379** | **0.2084****0.0674** | **1.0871****0.2726** |

Table 5.8 shows that the measurement errors are much higher than the other models. The Taylor Rule model is not performing as good as expected. In fact, it is the worst model of all, with respect to the measurement errors. However, the Taylor Model is a consistent model and performs almost equal for every exchange rate. This bad performance of the Taylor Model is an observation not in line with other research *(e.g. Molodtsova & Papell, 2009).* The reason for this, can be that the the Taylor Rule model consists of quarterly data, which gives less observations, and thus a higher forecast error. So in fact, it is not so strange that the errors are higher than the other forecast models. This can be corrected with the help of the Diebold-Mariano statistic.





***Figure 5.10: Taylor Rule Model (****€ / $)* ***forecasting (3, 12 Months)***



***Figure 5.11: Taylor Rule Model (****£ / $)* ***forecasting (3, 12 Months)***



***Figure 5.12: Taylor Rule Model (****¥ / $)* ***forecasting (3, 12 Months)***

**The next table shows the model performance according to the ratio of the model’s RMSE and the Random Walk’s RMSE.**

***Table 5.9: RMSE Ratio Comparison***

|  |  |  |
| --- | --- | --- |
| ***Model Performance Compared to Random Walk*** | ***Exchange Rate*** | ***RMSE Ratio***  |
| **Purchasing Power** **Parity** | € / $ Month Quarter Year£ / $ Month Quarter Year¥ / $ Month Quarter Year | **6.70****6.16****4.28****57.57****56.00****1.38****26.16****2.45****0.28\*** |
| **Uncovered Interest Rate Parity** | € / $ Month Quarter Year£ / $ Month Quarter Year¥ / $ Month Quarter Year | **14.55****4.59****0.17\*****73.07****120.00****3.96****28.58****3.51****0.57\*** |
| **Taylor Rule** | € / $ Quarter Year £ / $ Quarter Year¥ / $ Quarter Year | **18.93****6.56****5314.00****4.40****76.56****13.56** |

***\* Better than Random Walk***

**As you can see in the table above, almost no forecasting model is performing better than the Random Walk. There are three exceptions: the year ahead forecasts for the** ¥ / $ with the PPP and UIRP and the year ahead forecast for the € / $ in the UIRP. However, derived from this simple forecasting ratio, we cannot take strong conclusions. The next tables show the Diebold-Mariano statistics, from which we can take more accurate and statistically supported conclusions.

***Tabel 5.10: Quarterly Model Performance according to the Diebold-Mariano statistic***

|  |  |  |  |
| --- | --- | --- | --- |
| ***Model Performance Compared to Random Walk***  | ***Exchange Rate*** | ***SLD*** *(p-value)* | ***ALD*** *(p-value)* |
| **Purchasing Power Parity**  | € / $£ / $¥ / $ | 0.0063 (0.0000)\*\*0.0057 (0.0000)\*\*0.0040 (0.0000)\*\* | 0.0232 (0.0516)0.0224 (0.0491)\*-0.0105 (0.2838) |
| **Uncovered Interest Rate Parity** | € / $£ / $¥ / $ | 0.0075 (0.0006)\*\*0.0069 (0.0001)\*\*0.0120 (0.0008)\*\* | -0.0156 (0.2371)0.0049 (0.6989)-0.0268 (0.1057) |
| **Taylor Rule**  | € / $£ / $¥ / $ | 0.0613 (0.0001)\*\*0.0611 (0.0004)\*\*0.1776 (0.0119)\* | -0.0990 (0.0095)\*0.0742 (0.0566)-0.1824 (0.0047)\*\* |

*\* Significant at 95%-confidence level*

*\*\* Significant at 99%-confidence level*

***Tabel 5.11: Yearly Model Performance according to the Diebold-Mariano statistic***

|  |  |  |  |
| --- | --- | --- | --- |
| ***Model Performance Compared to Random Walk***  | ***Exchange Rate*** | ***SLD*** *(p-value)* | ***ALD*** *(p-value)* |
| **Purchasing Power Parity**  | € / $£ / $¥ / $ | 0.0145 (0.0074)\*\*0.0073 (0.0038)\*\*0.0172 (0.0396)\* | -0.0096 (0.8159)-0.0055 (0.8507)-0.0023 (0.9583) |
| **Uncovered Interest Rate Parity** | € / $£ / $¥ / $ | 0.0077 (0.0233)\*0.0083 (0.0131)\*0.0123 (0.0812) | -0.0545 (0.0417)\*-0.0241 (0.4315)-0.0260 (0.4860) |
| **Taylor Rule**  | € / $£ / $¥ / $ | 0.0527 (0.0603)0.0457 (0.0370)\*0.1366 (0.0198)\* | -0.1375 (0.0516)0.0281 (0.6996)-0.1604 (0.1824) |

 *\* Significant at 95%-confidence level*

*\*\* Significant at 99%-confidence level*

In the tables above, the squared loss differentials (SLD) and absolute loss differentials (ALD) are shown. The Diebold-Mariano or DM-statistic, as depicted in the tables above, tests whether the two models have equal forecasting accuracies. When the DM-statistics are positive and significant, the corresponding model performs better than the random walk model.

Table 5.10 shows the quarterly model performance compared to the ‘Random Walk’ model. Here it is clearly (for the squared loss differentials) visible that all the models significantly perform better than the random walk (at least with 95%-confidence level) in forecasting ¼ year ahead. This is not in line with the RMSE, MSE and MAE measurements of this research and also not in line with other research done at this topic. So for the short term, all models perform better than the Random Walk according to the SLD-statistic.

For the 1-year ahead forecast performance, we see a more expected outcome. Only for the Yen / US Dollar in the UIRP model and the Euro / US Dollar in the Taylor Rule Model, the 1 year ahead forecast is not significantly better than the random walk. You would expect this outcome. The Random Walk model is more likely to perform worse in the long run, because of the random feature. It is unexpected however that the model performs badly on the ¼ ahead forecast.

***5.5 Conclusion***

**Comparing the errors on the eye, we see that the Random Walk has the lowest forecast errors. However, if we consider the Diebold-Mariano statistic, for the short run and long run (¼ and 1 year ahead) forecast, every model is performing better than the Random Walk. Even the UIRP, using short term interest rates, which has been rejected by most studies, performs better than the Random Walk.**

***Table 5.12: Summary Table***

|  |  |  |  |
| --- | --- | --- | --- |
| ***Forecasting performance compared to Random Walk according to DM-statistic*** |  ***PPP*** |  ***UIRP*** |  ***Taylor Rule*** |
| € / $ |  **1**  |  **1** |  **0** |
| **Long run** £ / $¥ / $ € / $**Short run** £ / $ |  **1** **1** **1** **1** |  **1** **0** **1** **1** |  **1** **1** **1** **1** |
| ¥ / $ |  **1** |  **1** |  **1** |

**1 = Better than Random Walk Model, 0 = Worse than Random Walk model**

1. **Conclusion**

**This research tried to show the forecasting performance of the Fundamental UIRP and PPP models and the newer Taylor Rule model with the Random Walk model. This research has never been done with the Euro involved into the models. When looking solely at the errors of the models, it tells us that the naive Random Walk model is performing (still) better than the other models researched. This can be seen in the table 5.9. However, comparing the Diebold-Mariano statistic, which is more statistically supported, the Taylor Rule, UIRP and the PPP-model perform better than the Random Walk in the short term (¼ year) and long term (1 year) ahead forecasting. This holds even more for the short term (¼-ahead); all models perform better than the Random Walk model. These results are partially in line with excising literature. The fact that the Taylor Rule model is performing better is in line with recent research done by *Molodtsova & Papell (2007).* The fact that the fundamental models perform better in short term forecasting is in line with research done by *Wang (2006)* and Engel and West (2005)*.* The fact that the fundamental models perform better in the long run is in line with research done by *Mark (1995)* and *MacDonald & Marsh (1994).* We saw from earlier studies (e.g. *Molodtsova & Papell, (2007))* that the PPP and UIRP can beat the Random Walk in the short term forecasting. This research has shown that currencies can be forecasted significantly better with the help of the Fundamental Models and the Taylor Rule model, rather than the Random Walk.**

**Future research can maybe proof that the Taylor Rule can also significantly better forecast exchange rates on a monthly basis. For this research, the output gaps were only available on a quarterly basis. Secondly, this research used a period with a severe financial crisis. This fact could maybe have influenced the outcomes of the research. It would be very useful to investigate the performance of the models in a more stable period. Thirdly, this research used a relatively short period of data. After some decennia, it would be interesting to see if there are some changes if a more extensive period of data is used to measure the performance of the models.**

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**8. Appendix**

**DESCRIPTIVE STATISTICS CPI**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | US | UK | JAPAN | EU |
|  Mean |  2.548747 |  2.207534 | -0.289521 |  3.337397 |
|  Median |  2.719900 |  1.900000 | -0.300000 |  2.845000 |
|  Maximum |  5.600100 |  5.200000 |  2.290000 |  6.670000 |
|  Minimum | -2.097200 |  0.500000 | -2.520000 |  0.490000 |
|  Std. Dev. |  1.361241 |  1.154307 |  0.783240 |  1.433862 |
|  Skewness | -0.918936 |  0.771945 |  0.442823 |  0.677969 |
|  Kurtosis |  4.410503 |  2.724028 |  4.958819 |  2.765290 |
|  |  |  |  |  |
|  Jarque-Bera |  32.65104 |  14.96351 |  28.11318 |  11.51976 |
|  Probability |  0.000000 |  0.000563 |  0.000001 |  0.003151 |
|  |  |  |  |  |
|  Sum |  372.1171 |  322.3000 | -42.27000 |  487.2600 |
|  Sum Sq. Dev. |  268.6817 |  193.2017 |  88.95247 |  298.1144 |
|  |  |  |  |  |
|  Observations |  146 |  146 |  146 |  146 |
|  |  |  |  |  |
|  |  |  |  |  |

**DESCRIPTIVE STATISTICS INTEREST RATES**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | EU | JAPAN | UK | US |
|  Mean |  2.798639 |  0.925374 |  4.124082 |  2.225374 |
|  Median |  2.530000 |  0.900000 |  4.530000 |  1.680000 |
|  Maximum |  5.110000 |  2.700000 |  6.400000 |  6.370000 |
|  Minimum |  0.640000 |  0.270000 |  1.020000 |  0.010000 |
|  Std. Dev. |  1.356374 |  0.480450 |  1.273226 |  1.981061 |
|  Skewness |  0.104462 |  0.950559 | -0.791208 |  0.556185 |
|  Kurtosis |  1.803027 |  4.095778 |  2.671235 |  1.960880 |
|  |  |  |  |  |
|  Jarque-Bera |  9.042909 |  29.49176 |  15.99926 |  14.19248 |
|  Probability |  0.010873 |  0.000000 |  0.000336 |  0.000828 |
|  |  |  |  |  |
|  Sum |  411.4000 |  136.0300 |  606.2400 |  327.1300 |
|  Sum Sq. Dev. |  268.6035 |  33.70145 |  236.6814 |  572.9921 |
|  |  |  |  |  |
|  Observations |  147 |  147 |  147 |  147 |

**DESCRIPTIVE STATISTICS OUTPUT GAP**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | EU | JAPAN | UK | USA |
|  Mean | -0.162037 |  0.158038 | -0.220851 | -0.455374 |
|  Median | -0.305412 | -0.070822 | -0.189769 | -0.441589 |
|  Maximum |  2.890290 |  4.947053 |  1.210558 |  2.768291 |
|  Minimum | -2.472742 | -2.973932 | -2.214402 | -2.463260 |
|  Std. Dev. |  1.306127 |  1.958892 |  0.888824 |  1.263416 |
|  Skewness |  0.314528 |  0.473333 | -0.460500 |  0.408847 |
|  Kurtosis |  2.521576 |  2.495098 |  2.643698 |  2.391916 |
|  |  |  |  |  |
|  Jarque-Bera |  1.769707 |  3.261462 |  2.763044 |  2.942102 |
|  Probability |  0.412775 |  0.195786 |  0.251196 |  0.229684 |
|  |  |  |  |  |
|  Sum | -11.01850 |  10.74658 | -15.01788 | -30.96540 |
|  Sum Sq. Dev. |  114.2998 |  257.0963 |  52.93059 |  106.9467 |
|  |  |  |  |  |
|  Observations |  68 |  68 |  68 |  68 |

**DESCRIPTIVE STATISTICS EXCHANGE RATES**

 Yen/Dollar Pound/Dollar Euro/Dollar

|  |  |  |  |
| --- | --- | --- | --- |
|  Mean |  106.5805 |  0.602707 |  0.844567 |
|  Median |  109.1850 |  0.616085 |  0.788631 |
|  Maximum |  133.8800 |  0.714010 |  1.181614 |
|  Minimum |  76.13000 |  0.480380 |  0.634739 |
|  Std. Dev. |  14.41069 |  0.065602 |  0.152779 |
|  Skewness | -0.548795 | -0.137623 |  0.829982 |
|  Kurtosis |  2.389903 |  1.839561 |  2.386941 |
|  |  |  |  |
|  Jarque-Bera |  9.724360 |  8.771337 |  19.30981 |
|  Probability |  0.007734 |  0.012455 |  0.000064 |
|  |  |  |  |
|  Sum |  15773.92 |  89.20069 |  124.9959 |
|  Sum Sq. Dev. |  30527.18 |  0.632641 |  3.431182 |
|  |  |  |  |
|  Observations |  148 |  148 |  148 |
|  |  |  |  |

**UNIT ROOT TESTS FOR EXCHANGE RATES AND FIRST DIFFERENCES**

**EURO / DOLLAR**

|  |  |
| --- | --- |
| Null Hypothesis: EURO\_DOLLAR has a unit root |  |
| Exogenous: Constant |  |  |
| Lag Length: 0 (Automatic - based on SIC, maxlag=13) |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  | t-Statistic |   Prob.\* |
|  |  |  |  |  |
|  |  |  |  |  |
| Augmented Dickey-Fuller test statistic | -1.169460 |  0.6867 |
| Test critical values: | 1% level |  | -3.475819 |  |
|  | 5% level |  | -2.881400 |  |
|  | 10% level |  | -2.577439 |  |
|  |  |  |  |  |
|  |  |  |  |  |
| \*MacKinnon (1996) one-sided p-values. |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Augmented Dickey-Fuller Test Equation |  |
| Dependent Variable: D(EURO\_DOLLAR) |  |
| Method: Least Squares |  |  |
| Date: 03/15/13 Time: 15:56 |  |  |
| Sample (adjusted): 2000M02 2012M02 |  |
| Included observations: 145 after adjustments |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob.   |
|  |  |  |  |  |
|  |  |  |  |  |
| EURO\_DOLLAR(-1) | -0.017045 | 0.014575 | -1.169460 | 0.2442 |
| C | 0.012861 | 0.012538 | 1.025756 | 0.3067 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.009473 |     Mean dependent var | -0.001567 |
| Adjusted R-squared | 0.002547 |     S.D. dependent var | 0.026932 |
| S.E. of regression | 0.026897 |     Akaike info criterion | -4.379873 |
| Sum squared resid | 0.103457 |     Schwarz criterion | -4.338814 |
| Log likelihood | 319.5408 |     Hannan-Quinn criter. | -4.363189 |
| F-statistic | 1.367637 |     Durbin-Watson stat | 1.844135 |
| Prob(F-statistic) | 0.244164 |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**POUND / DOLLAR**

|  |  |
| --- | --- |
| Null Hypothesis: POUND\_DOLLAR has a unit root |  |
| Exogenous: Constant |  |  |
| Lag Length: 0 (Automatic - based on SIC, maxlag=13) |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  | t-Statistic |   Prob.\* |
|  |  |  |  |  |
|  |  |  |  |  |
| Augmented Dickey-Fuller test statistic | -1.526135 |  0.5177 |
| Test critical values: | 1% level |  | -3.475819 |  |
|  | 5% level |  | -2.881400 |  |
|  | 10% level |  | -2.577439 |  |
|  |  |  |  |  |
|  |  |  |  |  |
| \*MacKinnon (1996) one-sided p-values. |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Augmented Dickey-Fuller Test Equation |  |
| Dependent Variable: D(POUND\_DOLLAR) |  |
| Method: Least Squares |  |  |
| Date: 03/15/13 Time: 16:00 |  |  |
| Sample (adjusted): 2000M02 2012M02 |  |
| Included observations: 145 after adjustments |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob.   |
|  |  |  |  |  |
|  |  |  |  |  |
| POUND\_DOLLAR(-1) | -0.032534 | 0.021318 | -1.526135 | 0.1292 |
| C | 0.019694 | 0.012915 | 1.524913 | 0.1295 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.016026 |     Mean dependent var | 0.000101 |
| Adjusted R-squared | 0.009145 |     S.D. dependent var | 0.017009 |
| S.E. of regression | 0.016931 |     Akaike info criterion | -5.305618 |
| Sum squared resid | 0.040993 |     Schwarz criterion | -5.264559 |
| Log likelihood | 386.6573 |     Hannan-Quinn criter. | -5.288934 |
| F-statistic | 2.329088 |     Durbin-Watson stat | 1.757497 |
| Prob(F-statistic) | 0.129185 |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**YEN / DOLLAR**

|  |  |
| --- | --- |
| Null Hypothesis: YEN\_DOLLAR has a unit root |  |
| Exogenous: Constant, Linear Trend |  |
| Lag Length: 0 (Automatic - based on SIC, maxlag=13) |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  | t-Statistic |   Prob.\* |
|  |  |  |  |  |
|  |  |  |  |  |
| Augmented Dickey-Fuller test statistic | -2.603055 |  0.2797 |
| Test critical values: | 1% level |  | -4.022586 |  |
|  | 5% level |  | -3.441111 |  |
|  | 10% level |  | -3.145082 |  |
|  |  |  |  |  |
|  |  |  |  |  |
| \*MacKinnon (1996) one-sided p-values. |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Augmented Dickey-Fuller Test Equation |  |
| Dependent Variable: D(YEN\_DOLLAR) |  |
| Method: Least Squares |  |  |
| Date: 03/15/13 Time: 16:01 |  |  |
| Sample (adjusted): 2000M02 2012M02 |  |
| Included observations: 145 after adjustments |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob.   |
|  |  |  |  |  |
|  |  |  |  |  |
| YEN\_DOLLAR(-1) | -0.068504 | 0.026317 | -2.603055 | 0.0102 |
| C | 9.173186 | 3.335061 | 2.750530 | 0.0067 |
| @TREND(2000M01) | -0.027513 | 0.008783 | -3.132402 | 0.0021 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.065589 |     Mean dependent var | -0.174552 |
| Adjusted R-squared | 0.052428 |     S.D. dependent var | 3.021447 |
| S.E. of regression | 2.941177 |     Akaike info criterion | 5.015969 |
| Sum squared resid | 1228.374 |     Schwarz criterion | 5.077557 |
| Log likelihood | -360.6578 |     Hannan-Quinn criter. | 5.040994 |
| F-statistic | 4.983669 |     Durbin-Watson stat | 2.008811 |
| Prob(F-statistic) | 0.008095 |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**FIRST DIFFERENC EURO / DOLLAR**

|  |  |
| --- | --- |
| Null Hypothesis: DEURO\_DOLLAR has a unit root |  |
| Exogenous: Constant |  |  |
| Lag Length: 0 (Automatic - based on SIC, maxlag=13) |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  | t-Statistic |   Prob.\* |
|  |  |  |  |  |
|  |  |  |  |  |
| Augmented Dickey-Fuller test statistic | -11.31394 |  0.0000 |
| Test critical values: | 1% level |  | -3.476143 |  |
|  | 5% level |  | -2.881541 |  |
|  | 10% level |  | -2.577514 |  |
|  |  |  |  |  |
|  |  |  |  |  |
| \*MacKinnon (1996) one-sided p-values. |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Augmented Dickey-Fuller Test Equation |  |
| Dependent Variable: D(DEURO\_DOLLAR) |  |
| Method: Least Squares |  |  |
| Date: 03/15/13 Time: 16:10 |  |  |
| Sample (adjusted): 2000M03 2012M02 |  |
| Included observations: 144 after adjustments |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob.   |
|  |  |  |  |  |
|  |  |  |  |  |
| DEURO\_DOLLAR(-1) | -0.939120 | 0.083006 | -11.31394 | 0.0000 |
| C | -0.001785 | 0.002238 | -0.797918 | 0.4263 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.474084 |     Mean dependent var | -0.000386 |
| Adjusted R-squared | 0.470380 |     S.D. dependent var | 0.036840 |
| S.E. of regression | 0.026810 |     Akaike info criterion | -4.386292 |
| Sum squared resid | 0.102066 |     Schwarz criterion | -4.345045 |
| Log likelihood | 317.8130 |     Hannan-Quinn criter. | -4.369531 |
| F-statistic | 128.0052 |     Durbin-Watson stat | 1.993567 |
| Prob(F-statistic) | 0.000000 |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**FIRST DIFFERENC POUND / DOLLAR**

|  |
| --- |
| Null Hypothesis: DPOUND\_DOLLAR has a unit root |
| Exogenous: Constant |  |  |
| Lag Length: 0 (Automatic - based on SIC, maxlag=13) |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  | t-Statistic |   Prob.\* |
|  |  |  |  |  |
|  |  |  |  |  |
| Augmented Dickey-Fuller test statistic | -10.70203 |  0.0000 |
| Test critical values: | 1% level |  | -3.476143 |  |
|  | 5% level |  | -2.881541 |  |
|  | 10% level |  | -2.577514 |  |
|  |  |  |  |  |
|  |  |  |  |  |
| \*MacKinnon (1996) one-sided p-values. |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Augmented Dickey-Fuller Test Equation |  |
| Dependent Variable: D(DPOUND\_DOLLAR) |  |
| Method: Least Squares |  |  |
| Date: 03/15/13 Time: 16:11 |  |  |
| Sample (adjusted): 2000M03 2012M02 |  |
| Included observations: 144 after adjustments |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob.   |
|  |  |  |  |  |
|  |  |  |  |  |
| DPOUND\_DOLLAR(-1) | -0.894847 | 0.083615 | -10.70203 | 0.0000 |
| C | 5.89E-05 | 0.001419 | 0.041488 | 0.9670 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.446466 |     Mean dependent var | -0.000112 |
| Adjusted R-squared | 0.442568 |     S.D. dependent var | 0.022812 |
| S.E. of regression | 0.017032 |     Akaike info criterion | -5.293676 |
| Sum squared resid | 0.041192 |     Schwarz criterion | -5.252429 |
| Log likelihood | 383.1447 |     Hannan-Quinn criter. | -5.276916 |
| F-statistic | 114.5334 |     Durbin-Watson stat | 2.001357 |
| Prob(F-statistic) | 0.000000 |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**FIRST DIFFERENC YEN / DOLLAR**

|  |  |
| --- | --- |
| Null Hypothesis: DYEN\_DOLLAR has a unit root |  |
| Exogenous: Constant |  |  |
| Lag Length: 0 (Automatic - based on SIC, maxlag=13) |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  | t-Statistic |   Prob.\* |
|  |  |  |  |  |
|  |  |  |  |  |
| Augmented Dickey-Fuller test statistic | -12.40538 |  0.0000 |
| Test critical values: | 1% level |  | -3.476143 |  |
|  | 5% level |  | -2.881541 |  |
|  | 10% level |  | -2.577514 |  |
|  |  |  |  |  |
|  |  |  |  |  |
| \*MacKinnon (1996) one-sided p-values. |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Augmented Dickey-Fuller Test Equation |  |
| Dependent Variable: D(DYEN\_DOLLAR) |  |
| Method: Least Squares |  |  |
| Date: 03/15/13 Time: 16:12 |  |  |
| Sample (adjusted): 2000M03 2012M02 |  |
| Included observations: 144 after adjustments |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob.   |
|  |  |  |  |  |
|  |  |  |  |  |
| DYEN\_DOLLAR(-1) | -1.023209 | 0.082481 | -12.40538 | 0.0000 |
| C | -0.224574 | 0.249569 | -0.899848 | 0.3697 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.520097 |     Mean dependent var | -0.050486 |
| Adjusted R-squared | 0.516718 |     S.D. dependent var | 4.301135 |
| S.E. of regression | 2.990084 |     Akaike info criterion | 5.042272 |
| Sum squared resid | 1269.566 |     Schwarz criterion | 5.083519 |
| Log likelihood | -361.0436 |     Hannan-Quinn criter. | 5.059032 |
| F-statistic | 153.8934 |     Durbin-Watson stat | 1.998532 |
| Prob(F-statistic) | 0.000000 |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**IN-SAMPLE REGRESSION RANDOM WALK MODEL**

**EURO/DOLLAR**

|  |  |  |
| --- | --- | --- |
| Dependent Variable: DLNED |  |  |
| Method: Least Squares |  |  |
| Date: 04/16/13 Time: 17:58 |  |  |
| Sample (adjusted): 2000M02 2012M04 |  |
| Included observations: 147 after adjustments |  |
| HAC standard errors & covariance (Bartlett kernel, Newey-West fixed |
|         bandwidth = 5.0000) |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob.   |
|  |  |  |  |  |
|  |  |  |  |  |
| C | -0.005325 | 0.003908 | -1.362326 | 0.1752 |
| DLNED(-1) | 0.980985 | 0.016816 | 58.33480 | 0.0000 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.966444 |     Mean dependent var | -0.185243 |
| Adjusted R-squared | 0.966212 |     S.D. dependent var | 0.171841 |
| S.E. of regression | 0.031587 |     Akaike info criterion | -4.058641 |
| Sum squared resid | 0.144671 |     Schwarz criterion | -4.017955 |
| Log likelihood | 300.3101 |     Hannan-Quinn criter. | -4.042110 |
| F-statistic | 4176.121 |     Durbin-Watson stat | 1.904665 |
| Prob(F-statistic) | 0.000000 |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**POUND/DOLLAR**

|  |  |  |
| --- | --- | --- |
| Dependent Variable: DLNPD |  |  |
| Method: Least Squares |  |  |
| Date: 04/16/13 Time: 17:57 |  |  |
| Sample (adjusted): 2000M02 2012M04 |  |
| Included observations: 147 after adjustments |  |
| HAC standard errors & covariance (Bartlett kernel, Newey-West fixed |
|         bandwidth = 5.0000) |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob.   |
|  |  |  |  |  |
|  |  |  |  |  |
| C | -0.015820 | 0.009929 | -1.593295 | 0.1133 |
| DLNPD(-1) | 0.968955 | 0.018969 | 51.08138 | 0.0000 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.938373 |     Mean dependent var | -0.512520 |
| Adjusted R-squared | 0.937948 |     S.D. dependent var | 0.110962 |
| S.E. of regression | 0.027641 |     Akaike info criterion | -4.325515 |
| Sum squared resid | 0.110784 |     Schwarz criterion | -4.284829 |
| Log likelihood | 319.9254 |     Hannan-Quinn criter. | -4.308984 |
| F-statistic | 2207.854 |     Durbin-Watson stat | 1.770746 |
| Prob(F-statistic) | 0.000000 |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**YEN/DOLLAR**

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| --- | --- | --- |
| Dependent Variable: DLNYD |  |  |
| Method: Least Squares |  |  |
| Date: 04/16/13 Time: 17:59 |  |  |
| Sample (adjusted): 2000M02 2012M04 |  |
| Included observations: 147 after adjustments |  |
| HAC standard errors & covariance (Bartlett kernel, Newey-West fixed |
|         bandwidth = 5.0000) |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob.   |
|  |  |  |  |  |
|  |  |  |  |  |
| C | 0.044066 | 0.072059 | 0.611531 | 0.5418 |
| DLNYD(-1) | 0.990236 | 0.015436 | 64.14900 | 0.0000 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.960173 |     Mean dependent var | 4.659417 |
| Adjusted R-squared | 0.959898 |     S.D. dependent var | 0.143261 |
| S.E. of regression | 0.028689 |     Akaike info criterion | -4.251120 |
| Sum squared resid | 0.119340 |     Schwarz criterion | -4.210434 |
| Log likelihood | 314.4574 |     Hannan-Quinn criter. | -4.234589 |
| F-statistic | 3495.729 |     Durbin-Watson stat | 2.019962 |
| Prob(F-statistic) | 0.000000 |  |  |  |
|  |  |  |  |  |
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**FORECASTING FIGURES (MONTHLY, QUARTERLY AND YEARLY) RANDOM WALK**

**POUND / DOLLAR**

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**FORECASTING FIGURES (MONTHLY, QUARTERLY AND YEARLY) RANDOM WALK**

**YEN / DOLLAR**

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**IN-SAMPLE REGRESSION PPP MODEL**

**EURO / DOLLAR**

|  |  |  |
| --- | --- | --- |
| Dependent Variable: D(LNED) |  |  |
| Method: Least Squares |  |  |
| Date: 04/17/13 Time: 19:15 |  |  |
| Sample (adjusted): 2000M03 2011M12 |  |
| Included observations: 142 after adjustments |  |
| HAC standard errors & covariance (Bartlett kernel, Newey-West fixed |
|         bandwidth = 5.0000) |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob.   |
|  |  |  |  |  |
|  |  |  |  |  |
| C | -0.001919 | 0.002543 | -0.754446 | 0.4518 |
| EU\_US(-1) | 0.016448 | 0.004714 | 3.489114 | 0.0006 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.050602 |     Mean dependent var | -0.002291 |
| Adjusted R-squared | 0.043821 |     S.D. dependent var | 0.031782 |
| S.E. of regression | 0.031078 |     Akaike info criterion | -4.090673 |
| Sum squared resid | 0.135215 |     Schwarz criterion | -4.049042 |
| Log likelihood | 292.4378 |     Hannan-Quinn criter. | -4.073756 |
| F-statistic | 7.461881 |     Durbin-Watson stat | 2.013760 |
| Prob(F-statistic) | 0.007114 |  |  |  |
|  |  |  |  |  |
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**POUND / DOLLAR**

|  |  |  |
| --- | --- | --- |
| Dependent Variable: D(LDPD) |  |  |
| Method: Least Squares |  |  |
| Date: 04/17/13 Time: 19:25 |  |  |
| Sample (adjusted): 2000M03 2011M12 |  |
| Included observations: 142 after adjustments |  |
| HAC standard errors & covariance (Bartlett kernel, Newey-West fixed |
|         bandwidth = 5.0000) |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob.   |
|  |  |  |  |  |
|  |  |  |  |  |
| C | -5.98E-05 | 0.002538 | -0.023569 | 0.9812 |
| UK\_US(-1) | 0.011319 | 0.006956 | 1.627214 | 0.1059 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.035475 |     Mean dependent var | 0.000207 |
| Adjusted R-squared | 0.028585 |     S.D. dependent var | 0.028176 |
| S.E. of regression | 0.027771 |     Akaike info criterion | -4.315700 |
| Sum squared resid | 0.107968 |     Schwarz criterion | -4.274069 |
| Log likelihood | 308.4147 |     Hannan-Quinn criter. | -4.298783 |
| F-statistic | 5.149108 |     Durbin-Watson stat | 1.923557 |
| Prob(F-statistic) | 0.024787 |  |  |  |
|  |  |  |  |  |
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**YEN / DOLLAR**

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| --- | --- | --- |
| Dependent Variable: D(LNYD) |  |  |
| Method: Least Squares |  |  |
| Date: 04/17/13 Time: 19:33 |  |  |
| Sample (adjusted): 2000M03 2011M12 |  |
| Included observations: 142 after adjustments |  |
| HAC standard errors & covariance (Bartlett kernel, Newey-West fixed |
|         bandwidth = 5.0000) |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob.   |
|  |  |  |  |  |
|  |  |  |  |  |
| C | -0.002329 | 0.002308 | -1.008988 | 0.3147 |
| JAP\_US(-1) | -0.005228 | 0.006076 | -0.860490 | 0.3910 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.008118 |     Mean dependent var | -0.002311 |
| Adjusted R-squared | 0.001033 |     S.D. dependent var | 0.028078 |
| S.E. of regression | 0.028064 |     Akaike info criterion | -4.294700 |
| Sum squared resid | 0.110259 |     Schwarz criterion | -4.253069 |
| Log likelihood | 306.9237 |     Hannan-Quinn criter. | -4.277783 |
| F-statistic | 1.145798 |     Durbin-Watson stat | 2.114830 |
| Prob(F-statistic) | 0.286273 |  |  |  |
|  |  |  |  |  |
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**IN-SAMPLE REGRESSION UIRP MODEL**

**EURO / DOLLAR**

|  |  |  |
| --- | --- | --- |
| Dependent Variable: DLNED |  |  |
| Method: Least Squares |  |  |
| Date: 04/18/13 Time: 20:46 |  |  |
| Sample (adjusted): 2000M02 2011M12 |  |
| Included observations: 143 after adjustments |  |
| HAC standard errors & covariance (Bartlett kernel, Newey-West fixed |
|         bandwidth = 5.0000) |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob.   |
|  |  |  |  |  |
|  |  |  |  |  |
| C | -0.002005 | 0.002684 | -0.746799 | 0.4564 |
| EU\_US | 0.001057 | 0.009599 | 0.110085 | 0.9125 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.000085 |     Mean dependent var | -0.001977 |
| Adjusted R-squared | -0.007006 |     S.D. dependent var | 0.031892 |
| S.E. of regression | 0.032003 |     Akaike info criterion | -4.032057 |
| Sum squared resid | 0.144415 |     Schwarz criterion | -3.990619 |
| Log likelihood | 290.2921 |     Hannan-Quinn criter. | -4.015218 |
| F-statistic | 0.012023 |     Durbin-Watson stat | 1.920582 |
| Prob(F-statistic) | 0.912843 |  |  |  |
|  |  |  |  |  |
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**POUND / DOLLAR**

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| --- | --- | --- |
| Dependent Variable: DLNPD |  |  |
| Method: Least Squares |  |  |
| Date: 04/18/13 Time: 20:56 |  |  |
| Sample (adjusted): 2000M02 2011M12 |  |
| Included observations: 143 after adjustments |  |
| HAC standard errors & covariance (Bartlett kernel, Newey-West fixed |
|         bandwidth = 5.0000) |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob.   |
|  |  |  |  |  |
|  |  |  |  |  |
| C | 0.000250 | 0.002746 | 0.090858 | 0.9277 |
| UK\_US | -0.002957 | 0.009810 | -0.301395 | 0.7636 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.000799 |     Mean dependent var | 0.000243 |
| Adjusted R-squared | -0.006288 |     S.D. dependent var | 0.028080 |
| S.E. of regression | 0.028168 |     Akaike info criterion | -4.287358 |
| Sum squared resid | 0.111876 |     Schwarz criterion | -4.245919 |
| Log likelihood | 308.5461 |     Hannan-Quinn criter. | -4.270519 |
| F-statistic | 0.112685 |     Durbin-Watson stat | 1.806625 |
| Prob(F-statistic) | 0.737607 |  |  |  |
|  |  |  |  |  |
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**YEN / DOLLAR**

|  |  |  |
| --- | --- | --- |
| Dependent Variable: DLNYD |  |  |
| Method: Least Squares |  |  |
| Date: 04/18/13 Time: 20:57 |  |  |
| Sample (adjusted): 2000M02 2011M12 |  |
| Included observations: 143 after adjustments |  |
| HAC standard errors & covariance (Bartlett kernel, Newey-West fixed |
|         bandwidth = 5.0000) |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob.   |
|  |  |  |  |  |
|  |  |  |  |  |
| C | -0.001669 | 0.002305 | -0.723984 | 0.4703 |
| JAP\_US | -0.005554 | 0.007544 | -0.736160 | 0.4629 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.003317 |     Mean dependent var | -0.001864 |
| Adjusted R-squared | -0.003752 |     S.D. dependent var | 0.028487 |
| S.E. of regression | 0.028541 |     Akaike info criterion | -4.261096 |
| Sum squared resid | 0.114853 |     Schwarz criterion | -4.219658 |
| Log likelihood | 306.6684 |     Hannan-Quinn criter. | -4.244257 |
| F-statistic | 0.469243 |     Durbin-Watson stat | 2.051406 |
| Prob(F-statistic) | 0.494460 |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**IN-SAMPLE REGRESSION TAYLOR RULE MODEL**

**EURO / DOLLAR**

|  |  |  |
| --- | --- | --- |
| Dependent Variable: DLNED |  |  |
| Method: Least Squares |  |  |
| Date: 04/19/13 Time: 20:31 |  |  |
| Sample (adjusted): 2000Q2 2011Q4 |  |
| Included observations: 47 after adjustments |  |
| HAC standard errors & covariance (Bartlett kernel, Newey-West fixed |
|         bandwidth = 4.0000) |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob.   |
|  |  |  |  |  |
|  |  |  |  |  |
| C | -0.017251 | 0.006834 | -2.524392 | 0.0155 |
| EUINF | 0.008850 | 0.004367 | 2.026778 | 0.0491 |
| USINF | 0.008655 | 0.005814 | 1.488760 | 0.1440 |
| EU\_GAP | -0.005991 | 0.005449 | -1.099404 | 0.2779 |
| US\_GAP | -0.001843 | 0.004001 | -0.460762 | 0.6473 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.103086 |     Mean dependent var | -0.006662 |
| Adjusted R-squared | 0.017665 |     S.D. dependent var | 0.048329 |
| S.E. of regression | 0.047901 |     Akaike info criterion | -3.139085 |
| Sum squared resid | 0.096368 |     Schwarz criterion | -2.942261 |
| Log likelihood | 78.76851 |     Hannan-Quinn criter. | -3.065019 |
| F-statistic | 1.206806 |     Durbin-Watson stat | 1.854881 |
| Prob(F-statistic) | 0.322192 |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**POUND / DOLLAR**

|  |  |  |
| --- | --- | --- |
| Dependent Variable: DLNPD |  |  |
| Method: Least Squares |  |  |
| Date: 04/19/13 Time: 19:13 |  |  |
| Sample (adjusted): 2000Q2 2012Q2 |  |
| Included observations: 49 after adjustments |  |
| HAC standard errors & covariance (Bartlett kernel, Newey-West fixed |
|         bandwidth = 4.0000) |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob.   |
|  |  |  |  |  |
|  |  |  |  |  |
| C | -0.005137 | 0.009114 | -0.563630 | 0.5759 |
| UKINF | 0.001504 | 0.009464 | 0.158883 | 0.8745 |
| USINF | 0.012987 | 0.006988 | 1.858533 | 0.0698 |
| UK\_GAP | -0.012966 | 0.005715 | -2.268608 | 0.0283 |
| US\_GAP | 0.005097 | 0.005632 | 0.904978 | 0.3704 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.201736 |     Mean dependent var | 7.75E-05 |
| Adjusted R-squared | 0.129167 |     S.D. dependent var | 0.044512 |
| S.E. of regression | 0.041538 |     Akaike info criterion | -3.427948 |
| Sum squared resid | 0.075919 |     Schwarz criterion | -3.234905 |
| Log likelihood | 88.98472 |     Hannan-Quinn criter. | -3.354707 |
| F-statistic | 2.779907 |     Durbin-Watson stat | 1.475363 |
| Prob(F-statistic) | 0.038254 |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**YEN / DOLLAR**

|  |  |  |
| --- | --- | --- |
| Dependent Variable: DLNYD |  |  |
| Method: Least Squares |  |  |
| Date: 04/19/13 Time: 19:13 |  |  |
| Sample (adjusted): 2000Q2 2012Q2 |  |
| Included observations: 49 after adjustments |  |
| HAC standard errors & covariance (Bartlett kernel, Newey-West fixed |
|         bandwidth = 4.0000) |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob.   |
|  |  |  |  |  |
|  |  |  |  |  |
| C | -0.036615 | 0.030083 | -1.217120 | 0.2300 |
| JAPINF | -0.012873 | 0.010914 | -1.179471 | 0.2445 |
| USINF | 0.003133 | 0.007193 | 0.435649 | 0.6652 |
| JAPAN\_GAP | 0.001203 | 0.003330 | 0.361113 | 0.7197 |
| US\_GAP | 0.002335 | 0.001896 | 1.231576 | 0.2246 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.093171 |     Mean dependent var | -0.005156 |
| Adjusted R-squared | 0.010732 |     S.D. dependent var | 0.040223 |
| S.E. of regression | 0.040007 |     Akaike info criterion | -3.503087 |
| Sum squared resid | 0.070424 |     Schwarz criterion | -3.310044 |
| Log likelihood | 90.82564 |     Hannan-Quinn criter. | -3.429847 |
| F-statistic | 1.130185 |     Durbin-Watson stat | 1.981556 |
| Prob(F-statistic) | 0.354669 |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

1. Data comes from Datastream and OECD. [↑](#footnote-ref-1)
2. The potential GDP or structural GDP is the value of the countries full production capacity [↑](#footnote-ref-2)
3. http://seekingalpha.com/article/849181-the-output-gap-trap-for-policymakers [↑](#footnote-ref-3)