Efficiency of New Zealand's Spot FOREX Market after Twenty Four Years of Float

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Abstract

Government growth policies in the Asia-Pacific region throughout the 1980s involved a considerable amount of financial market liberalisation, which was intended to increase the efficiency of financial markets. The rationale for a freely floating currency rests heavily on the idea that an unregulated market will on average produce more appropriate (in an economic sense) exchange rates than a market managed by government officials. With this in mind, the New Zealand Government floated the New Zealand dollar in March of 1985. The purpose of this paper is to investigate the efficiency of the New Zealand spot FOREX market after the float, using both univariate and multivariate testing procedures. The data employed to obtain these results has a 14 year delay between the floating of the New Zealand dollar and the start of the sample allowing market participants to become more experienced and sophisticated in their dealings with the floated currency. This has allowed for the production of results that truly reflect the influence of the float on the efficiency of New Zealand's spot FOREX market. The results of these tests confirm the notion of informational market efficiency within New Zealand's spot FOREX market. These robust results provide strong support for market liberalisation in New Zealand, as efficiency has been achieved.

JEL Classification - G15 - International Financial Markets

Keywords: market efficiency, foreign exchange, floating currency

1.0 Introduction

Government growth policies in the Asia-Pacific region throughout the 1980s involved a considerable amount of financial market liberalisation, which was intended to increase the efficiency of markets (Groenewold & Ariff, 1998). The rationale for a freely floating currency rests heavily on the idea that an unregulated market will on average produce more appropriate (in an economic sense) exchange rates than a market managed by government officials (RBNZ, 1987). With this in mind the New Zealand Government floated the New Zealand dollar in March of 1985. Since then however, little has been done to study the effect of the float on the efficiency of New Zealand's spot foreign exchange (FOREX) market. The purpose of this paper is therefore to investigate the efficiency of the New Zealand spot FOREX market after the float, using both univariate and multivariate testing procedures.

Unlike many papers which examine the efficiency of currency markets immediately after they were floated, this paper takes a unique approach by examining data 14 years after the floating of the New Zealand dollar. The rationale behind this delay is that market participants will have had time to mature to the floating currency and therefore have learnt how to deal with its characteristics. This will give a far more accurate indication of the effect of the float on the efficiency of New Zealand's spot FOREX market. The paper is structured as follows; it begins by describing the theory of market efficiency and how the principle of cointegration is used to test market efficiency. It then provides a brief review of the literature. Technical details of both the univariate and multivariate tests used in this paper are provided, followed by a presentation of the results and conclusions.

The efficient operation of markets has always been an important subject for economists and policy analysts as it allows for the optimal allocation of resources (Bhar, 1998). In the case of FOREX markets, it is probably more important, as it is associated with the optimal allocation of resources across borders (Bhar, 1998). For a FOREX market to be efficient the prices of foreign currencies should reflect all information (Kan & Andreosso-O'Callaghan, 2007). If however, some additional information allows agents to predict the future values of an exchange rate, then arbitrage opportunities can be exploited, resulting in abnormal profits, a characteristic of an inefficient market (Kan & Andreosso-O'Callaghan, 2007). The efficient FOREX market argument (from here on called EMH) was put forward by Fama (1965). According to Fama (1965) it is impossible to forecast asset returns with currently available information, as it should be rapidly absorbed into prices. There are three forms the EMH can take, weak form, semi-strong form and strong form. This paper will test the weak and semi-strong forms of the EMH. The strong form of the EMH will not be tested in this paper.

The weak form of the EMH is a special case of the EMH where the information set is restricted to past values of the spot FOREX rate itself (Groenewold & Ariff, 1998). For this form of the EMH to hold, the past values of the spot rate cannot provide information about future values (Groenewold & Ariff, 1998). This means that a single spot FOREX rate time series is empirically well characterised as a random walk non-stationary series, or contain a unit root (integrated to the order of one $I(1)$), if it is weakly efficient

(Groenewold & Ariff, 1998). To test the existence of a unit root in a data series, researchers commonly apply unit root tests (Groenewold & Ariff, 1998). Two such tests are used in this paper to test the weak form of the EMH: the augmented Dickey-Fuller (ADF) (1979, 1981) and the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) (1992) tests.

The semi-strong form of the EMH occurs when the information set for future spot FOREX rates includes not only past returns but all publicly available information (Groenewold & Ariff, 1998). This form implies that all publicly available information should already be reflected in prices, thus this information cannot be used to predict future spot rates. An example of publicly available information, which could be used to predict spot rates, is the current spot rates of other exchange rates (Groenewold & Ariff, 1998). A spot FOREX market will be efficient if a spot rate or a combination of spot rates contains no predictive power for the next movement in any individual spot rates (Groenewold & Ariff, 1998). To determine whether any spot rates in our sample provide predictive power for any single spot rate this paper uses the concept of cointegration due to Engle and Granger (1987).

Cointegration is a measure of long-run behaviour between two or more non-stationary economic time series (Layton & Tan, 1992). If cointegration is found to exist between these time series, then it implies that the two series have a long-run equilibrium relationship (Layton & Tan, 1992). The implication of this, according to the representation theorem of Engle and Granger (1987), is that there will always be a tendency for them to retain a reasonable proximity to each other (Layton & Tan, 1992). The existence of a long-run equilibrium or cointegrating relationship suggests that one spot FOREX rate will hold useful information about the future values of another spot FOREX rate beyond that contained purely in the current individual prices (Layton & Tan, 1992). This will enable agents to predict the future movements of one spot rate by simply analysing the current values of another spot rate. This implies that the semi-strong EMH will be violated if cointegration exists between two or more spot rates. To test the existence of cointegration, the paper will employ a technique due to Johansen (1988), rather than the popular Engle-Granger (1987) two-step method. The reason for this and the technical details of the Johansen test will be explained in the following sections.

2.0 Literature Review

The use of cointegration tests as a tool for identifying the semi-strong form of the EMH in spot FOREX markets has been used by various researchers including, Macdonald and Taylor (1989), Baillie and Bollerslev (1989), Coleman (1990), Copeland (1991), Tronzano (1992), Rapp and Sharma (1999), Hakkio and Rush (1989), Liu and Maddala (1992) and Alexander and Johnson (1992) among others. One of the earliest studies in this area was carried out by MacDonald and Taylor (1989), who examined the Australian Dollar, the Belgian Franc, the Danish Krone, the French Franc, the German Mark, the Italian Lira, the Dutch Guilder, the Canadian Dollar, the Japanese Yen and the UK Pound Sterling using the Engle-Granger (1987) two-step method. They examined monthly

exchange rates over the period January 1973 to December 1985 and found no evidence of cointegration, supporting the EMH.

Coleman's (1990) paper on exchange market efficiency using a similar group of countries provided support for the findings of MacDonald and Taylor (1989). Rapp and Sharma's (1999) investigation of the G-7 group of countries provided further support for the early study by finding little evidence of market inefficiency for the period June 1973 to December 1996. A study of Asian and Australasian countries including Korea, Taiwan, Thailand, Indonesia, Malaysia, Philippines, Japan, Singapore, Australia and New Zealand by Kan and O'Callaghan (2007) generally support the EMH. Their study used the Johansen (1988) cointegration test, the technique employed in this paper, for the period December 1996 to May 2003. Phengpis's (2006) paper examined the effect of crises on Asian FOREX efficiency. During the 1992-1993 European currency crisis and during the 1997-1998 Asian currency crisis Phengpis's (2006) results showed that efficiency remained in Asian FOREX markets despite the major shocks.

However, not all studies using cointegration tests as a tool for detecting the semi-strong form of the EMH in FOREX markets have come to the same conclusion as the ones mentioned above. One such study by Hakkio and Rush (1989) using the Engle-Granger (1987) two-step method, examined the relationship between the exchange rates of Germany and the United Kingdom, over the period July 1975 to October 1986. Their results found evidence of cointegration which, as mentioned above, is inconsistent with market efficiency. Baillie and Bollerslev (1989) also found in their study of the exchange rates of the UK, West Germany, France, Italy, Switzerland, Japan, and Canada in relation to the US dollar, strong evidence of cointegration between daily spot and thirty-day forward exchange rates, also using the Engle-Granger (1987) two-step method. Finally, Liu and Maddala's (1992) study, which used both the weekly and monthly exchange rates of the British Pound, Deutsche Mark, Swiss Franc, and Japanese Yen, which were all denominated in US dollars, rejected the EMH.

Using mostly Asian and Australasian data Layton & Tan's (1992) study of the efficiency of Australia's spot FOREX market found the existence of cointegrating relationships among the spot rates, implying the existence of market inefficiencies in the Australian spot FOREX market. Jeon and Seo (2003) analysed the four countries hardest hit by the Asian crisis, including Thailand, Indonesia, Malaysia and Korea, for the period January 1996 to February 2001. They identified the existence of market inefficiency for the whole period, although estimations for sub-sample periods show results consistent with the EMH. As well as cointegration tests, unit root tests have been widely used in the literature to test for weak form efficiency in FOREX markets. Some of these studies include: Darby (1983), Adler and Lehmann (1983), Huizinga (1987), Baillie and Selover (1987) and Taylor (1988). All these studies fail to reject the unit root hypothesis for various spot FOREX rates, suggesting the existence of the weak form of the EMH. From this brief examination of the literature, it is readily apparent how mixed the results are with regard to the efficiency of FOREX markets. Using these past studies as a foundation, this paper will adopt both cointegration testing as well as unit root tests in an attempt to shed some light on the efficiency of New Zealand's spot FOREX market.

3.0 Data and Methodology

This paper will employ daily spot exchange rates for the United States, the United Kingdom, Australia, Japan and the Euro, denominated in New Zealand dollars. The exchange rate data was collected at 11:10am each day for the period 5th of January, 1999 to the 24th of July, 2009. The data is sourced from the Reserve Bank of New Zealand and is compiled by Reuters and the NZFMA. This high frequency data is employed because, according to Sohel-Azad (2009), it provides a better estimate of the efficiency of developed markets such as the ones used in this sample.

The natural logarithmic forms of the spot rates are used in all the computations for this paper. The logged values are used so the results avoid the Siegel paradox due to Jensen's inequality (Liu & Maddala, 1992).

3.1 Univariate unit root tests

The pioneering work on testing for unit roots (or the order of integration) in FOREX data, to determine the existence of the weak form of the EMH, was carried out by Meese and Singleton (as cited in Baillie & Bollerslev, 1989). They applied the original tests for unit roots due to Dickey and Fuller (1979, 1981). This paper will follow on from the work of Meese and Singleton by using the Dickey-Fuller test but also carry out confirmatory data analysis by employing the KPSS test, to counter the deficiencies of the Dickey-Fuller test.

The Dickey-Fuller test, as previously mentioned, is a unit-root testing procedure which examines the null hypothesis that $\psi = 0$[1] in

$$\Delta y_t = \psi y_{t-1} + u_t$$

(Brooks, 2008)

against the one sided alternative $\psi < 1$[2] if the test statistic[3] is more negative than the critical value[4] (Brooks, 2008).

The test above, however, is only valid if the error term, u_t, is white noise, and specifically not autocorrelated (Brooks, 2008). But if there is autocorrelation in the dependent variable, u_t will be autocorrelated and the chances of incorrectly rejecting a correct null hypothesis[5] will increase (Brooks, 2008). To overcome this problem the Augmented Dickey-Fuller test is employed.
The model can now be written as;

$$\Delta y_t = \psi y_{t-1} + \sum a_i \Delta y_{t-i} + u_t$$

[1] H_0: The series contains a unit root
[2] H_A: The series does not contain a unit root. (Brooks, 2008)
[3] *Test Statistic* = $\psi / SE(\psi)$ (Brooks, 2008)
[4] Therefore the null hypothesis is H_0: The series is non-stationary and is possibly $I(1)$ against the alternative H_A: The series is stationary and is $I(0)$ (Brooks, 2008).
[5] Type 1 error.

(Brooks, 2008)

The Dickey-Fuller test is augmented using p lags of the y variable and ensures that u_t is not autocorrelated as the lags of Δy_t 'soak up' any dynamic structure present in the dependent variable (Brooks, 2008).

However, Verbeek (2008) explains the unit root test described above, as with other unit root tests, have low testing power. To overcome this low test power Kwiatkowski, Phillips, Schmidt and Shin (KPSS) (1992) proposed an alternative stationarity test, where stationarity is the null hypothesis and the existence of a unit root is the alternative, thus reversing the null and alternative hypothesis of the Augmented Dickey-Fuller test (Brooks, 2008). The null and alternative hypotheses under each testing approach are as follows:

ADF/PP	KPSS
H_0: $y_t \sim I(1)$	H_0: $y_t \sim I(0)$
H_A: $y_t \sim I(0)$	H_A: $y_t \sim I(1)$

(Brooks, 2008)

There are four possible outcomes:

ADF/PP		KPSS
(1) Reject H_0	and	Do not reject H_0
(2) Do not reject H_0	and	Reject H_0
(3) Reject H_0	and	Reject
(4) Do not reject H_0	and	Do not reject H_0

(Brooks, 2008)

The KPSS test uses the test statistic:

$$KPSS\ Test\ Statistic = T^{-2} \sum S_t^2 / \sigma^2$$

(Verbeek, 2008).

The results of this test can be compared with the Augmented Dickey-Fuller test to see if the same conclusion is obtained (Brooks, 2008). For the conclusions to be robust, the results should fall under outcomes 1 or 2 above, which would be the case when both tests concluded that the series contains either a unit root or not (Brooks, 2008).

3.2 Multivariate cointegration test

Engle and Granger (1987) found that a linear combination of two $I(1)$ variables may be stationary. If the linear combination of these two variables is stationary or $I(0)$ then the $I(1)$ series are said to be cointegrated (Brooks, 2008).

More formally:

$$y_t = \beta_1+\beta_2 x_{2t}+\beta_3 x_{3t}+\ldots+\beta_k x_{kt}+u_t$$

(Brooks, 2008)

where the error term, u_t, presented above will be integrated to the order of zero, $I(0)$, if the variables, y_t, x_{2t}, x_{3t}, x_{kt}, are cointegrated. (Brooks, 2008). The preceding section has provided reassuring new evidence that daily spot FOREX rates are $I(1)$ or contain a unit root in their univariate time-series representations, thus the paper can proceed with cointegration testing (Baillie & Bollerslev, 1989). This is appropriate as FOREX markets involve the simultaneous determination of several exchange rates (Baillie & Bollerslev, 1989). Therefore, it is more natural to consider the joint modeling of two or more currencies (Baillie & Bollerslev, 1989). Accordingly, in this section a multivariate cointegration test due to Johansen (1988) is implemented in testing for the number of cointegrating relationships in the set of five daily spot FOREX rates.

The Johansen technique uses a systems approach to cointegration which will allow the determination of all *r* cointegrating relationships present amongst all the countries spot FOREX rates (Brooks, 2008). The Johansen technique turns a vector autoregressive (VAR) model with all five FOREX spot rates and *k* lags[6] into a vector error correction model (VECM) with the five variables on the left hand side, and *k*-1 lags of the dependent variables on the right hand side:

$$\Delta y_t = \prod y_{t-k} + \Gamma_1 \Delta y_{t-1} \ldots + \Gamma_{t-k} \Delta y_{t-(k-1)} + u_t$$

(Brooks, 2008).

The Johansen test treats the $\prod$ matrix in this VECM as the long run coefficient matrix (Brooks, 2008). To test for cointegration between the *y*s the rank of the $\prod$ matrix is analysed by looking at its eigenvalues (Brooks, 2008). Each significant non-zero eigenvalue in this matrix indicates a significant cointegrating vector. Thus, if the test statistic is greater than the critical value, the null hypothesis that there are *r* cointegrating vectors is rejected in favour of the alternative hypothesis that there are more than *r* cointegrating vectors. This test is repeated until the null can no longer be rejected.

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[6] The Johansen test can be affected by the lag length employed in the VECM, therefore this analysis will use the Schwarz Information criteria to select the optimal lag length (Brooks, 2008). The Schwarz Information Criteria (SIC) takes the form:

$$SIC_{Ln} = Ln(\sigma^2)+(K / T) * Ln\ T \qquad \text{(Stock \& Watson, 2007)}$$

The SIC selects the correct number of lags which minimises its value, thus will select the optimal lag length (Stock & Watson, 2007). The SIC looks at two areas, the residual sum of squares (RSS) and a form of penalty criteria which represents the loss of degrees of freedom caused by the addition of extra parameters (Stock & Watson, 2007). The addition of an extra lag to the model will reduce the value of the criteria only if the decrease in the RSS offsets the increase in the penalty term (Stock & Watson, 2007).

4.0 Results and Discussions

4.1 Univariate unit root test results

Table One – Augmented Dickey-Fuller tests

t-statistic	Australia	Euro	Japan	UK	USA
Levels	-2.13	-2.7*	-1.41	-1.73	-1.10
1st Diff	-52.18***	-53.91***	-57.83***	-52.75***	-53.49***

Presented above are the Augmented Dickey-Fuller t-statistics for each of the countries spot exchange rates studied. 1st Diff indicates the data has been differenced once. The SIC selected to include no lags of the data from the 12 pre-specified lags. *, ** and *** represent significance for all six data sets using the critical values of -2.58, -2.88 and -3.48 at the 10%, 5% and 1% significance level.

The results from the Augmented Dickey-Fuller tests are displayed in Table One. The null hypothesis of the existence of a unit root for the levels data[7] has been accepted for all five countries' spot exchange rates at the one percent significance level. To ensure the data is integrated to the order of one ($I(1)$), the spot rates are first differenced to see if this induces stationarity. As can be seen from the results, also displayed on Table One, the null hypothesis is rejected at the one percent significance level for all countries' spot FOREX rates. These results imply that the data contains a unit root, thus, the spot FOREX rates of the countries examined conform to the weak form of efficiency.

Table Two – KPSS tests

t-statistic	Australia	Euro	Japan	UK	USA
Levels	1.69***	0.86***	3.27***	4.32***	4.22***
1st Diff	0.08	0.11	0.13	0.05	0.14

Presented above are the KPSS t-statistics for each of the countries spot exchange rates studied. 1st Diff indicates the data has been differenced once. The SIC selected to include no lags of the data from the 12 pre-specified lags. *, ** and *** represent significance for all six data sets using the critical values of 0.347, 0.463 and 0.739 at the 10%, 5% and 1% significance level.

To ensure the validity of these findings, Table Two shows the results from the KPSS tests. The null hypothesis of stationarity is rejected for all countries' spot FOREX rates for the levels data at the one percent significance level. Table Two also shows the results of the KPSS test for the first differenced data. These results accept the null hypotheses of stationarity at the one percent significance level. The paper can therefore conclude that the data is integrated to the order of one ($I(1)$), confirming the results from the Augmented Dickey-Fuller test that the spot FOREX rates of the countries examined conform to the weak form of efficiency. The results from these univariate tests are significant. These findings are indicative of a weakly efficient New Zealand spot FOREX market. Thus, past information is absorbed rapidly to create the new price, meaning next period's values cannot be anticipated based purely on its past values. The paper will now investigate the semi-strong form of efficiency.

[7] Data that has not been first differenced.

4.2 Multivariate cointegration test results

Table Three – Johansen test

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		**Trace**		
No. of Cointegrating Equations	**Eigenvalue**	**Statistic**	**5% Critical Value**	**Probability**
None	0.0133	66.41	76.97	0.24
At most 1	0.0060	30.84	54.08	0.89
At most 2	0.0044	14.85	35.19	0.96
At most 3	0.0007	3.18	20.26	1.00
At most 4	0.0005	1.22	9.16	0.92

According to the Schwartz's information criteria (SIC) a lag length of one was used in conducting the Johansen test. Table Three shows the results of the Johansen test. An examination of the critical value and trace statistic reveals that the null hypothesis of no cointegrating relationships between the spot FOREX rates of the countries examined is accepted at the five percent significance level. Because of this result, there is no need to further test for higher levels of cointegration.

The sensitivity of this result with regard to the lag length used is then tested using lag lengths suggested by the Akaike information criterion (AIC) and Hannan-Quinn information criterion (HQIC). The above results do not change when different lag lengths are employed. This provides evidence of robust results. The results from the Johansen test, which prove no cointegrating relationships present between the spot FOREX rates, have significant implications for New Zealand's spot FOREX market.

It has proven the existence of the semi-strong form of the EMH, implying that all publicly available information is already reflected in prices, thus publicly available information cannot be used to predict future spot rates. It can therefore be concluded that New Zealand's spot FOREX market allocates and prices efficiently, eliminating the possibility for long term abnormal profits, which is an indication that the floating of the dollar has achieved its goal of efficiency.

5.0 Conclusion

This paper investigates the issue of efficiency in the New Zealand spot FOREX market several years after the New Zealand Dollar was floated. The paper applies both univariate and multivariate tests and the results confirm the notion of market efficiency within New Zealand's spot FOREX market. The 14 year period between the floating of the New Zealand dollar and the start of the sample allowed market participants to become more experienced and sophisticated in their dealings with the floated currency. This has allowed for the production of results that truly reflect the influence of the float on the efficiency of New Zealand's spot FOREX market.

Results of similar studies conducted using other currencies have produced results that oppose this study's conclusions. This may be due to the methodology used and time period examined. Many of these studies employ the Engle-Granger (1987) two-step method for identifying cointegration which is susceptible to simultaneous equation bias among other things. The Johansen test adopted by this paper avoids many of the issues surrounding the use of the Engle-Granger (1987) two-step method. In terms of the time period used, many studies examine data directly after the floating of the dollar. As discussed previously this does not give adequate time for market participants to adjust to the new characteristics of the floated currency. These robust results provide strong support for market liberalisation of New Zealand's spot FOREX market, as efficiency has been achieved.

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