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Master Thesis

A time series Analysis of NZD/USD exchange rate

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Abstract

The exchange rate had always been a very interesting research field. The Foreign exchange (FX) market is the largest financial market in the world with average transactions of more than 5 trillion. (Anirban Nag, 2016) The foreign exchange market acts as an intermediary between the interbank or wholesale market, and the client or retail market. On a global basis investment banks, hedge funds, pension funds, mutual funds and insurance companies are playing a much bigger role in FX markets.

The Bank of International Settlements global foreign exchange rates shows that the New Zealand dollar is the world's 10th most traded currency. In a 15-year period NZD rise from 17th to 10th position. A slang term for the New Zealand dollar (NZD) is kiwi. This name is especially prevalent in commercial transactions of currency because the exchange rate of New Zealand is closely linked to the price and demand for agricultural and forestry products in the country.

The purpose of this study is to build a model of economic and financial variables that can explain the exchange rate. Initially, there is a literature review that examines what different methodologies and different models the researchers have used before us as well as analyzes an economic methodology that we will follow. Thereinafter, we will move in empirical analysis where we will study the relationship between economic and financial factors in relation to the exchange rate in both the long-term model and the short-term model. In the long-term model, we will use the independent variables in logarithms as the dependent variable of NZD/USD exchange rate and in the short model we will use the first differences of selected variables. Additionally, we will try to predict the changes in the exchange rate after the crisis of 2008 with a view to understand and make the model reliable as well as the ability of our model to beat the random walk and the ability of the short-term model to make future forecasts. Finally, we will analyze and evaluate the results of our model.

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1.Introdution

This paper aims to analyze the relationship between the exchange rate of New Zealand Dollar/ U.S dollar using macroeconomic fundamentals of the two countries. The data is expressed in quarters. The period of data that is used comes from the second quarter of 1999 until the end of 2014. According to Richard Sullivan (Sullivan, 2013) the period that the sample was tested is called the price stability period (1992-present) where monetary policy has largely been directed towards inflation targeting, without capital controls or exchange rate intervention.

For determining this economic methodology is used them including analysis techniques such as Cointegration Analysis and the Error Correction Model. Thereby specifying the variables of the long-term model, through residues, it is approached the short-term fluctuations of the exchange rate.

1.1History of New Zealand Dollar and U.S dollar

In early 1840, Captain William Hobson, RN was the first Governor of New Zealand. During the first 10 years he was governor, he presented shortage of coins, especially copper coins. After an unsuccessful correction process of this crisis, in 1850 some companies in Auckland and Dunedin decided to issue copper tokens. Approximately 50 traders issued their own penny and half-penny tokens. This practice survived until 1881 with their use gradually declining in the 1880s. However only the British currency was legal tender. At 1914 was the withdrawal of gold coins.

By 1933, was decided in New Zealand minting its own currency from a single bank. Despite the community's suggestions for a currency that would use decimal-based currency it was introduced a fractional system. Those coins had many features in common with British coins.

The story of New Zealand dollar began in 1967 when the decision to decimal currency was taken. However, the debate on the decimal currency system began in 1959 and it was also appointed a committee to carry out the research (History of New Zealand Coinage, 2017).

On the other side, the history of the US dollar starts from the time of independence of America in 1776 when the US Congress decided to adopt the word “dollar” for their monetary unit instead of keeping the British pound. The dollar word originally referred to various currencies of Central European countries and even in the Spanish Peso and Portuguese Riyal. Until 1862, the American used only circulating coins dollar. For this reason, the Congress decided to print the first bank note which would have been spilled in gold or silver. In circulating are coins denominations 1 ¢ (Cent, aka Penny), 5 ¢ (Nickel), 10 ¢ (Dime), 25 ¢ (officially "quarter dollar», Quarter Dollar, or simply Quarter), 50 ¢ (half dollar, rare) and $ 1 (dollar also rare) (The History of American Money, 2017).

1.2History of Fixed and Floating Exchange Rate

1.2.1 Fixed Exchange Rate of New Zealand

Over the past two centuries, major changes have taken place in the evolution of international monetary policy regimes. The changes from fixed to floating exchange rates were of significant importance (C Schenk, 2017). After World War II, the IMF establishes in Bretton Woods an international exchange rate system where the currencies of the countries will be determined by the US dollar offsetting the gold standard. New Zealand was not a member of the IMF until 1961, so it maintained the fixed exchange rate regime. After the Smithsonian Agreement, New Zealand linked its currency to the US dollar. Linking the dollar caused a depreciation of the New Zealand dollar against other currencies.

In July 1973, New Zealand shifted to a fixed, but occasionally regulated, monetary policy which was reflected in a basket of currencies. The corrective changes were made to the New Zealand dollar in order to prevent the foreign inflation. However, these changes have highlighted the poor profitability of the agricultural sector. There have been many adjustments and depreciations to maintain competitiveness, but fluctuations in both trade and inflation have led to changes in the nominal exchange rate. New Zealand's inflation was higher than its trading partners, which resulted in a lack of competitiveness, resulting in strong uncertainty for both importers and exporters. In 1979, it was understood that a flexible system was needed, and for that reason a crawling peg was introduced. This system was used until 1982 when the wage and price freezes were introduced. The central bank of New Zealand, along with the country's finance ministry, determined the exchange rate against the basket with occasional discrete adjustments. In March 1983, the us dollar was depreciated by 6% in response to a devaluation of Australia (Sullivan, 2013).

According to Dane (1981) in 1981, the central bank of New Zealand noted three methods of determining when setting the exchange rate. The former was the purchasing power parity, the second was the underlying external trade balance deficit and the third the market disruption of the assets.

1.2.2 Floating Exchange Rate of New Zealand

Following the abolition of capital controls, the New Zealand dollar has been floating freely since March 1985. The central bank of New Zealand had foreign exchange reserves only for reasons of interference in times of crisis. Since 1985 the central bank has had its foreign currency assets repaid in foreign currency. (Hutchison, 2007)

This decision was changed in 2007 as a new decision was taken that altered the way to finance and manage New Zealand's foreign currency reserves. Under the new arrangements, the central bank held some foreign exchange reserves as an "open foreign exchange position", ie the foreign reserve currency portfolio would be funded with the domestic currency of New Zealand rather than foreign currencies. (The Treasure, 2017)

1.2 NZD/USD exchange rate

Figure 1 plots the great volatility during the entire time period studied of the price of the exchange rate. On inspection of 1999 and 2001 there is a downward trend in the price reaching NZ dollar valued of 0.4. From 2002 onwards until the crisis of 2008 there was a marked rise. After the crash in 2008 the price rate fell quickly to 0.5 but almost immediately bounced back and reached up to 0.72. After the crisis the price of the exchange rate continued with an upward trend and high volatility.

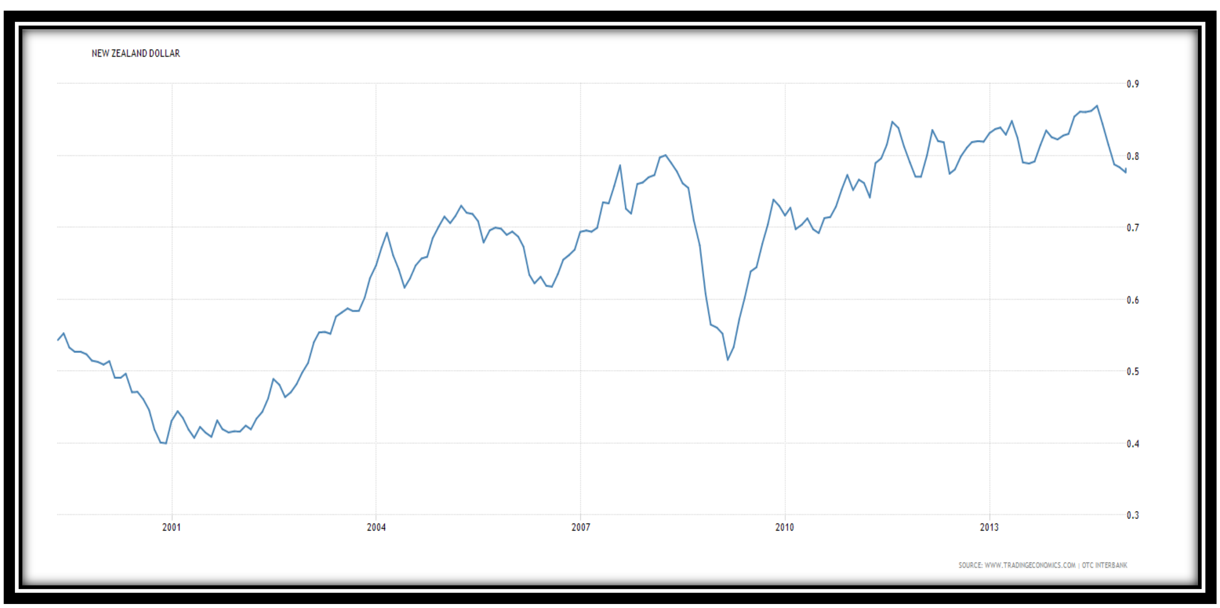


Figure 1NZD/USD exchange rate from 1999 to 2014 (New Zealand Dollar, 2017)

1.3 Macroeconomic – Financial Factors

There are two basic theories of exchange rate determinations. The first is relates exchange rate to interest rate differential and it is called the Uncovered Interest Parity (UIP) condition. The second theory are related the exchange rate to inflation differential and is termed Purchasing Power Parity (PPP) condition. Apart from these factor, the economic researcher have examined the effect of GDP , the yield bond and the balance of trade on exchange rate.

An important factor is the interest rate. Difference in interest rates between countries are important influences on behavior of exchange rates. Higher interest rates attract foreign capital resulting increase exchange rate. To make it more understandable, Brunnermeier (2009) have studied how exchange rate dynamics relate to the carry trade positions and explain the process. For example, they used a country with low interest rates, such as Japan, and a country with high rates such as New Zealand. If New Zealand increase even further the Japanese interest rates and interest rates remain constant, then we will have a transfer of funds to New Zealand and this will lead to an appreciation of the domestic currency.

An important determinant is the inflation rate. Changes in the rate of inflation affect the exchange rate through the PPP effect. For example, if domestic inflation rate increases relative to the foreign inflation rate the PPP domestic currency decreases and consequently the domestic currency depreciates. have the opposite results from those in interest rates. This means that if increased inflation in a country then the purchasing power in relation against other countries is reduced, resulting in depreciation of the exchange rate. Furthermore, such an event entails the reduction of exports of domestic country, thus reducing the demand of the domestic currency devaluation hence the exchange rate.

Another important determinant is the Gross Domestic Product (GDP). If GDP of a country increases, then the currency of this country will increase too. Just the opposite would happen if the country's GDP started to decline that will decrease and the rate of exchange.

To continue, some other economical factor determinate many of the exchange rates global is the balance of trade between a country and its trading partners. At this point we will be given an example for understanding the effects of the trade balance in exchange rates. On one side, there is the domestic country and on the other hand there is the foreign country. If the domestic country exporting more and importing less than in the foreign country, the domestic currency will appreciate and conversely.

Another crucial finance factor which is highly connected during times of crises is the Bond. Via interest rates of long-term government bonds determined the exchange rate. The higher the yield of a government rate, the more insecure are investors in relation to the country's progress and this entails the depreciation of the currency.

Finally, very important role has the stock market to determinate the exchange rate. An increase in the financial index of a stock market in one country can have an immediate positive reaction in the domestic currency and to affect exchange rates.

2. Literature Review

After the Asian crisis in 1997, New Zealand dollar was one of the strongest currencies, not only in Asia but throughout the world, as now occupies the tenth place worldwide. It is strange when you consider the population of New Zealand compared to other countries that were passed in the rankings. Because of the strengthening of the currency, many researchers have tried to explain this phenomenon and try to predict its evolution. On the other hand, U.S dollar dominates in world economy. It is the most marketable currency.

Carroll (2012) made an extensive reference to the economy of New Zealand starting observations from 1952 to 2012 studying the most important macroeconomic variables. He splited the sample into three time periods: a) 1952-1972, b) 1972-1992 c) 1992-2012 and he studied these variables in relation to other countries such as United Kingdom, Western Europe, the USA, Australia and Canada. Initially, during the first period there was strong economic growth with GDP growth when there were some shocks in trade relations. Nonetheless it continued to have growth due to great increase of technology. Then during the second period, a slight growth was due to an increase in oil prices combined with the decline in purchasing power affecting consumption, savings and investment. The third and last period is called period of moderation. Unemployment rates fell from historical highs and the inflation rate stabilized while the GDP growth rate declined. The results of the products demand were positive (positive trade balance). Additionally, it is important that America is the fourth country of New Zealand exports and the third of its imports. Some of these macroeconomic data are used by researchers in order to check the relationship between NZD / AUD. They use the 'vector error correction' (VECM) model. This technique considers interdependent variables. Furthermore, another important element of this model is that accounts for both long-run and short-run influences in the same model. Finally, they applied the theory of random walk in terms of prediction. (Franulovich, 2002) However apart from the provision of parity means of VECM model, was also used the ARIMA methodology. (Cahan, 2005)

Olser (2006) tried through empirical microeconomic analysis, using four different methods, to model short-term rates. Originally the first model was based on previous research supporting the internal and external demand for bonds which is determined by the performance of the resulting change in exchange rates. Such a model was based on the research of empirical test of Smyth (Smyth, 2009) on the NZD / USD and AUD / USD exchange rates based on the contemporaneous relationship between order flow and changes in the exchange rate and the evaluation was made using Newey-West standard errors to correct for heteroscedasticity and serial correlation in the residuals. The next Olsen(2006) model was correlated between the equilibrium constant of the shares in the money markets at home and abroad. As dependent variable is the domestic money stock and as independent variable are domestic prices and income. Subsequently there is a more contemporary version of the model which uses loglinearized variables. This version further assumes rational expectations and UIP. According to this methodology, the standard `UIP' residual may affect the expected yields as well as the exchange rate (Reserve Bank of New Zealand, 2014). However, this methodology seems to be rejected by researchers because empirical studies have shown that the UIP model is not explained in the short term (Rowland, 2003). On the other hand, Munro (2005) based on the theory of cointegration and error correction model (EMC) to examine the changes in the currency parity of New Zealand and the USA exchange rate. In this way resulted the fact that long-term interest rates determinated in the global capital market and the UIP can be achieved means adjustments in interest rates. Finally, when the risk and return calculated on a ten-year horizon then the UIP cannot be dismissed (Munro, 2014).

Furthermore, a very important place in empirical models of researchers in relation to the rate NZD / USD holds commodity price. Stephens (2007) used the prices of commodities, rates of GDP, immigration, inflation and interest rates to create a model to predict the NZD/AUD exchange rate. The predicted values do not make use of the facts of the exchange rate. Due to not having access to data, made an out of sample forecast using the data that was available. The time period of the model lasted from 1999 until 2008. Researchers compared the effects of forecast of the model in contrast to random walk forecast. The measure of comparison is the root mean squared error (RMSE) from out-of-sample forecasts. However, the model failed to produce better prediction than a random walk.

Furthermore, a very interesting research carried out by Kohlscheen et all(2016) when they tried to understand the close relationship between commodity price and exchange rate even at fairly high frequencies. They used commodity prices of eleven main export products in order to predict the movements of exchange rates. Firstly, they ran regressions and tried to investigate the simultaneous relationship between exchange rates and commodity prices. All variables were in log. The dependent variable was the nominal exchange rate of countries and the independents variables were the country-specific commodity export price index, the constant term, the country fixed effects, a vector of year dummies and the error term. The exercise was based on 30,294 country-day observations and the time period wherein the sample tested, was from January 2004 to February 2015. The result taken shows an increase of the price of commodity which exported from a country by 10% will increase the conversion rate of 2.1% of its currency. Moreover, at the same paper they made a forecast analysis in the same model and the panel regression was from 1 day up to 3 months. The results showed that commodity prices can be predicted up to two months. (Kohlscheen et all, 2016)

Huang (2004) considered a finite sample using cointegration tests in order to understand the exchange rate in the long term. The data that Huang used in the survey was the commodity export prices, the real output differentials, the inflation differentials and the nominal short-term interest rate differentials for New Zealand and the US. The data was quarterly from 1986Q1 to 2003Q2. Firstly, augmented Dickey-Fuller (ADF) test used to see if there are unit roots in the variables and then applied cointegration tests. Huang was making time series analysis of data using the cointegration method of Johansen as well as Engle-Granger's ADF test to find if there are cointegration relations. The results seem to have a long-term relationship between the exchange rate of New Zealand and the US as well as all the variables which used in the model. Additional, in order to estimate the cointegration between NZ and US exchanges rates, Huang used methodologies as DOLS and Phillips and Loretan's nonlinear least squares.

3.Econometric Methodology

Econometrics is concerned with the development of methods for measuring economic relationships specified by econometric models. In this section, we will apply the economic methodology using the time series analysis on the exchange rate of NZD/USD as well as on macroeconomic variables of our model. The long-term model has dependent and independent variables which they are linearly related to each other. Then we should check out if the models variables are stationary or not. The test that we will using is unit root test. Moreover, we should be discovered whether there is cointegration between variables using the Ordinary Least Squares (OLS) Method. Through this method is run a regression model wherewith examined the relationship of the dependent variable, which is the exchange rate, with the independent variables that are set by the signs of the coefficients and statistical significance. Subsequently, we will analyze the short-term model using the residuals of long-term model and we will be used error correction model. The importance of long-term model residuals is particularly important because through them we can better understand the relationship of variables and the price fluctuations of the exchange rate in the short term.

3.1 Stationarity

Initially, for our economic analysis it is very important to consider whether the time series is stationary or not. A time series defined stationary if the mean and variance remain stable for each given lag. Additional, the value of the covariance between two time periods depends on their distance and not from the time period (Steffen, 2016). If there is not stagnant in time series cannot be applied economic analysis. This may be corrected by cointegration method when combining non-stationary variables and they have resulted stationary time series which may be analyzed as long as the residues are integrated of order 0.

There is an example of stationary and non-stationary time series:

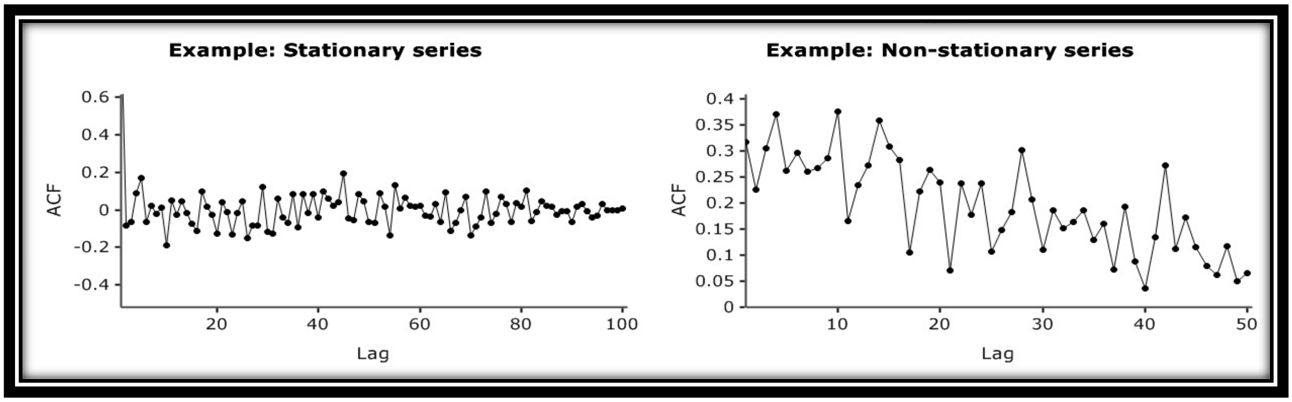


Figure2 stationary and non-stationary plot (http://www.maxstat.de/vorschau/images/Dokumentation/time_series_analysis.htm)

There are several reasons why the concept of stationarity is so important. Firstly, the main reason is that stationarity can affect the behavior of the variable under consideration. If there is a shock to the market, that an unexpected change in a variable, then as long as there is stationarity in the time series the shocks slowed in time. On the other hand, in non-stationary time series the shock is magnified in time. Moreover, several times the non-stationary data produce spurious regressions causing the value of R^2 being particularly high, characterized irrelevant and that this result may not be correct estimation of the model. Last but especially great importance is the use of t and F statistic distributions. These cannot be applied as long as the variables used in a regression model is not stationary it can be proved that it will not be valid the standard assumptions for asymptotic analysis (Brooks, 2014).

3.2 Unit Roots

To test the hypothesis that a linear model y is integrated first degree, we must be watching the case that α = 1 to reflux without constant term:

$$y_t = ay_{t-1} + \varepsilon_t$$

If the residues is a white noise process and a = 1, then the equation is random walk without displacement and y_t is I(1), that has a unit roots and is not stationary. Conversely, if α ≠1 then y_t is integrated I (0) and is stationary. Nevertheless, we wanting to evaluate the regression of the y_t liner model with the ordinary least-squares method and using the t-stat by checking for a = 1, that is not correct since we do not know the distribution of t-stat where y is non-stationary and the coefficient a is biased in an autoregressive equation. In those cases, we perform other tests like as DF test or the ADF test or the Phillips- Perron test or at least KPSS test (Guaita, 2016).

3.3 Cointegration and Error Correction

The concept of cointegration is particularly important as it allows us to describe if two or more economical time series have equilibrium relationship. Each of the time series must have unit roots and they should be non-stationary. In addition, there are three reasons why the cointegration is important to complete time series models. They are:

1. The cointegration connecting higher degree of integration sequences for which there is a linear combination of a lower degree of integration can be characterized by the equilibrium relationship between these sequences. Let $y_{1,t}$ and $y_{2,t}$ are two variables which are integrated of order 1(I(1)) and are described by the model:

$$y_{1,t} = \alpha + \beta y_{2,t} + \varepsilon_t$$

2. The cointegration test is useful for identifying spurious regression. Then if the residuals are integrated of order zero (I(0)) then we can say that $y_{1,t}$ and $y_{2,t}$ are cointegrated. and regression which can be interpreted.

Whether two variables $y_{1,t}$ and $y_{2\ t}$ that they are grade I (1), and they have not a linear combination of grade I (0). Evaluate the relationship between two or more non-stationary variables implies that we determining factor for high rate and DW with low rate are evidence of autocorrelation of first degree. According to the Granger & Newbold (P., 1974) $R^2 > d$ then we estimate that the regression is without interpretative result. In this way, we observe various problems but there are two ways to circumvent. Originally to include first lags of variables in the model and secondly to assess the equation in the first differences.

- $y_{1,t} = \alpha + \beta y_{2,t} + \gamma y_{1,t-1} + \delta y_{2,t-1} + \varepsilon_t$
- $\Delta y_{1,t} = \alpha + \beta \Delta y_{2,t} + \varepsilon_t$

Therefore, in both the above equations we conclude that the variable is I (0) so the $y_{1,t}$ and $y_{2,t}$ cointegrated. (Sweden, 2003)

3. If the variables cointegrated must have an error correction model (ECM) of the form:

.

- $\Delta y_{1,t} = \gamma_0 + \gamma_1 \Delta y_{2,t} + \gamma_2\ \varepsilon_{t-1}$

Where $\Delta y_{1,t}$ and $\Delta y_{2,t}$ are the first differences of $y_{1,t}$ and $y_{2,t}$.

4 Empirical Analysis

4.1 Data

The data used in our study were obtained from the databases www.quandl.com and https://fred.stlouisfed.org/ and the software used was Gretl (http://gretl.sourceforge.net/). The data sample starts at the second quarter of 1999 and end at quarter of 2014 in order to have a sufficient sample for the examination of our results. We used macroeconomic and financial variables for both the long and the short term our model in order to build an econometric model where we will be determining a satisfactory forecast of the NZD/USD exchange rate. The variables we are use are the following:

- The exchange rate (XP)
- Import price Index of USA (Pim)
- Export price Index of New Zealand (Pex)
- GDP difference New Zealand and America (GDP)
- World commodity price index (W)
- Differences between 10-year long bond and 3- months bond.(Yc)
- α,β,γ,δ,ε,ζ: constant values

The long term model is given by:

$$\boxed{XP = \alpha + \beta * Pim - \gamma * Pex + \delta * GDP + \varepsilon * W + \zeta * Yc}$$

And the short term model is given by:

$$\boxed{\Delta XP = a * \ \Delta Pim - \beta * \Delta Pex + \gamma * \Delta Yc + \Delta W - \varepsilon * uhat}$$

Where the short-term variables are:

- The first logarithmic differences of exchange rate (ΔXP)
- The first logarithmic differences of Imports price Index of USA (ΔPim)
- The first logarithmic differences of Export price Index of New Zealand (ΔPex)
- The first logarithmic differences between 10-year long bond and 3- months bond (ΔYc)
- The first logarithmic differences of World commodity price Index (ΔW)
- Uhat are the residuals of the long model, which they must have a negative coefficient in order to give to the model a dynamic stability

The following graphs display the variables of the models. Same of the variables used only in one of the two models. To be more precise, for the long-term model, the dependent and independent variables are indispensability in logarithms. On the other hand, in the short-term model, we illustrate the first differences of logarithms of the dependent and independent variables.

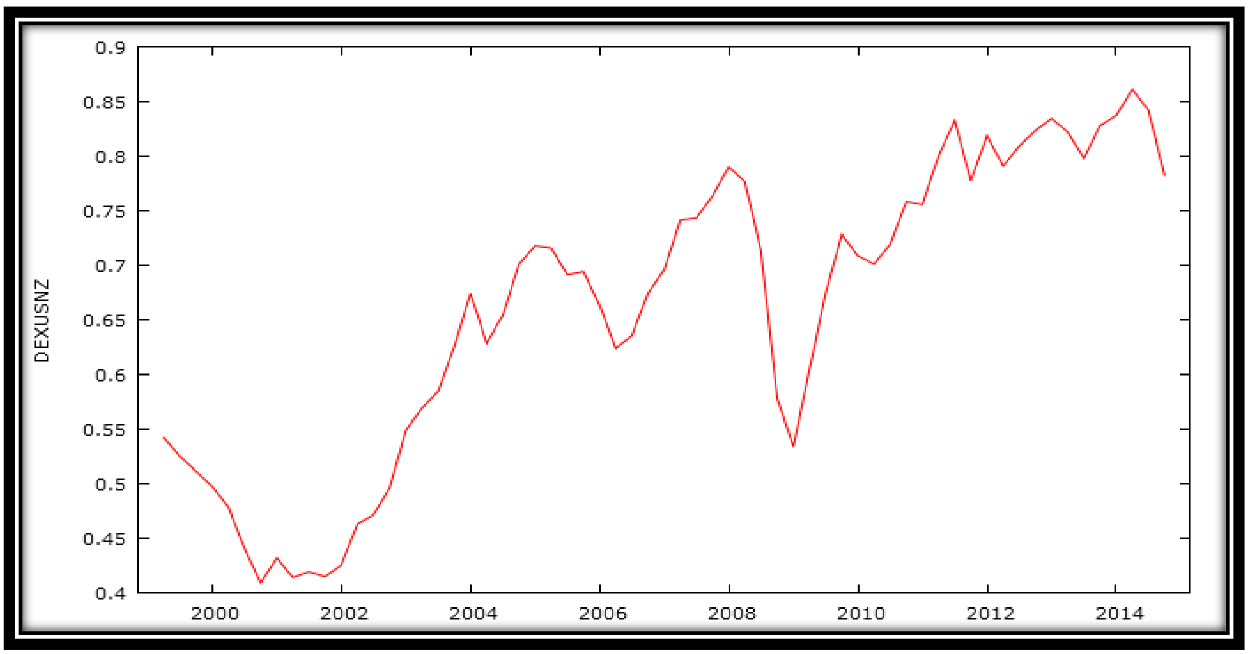


Figure 3 NZD/USD exchange rate from 2Q 1999 to 4Q 2014

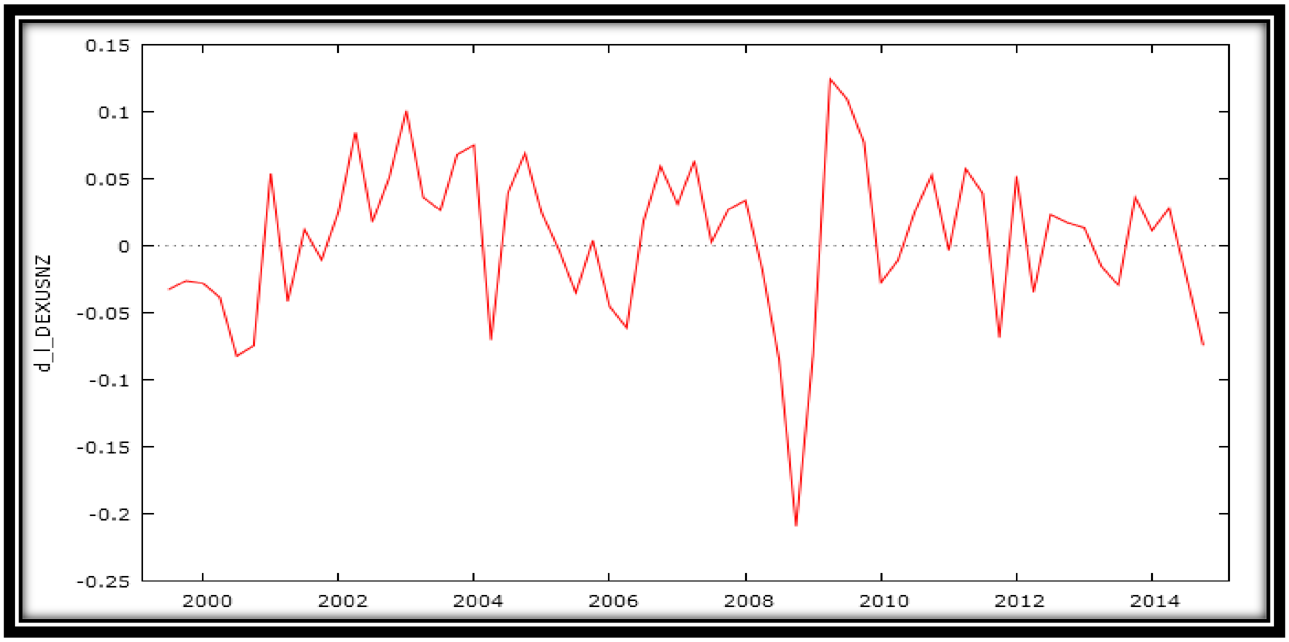


Figure 4 First Differences of NZD/USD exchange rate logarithm

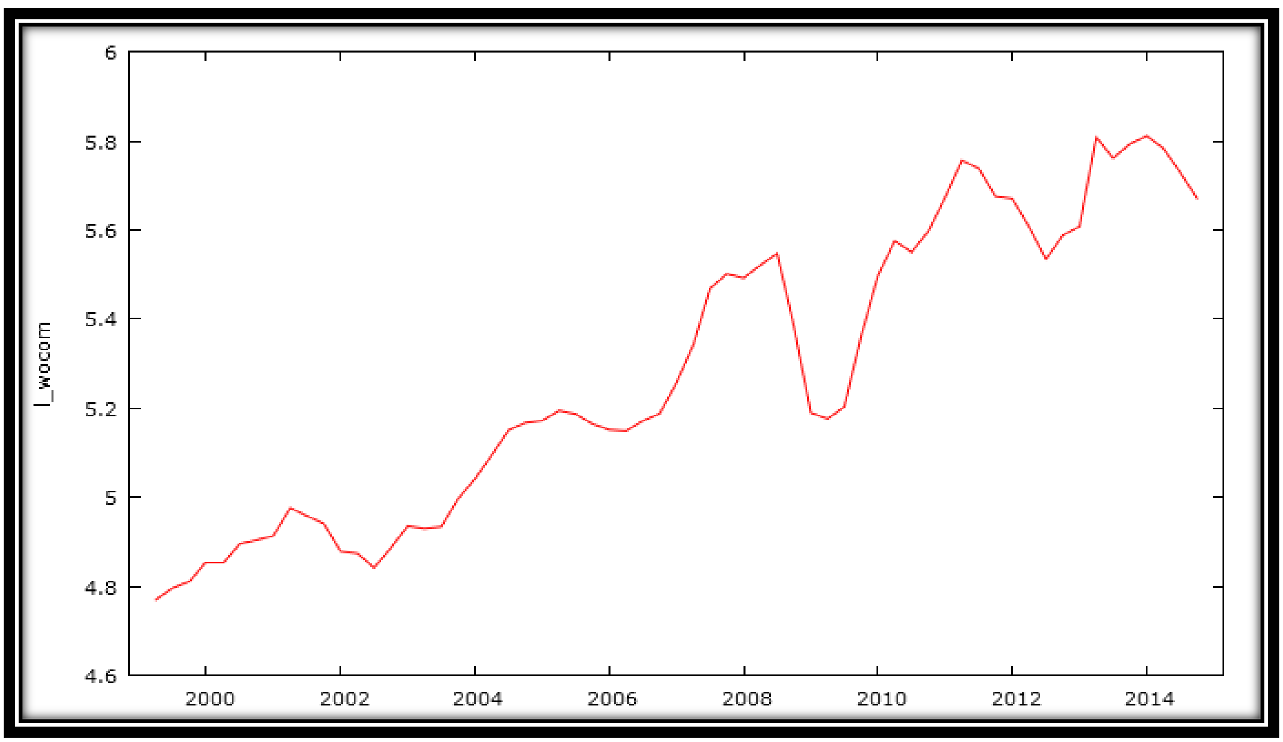


Figure 5 World Commodity Price Index

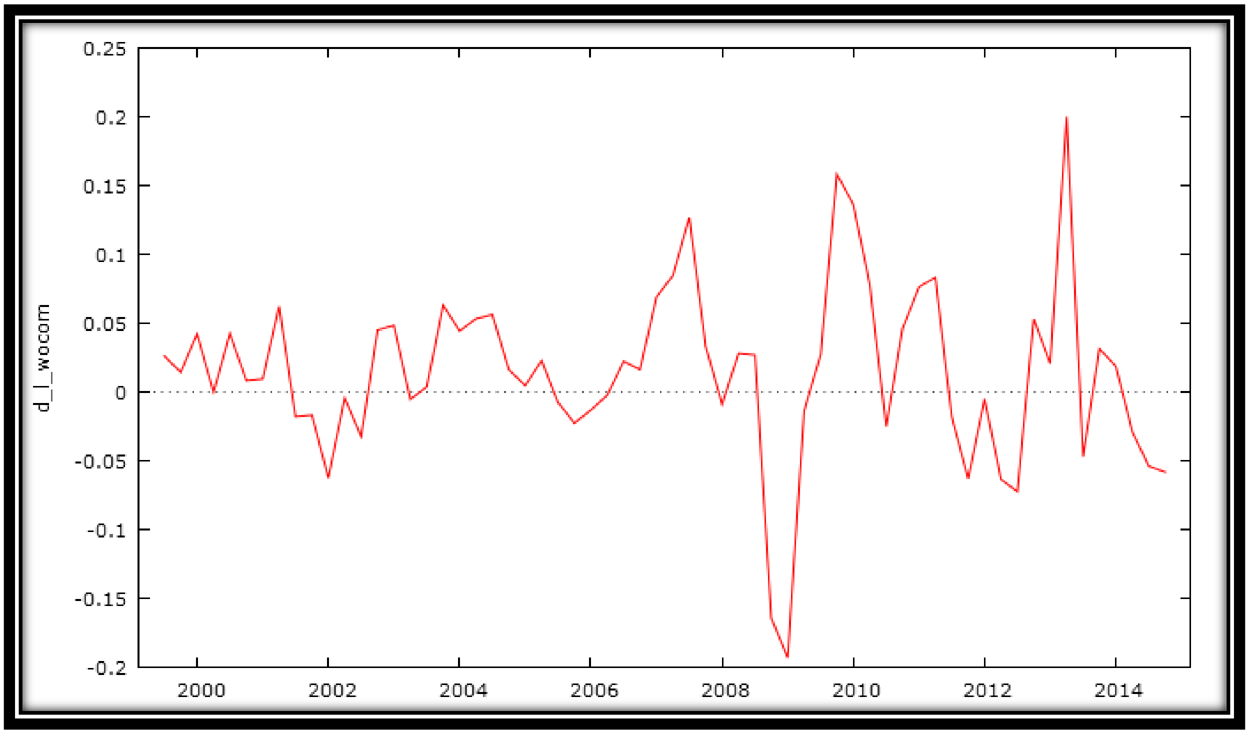


Figure 6 First Differences of logarithm of World Commodity Price Index

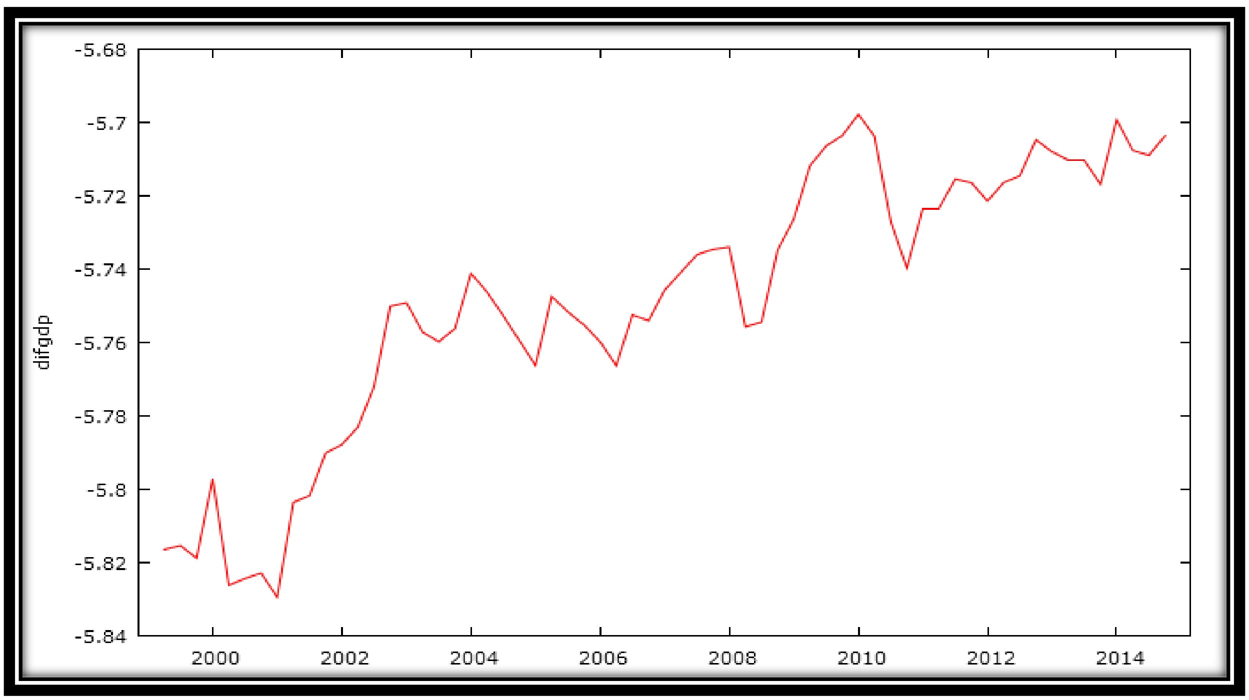


Figure 7 differences between GDP New Zealand and the US

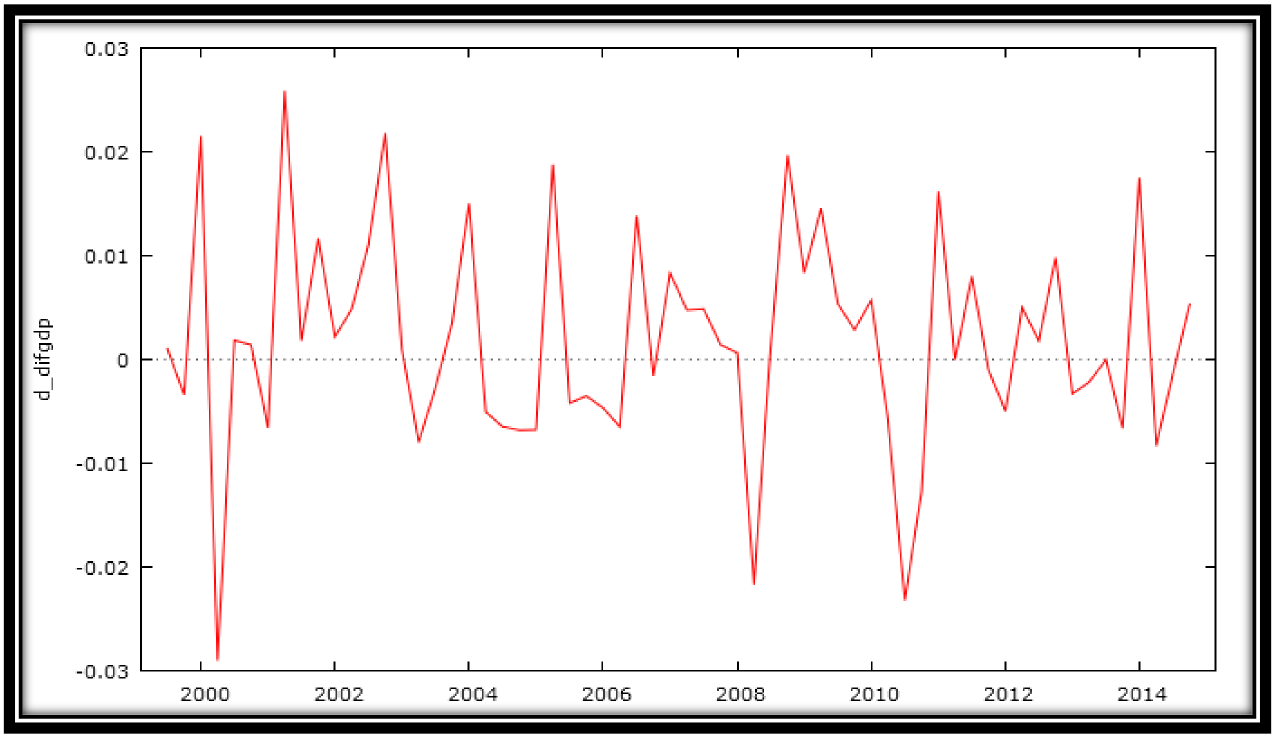


Figure 8 First logarithm differences between GDP of New Zealand and the US

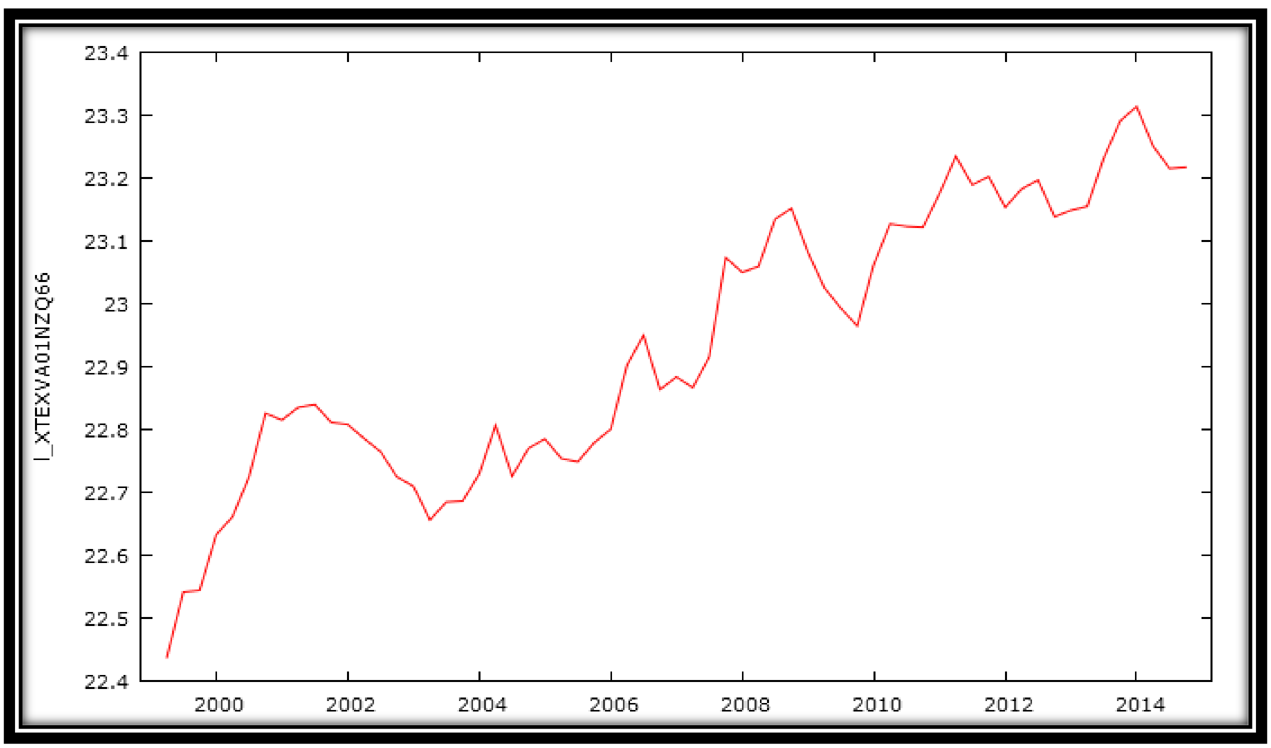


Figure9 Export Price Index of New Zealand

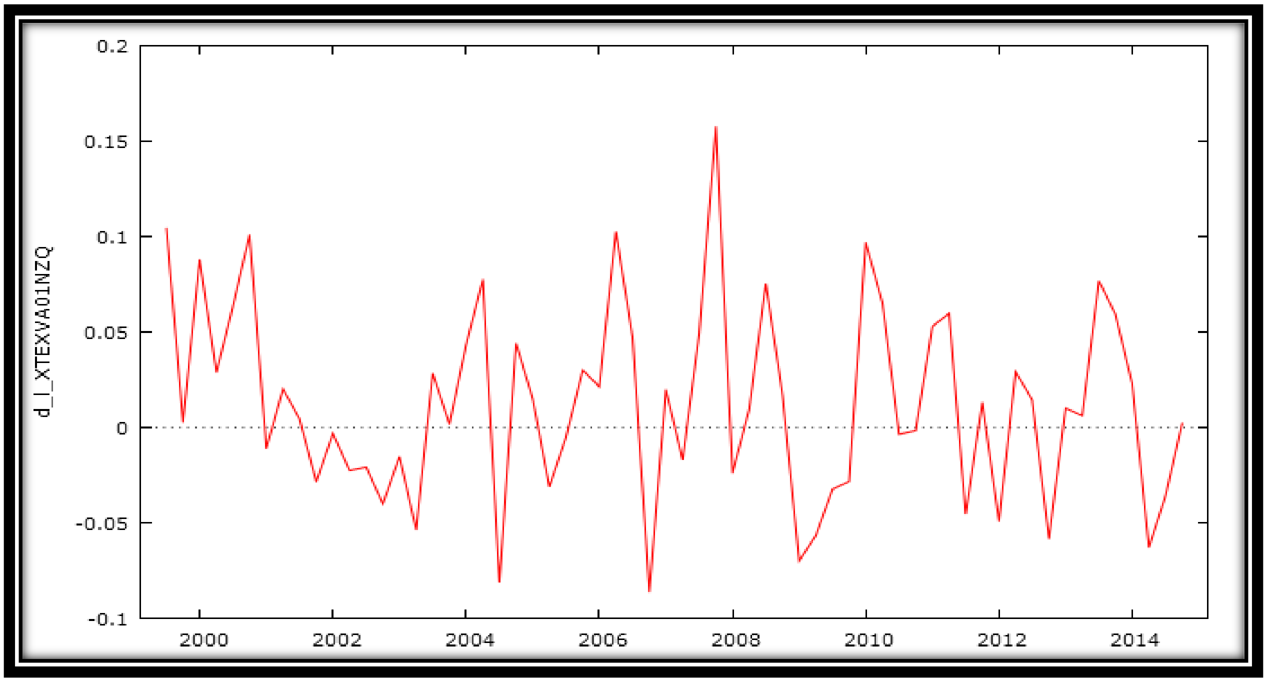


Figure 10 First logarithm differences of Export Price Index of New Zealand

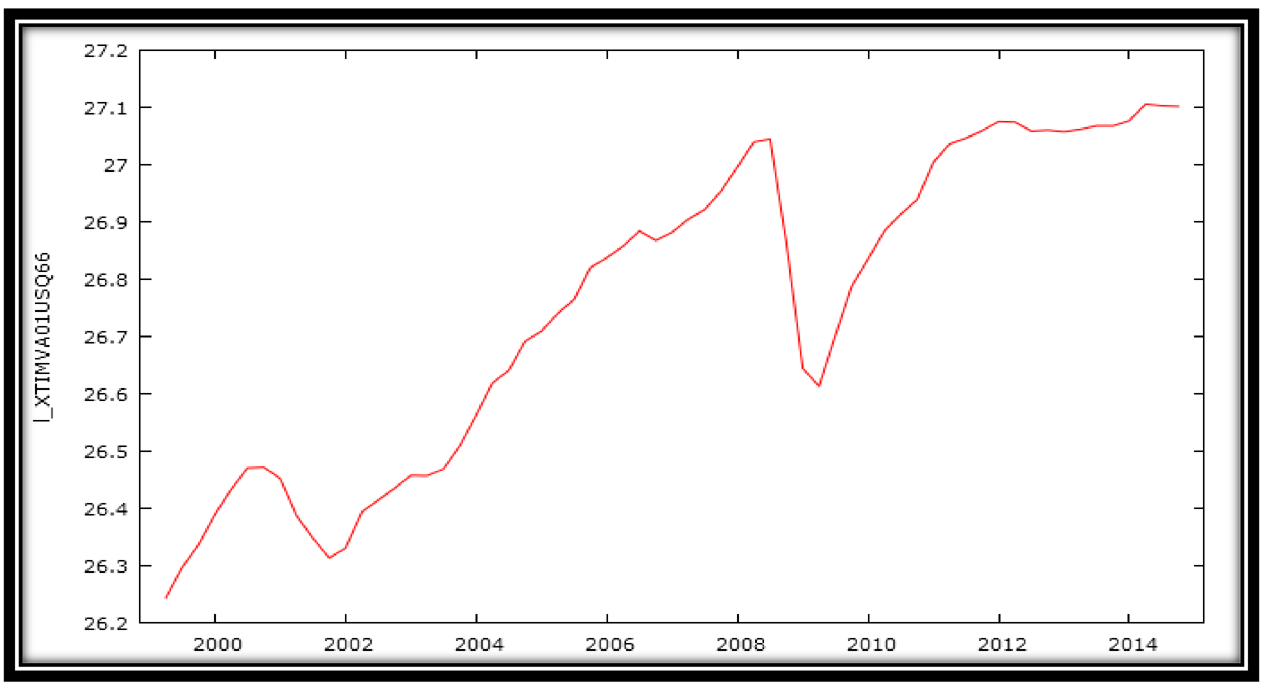


Figure 11 Import Price Index of the US

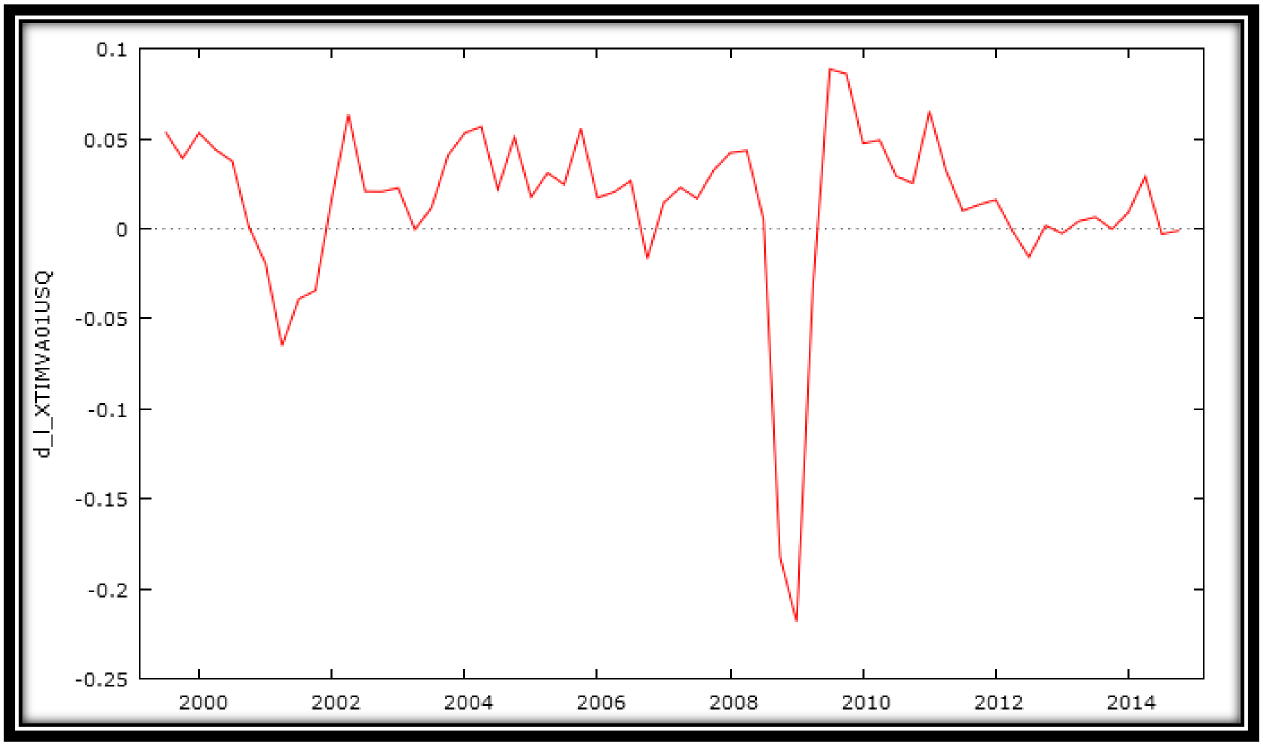


Figure 12 First logarithm differences of Import Price Index of the US

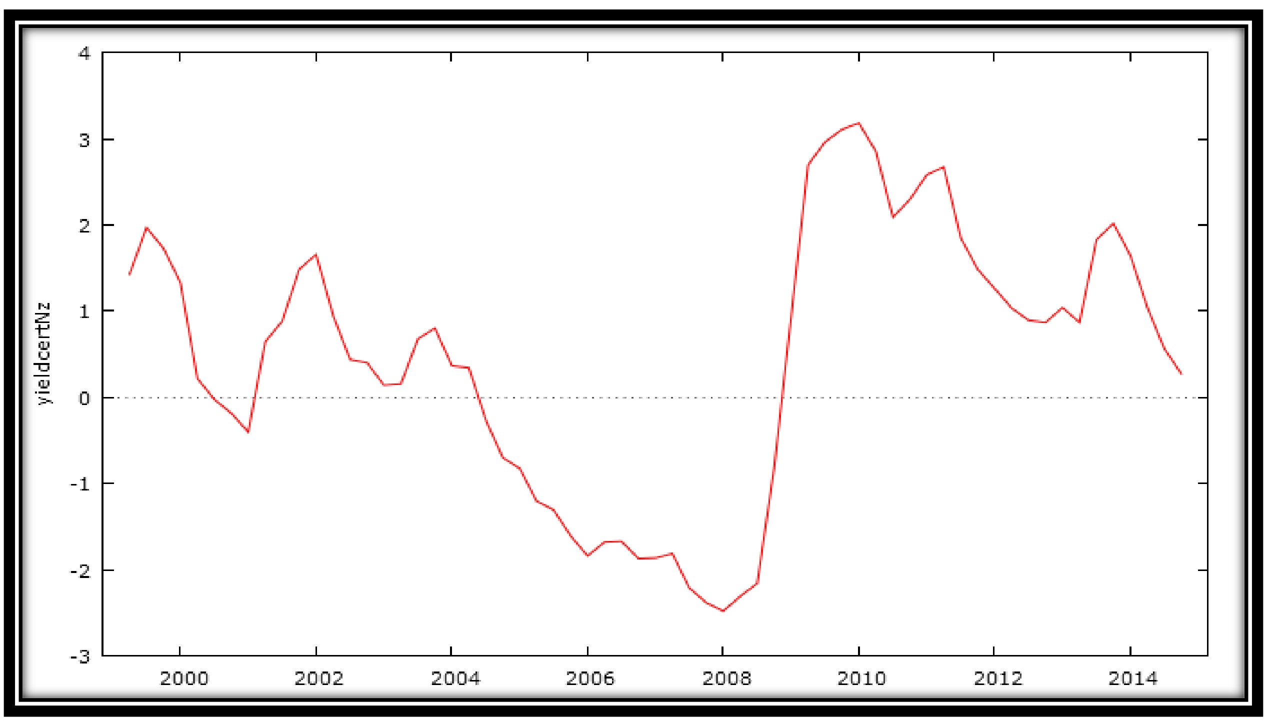


Figure 13 differences between 10-year long bond and 3- months bond

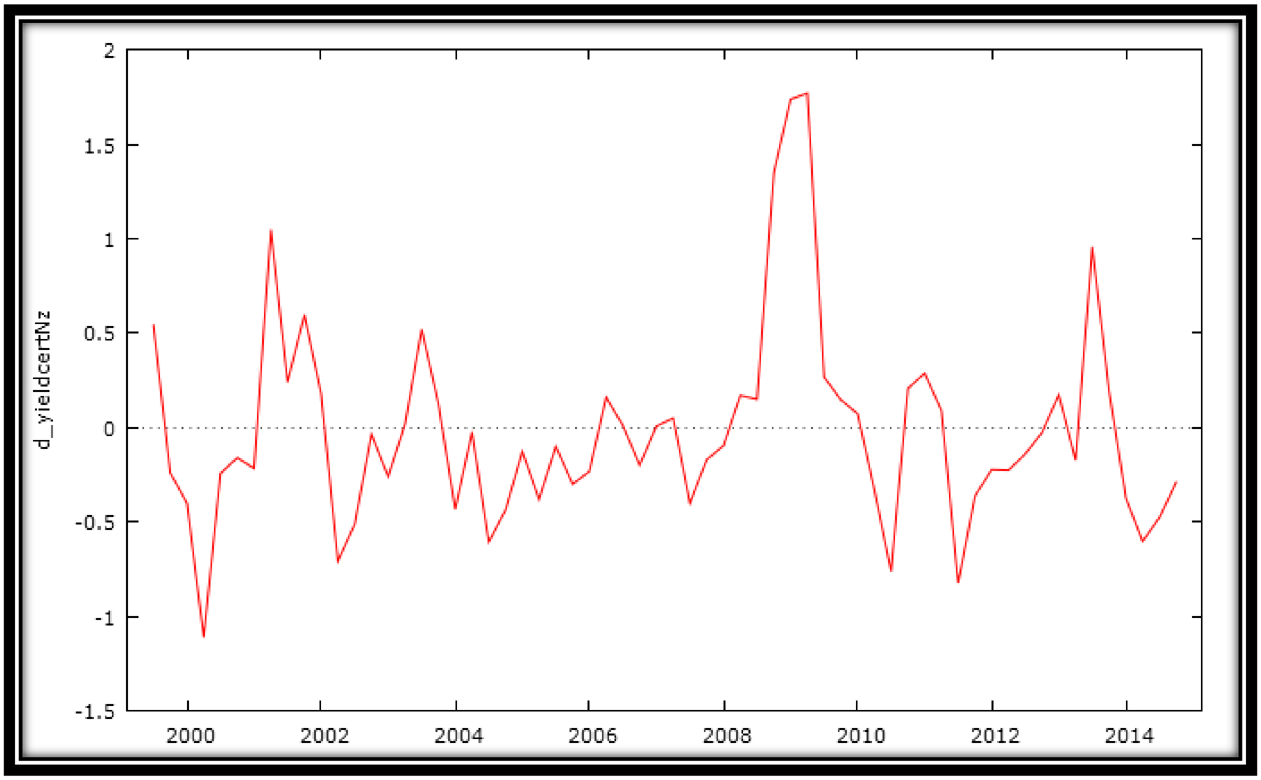


Figure 14 First logarithm differences of difference between ten-year bond and three-month bond

4.2 Unit Root Test

Firstly, we test whether our variables are non-stationary. According to plotting above, we realize that most of the variables if not all, are non-stationary in their levels, that is, the average varies from zero. In addition, there is high volatility so that the variation is not constant. Consequently, we should do a stationary test to confirm our above words. This test is the Augmented Dickey Fuller Test (ADF). The ADF test with one lag of the dependent variable is used to test for unit root. The rejection of the null hypothesis implies that the time series is stationary.

Thereafter, we will examine one by one all the variables that are used both in long-term model and the short-term model, having in mind that the null hypothesis has a unit root. For values, less than 5% or 10% in some cases, we reject the null and accept the alternative hypothesis. Furthermore, in the same way we react to the value of the ADF t-statistic if the price is less than the -3.90

Table 1 present the results for variable XR. The value of the t-statistic is equal to -2.89044 and the p-value of 0.1655 shows that the null hypothesis cannot be rejected. Thus, XR contains a Unit Root.

Table 1 ADF Test for NZD/USD exchange rate

```
Augmented Dickey-Fuller test for l_DEXUSNZ
including one lag of (1-L)l_DEXUSNZ (max was 10)
sample size 61
unit-root null hypothesis: a = 1

   test with constant
   model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: 0.044
   estimated value of (a - 1): -0.0495514
   test statistic: tau_c(1) = -1.5764
   asymptotic p-value 0.4947

   with constant and trend
   model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: 0.025
   estimated value of (a - 1): -0.175707
   test statistic: tau_ct(1) = -2.89044
   asymptotic p-value 0.1655
```

Table 2 present the results for variable GDP. we affirm the existence of unit root as the p-value is 0.07366 and the ADF t-statistics is equal to -3.25647 so the variable is non-stationary.

Table 2 ADF Test of differences between GDP of New Zealand and the US

```
Augmented Dickey-Fuller test for difgdp
including 5 lags of (1-L)difgdp (max was 10)
sample size 57
unit-root null hypothesis: a = 1

   test with constant
   model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: 0.026
   lagged differences: F(5, 50) = 2.126 [0.0775]
   estimated value of (a - 1): -0.0797159
   test statistic: tau_c(1) = -2.14134
   asymptotic p-value 0.2285

   with constant and trend
   model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: -0.025
   lagged differences: F(9, 41) = 1.668 [0.1284]
   estimated value of (a - 1): -0.447733
   test statistic: tau_ct(1) = -3.25647
   asymptotic p-value 0.07366
```

Table 3 present the results of variable Yc. The value of the t-statistic is equal to –2.89044 and the p-value of 0.08277 shows that the null hypothesis cannot be rejected. Thus, Yc contains a Unit Root.

Table 3 ADF Test for Differences between 10 years bond and 3 months bond of New Zealand

```
Augmented Dickey-Fuller test for yieldcertNz
including one lag of (1-L)yieldcertNz (max was 10)
sample size 61
unit-root null hypothesis: a = 1

   test with constant
   model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: -0.003
   estimated value of (a - 1): -0.0956682
   test statistic: tau_c(1) = -2.6513
   asymptotic p-value 0.08277

   with constant and trend
   model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: -0.008
   estimated value of (a - 1): -0.105261
   test statistic: tau_ct(1) = -2.83725
   asymptotic p-value 0.1837
```

According to the bellow table, we do not accept the null hypothesis of a unit root, as the ADF t-statistics is equal to -4.65421 and the p-value of 0.0007905 .

Table 4 ADF Test in World Commodity Price Index

```
Augmented Dickey-Fuller test for l_wocom
including 8 lags of (1-L)l_wocom (max was 10)
sample size 54
unit-root null hypothesis: a = 1

   test with constant
   model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: -0.039
   lagged differences: F(8, 44) = 2.913 [0.0107]
   estimated value of (a - 1): -0.00627909
   test statistic: tau_c(1) = -0.213697
   asymptotic p-value 0.9344

   with constant and trend
   model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: -0.017
   lagged differences: F(2, 55) = 13.596 [0.0000]
   estimated value of (a - 1): -0.393563
   test statistic: tau_ct(1) = -4.65421
   asymptotic p-value 0.0007905
```

Table 5 present the results for variable Pex. Pex is a non-stationary variable to our model and it have unit root. This we understand from the table above as p-value is 0.1072 and the ADF t-statistics is -3.09576. Consequently, we accept the null hypothesis.

Table 5 ADF Test in Export Price Index of the New Zealand

```
Augmented Dickey-Fuller test for l_XTEXVA01NZQ66
including 9 lags of (1-L)l_XTEXVA01NZQ66 (max was 10)
sample size 53
unit-root null hypothesis: a = 1

   test with constant
   model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: 0.063
   lagged differences: F(9, 42) = 2.101 [0.0512]
   estimated value of (a - 1): -0.00257814
   test statistic: tau_c(1) = -0.0708854
   asymptotic p-value 0.9508

   with constant and trend
   model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: -0.023
   lagged differences: F(9, 41) = 2.352 [0.0304]
   estimated value of (a - 1): -0.395925
   test statistic: tau_ct(1) = -3.09576
   asymptotic p-value 0.1072
```

Finally, the table 6 present the result for variable Pim. The value of the ADF t-statistic is equal to -2.29356 and the p-value is equal to 0.4369 shows that the null hypothesis cannot be rejected. Thus, Pim contains a Unit Root.

Table 6 ADF test in Import Price Index of the US

```
Augmented Dickey-Fuller test for l_XTIMVA01USQ66
including 2 lags of (1-L)l_XTIMVA01USQ66 (max was 10)
sample size 60
unit-root null hypothesis: a = 1

   test with constant
   model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: 0.041
   lagged differences: F(2, 56) = 30.442 [0.0000]
   estimated value of (a - 1): -0.0213591
   test statistic: tau_c(1) = -1.22731
   asymptotic p-value 0.6649

   with constant and trend
   model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: 0.069
   lagged differences: F(2, 55) = 31.974 [0.0000]
   estimated value of (a - 1): -0.110549
   test statistic: tau_ct(1) = -2.29356
   asymptotic p-value 0.4369
```

Thereinafter, we will carry out unit root test with the Augmented Dickey Fuller methodology in first logarithm differences of the variables. According to the theory, we expect variables to be stationary and with not unit roots. Nonetheless, there may be exceptions because some variables may need some dummy to give due consideration to the model. The following tables confirm the theory.

The first differences of Export Price Index of New Zealand are non-stationary and with unit root. According to the table 7, we can cross the fact that the p-value is equal to 0.1197, marginally close to 10% and the ADF t-statistics is -3.04598.

Table 7 ADF test of the first differences Export Price Index of New Zealand

```
Augmented Dickey-Fuller test for d_l_XTEXVA01NZQ
including 8 lags of (1-L)d_l_XTEXVA01NZQ (max was 10)
sample size 53
unit-root null hypothesis: a = 1

   test with constant
   model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: 0.063
   lagged differences: F(8, 43) = 2.429 [0.0291]
   estimated value of (a - 1): -1.49909
   test statistic: tau_c(1) = -3.0295
   asymptotic p-value 0.03225

   with constant and trend
   model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: 0.059
   lagged differences: F(8, 42) = 2.432 [0.0294]
   estimated value of (a - 1): -1.51957
   test statistic: tau_ct(1) = -3.04598
   asymptotic p-value 0.1197
```

Thereinafter, we observe that the theory is confirmed in the table 8 which shows the first differences of World Commodity Price Index. P-value is 0.000713 and the ADF t statistics is -4.67955 so we conclude that this variable is stationary with not unit root.

Table 8 ADF test in First differences of the World Commodity Price Index

```
Augmented Dickey-Fuller test for d_l_wocom
including 7 lags of (1-L)d_l_wocom (max was 10)
sample size 54
unit-root null hypothesis: a = 1

   test with constant
   model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: -0.040
   lagged differences: F(7, 45) = 1.992 [0.0773]
   estimated value of (a - 1): -1.96009
   test statistic: tau_c(1) = -4.72956
   asymptotic p-value 7.06e-005

   with constant and trend
   model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: -0.040
   lagged differences: F(7, 44) = 1.949 [0.0844]
   estimated value of (a - 1): -1.96242
   test statistic: tau_ct(1) = -4.67955
   asymptotic p-value 0.000713
```

Table 9 present the results for variable ΔYc. We observe that in this table the variable of the ΔYc is stationary and it has not unit root. P- value is 0.005354 and ADF t-statistic -4.33646.

Table 9 ADF test in First Logarithmic Differences of 10 years' bond and 3 months' bond of New Zealand

```
Dickey-Fuller test for d_yieldcertNz
sample size 61
unit-root null hypothesis: a = 1

   test with constant
   model: (1-L)y = b0 + (a-1)*y(-1) + e
   1st-order autocorrelation coeff. for e: 0.054
   estimated value of (a - 1): -0.478937
   test statistic: tau_c(1) = -4.35179
   p-value 0.0008842

   with constant and trend
   model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
   1st-order autocorrelation coeff. for e: 0.055
   estimated value of (a - 1): -0.48154
   test statistic: tau_ct(1) = -4.33646
   p-value 0.005354
```

According to the table 10 we accept the null hypothesis as p value is much lower than 1% and ADF t statistics is equal to -5.97893. This means that this variable is stationary with not unit root.

Table 10 ADF test in First differences of Imports in US

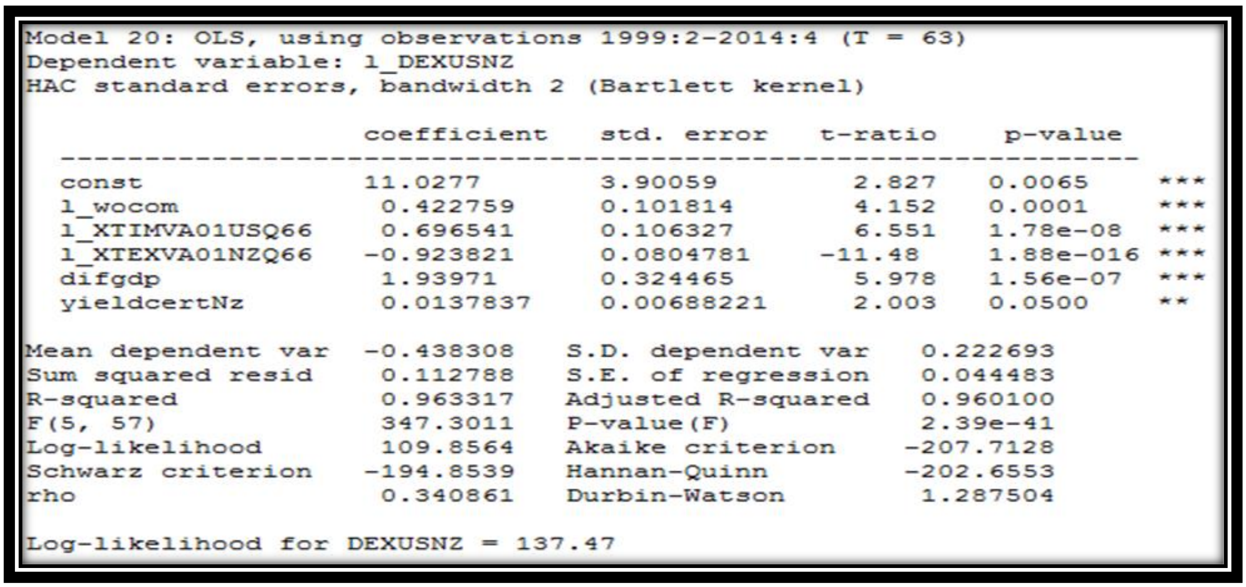
```
Augmented Dickey-Fuller test for d_l_XTIMVA01USQ
including one lag of (1-L)d_l_XTIMVA01USQ (max was 10)
sample size 60
unit-root null hypothesis: a = 1

   test with constant
   model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: 0.035
   estimated value of (a - 1): -0.615669
   test statistic: tau_c(1) = -6.00241
   asymptotic p-value 1.182e-007

   with constant and trend
   model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: 0.035
   estimated value of (a - 1): -0.619775
   test statistic: tau_ct(1) = -5.97893
   asymptotic p-value 1.306e-006
```

In sum up, the unit root tests have indicated that all variables used in the present analysis can be approximated as non-stationary processes.

4.3 Cointegration Results – Long Term Model

According to ADF test we conclude that most of the variables that used in the long-term model is nonstationary. This leads us to the fact that we should ensure the model residuals so that they can certify that the variables are cointegrated, namely that there is a linear relationship that explains the movement of variables over time. To effect this process, we should run a linear regression by the method of the ordinary least squares. Continuously, we must save the residuals of this model in order to use them to check out whether our model have unit root with the ADF test. To be reliable our model, the residues should not have a unit root.

Table 11 Long Term Model from 2Q1999 to 4Q2014



Model 20: OLS, using observations 1999:2-2014:4 (T = 63)
Dependent variable: l_DEXUSNZ
HAC standard errors, bandwidth 2 (Bartlett kernel)

	coefficient	std. error	t-ratio	p-value	
const	11.0277	3.90059	2.827	0.0065	***
l_wocom	0.422759	0.101814	4.152	0.0001	***
l_XTIMVA01USQ66	0.696541	0.106327	6.551	1.78e-08	***
l_XTEXVA01NZQ66	-0.923821	0.0804781	-11.48	1.88e-016	***
difgdp	1.93971	0.324465	5.978	1.56e-07	***
yieldcertNz	0.0137837	0.00688221	2.003	0.0500	**

Mean dependent var	-0.438308	S.D. dependent var	0.222693
Sum squared resid	0.112788	S.E. of regression	0.044483
R-squared	0.963317	Adjusted R-squared	0.960100
F(5, 57)	347.3011	P-value(F)	2.39e-41
Log-likelihood	109.8564	Akaike criterion	-207.7128
Schwarz criterion	-194.8539	Hannan-Quinn	-202.6553
rho	0.340861	Durbin-Watson	1.287504

Log-likelihood for DEXUSNZ = 137.47

To continue our analysis, we should initially check out the residuals to see if the variables are cointegrated. Additionally, we must check the stationarity of the residuals. When we have completed these procedures, we will be able to comment on all the results of the Ordinary least squares method and our model.

Below graphics residues of long-term model are shown, as well as the ADF residue test for the existence of unit root and stagnation.

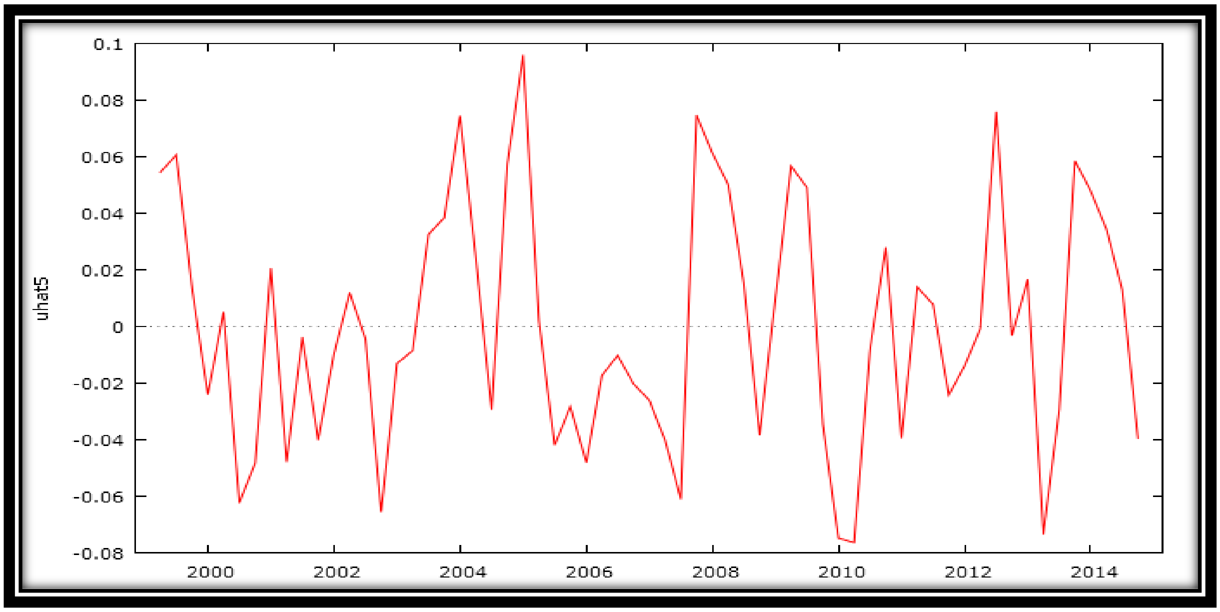


Figure 15 Residual of the Long-Term Model

We see from the chart that the residual values are moving around zero so we conclude that they are white noise, so performing ADF tests we expect that residues will be stationary.

Table 12 present that the residuals of our long-term model have not unit root and are stationary. This arises because the p value is 0.001281, much lower than 1% and the ADF t-statistics is equal to -4.53302 limiting larger than the critical value 3.9.

Table 12 ADF Test of Residual for Long Term Model

```
Augmented Dickey-Fuller test for uhat5
including 9 lags of (1-L)uhat5 (max was 10)
sample size 53
unit-root null hypothesis: a = 1

   test with constant
   model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: 0.008
   lagged differences: F(9, 42) = 2.447 [0.0244]
   estimated value of (a - 1): -1.81806
   test statistic: tau_c(1) = -4.55594
   asymptotic p-value 0.0001

   with constant and trend
   model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... +
   1st-order autocorrelation coeff. for e: 0.006
   lagged differences: F(9, 41) = 2.423 [0.0261]
   estimated value of (a - 1): -1.8408
   test statistic: tau_ct(1) = -4.53302
   asymptotic p-value 0.001281
```

Initially to estimate the model must focus on R^2. So, we see that we have a fairly high R^2 equals 0.963317 units which means that the exchange rate can be explained by the variables that we set at 96.3317% in the period of observations. Once we have a good R^2 should look one by one the variable and observe what of the variables are statistical significance and if the rates of they are consistent with economic and financial theory.

Firstly, we have the world commodity price index which is statistically significant with p-value less than 1%. This coefficient is positive which means that leads to the NZD/USD exchange rate in an increase of 0.422759. Thereinafter, considering the second factor, which is the export price index of New Zealand, is statistically significant as it has a p-value less than 1% and has a negative sign with a value -0. 923821.This means that the prices fall in New Zealand so the country becomes more competitive as a result the currency to appreciate. Moreover, the index difference of the GDP of New Zealand and America are positive and statistically significant for p-value of less than 1%, as expected according to economic theory. This factor leads to the exchange rate increase, or otherwise the exchange rate appreciating by 1.93971. The difference of ten-years bonds and three months' bond is the next variable. This variable has a positive sign and value 0.0137837 which means that the ten-year bond minus the three months' bond in New Zealand will appreciate by approximately 0.0137 the exchange rate if the growth rate is increased by 1%. The fourth variable is the Imports price index of the US. This variable is positive and statistically significant for p-value less than 1%. This would mean the US dollar will increase.

Below follows the graph of the actual fluctuation of our exchange rate and the fitted ones produced by our long-term model. The truth is that our model is development and optimization margins using different variables. Nevertheless, we are satisfied because our results are consistent with economic theory.

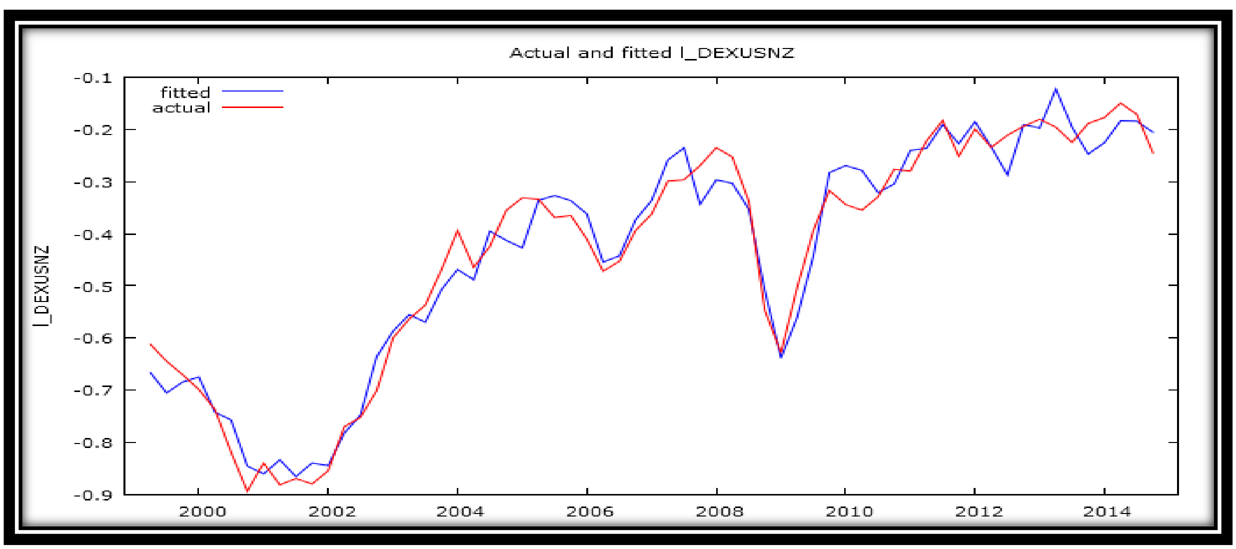


Figure 16 Actual and Fitted Long Term NZD/USD Time Series

4.4 Error Correction Model – Short Term Model

According to the section above, we come to the fact that our variables have a long relationship equilibrium. However, we know from economic theory that short term there may be no balance. The mechanism that reconciles short-term and long-term behavior is the error correction mechanism. At this point we should be noted that all error correction models have the conditional of the cointegration of variables. Through ECM perceive the exchange rate adjustment each quarter and how quickly approaching the actual values.

To determine the short-term model, we pass by the price level of the variables in first differences. In the below table, we show the variables used in the model and the residues of long-term model with a time lag. Then we will comment on the model variables and the adjustments of residues every quarter.

Table 13 Short Term Model from 2Q 1999 to 4Q 2014

Model 8: OLS, using observations 1999:3-2014:4 (T = 62)
Dependent variable: d_l_DEXUSNZ
HAC standard errors, bandwidth 2 (Bartlett kernel)

	coefficient	std. error	t-ratio	p-value	
uhat5_1	-0.495423	0.108069	-4.584	2.54e-05	***
d_l_wocom	0.158529	0.0767147	2.066	0.0433	**
d_l_XTEXVA01NZQ	-0.785690	0.124928	-6.289	4.81e-08	***
d_l_XTIMVA01USQ	0.910997	0.134101	6.793	7.03e-09	***
d_yieldcertNz	0.0339561	0.0120442	2.819	0.0066	***

Mean dependent var	0.005913	S.D. dependent var	0.057380
Sum squared resid	0.075553	S.E. of regression	0.036407
R-squared	0.627829	Adjusted R-squared	0.601712
F(5, 57)	28.31341	P-value(F)	2.67e-14
Log-likelihood	120.0375	Akaike criterion	-230.0750
Schwarz criterion	-219.4394	Hannan-Quinn	-225.8992
rho	0.198196	Durbin-Watson	1.586917

Initially we should consider R^2 and the statistical significance of the variables. In the ECM, we are particularly interest to the residues and especially if they are statistical significantly. Moreover, we used the HAC standard error methodology to eliminate the autocorrelation and the homoscedasticity in our model.

As in long term model so in short term the first price look is R^2. Therefore, we observe that R^2 is scoring 62.78%, very high percentage relative to the existing literature. Furthermore, focusing at residues from the long model, we observe that the p-value is sufficiently smaller than 1% wherein means that they are statistically significant. Additional, very important role in economic theory is the negative sign of residues as it gives a dynamic stability in our model. Moreover, the coefficient of the residuals shows the corrections of the model each quarter. This means that the coefficient shows that every quarter the model “fixes” and reaches the actual prices for about 49.5423%. The next variable is the export index of New Zealand which is statistically significant as the p-value is less than 1%. The coefficient of the variable is negative which means that the exchange rate will depreciate and this implies that exports will encourages. Subsequently, we have the import index of America which is also statistically significant as the p-value is much lower than 1%. The coefficient of the variable is positive which means that a price increase would expect appreciation of the US dollar. One more variable that we have already used in the long-term model is the difference between the 10 year long bond minus 3-months bond of New Zealand. This variable is also particularly significant as the p-value is less than 1%. The coefficient is positive and has value 0.0339561, which means that a positive change in the difference of the bonds will result in the appreciation of the exchange rate. Finally, one more variable present in the model is the World commodity price index .The World commodity price index has positive coefficient which implies that a positive change in the order of 1% would revalue the exchange rate at 0.186708 leading it to appreciation.

Figure 19 below shows the diagram of the actual fluctuation in the exchange rate and also the fitted where they produced by our short-term error correction model. In general, we can say that we are satisfied with the way the predicted values are adjusted to actual values. This value seems to fit considerably in the 2008 crisis notwithstanding certainly there are many factors that affect the model and are not included in it.

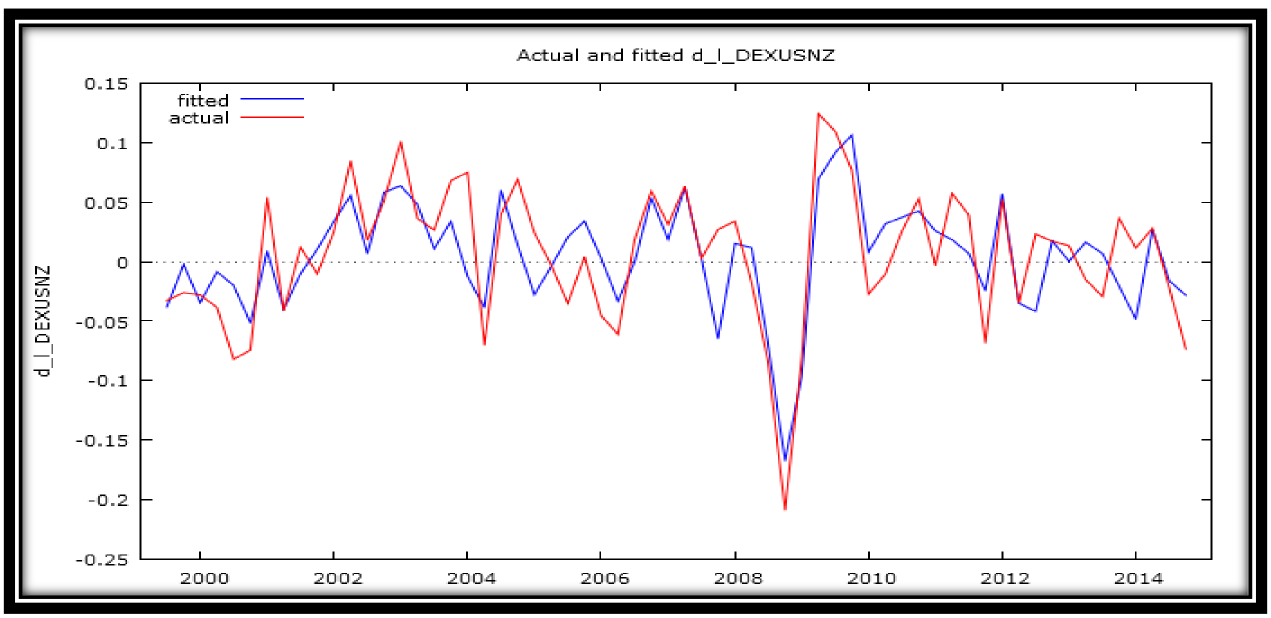


Figure 17 Actual and Fitted Short Term NZD/USD time series

4.5 Forecasts

In the last section of our empirical research, our main goal is to forecast the NZD/USD exchange rate from the third quarter of 2008 until the fourth quarter of 2014 and compare the forecast with the Random Walk.

We observe from the below figure that our prediction sometime catch the trend of the exchange rate nevertheless is very difficult to follow all the fluctuations. Furthermore, the error correction model seems to change faster the trend than the NZD/USD exchange rate.

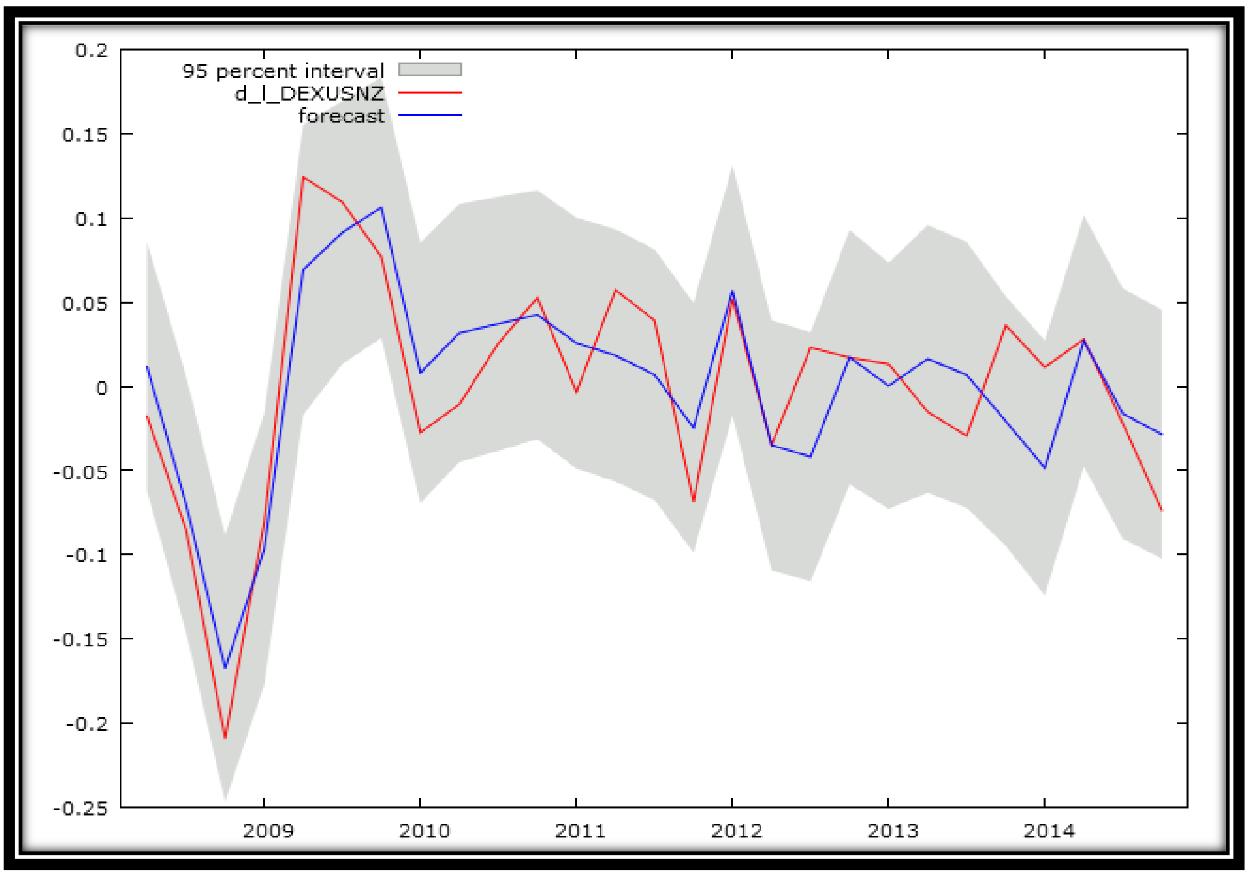


Figure 18 Forecast for the short term model

The following table contains the characteristics of our forecasts and shows us the quality of our predictions.

Table 14Forecast of our model

Forecast evaluation statistics	
Mean Error	-0.0013061
Mean Squared Error	0.001166
Root Mean Squared Error	0.034147
Mean Absolute Error	0.028426
Mean Percentage Error	121.28
Mean Absolute Percentage Error	-27.031
Theil's U	0.64432
Bias proportion, UM	0.001463
Regression proportion, UR	0.001209
Disturbance proportion, UD	0.99733

Having the results of the forecast for our model, the next step is to compare the results with those of random walk. To effect this comparison should be run a linear regression of first logarithmic difference of NZD/USD exchange rate, having only the constant term as the independent variable. Then we will analyze the result.

Table 15 Forecast Statistics of random walk for the same period

Forecast evaluation statistics	
Mean Error	-0.0062758
Mean Squared Error	0.0044495
Root Mean Squared Error	0.066704
Mean Absolute Error	0.049553
Mean Percentage Error	105.35
Mean Absolute Percentage Error	-22.563
Theil's U	0.8763

Comparing the two tables above we see that the Root Mean Squared Error of our model is 0.034147 which is significantly less than in the Root Mean Squad Error of Random Walk. Furthermore, the Mean Error in Random walk is -0.0062758 significantly lower than the Mean Error in our model which is -0.0013061. Finally, we check the price of Theil's U which is known that lesser the index is the better for the model. In our model the Theil's U is 0.64432 in contrast with Random walk which is 0.8763. At this point we conclude that our model has beats the random walk.

To conclude, we present the figure of the forecasts of random walk for the period from 2Q 2008 until 4Q 2014. As we observe the random walk is not as functional in many respects the values of the NZD / USD exchange rate and the fluctuations are outside the shaded area where is the confidence interval 95% nevertheless that does not really apply.

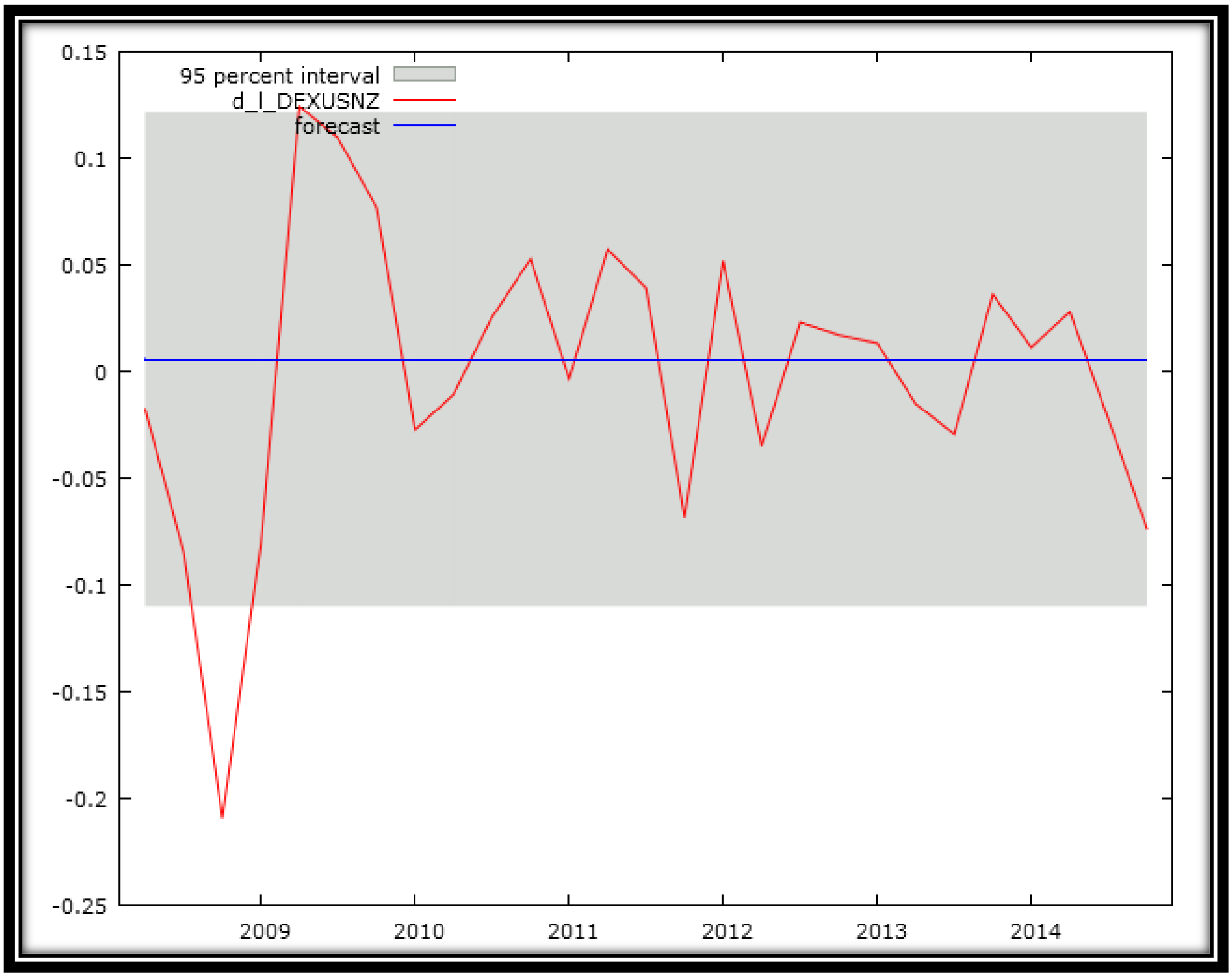


Figure 19 Forecast according to Random Walk from 2Q 2008 to 4Q 2014

5 Conclusions

The present thesis has examined the NZD/USD exchange rate over the period from 2Q 1999 to 4Q 2014 using economic and financial data. The research was based on extensive review of the literature of the NZD/USD exchange rate. Concluding, a great number of researchers have dealt the specific exchange rate and have analyzed, using different models and with different methods.

Initially the first step of the research was to collect all the data to be used in the model into quarters. Subsequently, theoretically studied economic and financial variables that generally affect exchange rates. After thorough investigation of variables using the Ordinary Least Squared method, we decided the most relevant variables that explain the NZD / USD exchange rate. Of particular importance is the testing for cointegration between the dependent variable (exchange rate) and the independent variables. Their stationarity is tested with the ADF test for unit roots. According to this test, the variables have not been cointegrated since most of them were non-stationary except from the residuals of the model which was stationary and have not unit root. Advancing research, we pass from long-term model to short-term model using the error correction model. The long-term model is expressed in logarithm and price levels as opposed to the short-term model where we have the first differences of variables which first differences are particularly important for the assessment of price changes and fluctuations of the exchange rate per quarter. In conclusion, both long-term model and short-term model results show them to conform to economic theory and tend to largely explain the evolution of the NZD/USD exchange rate time series within the time period examined.

Finally, we made some predictions for the period between Q2 2008 to Q4 2014. Our aim was to obtain a sample in the crisis of 2008 to see if our model can catch the intense changes. As a result, the model used is particularly satisfactory as its results are much better than those resulting from the random walk.

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