Durham University Business School

Combining exchange rate models to produce more accurate forecasts

Can model averaging solve the 'Meese-Rogoff puzzle'?

Abstract

This paper examines the application of model averaging to exchange rate forecasting. Multivariate models are employed to assess the forecasting ability of three exchange rate theories alongside two univariate time-series models. The study explores whether a combination of forecasts can outperform either the individual models or, more importantly, the random walk. Six currencies were considered over three 8-year periods with out-of-sample forecasts produced for 1997, 2005 and 2013. The empirical evidence suggests that model averaging could not solve the 'Meese-Rogoff puzzle' and that the univariate models generally saw more forecasting success. Overall, this paper reinforces the view that monetary models (both flexible and sticky price versions) are weak at predicting exchange rates and that the random walk forecast is exceptionally difficult to beat.

Jack Sellers

A research dissertation (MSc Economics and Finance)

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1. INTRODUCTION

1.1 The 'Meese-Rogoff puzzle'

Conventional wisdom dictates that exchange rates are influenced by macroeconomic events. A change in a nation's fundamentals should, *ceteris paribus*, lead to a change in their currency's value. Yet, as the data often shows us, conventional wisdom can be misleading. In their seminal papers, Meese and Rogoff (1983a,b) were among the first to describe the failure of economic theory at predicting exchange rates. Their results suggested that structural models based on macroeconomic variables were unable to outperform the random walk forecast[1]. This quandary is known as the 'Meese-Rogoff puzzle' and has since inspired many researches to find innovative ways of solving it.

Before addressing the puzzle, it is important to understand what might make exchange rates more difficult to predict. The foreign exchange market is decentralised, operates around the clock and sees greater liquidity than any other market[2]. Greater market efficiency could, therefore, be one explanation of unpredictability. However, this is difficult to measure and seems like a somewhat unsatisfactory answer, as it does not necessarily imply a disparity between exchange rates and their fundamentals. Explanations of the Meese-Rogoff puzzle tend to come from elsewhere, focusing on the shortcomings of the structural models, non-linearities in the data, sampling error and model misspecification. Yet, despite the numerous studies aimed at finding a consistent predictor of exchange rates, it is clear how inconsistent the results have been. Currency forecasters must successfully choose the right model, sample period, data frequency and estimation method before seeing any progress and even then, their model's forecasting ability may not hold in other periods.

1.2 The aim of this paper

Meese and Rogoff carried out their first study in 1983, only looking at 3 currency pairs over a short time period. Since then, there have been a number of similar studies but with varying results, hence the difficulty in drawing overall conclusions about the monetary models' forecasting abilities. This paper aims to provide a more extensive investigation of the Meese-Rogoff puzzle whilst considering a combination of the forecasts and how it compares to that of the random walk. Indeed, Meese and Rogoff also attempted to combine their forecasts

[1] The random walk forecast essentially predicts no change in price (tomorrow's price will be equal to today's)
[2] The Bank for International Settlements (BIS) estimated daily turnover to be $5.3 trillion in 2013

using a different method, but still failed to beat the random walk. Due to the discrepancies in the literature, it was important to consider multiple currencies in this study. Many studies have claimed success in predicting a small number of exchange rates, only for their results to be rejected by larger studies across numerous currencies. Furthermore, it was not sufficient to simply consider each currency's relationship with the US dollar, as most papers have focused on. In order to get a more complete appreciation of how currencies interact with macroeconomic fundamentals, this study sets itself apart from the literature by examining each combination of currency pairs within six free-floating currencies. By doing so, the aim was to examine a more general application of the structural models that did not rely exclusively on dollar exchange rates, since the dollar is the world reserve currency and may not necessarily behave according to established economic principles. There are multitudes of cross country trade and investment patterns that cannot be captured by comparing each country's fundamentals to those of the USA. Lastly, it may also be informative to see how major currency pairs differ in behaviour and relation to their fundamentals, relative to minor currency pairs, where greater liquidity in the former could result in less predictability. Of the 225 forecasts produced in this study (not including the benchmarks), 135 were of the structural models and 90 were of the univariate models.

The variables in question underwent unit root and cointegration tests, revealing the existence of long-run relationships in the data. This motivated the decision to use vector error correction models (VECMs) as the preferred method of estimating the structural forecasts, with stationary vector autoregressive (VAR) models used when cointegration was not observed. In addition, two univariate models; an autoregressive moving average (ARMA) model and a generalised autoregressive conditional heteroscedasticity (GARCH) specification are also employed to capture the effects of "chartists" in the market, those who simply rely on past trends in a currency pair's price. Together, there were five forecasts produced for each sample period alongside the random walk (RW) and random walk with drift (RWD) forecasts acting as benchmarks. To evaluate the forecasts, both the root mean squared errors (RMSEs) and mean absolute errors (MAEs) are evaluated, with average values for these over all of the 45 samples (15 currency pairs over 3 time periods) and for each forecast horizon. The method chosen for model averaging gives weights to each forecast based on the Akaike Information Criterion (AIC), which acts as a measure of its quality.

1.3 The main findings of this paper

Overall, the structural models failed to shed their reputations as poor out-of-sample forecasters. Interestingly, however, the univariate models tended to produce more accurate predictions, with an ARMA-GARCH(1,1) model dominating the 12 month forecasts. Nevertheless, none of the models in this study can be endorsed as consistent exchange rate predictors. A currency trader would have incurred significant losses by following any of the models and could not even count on them for a correct direction of change prediction. Moreover, the combined forecasts fared better than the structural models' due to the inclusion of the univariate models, rather than for being an effective method for averaging forecasts. AIC proved to be a poor measure of quality as the weights for each model tended to be very similar, equating the technique to a naïve strategy of equal weighting. All in all, the results raise doubt over the validity of these structural models, echoing the scepticism that Meese and Rogoff brought into the exchange rate forecasting literature.

The paper is arranged as follows; section 2 looks at the derivation of the monetary models and how they have been interpreted, both theoretically and empirically. Section 3 describes the data used in this study, along with its characteristics and limitations. Section 4 outlines the full methodology employed by this study with section 5 assessing its results. Finally, a brief conclusion of the results is found in section 6, with references and appendices thereafter.

2. LITERATURE REVIEW

The following chapter considers the existing literature on exchange rate forecasting, with the first three sections looking at the theoretical background of the monetary models and what researchers have had to say about them since their inception. The final section focuses on the empirical evidence produced by researchers who have tested such models, and how their results have differed.

2.1 International parity conditions

Identifying the factors that drive exchange rates is a challenge in itself. The traditional approach to modelling exchange rates comes from looking at parity conditions in the goods market. Purchasing power parity (PPP) was developed as a rudimentary way of evaluating currency values relative to one another, given free trade conditions and an absence of transaction costs. Its usefulness at explaining exchange rates has been questioned repeatedly throughout the last century, although Taylor (2003) notes a recent move towards accepting PPP over the long-run. The PPP equation is

$$\mathbf{S}_t = \mathbf{P}_t - \mathbf{P}_t^* \tag{1}$$

where S_t is the spot exchange rate, P_t is the domestic price level and P_t* is the foreign price level[3]. Also, interest rates have been a key part of many exchange rate theories, most notably in the uncovered interest rate parity (UIP) which defines a no-arbitrage condition between countries with different rates of return on bank deposits. The UIP equation is

$$\Delta \mathbf{S}_t^e = \mathbf{i}_t - \mathbf{i}_t^* \tag{2}$$

with ΔS_t^e denoting the expected depreciation of the domestic currency and i_t being the interest rate. Covered interest rate parity (CIP) extends this concept to include forward contracts as a way of mitigating exchange rate risk, since one can assume that some countries will face a risk premium regardless of the rates they offer. In general, CIP holds for recent sample periods in countries where capital controls have been removed, and deviations from the parity

[3] Throughout this paper, all capital lettered variables are logarithmic and all foreign variables are denoted with *

condition are short lived (Coffey et al., 2009). Yet neither the goods nor interest rate markets provide a complete explanation of exchange rates. For example, current account balances have been studied extensively as a potential sign of a currency's strength, even though the increasing role of capital market activity in the foreign exchange market may have since rendered this as a less important factor (Krueger, 1983). Determining which factors to include is far from straightforward, but there is something instinctive about applying economic "truths" to exchange rate prediction. Whether they hold true in reality or not is another matter.

2.2 The monetary approach to exchange rate determination

It is desirable, therefore, for an exchange rate model to incorporate multiple dynamics whilst remaining parsimonious[4] enough for out-of-sample forecasts. The monetary approach to exchange rate modelling satisfies these prerequisites, building from the PPP condition and allowing for other variables to be introduced. The reasoning behind this approach is to analyse the determinants of exchange rates in terms of the supply and demand for both assets (Frenkel, 1976). In the flexible-price version, monetary equilibrium is given by

$$\mathbf{M}_t = \mathbf{P}_t + \boldsymbol{\phi}\mathbf{Y}_t - \lambda\mathbf{i}_t \tag{3}$$

$$\mathbf{M}_t{}^* = \mathbf{P}_t{}^* + \boldsymbol{\phi}^*\mathbf{Y}_t{}^* - \lambda^*\mathbf{i}_t{}^* \tag{4}$$

where M_t is the money supply and Y_t is the level of real income. Since PPP is assumed to hold, equations (3) and (4) can be substituted into (1) to get

$$\mathbf{S}_t = \mathbf{M}_t - \mathbf{M}_t{}^* - \boldsymbol{\phi}\mathbf{Y}_t + \boldsymbol{\phi}^*\mathbf{Y}_t{}^* + \lambda\mathbf{i}_t - \lambda^*\mathbf{i}_t{}^* \tag{5}$$

Allowing the domestic and foreign coefficients of income and interest rates to be equal ($\phi = \phi^*$, $\lambda = \lambda^*$), we get the model of Frenkel (1976) and Bilson (1978a) (hereafter FB model)

$$\mathbf{S}_t = (\mathbf{M}_t - \mathbf{M}_t{}^*) - \boldsymbol{\phi}(\mathbf{Y}_t - \mathbf{Y}_t{}^*) + \lambda(\mathbf{i}_t - \mathbf{i}_t{}^*) \tag{6}$$

[4] The idea of parsimony here means to achieve a desired outcome while keeping the number of model parameters as low as possible.

Dornbusch (1976) provided an alternative to this model by contesting the assumption of flexible prices. In his sticky-price version, PPP only holds in the long-run which means that the FB equation also only holds in the long-run (long-run variables are given an overline)

$$\bar{\mathbf{S}}_t = (\bar{\mathbf{M}}_t - \bar{\mathbf{M}}_t{}^*) - \boldsymbol{\phi}(\bar{\mathbf{Y}}_t - \bar{\mathbf{Y}}_t{}^*) + \lambda(\bar{\mathbf{i}}_t - \bar{\mathbf{i}}_t{}^*) \quad \textbf{(7)}$$

The exchange rate should, therefore, deviate from its equilibrium value over the short-run, subject to market expectations of future inflation (π). The expected depreciation of the domestic currency can, thus, be expressed in terms of the difference between the long and short-run exchange rate and the long-run inflation rate differential

$$\Delta \boldsymbol{S}_t{}^{\boldsymbol{e}} = -\boldsymbol{\theta}(\boldsymbol{S}_t - \bar{\boldsymbol{S}}_t) + \bar{\boldsymbol{\pi}}_t - \bar{\boldsymbol{\pi}}_t{}^* \quad \textbf{(8)}$$

Combining the UIP condition (2) with equation (8), we are left with an expression for the difference between the short and long-run exchange rates

$$\mathbf{S}_t - \bar{\boldsymbol{S}}_t = -\frac{\mathbf{1}}{\boldsymbol{\theta}}[(\boldsymbol{i}_t - \bar{\boldsymbol{\pi}}_t) - (\boldsymbol{i}_t{}^* - \bar{\boldsymbol{\pi}}_t{}^*)] \quad \textbf{(9)}$$

which can be combined with equation (7) to get the Dornbusch overshooting model

$$\bar{\mathbf{S}}_t = \left(\bar{\mathbf{M}}_t - \bar{\mathbf{M}}_t{}^*\right) - \boldsymbol{\phi}\left(\bar{\mathbf{Y}}_t - \bar{\mathbf{Y}}_t{}^*\right) - \frac{\mathbf{1}}{\boldsymbol{\theta}}(\mathbf{i}_t - \mathbf{i}_t{}^*) + (\lambda + \frac{\mathbf{1}}{\boldsymbol{\theta}})(\bar{\boldsymbol{\pi}}_t - \bar{\boldsymbol{\pi}}_t{}^*) \quad \textbf{(10)}$$

Frankel (1979) extends this model to incorporate secular (persistent) inflation and simplifies the last two coefficients to single values. This is known as the Dornbusch-Frankel model (hereafter DF model)

$$\bar{\mathbf{S}}_t = \left(\bar{\mathbf{M}}_t - \bar{\mathbf{M}}_t{}^*\right) - \boldsymbol{\phi}\left(\bar{\mathbf{Y}}_t - \bar{\mathbf{Y}}_t{}^*\right) + \boldsymbol{\alpha}(\mathbf{i}_t - \mathbf{i}_t{}^*) + \boldsymbol{\beta}(\bar{\boldsymbol{\pi}}_t - \bar{\boldsymbol{\pi}}_t{}^*) \quad \textbf{(11)}$$

Finally, Hooper and Morton (1982) develop this to "allow for large and sustained changes in real exchange rates", which are assumed to be related to changes in the current account (CA). The Hooper-Morton model (hereafter HM model) is

$$\mathbf{\bar{S}}_t = \left(\mathbf{\bar{M}}_t - \mathbf{\bar{M}}_t^{*}\right) - \phi\left(\mathbf{\bar{Y}}_t - \mathbf{\bar{Y}}_t^{*}\right) + \boldsymbol{\alpha}(\mathbf{i}_t - \mathbf{i}_t^{*}) + \boldsymbol{\beta}(\bar{\pi}_t - \bar{\pi}_t^{*}) + \gamma CA_t + \gamma^{*} CA_t^{*} \qquad \mathbf{(12)}$$

2.3 Theory

Discussion of the theory should begin with the monetary equilibrium conditions (3) and (4), since they are the basis of the three structural models. The premise that demand for money depends on prices, incomes and yields is a relatively uncontroversial one[5]. Yet, the equations have come under scrutiny for not including lagged terms (Bilson, 1978b) or wealth levels (Frankel, 1982). Also, the most immediate feature of these money demand functions is that their explanatory variables must be estimated using proxies. The issue of proxy estimation is highlighted by Dornbusch (1980) who reminds us that exchange rate movements depend on unanticipated changes in the macroeconomic variables, due to the introduction of rational expectations (ΔS_t^e) into the models. This implies that each currency forecaster must be able to measure the expected values provided by all other economic agents in order to make a rational judgement on the 'true' price of a currency. Indeed, this problem applies to the DF model which includes expected inflation as a factor, something which must necessarily be approximated with either historical inflation or with surveys, the latter suffering from various problems of its own (see Croushore, 1998). Thus, the proxies used in place of expected values pose a very real problem of misspecification.

The argument against the flexible-price FB model is broadly twofold. First, its assumptions are very simplistic and often empirically inaccurate. They state that money markets are always in equilibrium, PPP holds continuously and that, of course, prices are flexible. Goldfeld (1973) relaxes the first assumption by adding lagged terms of the money supply and price level, while the overshooting model deals with the issue of PPP by taking prices to be sticky and, thus, allowing exchange rates to deviate from their long-run PPP equilibria. The

[5] However, Simpson and Porter (1980) describe a particular lack of evidence for US money demand equations. This was another reason for examining all currency pair combinations.

second argument against the FB model is that it does not capture all the dynamics of an open economy (Saville, 1980). It implies that a relative increase in the domestic money supply leads to currency depreciation, whilst the opposite is true for a relative increase in domestic output. However, what may seem peculiar is that a relative increase in the domestic interest rate is said to devalue the currency. The FB models treats higher interest rates as a disincentive for people to acquire that currency, since demand for borrowing should be lower. This ignores the effects of capital inflows. Bilson (1979) argues that these contradictions can be overcome by fully specifying the determinants of each variable. For example, he contends that the FB model would seem to be valid if an increase in real income was due to 'real' factors such as population and productivity growth. The determinants of interest rates, though, are more difficult to identify. The sticky-price DF model does, however, differ in that the sign of its interest rate coefficient is negative[6].

One criticism of all of the models is that they take the variables to be exogenous when real income, interest rates and expected inflation could themselves be affected by the money supply. Putman and Woodbury (1979) argue that real income and interest rates are independent of the money supply since it is only unanticipated shocks that have any effect. They maintain that the question of exogeneity can then be overcome by assuming expected inflation to be an autoregression of past prices or a rational expectations model with lagged values of the money supply. Another problem with the monetary approach is that it ignores the trends seen in capital markets. Chinn (1989) claims that financial globalisation has led to a greater link between foreign exchange and equity markets which is not observable using the monetary models. It must be noted, though, that the models can be easily modified to include other variables.

2.4 Evidence

This section is dedicated to studies that evaluated the structural models' out-of-sample forecasts. Meese and Rogoff (1983a) used both instrumental variable (IV) estimation and an unconstrained vector autoregressive (VAR) model to estimate the reduced form equation. In their results, the random walk outperformed on all forecast horizons except for the dollar-deutschmark at one month ahead, where the FB model was more accurate. VAR models are inappropriate if there is cointegration between the variables and it wasn't until later studies

[6] In fact, the regression results found in appendices II and III show that most coefficients of the interest rate differential (that were statistically significant) tended to be positive. This implies that the FB model is correct to ignore capital inflows.

that cointegration was examined in this setting. MacDonald and Taylor (1994) note that “the broad conclusion to emerge from this body of work is that exchange rates are not cointegrated with the standard vector of monetary variables.” Nevertheless, they find evidence of cointegration in their data and conclude that the error correction model (ECM) yields the best out-of-sample results, beating the random walk over all of their forecast horizons. However, their cointegrating vector was estimated over the entire sample which gave the ECM an unfair advantage over the random walk.

Mark (1995) found that the ECM could predict exchange rates over long horizons when the coefficients and cointegrating vector were calibrated *a-priori*. This differs with the results of Cheung et. al (2005) and Alquist and Chinn (2008) who estimated the coefficients, finding that the ECM could not predict exchange rates[7]. Three researchers who used an identical ECM specification were Kilian (1999), Groen (1999) and Rossi (2005), the first two concluding no evidence of exchange rate predictability and the latter concluding the opposite. Such inconsistencies in the literature are commonplace and represent the myriad of different factors that can influence exchange rate predictability, even when the model specification is identical. MacDonald and Taylor (1993) had successful results when applying VECMs to the monetary model, whereas Cheung et. al (2005) favoured the single-equation version because “the short-run dynamics of exchange rates are difficult to estimate”. Cause for concern may arise from the findings of Rapach and Wohar (2002), who observed the impact of money supply, real income and interest rates on 14 countries over a period of 115 years using VECMs. They noted that success varied greatly between the countries and that it was difficult to draw robust conclusions. Moreover, Diebold et. al (1994) attributed their poor VECM forecasts to a general lack of cointegration in asset markets. Nonetheless, cointegrating equations were detected in many of this study’s samples, making the VECM methodology appropriate. There is also an information gain from estimating all of the equations in the system.

Finally, what makes this paper different to most of the literature is its use of model averaging. Meese and Rogoff (1983a) considered the model averaging approach of Granger and Newbold (1997), where the actual exchange rate is regressed against the different models’ forecasts. They reported that a combination of all forecasts never outperformed the random walk, but that linear combinations taken two at a time sometimes did. However, they found

[7] It should be noted that this present study also estimated the cointegrating vector as opposed to calibrating it. This was due to the unconvincing results of the preliminary regression.

that the same combination never worked for more than one exchange rate. Bayesian model averaging (BMA) is a more popular technique that combines the forecasts of separate models using weights estimated by posterior probabilities. In the frequentist (as opposed to Bayesian) approach, this can be achieved by using some measure of each model's quality, which was the AIC in this case. These are referred to as measures of 'marginal likelihood' in the BMA framework. Wright (2008) explored the use of BMA in the context of exchange rate models, considering a multitude of different factors (including the standard monetary variables as well as stock prices, productivity and the current account). Wright refers to the "folklore of the forecasting literature that taking forecasts from several different models and simply averaging them gives better predictions than any one model on its own"[8]. Nevertheless, he concluded that model averaging techniques gave encouraging results for out-of-sample exchange rate forecasting.

[8] See Bates and Granger (1969) and Stock and Watson (2004) for similar references

3. DATA

3.1 Time-series data

The data consists of monthly spot exchange rates and macroeconomic variables. The currencies examined were the US dollar (USD), Japanese yen (JPY), British pound (GBP), Swiss franc (CHF), Canadian dollar (CAD) and Australian dollar (AUD). These gave the following crosses:

AUD-GBP	*CAD-GBP*	*CHF-CAD*	*JPY-AUD*	*JPY-GBP*
AUD-USD	*CAD-USD*	*CHF-GBP*	*JPY-CAD*	*JPY-USD*
CAD-AUD	*CHF-AUD*	*CHF-USD*	*JPY-CHF*	*USD-GBP*

Until 1971, all of these currencies had been pegged to the US dollar which was convertible to gold at $35 per ounce. This was part of the Bretton Woods agreement, an initiative by political leaders to regulate the foreign exchange market in a post-war world. However, increased pressure[9] on the dollar had led to an outflow of gold from the US, culminating in President Nixon's decision to suspend the gold link. Following the Canadian dollar's flotation in 1970, the British pound was allowed to float in 1971 with the USA, Switzerland[10] and Japan following suit in 1973. Australia joined the list of free floating currencies in 1983. The end of the Bretton Woods era gave rise to a new system of fiat currencies, their survival resting on the discipline of central banks and policymakers not to debase them. Although most fiat currencies have lost significant value since 1971, they are evaluated relative to one another which can mask their long-run declines in purchasing power.

Each was examined over three 8-year periods (1989 – 1996, 1997 – 2004, and 2005 – 2012), with out-of-sample forecasts produced for 1997, 2005 and 2013. These currencies were selected due to them all being free-floating throughout the periods in question, with the exception of the Swiss franc which was reclassified as a managed floating currency in 2012 (IMF, 2012). The currencies chosen are also the six biggest by trade volume (BIS, 2013), not counting the Euro which was only floated in 1999. The macroeconomic data comprised M1 money supply, real GDP (adjusted for inflation), short-term interbank interest rates, CPI

[9] The Vietnam war and Great Society programs were major causes of inflation in the USA (Cooper 1984).
[10] Switzerland retained a gold link and backed the franc with 40% gold reserves until 2000.

inflation and current account balances. All of the data was available from Datastream and Bloomberg, with the sources given in Appendix I.

3.2 Limitations

Annual CPI inflation was used as a proxy for expected inflation, as is typical in the literature[11]. Furthermore, where Meese and Rogoff used trade balance as a proxy for the current account (which is only available quarterly), monthly estimates for the current account were achieved using cubic spline interpolation. Linear interpolation is generally accepted as a valid method of data transformation, although it does introduce serial correlation between the actual (quarterly) data points. Nevertheless, Wold (1974) finds the only disadvantage to using spline functions as "mainly psychological" and defends their use in economic analysis as Poirier (1973) had done before him.

It should also be noted that the periods in question were not tailored to the data. Structural breaks may be present in some of the samples, but it was desirable that each currency pair be evaluated over the same timeframes in order to maintain consistency. It was also unclear whether the financial crisis of 2008 had affected all of the currencies significantly, although some of the currencies saw sharp depreciations throughout this period. That said, many countries also saw a significant change in their macroeconomic fundamentals during the crisis so it was informative to see how well this was represented in the models. Figures 3.3a to 3.3e give a visual representation of each macroeconomic variable, with the first showing how the USA and Canada saw a steady increase in their post-crisis money supplies as opposed to the more volatile changes felt in the UK and Australia. Switzerland saw a sharp increase in its money supply while Japan's remained fairly constant[12]. Real GDP contracted across all countries except Australia, and interbank rates underwent a similar process. However, although inflation rates came down sharply during the crisis, they had been volatile across all three time periods. Likewise, current account balances were affected unevenly by the crisis, with only Switzerland showing a noticeable change. It was often the case that when one or more variables saw a sharp adjustment, the others did not follow suit. For this reason the third time period included the crisis to see how the models faired. Each sample had 96 observations in total, notwithstanding any lagged terms being removed.

[11] See Frankel (1981) and Hooper and Morton (1982).
[12] M1 does not include time deposits and money market funds.

3.3 Descriptive statistics

Out of the 45 samples, the average return was positive in 29 and negative in 16, although their t-statistics indicated that none of them were significantly different from zero. Standard deviation was spread unevenly across the samples; JPY-CHF, CHF-USD and CHF-GBP were the most volatile pairs while JPY-USD, JPY-GBP and CAD-AUD were the least. The Swiss franc's inclusion in the riskiest pairs may surprise some due to its 'safe haven' status. However, times of uncertainty have often resulted in sharp appreciations of the franc as investors search for safety. This was one of the reasons why the Swiss National Bank effectively ended its free-floating status in 2012. On average, volatility decreased between the first two periods by 6.25% while increasing between the last two by 13.13%. JPY-GBP, JPY-CHF and GBP-CHF were the most negatively skewed pairs while skewness in JPY-CAD, JPY-AUD and CAD-AUD was the most positive[13]. The Jarque-Bera[14] statistics suggest that 16 out of the 45 series were normally distributed and the Ljung-Box[15] statistics give evidence that most of the series were white noise processes[16]. Table 3.3 gives a summary of the exchange rate descriptive statistics.

[13] Skewness refers to how asymmetrical a statistical distribution is.
[14] The Jarque–Bera test is a goodness-of-fit measure of whether the sample data has the skewness and kurtosis matching a normal distribution.
[15] The Ljung–Box test determines whether a group of autocorrelations contains any that are different from zero.
[16] A white noise process is a sequence of serially uncorrelated random variables with zero mean and finite variance.

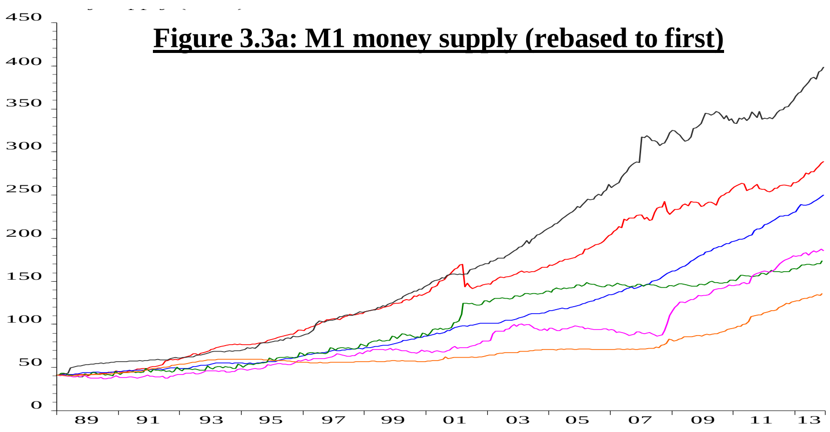


Figure 3.3a: M1 money supply (rebased to first)

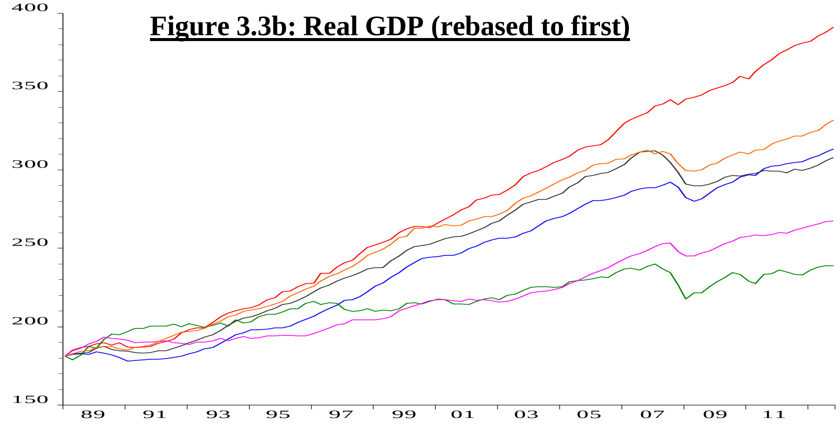


Figure 3.3b: Real GDP (rebased to first)

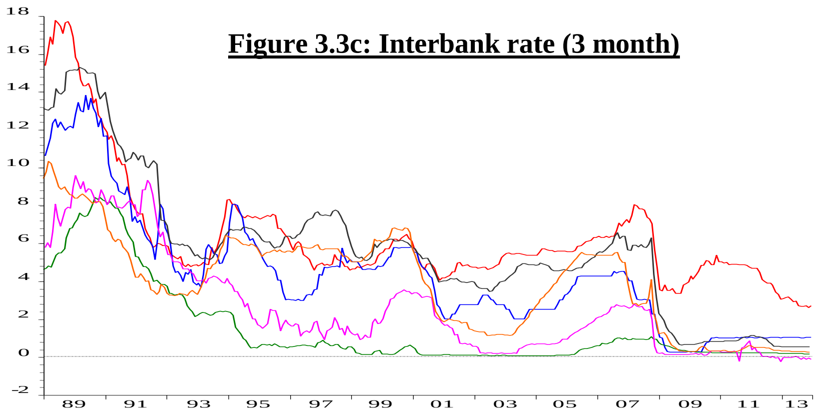


Figure 3.3c: Interbank rate (3 month)

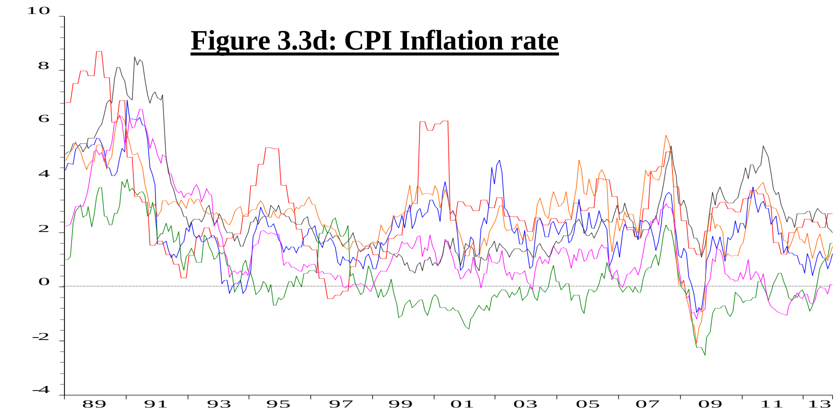


Figure 3.3d: CPI Inflation rate

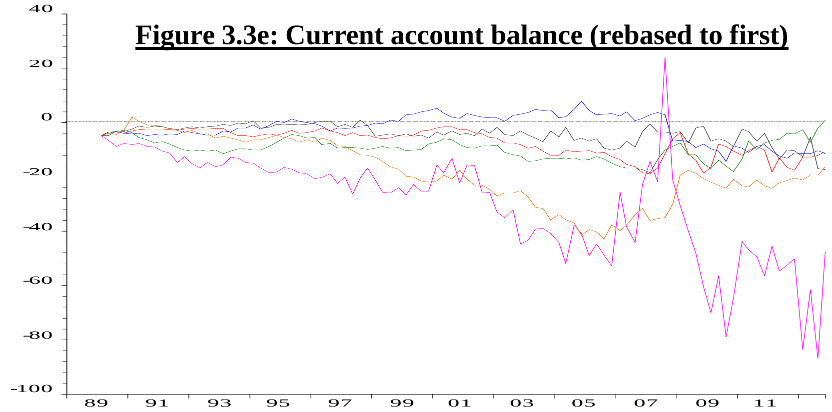


Figure 3.3e: Current account balance (rebased to first)

Australia — Switzerland
Canada — UK
Japan — USA

Source: Thomson Reuters Datastream

The graphs that are 'rebased to first' are all given an arbitrary value at the start of that range, so the vertical axis in these cases are simply a scale of relative value. For Figure 3.3c and 3.3d, these are percentages and in all cases the horizontal axis gives the time period in years.

Table 3.3: Descriptive statistics for the logarithmic returns of each currency pair (1989 – 2012)

		JPY-USD	USD-GBP	CHF-USD	CAD-USD	AUD-USD	JPY-GBP	JPY-CHF	JPY-CAD	JPY-AUD	CHF-GBP	CAD-GBP	AUD-GBP	CHF-CAD	CAD-AUD	CHF-AUD
Mean	***89 - 96***	-0.000357	0.003397	0.003041	0.000950	0.001307	-0.002084	-0.002421	0.002814	-0.000613	-0.001726	0.000453	-0.001413	-0.001413	0.000742	-0.000984
	97 - 04	0.001556	0.000323	0.001880	0.001361	-0.000191	-0.000519	-0.001464	-0.000133	-0.000413	0.000358	0.000546	-0.001439	-0.001439	-0.001405	-0.001048
	05 - 12	-0.000998	0.000290	-0.000699	-0.004717	-0.003728	-0.004021	0.001232	-0.000243	-0.000539	-0.004212	-0.003073	-0.002215	-0.002215	0.001882	-0.002330
Standard deviation	***89 - 96***	0.022784	0.036837	0.043234	0.038688	0.034405	0.025918	0.040210	0.034672	0.030676	0.034707	0.025458	0.035834	0.035834	0.033607	0.032071
	97 - 04	0.024385	0.031278	0.036545	0.033019	0.026146	0.023697	0.039341	0.036881	0.036059	0.037458	0.032040	0.029038	0.029038	0.022029	0.036414
	05 - 12	0.029371	0.036017	0.032870	0.031983	0.026980	0.031244	0.051516	0.043062	0.037428	0.040104	0.043640	0.037134	0.037134	0.029885	0.027166
Skewness	***89 - 96***	0.570200	-0.373193	0.153875	-0.206497	-0.743738	-0.914129	-0.404606	-0.044420	0.314805	-1.162306	0.641997	0.573239	0.573239	1.336840	-0.052011
	97 - 04	-0.105925	0.185994	0.371984	0.346882	-0.001199	0.153181	-0.693094	1.207020	0.660390	-1.173778	0.133549	-0.341998	-0.341998	-0.027338	-0.909093
	05 - 12	0.339130	0.712117	1.011482	-0.169586	0.070158	-1.661909	-1.358590	1.090160	0.769971	-1.101556	0.589398	0.211091	0.211091	0.529291	0.373368
Kurtosis	***89 - 96***	4.551426	3.154445	3.050180	3.522122	4.764479	7.009809	4.443214	4.316984	2.788824	6.588013	4.802583	3.851870	3.851870	6.521415	4.251167
	97 - 04	3.038486	2.497818	2.967410	3.343294	3.648115	3.014552	3.696931	6.900005	5.016201	8.209217	2.191898	2.392029	2.392029	3.096162	6.243968
	05 - 12	3.474280	3.720867	5.655850	4.773503	3.243701	11.86624	7.535094	7.060223	4.156701	5.820373	4.619040	5.529504	5.529504	5.480407	3.472492
JB	***89 - 96***	14.67527	2.299571	0.384860	1.754234	21.08198	76.87515	10.83669	6.896757	1.745638	72.34907	19.38770	8.075382	8.075382	77.38116	6.239280
	97 - 04	0.185446	1.562244	2.218206	2.396640	1.680235	0.376276	9.628927	84.15050	23.23811	130.5878	2.897479	3.349915	3.349915	0.048947	55.31650
	05 - 12	2.739908	10.19238	44.58371	13.04140	0.316314	358.6320	111.8006	84.95685	14.83752	51.23282	16.04340	26.30651	26.30651	29.09205	3.123460
LB(20)	***89 - 96***	17.931	18.094	16.196	12.817	20.097	17.376	14.441	19.097	25.293	35.648	23.143	25.702	25.702	22.226	22.364
	97 - 04	11.589	36.540	26.164	19.487	12.047	18.189	24.905	16.445	15.727	18.314	12.586	28.257	28.257	25.425	0.142
	05 - 12	24.516	31.996	20.643	22.920	40.195	26.819	16.348	32.280	23.527	34.641	23.561	34.197	34.197	22.704	23.737

Shaded boxes indicate significant values within a 95% confidence interval (for the sample means this shows that the mean is statistically no different from zero). For the Jarque-Bera (JB) statistic, these represent a normal distribution. The Ljung-Box (LB) statistic shows serial correlation up to the 20^{th} lag term, where significant values represent a white noise process. Critical values in both cases are χ^2 distributed.

4. Methodology

4.1 Hypotheses

Given the available data, there were many possible approaches that could have been taken. Although this paper focuses on the below hypotheses, there is also discussion later of slight variations to the methodology. The hypotheses are:

H_1: Model averaging produces more accurate forecasts than the *individual models*

H_2: Model averaging produces more accurate forecasts than the *random walk*

The random walk forecast is notoriously hard to beat, as the literature widely accepts. Since studies that managed this feat often relied on more advanced estimation methods, outperforming the random walk was seen as a secondary objective after outperforming the individual models. As section 5 explains, however, both of these hypotheses were rejected.

4.2 Multivariate cointegration

The first and most important step in the methodology was determining whether or not long-run relationships existed between the exchange rates and macroeconomic variables. This process follows the approach of Johansen (1991), whereby the order of integration[17] for each variable is determined before assessing how many cointegrating relationships[18] are present. First, the Augmented Dickey Fuller (ADF) test is used to define whether the series have unit roots and are, therefore, non-stationary. The most restrictive model (with a deterministic component and intercept) is assessed first, followed by more restrictive versions until the null hypothesis of a unit root is rejected for the first time. The inclusion of trend and intercept variables is then verified by their ADF test equation p-values, by assessing how significantly their coefficients differ from zero. In cases where there was a marginal rejection of a trend or intercept, despite it being clearly present in the data, a Dickey-Fuller generalised least squares (GLS) test was used to reassess the result. This was done in order to prevent non-differenced (level) data being falsely defined as I(0) when it did not exhibit the properties of a stationary process. Subsequent ADF tests can then define them as I(1) variables (stationary after first-differencing) or I(2) variables (stationary after second-differencing). Next, a VAR model is

[17] A variable's order of integration is the number of times it needs to be transformed before becoming stationary
[18] Two variables share a cointegrating relationship if there exists some linear combination of them that has a lower order of integration

constructed for the I(1) variables, with any I(0) variables included exogenously and I(2) variables first-differenced. The procedure for selecting the number of lags is discussed in section 4.5. This lag length (p) is then applied to a VAR(p) model

$$\mathbf{X}_t = \boldsymbol{\mu} + \mathbf{A}_1\mathbf{X}_{t-1} + \mathbf{A}_2\mathbf{X}_{t-2} + \ \dots + \mathbf{A}_p\mathbf{X}_{t-p} + \boldsymbol{\varepsilon}_t \qquad \textbf{(13)}$$

where μ is a constant, X and A are vectors of the I(1) variables and coefficient terms, respectively, and ε_t is an error term vector. This model is subjected to the Johansen test[19], which identifies the number of long-run relationships between the variables through a trace statistic. Finally, Granger causality[20] tests are also employed to examine one directional causal relationships between each macroeconomic variable and the exchange rate. These comprise of F-tests on the joint significance of the sum of lags of each explanatory variable.

4.2 Cointegrated regression

The structural models are estimated in a generalised form to satisfy parsimony and avoid multicollinearity. It should be noted that this form may lead to misspecification since the domestic and foreign coefficients are assumed to be equal (see Haynes and Stone, 1981). However, Meese and Rogoff reported no gains from estimating separate coefficients. The reduced form equation is

$$\mathbf{S}_t = \boldsymbol{\beta}_0 + \boldsymbol{\beta}_1(\mathbf{M}_t - \mathbf{M}_t^{*}) + \boldsymbol{\beta}_2(\mathbf{Y}_t - \mathbf{Y}_t^{*}) + \boldsymbol{\beta}_3(\mathbf{i}_t - \mathbf{i}_t^{*}) + \boldsymbol{\beta}_4(\bar{\boldsymbol{\pi}}_t - \bar{\boldsymbol{\pi}}_t^{*}) + \boldsymbol{\beta}_5(\boldsymbol{CA}_t - \boldsymbol{CA}_t^{*}) \qquad \textbf{(14)}$$

Each of the monetary models hypothesise $\beta_1 = 1$, implying first-degree homogeneity in relative money supplies. This restriction can be imposed along with $\beta_2 = -1$, which would describe an income elasticity of demand to unity. The FB model sets $\beta_4 = \beta_5 = 0$ and the DF model sets $\beta_5 = 0$, while none of the coefficients are zero in the HM model. The purpose of estimating this generalised model is to measure its in-sample fit, see which models posit the right coefficient constraints and explore whether restrictions should be set on the cointegrating vector to reflect this. Fully-modified OLS (FM-OLS)[21] and dynamic OLS

[19] Trends are allowed in the data but not in the cointegrating equations
[20] If knowledge of a variable helps to predict the future of another, it is said to Granger cause that variable
[21] See Philips and Hansen (1990)

(DOLS)[22] are used to avoid the problem of spurious regressions, which occur when working with cointegrated variables. For the FM-OLS method, the approach of Hansen (1992) is taken by using a quadratic kernel and the Andrews (1991) automatic bandwidth selector. For the DOLS method, the number of leads and lags is set to 2 following the application of Stock and Watson (1993), along with heteroscedasticity and correlation consistent (HAC) standard errors (see Newey-West, 1987).

4.3 Vector error correction models

For the samples where cointegration was detected, VECM models are constructed from the I(1) variables by adding an error correction term to the stationary VAR

$$\Delta \mathbf{X}_t = \boldsymbol{\mu} + \mathbf{B}_1 \Delta \mathbf{X}_{t-1} + \mathbf{B}_2 \Delta \mathbf{X}_{t-2} + \ \dots \ + \mathbf{B}_p \Delta \mathbf{X}_{t-p+1} + \prod \boldsymbol{X}_{t-1} + \boldsymbol{\varepsilon}_t \qquad \textbf{(15)}$$

In this model, $B_i = -(I - A_1 - A_2 - \dots - A_i)$ and $\prod = -(I - A_1 - A_2 - \dots - A_p)$, where I denotes the identity matrix and i = (1,2,…,p-1). If Π comprises of r linearly independent columns (r < k) and k is the number of variables in X_t, equation (15) convergences to a long-run equilibrium described by $\prod = \alpha\beta'$, where α and β are both (k×r) matrices. Matrix α includes the coefficients of the speed of adjustment toward the long-run equilibrium and matrix β contains the coefficients defining the long-run relationship. The rank of ∏ corresponds to the number (r) of linearly independent columns in ∏, and for the FB, DF and HM models, k will be equal to 4, 5 and 6, respectively. For example, the HM model is described below, where each macroeconomic variable denotes the domestic-foreign differential as written out in equation (14)

$$\begin{pmatrix} \Delta\mathbf{S}_t \\ \Delta\mathbf{M}_t \\ \Delta\mathbf{Y}_t \\ \Delta\mathbf{i}_t \\ \Delta\boldsymbol{\pi}_t \\ \Delta\mathbf{CA}_t \end{pmatrix} = \boldsymbol{\mu} + \mathbf{B}_1 \begin{pmatrix} \Delta\mathbf{S}_{t-1} \\ \Delta\mathbf{M}_{t-1} \\ \Delta\mathbf{Y}_{t-1} \\ \Delta\mathbf{i}_{t-1} \\ \Delta\boldsymbol{\pi}_{t-1} \\ \Delta\mathbf{CA}_{t-1} \end{pmatrix} + \mathbf{B}_2 \begin{pmatrix} \Delta\mathbf{S}_{t-2} \\ \Delta\mathbf{M}_{t-2} \\ \Delta\mathbf{Y}_{t-2} \\ \Delta\mathbf{i}_{t-2} \\ \Delta\boldsymbol{\pi}_{t-2} \\ \Delta\mathbf{CA}_{t-2} \end{pmatrix} + \ \dots \ + \mathbf{B}_p \begin{pmatrix} \Delta\mathbf{S}_{t-p+1} \\ \Delta\mathbf{M}_{t-p+1} \\ \Delta\mathbf{Y}_{t-p+1} \\ \Delta\mathbf{i}_{t-p+1} \\ \Delta\boldsymbol{\pi}_{t-p+1} \\ \Delta\mathbf{CA}_{t-p+1} \end{pmatrix} + \prod \begin{pmatrix} \mathbf{S}_{t-1} \\ \mathbf{M}_{t-1} \\ \mathbf{Y}_{t-1} \\ \mathbf{i}_{t-1} \\ \boldsymbol{\pi}_{t-1} \\ \mathbf{CA}_{t-1} \end{pmatrix} + \boldsymbol{\varepsilon}_t \qquad \textbf{(16)}$$

The VECMs provide information on the short-run dynamics of the structural models whilst maintaining a long-run equilibrium. Their main purpose in this study is to produce dynamic

[22] See Stock and Watson (1993)

12 step-ahead forecasts. Stationary VARs were used in any instances where cointegration was not observed, and also in the two samples where the exchange rate was I(0) since the dependent variable cannot be included exogenously.

4.4 Univariate models

Many currency traders attempt to identify patterns and trends in the exchange rate rather than model macroeconomic fundamentals. Their actions have sometimes been approximated to that of a simple univariate model (see Frankel and Froot, 1986; Allen and Taylor, 1990) and have been included in many studies that focus on the monetary approach, including Meese and Rogoff's paper that provided univariate models as a forecast comparison. Technical analysis (following past trends) may be of little value according to the efficient market hypothesis (EMH) since a currency pair's historical prices are widely available and should, in theory, already be reflected in the current price. However, the widespread use of technical analysis means that the actions of chartists can reinforce existing trends (Dick and Menkhoff, 2013). Following the Box-Jenkins (1970) approach, the first univariate model to be estimated by OLS was an ARMA(p,q) model of the exchange rate series

$$\Delta S_t = \mu + \emptyset_1 \Delta S_{t-1} + \emptyset_2 \Delta S_{t-2} + \ldots + \emptyset_p \Delta S_{t-p} + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \ldots + \theta_q \varepsilon_{t-q} + \varepsilon_t \qquad (17)$$

where p and q denote the autoregressive and moving average lag lengths, respectively. The appropriate checks for white noise errors and model stability were then carried out. Next, the series were tested for ARCH effects, which is evidence of persistent volatility clustering and leverage distortions in the market. Indeed, the descriptive statistics in table 3.3 have already showed signs of skewness and non-normality in many of the exchange rate series. ARCH effects are detected by regressing squared residuals on their lagged values and carrying out a Lagrange Multiplier (LM) test. For models that exhibited no ARCH effects, this process was skipped, otherwise a GARCH(1,1) specification was then estimated for the ARMA(p,q) model

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 \sigma_{t-1}^2 + \varepsilon_t \qquad (18)$$

where σ_t^2 is time-dependent standard deviation, ε_t^2 is the squared error term and the α terms are constants. Unlike the standard ARMA model, the GARCH requires an assumption about the error distribution. The three main options are normal (Gaussian), student's t-distribution and generalised error distribution (GED). Kim et al. (1998) noted the advantage of using t-distributed errors when they assessed the GARCH(1,1) in Monte Carlo simulations. Likewise, Hansen and Lunde (2001) compared 330 different volatility models and usually found more accurate results when t-distribution was considered. Moreover, they also found that even the best models did "not provide a significantly better forecast than the GARCH(1,1) model". For these reasons, and the fact that many of the currency pairs exhibited non-normal behaviour, an ARMA-GARCH(1,1) (hereby GARCH) model with t-distributed errors was used.

4.4 Lag length selection

An important consideration that has, so far, been avoided is the method of selecting the right lag length for each model. The classic trade-off is between the bias of parsimony and the inefficiency of overfitting. The importance of lag length selection was highlighted by Braun and Mittnik (1993) who showed that estimators of a VAR model, for which the lag length is not set at its true value, are inconsistent. The forecasts they generate will have higher RMSE values if the model is overfitted, and autocorrelation will be present if the model is underfitted (Lütkepohl, 1993). In a Monte Carlo simulation, Ozcicek and McMillin (1999) found that the AIC selected the 'true' lags most frequently and performed better in VAR models that had a longer lag length. In a similar study, Ivanov and Kilian (2005) saw that for monthly data and smaller sample sizes (less than 120), AIC produced more accurate impulse response estimates. Despite there not being a "correct" criterion for out-of-sample forecasting, the AIC seems most suitable for this study. However, due to the AIC's tendency to select larger lag lengths than would typically be used for forecasting, a maximum length was set at 6. Although this is set arbitrarily, it is rare for forecasting models to exceed this number. Moreover, lag lengths of 4 or less tended to produce heteroscedastic residuals, so up to 6 was usually appropriate.

Once the AIC was minimised, residual diagnostics had to be carried out. The first of these was the LM test for autocorrelation[23] which, if detected, may be due to omitted variables contained in the error term. As such, the usual solution of adding more lags could result in overfitting and a misspecified cointegration rank, with the Johansen test also losing power and identifying too few long-run relationships. This is another reason why a maximum lag length had to be set. The last procedures were a multivariate Jarque-Bera test for normally

[23] The autocorrelation of a process is the correlation between values of the process at different times.

distributed errors and a White test for homoscedasticity[24] with no cross terms (cross multiples of the residuals). However, even if these null hypotheses were rejected, they still did not warrant lag lengths over 6 as this paper's primary concern is out-of-sample forecasting which is highly sensitive to overfitting. Thus, parsimony took precedence over error specification.

4.5 Model averaging

After each forecast was produced, the AIC values for each model (m) were recorded and subtracted from that of the 'best' model (lowest AIC value). This allows the figures to be more easily compared across different samples and is known as the AIC difference

$$\Delta_m = \mathbf{AIC}_m - \mathbf{AIC}_{min} \tag{19}$$

The AIC difference forces the best model to have a value of 0, with the other models having positive numbers. Each of these standardised values is then inputted into the following formula to calculate that model's weight, with the top half of the fraction representing the relative likelihood of the model, given the data (Akaike, 1981)

$$\mathbf{w}_m = \frac{\mathbf{exp}\left(-\frac{1}{2}\Delta_m\right)}{\sum_{j=1}^{M} \mathbf{exp}\left(-\frac{1}{2}\Delta_j\right)} \tag{20}$$

Then, a combined forecast was made by weighting the forecasts of each model at every step (1 to 12). One advantage of using an AIC based weighting system as opposed to BMA is that it allows for model misspecification which, as explained in the previous section, is sometimes necessary in order to keep the model parsimonious. Indeed, the Bayesian approach is to search for the 'true' model out of a number of potential candidates. Burnham and Anderson (2002) proposed that the AIC be used to correct this, as the BMA weights are approximately equivalent to equation (19) where BIC is used in place of AIC. It also made little sense to select the lag lengths based on AIC but weight the models using another criterion, since lag length has such a profound impact on the forecasts.

[24] A sequence of random variables is homoscedastic if all random variables in the sequence have the same finite variance.

4.6 Forecast evaluation

Finally, all of the forecasts had to be assessed according to standard measures. The most common of these, especially for forecasting, is the root mean squared error (RMSE)

$$\mathbf{RMSE} = \sqrt{\frac{\sum_{t=1}^{T}(\hat{S}_t - S_t)^2}{T}} \tag{21}$$

where $\hat{S}_t$ is the forecasted exchange rate, S_t is the actual exchange rate and T is the number of predictions. However, there is a tendency for RMSE to vary depending on its use and to increase in a non-monotonic fashion. Thus, a more unambiguous measure is the mean absolute error (MAE)

$$\mathbf{MAE} = \frac{\sum_{t=1}^{T}|\hat{S}_t - S_t|}{T} \tag{22}$$

Ideally, the Diebold-Mariano (DB) test (1995) would have been used to assess whether the AIC-weighted forecasts perform significantly better than those of the individual models or random walk. However, this was not feasible since the weighted forecasts were not produced by a single model. Instead, a final overview of the models' forecasting abilities is given by how often they correctly predicted the future direction of exchange rates, and the financial profit or loss a currency trader would have made by following their predictions.

5. Empirical results

5.1 Unit root tests

The majority of variables were I(1), although there were some notable exceptions to this. Real GDP was often classed as I(2) which meant that it had to be differenced before use in many of the VECMs and VARs. Similarly, there were a few cases where money supply was deemed to be I(2) and one where the current account was also. In addition to this, 14 of the variables were I(0) which meant that they entered the models exogenously. Rapach and Wohar (2002) noted the difficulty in distinguishing I(0) from I(1), a problem they overcame in some cases by using multiple unit root tests. A similar process was followed in this study. Stationarity before differencing was most commonly found for inflation and interest rates, which are also the only two variables that have a standardised measurement across all countries (percentage points are universal unlike national accounts that are country specific). They also tend not to have long-term trends, unlike the money supply and real GDP. This means that the cross-country differentials of these two variables are more likely to exhibit mean-reverting behaviour. More problematic, however, was the fact that two samples yielded I(0) exchange rates. Since this is the forecasting variable, it meant that a VECM construction was not possible and stationary VARs had to be used instead, regardless of cointegration. Tables 5.1a to 5.1c display the unit root test results with colour coding to indicate the test specifications.

5.2 Cointegration tests

Out of the 135 level VARs that were constructed, 14 yielded no cointegrating equations which meant that stationary VARs could be used instead of VECMs. Cointegration was observed in all other instances, with the number of cointegrating equations varying considerably across the samples. Tables 5.2a to 5.2c display the residual characteristics and cointegration test results for each of the VARs. LM test statistics indicated that serial correlation was unlikely to be present in any of the models, an important precondition for the Johansen test's lag length to be appropriate. Similarly, the White test statistics showed that errors were likely to be homoscedastic in all but 14 of the models; heteroscedasticity was usually purged from the models by increasing the lag length. However, the Jarque-Bera tests revealed that normally distributed errors were more of a rarity, with only 26 VARs exhibiting these.

Table 5.1a: ADF test results (1)

		ADF test on levels						ADF test on first-differences						ADF test on second-differences					
		S	M	Y	i	π	CA	d(S)	d(M)	d(Y)	d(i)	d(π)	d(CA)	d(d(S))	d(d(M))	d(d(Y))	d(d(i))	d(d(π))	d(d(CA))
AUD-GBP	1989 - 1996	-2.577542	-1.104332	-3.163251	-1.81704	-2.606018	-1.856716	-9.589271	-11.28432	-1.206906	-7.759085	NA	-2.78021	NA	NA	-3.330022	NA	NA	NA
		0.101	*0.243*	*0.0981*	*0.066*	*0.0096*	*0.0606*	*0*	*0*	*0.2071*	*0*		*0.0058*			*0.0011*			
	1997 - 2004	-2.741137	-2.763722	-2.479372	-1.386476	-0.990501	-1.135926	-11.0642	-6.983235	-1.749047	-5.407021	-3.844717	-2.940424	NA	NA	-4.444696	NA	NA	NA
		0.0707	*0.2142*	*0.3376*	*0.1531*	*0.2866*	*0.2315*	*0*	*0*	*0.0762*	*0*	*0.0002*	*0.0036*			*0*			
	2005 - 2012	-1.243164	-2.605042	-2.740337	-0.116662	-1.383271	0.25383	-8.649079	-9.933167	-3.821943	-8.23332	-4.959217	-4.872277	NA	NA	NA	NA	NA	NA
		0.1954	*0.0953*	*0.2232*	*0.6411*	*0.1539*	*0.7577*	*0*	*0*	*0.0038*	*0*	*0*	*0*						
AUD-USD	1989 - 1996	0.152375	2.643412	0.234122	-2.023413	-2.374846	-2.766855	-10.37713	-9.96133	-2.27768	-9.183386	NA	-2.495951	NA	NA	NA	NA	NA	NA
		0.7282	*1*	*0.7521*	*0.5814*	*0.0177*	*0.2132*	*0*	*0*	*0.0227*	*0*		*0.0129*						
	1997 - 2004	-1.844992	-2.085768	0.726879	-1.223586	-1.669151	2.994043	-9.931474	-10.8324	-2.536715	-2.422578	-4.828056	-3.673258	NA	NA	NA	NA	NA	NA
		0.6754	*0.2509*	*0.8702*	*0.2017*	*0.0897*	*0.9993*	*0*	*0*	*0.0115*	*0.0156*	*0.0008*	*0.006*						
	2005 - 2012	-3.089506	-2.349175	2.045038	-2.179516	-1.530477	-2.099652	-4.70957	-9.725518	-2.515103	-4.332809	-4.546382	-3.49037	NA	NA	-2.915166	NA	NA	NA
		0.1144	*0.4038*	*0.99*	*0.215*	*0.1176*	*0.5393*	*0*	*0*	*0.1151*	*0*	*0*	*0.0006*			*0.0039*			
CAD-AUD	1989 - 1996	-1.326749	-1.828494	-1.387218	-2.758719	-2.064136	-1.157701	-7.967168	-11.04416	-2.558856	NA	NA	-3.361997	NA	NA	NA	NA	NA	NA
		0.1698	*0.6837*	*0.1528*	*0.0062*	*0.038*	*0.2238*	*0*	*0*	*0.0109*			*0.001*						
	1997 - 2004	-2.172528	-0.112622	-4.041562	-0.908236	-1.514185	-1.770245	-10.52776	-11.46761	NA	-5.147543	-4.722275	-2.650891	NA	NA	NA	NA	NA	NA
		0.2176	*0.6425*	*0.0104*	*0.3205*	*0.1212*	*0.3931*	*0*	*0*		*0*	*0*	*0.0084*						
	2005 - 2012	-3.763417	-2.144667	-1.929498	-0.53649	-2.024743	-0.300038	NA	-9.617142	-3.295983	-4.226487	-5.14963	-2.363418	NA	NA	NA	NA	NA	NA
		0.0225	*0.5149*	*0.6314*	*0.4821*	*0.2759*	*0.5752*		*0*	*0.0178*	*0*	*0*	*0.0182*						
CAD-GBP	1989 - 1996	-2.556742	1.733263	-3.442678	-1.204482	-0.769322	-1.156561	-10.24532	-13.45112	-0.838009	-7.821942	-5.218632	-3.363404	NA	NA	-2.965488	NA	NA	NA
		0.1054	*0.9795*	*0.0519*	*0.208*	*0.3804*	*0.2242*	*0*	*0*	*0.3504*	*0*	*0*	*0.001*			*0.0034*			
	1997 - 2004	-0.634977	-1.892569	-2.110412	-2.041693	-1.072364	-1.772044	-11.29826	-11.11901	-1.253615	NA	-4.331395	-2.651032	NA	NA	-4.005205	NA	NA	NA
		0.4399	*0.6511*	*0.5331*	*0.04*	*0.2548*	*0.3922*	*0*	*0*	*0.1919*		*0*	*0.0084*			*0.0001*			
	2005 - 2012	-1.169908	-2.184104	-0.797466	-1.845316	-2.51179	-0.302825	-3.503468	-4.570349	-1.698379	-10.11188	-4.533108	-2.361862	NA	NA	-4.613902	NA	NA	NA
		0.2197	*0.4929*	*0.9618*	*0.0621*	*0.1159*	*0.5741*	*0.0006*	*0*	*0.0846*	*0*	*0*	*0.0183*			*0*			
CAD-USD	1989 - 1996	-2.650681	0.638326	-2.351018	-3.860405	-0.575779	-1.159248	-3.099197	-2.493548	-1.810245	NA	-6.464773	-3.365338	NA	NA	-4.526804	NA	NA	NA
		0.0864	*0.8526*	*0.1585*	*0.0173*	*0.4654*	*0.2233*	*0.0022*	*0.0129*	*0.067*		*0*	*0.001*			*0*			
	1997 - 2004	-0.588439	3.988812	-3.317862	-0.809757	-0.861791	-1.761732	-9.652934	-8.816731	-2.418111	-9.302932	-3.670536	-2.64479	NA	NA	NA	NA	NA	NA
		0.4602	*1*	*0.0696*	*0.9607*	*0.3401*	*0.3973*	*0*	*0*	*0.0158*	*0*	*0.0003*	*0.0086*						
	2005 - 2012	-3.219827	-2.152054	-2.123091	-1.566477	-1.363559	-0.317435	-5.391471	-4.627068	-2.588449	-9.297734	-6.501513	-2.360017	NA	NA	NA	NA	NA	NA
		0.0864	*0.2252*	*0.5262*	*0.1098*	*0.1593*	*0.5687*	*0*	*0.0016*	*0.01*	*0*	*0*	*0.0184*						

UNIT ROOT DETECTED	
-2.577542	Trend & intercept
-2.577542	Intercept
-2.577542	Neither

UNIT ROOT REJECTED	
-2.57754	Trend & intercept
-2.57754	Intercept
-2.57754	Neither

All shaded values are ADF t-statistics that are significant at the 5% level, with their corresponding p-values in italics underneath. Non-shaded values in the first section (ADF test on levels) indicate the presence of an I(0) process, with the second and third sections showing I(1) and I(2) variables as non-shaded, respectively. NA refers to a variable that is already stationary.

Table 5.1b: ADF test results (2)

		ADF test on levels						ADF test on first-differences						ADF test on second-differences					
		S	M	Y	i	π	CA	d(S)	d(M)	d(Y)	d(i)	d(π)	d(CA)	d(d(S))	d(d(M))	d(d(Y))	d(d(i))	d(d(π))	d(d(CA))
CHF-AUD	1989 - 1996	-2.549711	-1.709871	-3.228468	-2.161299	-4.183028	-3.060945	-10.08503	-1.450159	-1.258665	-4.191441	NA	-1.963169	NA	-8.002622	-2.300985	NA	NA	NA
		0.3042	*0.7394*	*0.0852*	*0.2217*	*0.0001*	*0.1218*	*0*	*0.1365*	*0.1903*	*0*		*0.0479*		*0*	*0.0214*			
	1997 - 2004	-1.67645	-0.872831	-3.059023	-0.135464	-0.415777	0.131314	-11.39299	-10.31882	-2.156464	-8.733353	-4.757783	-1.251249	NA	NA	NA	NA	NA	-3.636322
		0.0884	*0.3357*	*0.1222*	*0.6347*	*0.531*	*0.7217*	*0*	*0*	*0.0305*	*0*	*0*	-3.788419						*0.0004*
	2005 - 2012	-2.608759	-2.2927	-2.108984	-3.737218	-3.103335	-2.161853	-9.42858	-6.03202	-3.451737	-4.030188	-3.409683	-3.788419	NA	NA	NA	NA	NA	NA
		0.0944	*0.4339*	*0.5341*	*0.0243*	*0.1115*	*0.2216*	*0*	*0*	*0.0115*	*0.0001*	*0.0008*	*0.0002*						
CHF-CAD	1989 - 1996	-1.776591	-1.002055	-0.909375	-1.71314	-2.365029	-1.156827	-9.733444	-2.704916	-0.781448	-8.823113	NA	-3.362065	NA	NA	-2.159179	NA	NA	NA
		0.0719	*0.282*	*0.3199*	*0.0821*	*0.0181*	*0.2241*	*0*	*0.0073*	*0.3751*	*0*		*0.001*			*0.0304*			
	1997 - 2004	-2.306106	-1.002055	-0.909375	-1.71314	-2.365029	-1.156827	NA	-2.704916	-0.781448	-8.823113	NA	-3.362065	NA	NA	-2.159179	NA	NA	NA
		0.021	*0.282*	*0.3199*	*0.0821*	*0.0181*	*0.2241*		*0.0073*	*0.3751*	*0*		*0.001*			*0.0304*			
	2005 - 2012	-3.447228	-2.165763	-0.050225	-1.135368	-0.768839	-0.298437	-12.83215	-5.70132	-4.117882	-11.62559	-4.11299	-2.362371	NA	NA	NA	NA	NA	NA
		0.0507	*0.22*	*0.6636*	*0.2319*	*0.3807*	*0.5758*	*0*	*0*	*0.0001*	*0*	*0.0001*	*0.0183*						
CHF-GBP	1989 - 1996	-0.554283	-2.863549	-2.813641	-0.91319	-1.892542	-2.693204	-8.364805	-3.404448	-3.108313	-10.51364	-11.22396	-2.854757	NA	NA	-3.542675	NA	NA	NA
		0.4748	*0.1791*	*0.0601*	*0.9499*	*0.056*	*0.0789*	*0*	*0.0008*	*0.1103*	*0*	*0*	*0.0047*			*0.0005*			
	1997 - 2004	-3.301825	1.200197	-2.138669	-2.777372	-1.950683	1.11965	-11.43755	-4.214328	-2.492356	-9.440846	NA	-2.388549	NA	NA	NA	NA	NA	NA
		0.0715	*0.9404*	*0.2303*	*0.0652*	*0.0493*	*0.9311*	*0*	*0*	*0.013*	*0*		*0.0171*						
	2005 - 2012	-1.529373	-1.064929	-1.867342	-1.898095	-0.020401	0.336186	-11.40265	-4.894812	-2.824756	-8.597457	-4.284683	-2.807665	NA	NA	NA	NA	NA	NA
		0.1179	*0.7274*	*0.0592*	*0.0554*	*0.6735*	*0.7804*	*0*	*0*	*0.0051*	*0*	*0*	*0.0054*						
CHF-USD	1989 - 1996	-2.274484	0.991182	-1.047738	-2.708723	-2.28116	-2.821712	-3.099197	-0.963146	-1.219473	-7.845753	-4.402816	-2.353212	NA	-9.577886	-2.995349	NA	NA	NA
		0.1821	*0.9142*	*0.2641*	*0.2354*	*0.4397*	*0.1933*	*0.0022*	*0.2976*	*0.2029*	*0*	*0*	*0.0187*		*0*	*0.0031*			
	1997 - 2004	-0.419612	1.313093	-3.312008	-0.622214	0.313685	3.307413	-9.962261	-8.068142	-1.981567	-6.157331	-3.26563	-3.664024	NA	NA	NA	NA	NA	NA
		0.5298	*0.9517*	*0.0705*	*0.4456*	*0.7743*	*0.9997*	*0*	*0*	*0.046*	*0*	*0.0193*	*0.0062*						
	2005 - 2012	-3.311092	0.098376	-3.1139	-1.080665	-0.911305	-1.815963	-5.451989	-4.562049	-3.683002	-8.699988	-4.448716	-3.059895	NA	NA	NA	NA	NA	NA
		0.0702	*0.7117*	*0.1089*	*0.2519*	*0.3191*	*0.0662*	*0*	*0*	*0.0003*	*0*	*0*	*0.0025*						
JPY-AUD	1989 - 1996	-0.814206	-2.643965	-2.36721	-2.363449	-1.784132	0.089628	-10.19548	-1.086774	-4.942765	NA	-10.95962	-3.291321	NA	-12.33061	NA	NA	NA	NA
		0.361	*0.2623*	*0.3942*	*0.0182*	*0.0708*	*0.7089*	*0*	*0.2494*	*0.0001*		*0*	*0.0012*		*0*				
	1997 - 2004	-0.23083	-2.387153	-0.588766	-0.010344	-0.780578	1.158144	-11.26192	-9.744211	-4.262557	-8.385744	-10.31388	-4.186914	NA	NA	NA	NA	NA	NA
		0.6009	*0.3841*	*0.4599*	*0.6771*	*0.3758*	*0.9356*	*0*	*0*	*0*	*0*	*0*	*0*						
	2005 - 2012	-2.640166	-1.312988	-1.984675	-2.921872	-0.749371	-1.895875	-9.03634	-9.11273	-1.92995	-6.3387	-4.677213	-2.779739	NA	NA	-3.393226	NA	NA	NA
		0.0882	*0.8794*	*0.6019*	*0.1601*	*0.3893*	*0.6489*	*0*	*0*	*0.0516*	*0*	*0*	*0.0059*			*0.0009*			

UNIT ROOT DETECTED	
-2.577542	Trend & intercept
-2.577542	Intercept
-2.577542	Neither

UNIT ROOT REJECTED	
-2.57754	Trend & intercept
-2.57754	Intercept
-2.57754	Neither

All shaded values are ADF t-statistics that are significant at the 5% level, with their corresponding p-values in italics underneath. Non-shaded values in the first section (ADF test on levels) indicate the presence of an I(0) process, with the second and third sections showing I(1) and I(2) variables as non-shaded, respectively. NA refers to a variable that is already stationary.

Table 5.1c: ADF test results (3)

		ADF test on levels						ADF test on first-differences						ADF test on second-differences					
		S	M	Y	i	π	CA	d(S)	d(M)	d(Y)	d(i)	d(π)	d(CA)	d(d(S))	d(d(M))	d(d(Y))	d(d(i))	d(d(π))	d(d(CA))
JPY-CAD	1989 - 1996	-0.56939	-2.472465	-3.269054	-1.369571	-1.732159	-2.457938	-9.578234	-2.016447	-1.964743	-8.116297	-4.659231	-2.2313	NA	NA	NA	NA	NA	NA
		0.4684	0.1254	0.0778	0.1578	0.0789	0.129	0	0.0425	0.0478	0	0	0.0254						
	1997 - 2004	0.333636	-0.227582	0.486633	-0.362562	-0.202381	-0.16476	-6.947279	-2.0984	-4.27353	-3.732836	-3.841587	-2.549739	NA	NA	NA	NA	NA	NA
		0.7799	0.6018	0.8186	0.5518	0.6108	0.6242	0	0.0351	0	0.0003	0.0002	0.0111						
	2005 - 2012	0.252621	-2.49286	-2.92903	-1.312912	-1.15178	-0.827629	-5.774631	-2.647292	-2.206348	-2.147529	-4.47073	-2.608369	NA	-7.525124	NA	NA	NA	NA
		0.7575	0.1204	0.1583	0.1739	0.2259	0.3549	0	0.2609	0.027	0.0312	0	0.0095		0				
JPY-CHF	1989 - 1996	-1.259345	-3.086142	-3.185169	-2.698619	-2.257748	-2.09449	-7.886185	NA	-1.827496	-9.113218	-3.278419	-1.976037	NA	NA	-2.188879	NA	NA	NA
		0.1903	0.031	0.0937	0.0776	0.4524	0.2474	0		0.0646	0	0.0013	0.0465			0.0282			
	1997 - 2004	-0.792584	-2.686163	-2.312493	-0.894821	-3.33907	1.157731	-11.32545	-2.377549	-2.031873	-9.493219	NA	-4.188082	NA	NA	NA	NA	NA	NA
		0.3705	0.2447	0.1702	0.3263	0.0158	0.9356	0	0.0176	0.041	0		0						
	2005 - 2012	-1.496787	-2.726614	-2.784863	-1.432348	-1.02698	-1.89586	-10.68118	-4.024404	-3.312452	-8.092511	-4.858956	-2.779306	NA	NA	NA	NA	NA	NA
		0.1253	0.2286	0.2065	0.1411	0.2722	0.6489	0	0.0001	0.0011	0	0	0.0059						
JPY-GBP	1989 - 1996	-0.141067	-2.859302	1.167243	-2.682707	-2.319972	-2.094555	-3.366088	-3.043813	-1.406886	-3.986231	-3.294111	-1.976206	NA	NA	-3.580388	NA	NA	NA
		0.6326	0.1805	0.9366	0.0807	0.419	0.2474	0.0009	0.0027	0.1476	0.0122	0.0012	0.0465			0.0005			
	1997 - 2004	0.161084	-3.313684	-1.998865	-0.626087	-2.887076	1.15873	-12.86186	NA	-3.888583	-5.785068	-3.655121	-4.187758	NA	NA	NA	NA	NA	NA
		0.7309	0.0169	0.287	0.4439	0.0506	0.9357	0		0.003	0	0.0004	0						
	2005 - 2012	-0.291823	-2.226949	-2.563591	-1.615966	-0.415884	-1.896569	-7.90472	-10.49161	-4.072601	-6.03327	-4.618172	-2.779981	NA	NA	NA	NA	NA	NA
		0.5785	0.1981	0.1042	0.0998	0.531	0.6485	0	0	0.0095	0	0.0017	0.0058						
JPY-USD	1989 - 1996	-0.039833	0.739095	-2.355616	-3.372492	-1.023149	-2.094919	-8.983691	-0.386646	-1.654685	-6.946217	-3.691174	-1.97398	NA	-4.369196	-3.683776	NA	NA	NA
		0.6673	0.8725	0.1572	0.0607	0.2737	0.2472	0	0.5423	0.0924	0	0.0003	0.0468		0	0.0003			
	1997 - 2004	-2.628441	-3.106047	0.230182	-0.755702	-2.424755	1.168717	-5.500579	-1.772821	-2.158523	-2.234197	-3.284167	-4.181867	NA	-4.904165	NA	NA	NA	NA
		0.0907	0.1109	0.7509	0.3867	0.1377	0.9368	0	0.0725	0.0304	0.0252	0.0013	0.0001		0				
	2005 - 2012	-0.014292	-2.505407	1.52137	-1.077154	-1.400461	-1.898277	-9.111329	-5.126067	-2.324171	-8.067482	-5.944266	-2.777565	NA	NA	NA	NA	NA	NA
		0.6758	0.3251	0.9678	0.2532	0.1493	0.6477	0	0	0.0202	0	0	0.0059						
USD-GBP	1989 - 1996	-2.710252	1.239167	-3.563589	-2.758952	-1.815907	0.459833	-7.397684	-4.914916	-1.202534	-7.621749	-5.55358	-2.077669	NA	NA	-4.035324	NA	NA	NA
		0.0756	0.9445	0.0384	0.2159	0.0662	0.812	0	0	0.2085	0	0	0.0368			0.0001			
	1997 - 2004	0.217019	-3.273861	-2.578066	-1.019464	-0.401308	3.365024	-2.90205	-9.23485	-1.316241	-5.413334	-3.571447	-3.942036	NA	NA	-4.243256	NA	NA	NA
		0.7472	0.0762	0.2912	0.2754	0.5367	0.9998	0.0041	0	0.1728	0	0.0005	0.0026			0			
	2005 - 2012	-2.2508	-2.086812	-2.713782	-2.396366	-1.451242	-1.912514	-4.831882	-5.164862	-2.765168	NA	-5.651516	-4.158095	NA	NA	-5.053727	NA	NA	NA
		0.19	0.5469	0.0754	0.0167	0.1362	0.6403	0	0	0.2139		0	0.0013			0			

UNIT ROOT DETECTED	
-2.577542	Trend & intercept
-2.577542	Intercept
-2.577542	Neither

UNIT ROOT REJECTED	
-2.57754	Trend & intercept
-2.57754	Intercept
-2.57754	Neither

All shaded values are ADF t-statistics that are significant at the 5% level, with their corresponding p-values in italics underneath. Non-shaded values in the first section (ADF test on levels) indicate the presence of an I(0) process, with the second and third sections showing I(1) and I(2) variables as non-shaded, respectively. NA refers to a variable that is already stationary.

Table 5.2a: Cointegration test results and VAR residual diagnostics (1)

		FB-VAR						DF-VAR						HM-VAR					
		Lags	LM test	JB test	White test	Trace statistic	Cointegrating equations	Lags	LM test	JB test	White test	Trace statistic	Cointegrating equations	Lags	LM test	JB test	White test	Trace statistic	Cointegrating equations
AUD-GBP	1989 - 1996	5	10.51236	N	411.5815	2.507453	3	5	11.96646	N	421.3706	0.373255	3	6	24.26095	N	904.5987	26.11996	2
			0.8385		*0.3339*	*0.1133*			*0.7463*		*0.472*	*0.5412*			*0.5043*		*0.7187*	*0.1252*	
	1997 - 2004	6	12.39307	NN	461.1965	24.23922	1	6	20.77786	NN	878.7442	1.67801	4	6	33.91124	NN	1499.561	0.835184	5
			0.7165		*0.7235*	*0.1905*			*0.7049*		*0.6877*	*0.1952*			*0.5683*		*0.585*	*0.3608*	
	2005 - 2012	4	9.044917	NN	384.5997	26.54721	1	6	20.98735	NN	967.5384	25.54918	2	6	43.17101	NN	1538.136	2.63004	5
			0.9116		*0.0076*	*0.1132*			*0.6933*		*0.0583*	*0.1427*			*0.1916*		*0.314*	*0.1049*	
AUD-USD	1989 - 1996	6	14.87793	NN	450.6004	6.245285	3	6	19.31519	NN	478.9097	9.316199	3	6	33.73289	NN	918.8715	7.447449	4
			0.5336		*0.8283*	*0.0125*			*0.2527*		*0.7439*	*0.0023*			*0.1137*		*0.5962*	*0.0063*	
	1997 - 2004	5	10.43502	NN	427.675	22.04131	1	6	33.02465	NN	955.5194	21.84939	2	6	38.7595	NN	1544.449	26.98973	3
			0.8429		*0.1635*	*0.2962*			*0.1305*		*0.0971*	*0.3069*			*0.3463*		*0.2749*	*0.1019*	
	2005 - 2012	6	24.13607	NN	524.4505	26.43704	1	6	33.11452	NN	881.7093	24.21146	2	5	41.6825	NN	1238.167	9.590158	4
			0.0866		*0.0787*	*0.1162*			*0.1282*		*0.6621*	*0.1916*			*0.2373*		*0.6643*	*0.3136*	
CAD-AUD	1989 - 1996	6	6.674064	NN	255.3639	9.66178	1	6	6.560961	NN	272.0718	9.960876	1	6	16.84117	NN	548.2736	41.0423	0
			0.671		*0.103*	*0.3077*			*0.6827*		*0.0759*	*0.2837*			*0.3959*		*0.1889*	*0.1873*	
	1997 - 2004	3	2.880268	NN	144.3228	13.32752	1	4	28.36031	NN	656.7062	45.31019	0	6	24.8708	NN	975.8356	4.415695	4
			0.9689		*0.0646*	*0.1033*			*0.2915*		*0.054*	*0.0851*			*0.4696*		*0.354*	*0.0356*	
	2005 - 2012	6	19.81389	N	518.235	NA	NA	5	18.13034	N	794.9008	NA	NA	5	30.27548	N	1299.512	NA	NA
			0.2287		0.1105				*0.8368*		*0.1242*				*0.7371*		*0.2141*		
CAD-GBP	1989 - 1996	4	7.653165	NN	270.1965	43.90751	0	4	21.84378	NN	665.2116	40.90261	1	5	49.21921	NN	1271.837	26.68997	3
			0.9585		*0.98*	*0.1119*			*0.6447*		*0.0331*	*0.1918*			*0.0699*		*0.4019*	*0.1094*	
	1997 - 2004	5	17.69848	NN	445.7177	38.5405	0	5	22.41304	N	458.0809	11.79753	1	5	16.68382	N	785.747	39.4584	1
			0.3418		*0.867*	*0.279*			*0.1303*		*0.097*	*0.9387*			*0.8929*		*0.4356*	*0.2425*	
	2005 - 2012	5	16.87101	NN	470.5249	21.59101	1	5	23.11094	NN	794.7378	42.91728	1	6	48.03988	NN	1497.166	14.96821	4
			0.394		*0.0086*	*0.3218*			*0.5711*		*0.1251*	*0.1346*			*0.0865*		*0.602*	*4.088723*	
CAD-USD	1989 - 1996	5	1.402974	N	174.9826	8.248308	1	5	4.985231	N	413.9084	25.1144	1	6	18.31703	N	757.6863	4.088723	4
			0.9978		*0.8054*	*0.4392*			*0.9958*		*0.5746*	*0.1574*			*0.8286*		*0.71*	*0.0432*	
	1997 - 2004	6	15.75834	NN	440.0514	26.64071	1	6	34.96977	NN	881.453	47.04241	1	5	44.99214	NN	1277.701	36.77481	2
			0.47		*0.9041*	*0.1107*			*0.0888*		*0.6644*	*0.0595*			*0.1447*		*0.3578*	*0.3582*	
	2005 - 2012	6	14.94673	NN	521.7982	27.72225	1	6	24.30522	NN	920.5057	24.82285	2	6	43.44974	NN	1509.672	26.212	3
			0.5285		*0.0912*	*0.0852*			*0.5018*		*0.3102*	*0.1678*			*0.1837*		*0.5121*	*0.1225*	

Trace statistics are shaded if cointegration was detected. All other shaded values are significant at the 5% level, with their corresponding p-values in italics underneath. For trace statistics with p-values of less than 0.05, these refer to the null hypothesis that the number cointegrating equations is the figure stated despite the ‘true’ number being one greater. This occurred where the ‘true’ number was too high for a VECM in that particular case, so the lower figure had to be quoted instead. The LM and White tests are both $\chi 2$ distributed. Since the multivariate JB test gives multiple test statistics, normality is simply given by N and non-normality as NN. In the two samples that the exchange rate was I(0), cointegration results show NA. Rows in bold refer to instances where no cointegration was observed and, thus, those residual diagnostics are for a stationary VAR which was used to produce a forecast. All other rows are for level VARs which were later transformed into VECMs with the corresponding number of cointegrating equations.

Table 5.2b: Cointegration test results and VAR residual diagnostics (2)

		FB-VAR						DF-VAR						HM-VAR					
		Lags	LM test	JB test	White test	Trace statistic	Cointegrating equations	Lags	LM test	JB test	White test	Trace statistic	Cointegrating equations	Lags	LM test	JB test	White test	Trace statistic	Cointegrating equations
CHF-AUD	1989 - 1996	6	11.40361	N	526.9277	4.04262	3	6	12.06782	N	535.6964	5.128383	3	6	25.83433	N	936.1953	22.76213	2
			0.7839		*0.0682*	*0.0444*			*0.7393*		*0.1305*	*0.0235*			*0.4165*		*0.4369*	*0.2579*	
	1997 - 2004	5	17.87189	NN	426.4871	28.44184	1	6	25.27512	NN	939.6116	12.58407	3	5	49.61295	NN	1280.709	28.62602	3
			0.3315		*0.1736*	*0.071*			*0.447*		*0.1746*	*0.131*			*0.065*		*0.3359*	*0.0678*	
	2005 - 2012	6	20.64687	NN	542.9528	14.44373	2	6	25.02692	NN	968.6707	29.68024	2	5	38.4885	N	1380.459	28.2103	3
			0.1925		*0.0244*	*0.0715*			*0.4609*		*0.0554*	*0.0516*			*0.3576*		*0.0096*	*0.0753*	
CHF-CAD	1989 - 1996	4	12.33705	NN	409.1825	23.11475	1	2	13.04698	NN	233.512	26.62299	1	6	36.99105	NN	982.7403	44.48616	1
			0.7205		*0.0005*	*0.2405*			*0.6693*		*0.0045*	*0.1112*			*0.0578*		*0.112*	*0.1001*	
	1997 - 2004	6	10.71366	N	514.9449	NA	NA	6	19.51775	NN	912.0007	NA	NA	6	40.07525	NN	1500.826	NA	NA
			0.8268		*0.1307*				*0.7716*		*0.3831*				*0.2942*		*0.576*		
	2005 - 2012	5	18.67071	NN	504.4795	6.439026	3	4	23.68147	NN	647.0172	5.717213	4	5	38.83388	NN	1263.363	44.02634	2
			0.2861		*0.0003*	*0.0112*			*0.5378*		*0.0897*	*0.0168*			*0.3432*		*0.468*	*0.1094*	
CHF-GBP	1989 - 1996	6	12.85047	NN	503.4866	6.082654	3	4	24.29562	NN	647.3227	22.25881	2	6	37.93265	NN	1477.19	14.48537	4
			0.6837		*0.2214*	*0.0136*			*0.5023*		*0.0884*	*0.2844*			*0.3813*		*0.7343*	*0.0705*	
	1997 - 2004	5	11.59	NN	440.7098	14.86427	2	5	11.67853	NN	464.2079	25.5638	1	6	35.22264	N	979.7804	0.038243	4
			0.7717		*0.0783*	*0.0621*			*0.7658*		*0.0671*	*0.1423*			*0.0843*		*0.1251*	*0.8449*	
	2005 - 2012	6	17.85817	NN	579.8659	13.63346	2	4	27.90495	NN	748.7049	14.01653	3	5	40.50621	NN	1422.305	13.0043	4
			0.3323		*0.0012*	*0.0936*			*0.3122*		*0*	*0.0825*			*0.2782*		*0.0009*	*0.1147*	
CHF-USD	1989 - 1996	4	18.53083	N	396.6863	12.21428	2	5	35.93728	N	779.7076	25.46078	2	5	43.96257	N	1290.898	13.95051	4
			0.2937		*0.0022*	*0.1469*			*0.0726*		*0.2194*	*0.1456*			*0.17*		*0.2664*	*0.0843*	
	1997 - 2004	6	25.23124	NN	487.1624	12.97566	2	6	33.10078	N	898.0122	10.61865	3	6	44.61346	N	1523.477	13.18887	4
			0.0659		*0.4007*	*0.1157*			*0.1286*		*0.5124*	*0.2361*			*0.1536*		*0.4128*	*0.1081*	
	2005 - 2012	6	16.69233	NN	519.0329	11.8626	2	5	21.18842	NN	782.6892	27.3027	2	5	32.33473	NN	1261.836	24.60689	3
			0.4058		*0.1059*	*0.1636*			*0.6821*		*0.1979*	*0.0944*			*0.6436*		*0.4801*	*0.176*	
JPY-AUD	1989 - 1996	6	7.782537	NN	484.1146	29.42637	0	4	17.43975	NN	357.8907	12.17584	2	6	21.55248	NN	956.9533	5.340505	4
			0.9551		*0.4388*	*0.0551*			*0.3577*		*0.242*	*0.1487*			*0.6614*		*0.2629*	*0.0208*	
	1997 - 2004	4	25.05842	NN	328.6727	22.26828	1	6	29.1251	NN	940.0289	17.64777	2	6	33.93166	NN	1530.361	29.5313	3
			0.0688		*0.3572*	*0.2839*			*0.2587*		*0.1722*	*0.5922*			*0.5673*		*0.3652*	*0.0536*	
	2005 - 2012	4	24.11458	NN	394.4148	37.24957	0	5	19.09963	NN	774.681	60.90494	0	5	44.26371	N	1359.718	65.76203	1
			0.087		*0.0028*	*0.3359*			*0.7923*		*0.2586*	*0.2086*			*0.1622*		*0.0256*	*0.1009*	

Trace statistics are shaded if cointegration was detected. All other shaded values are significant at the 5% level, with their corresponding p-values in italics underneath. For trace statistics with p-values of less than 0.05, these refer to the null hypothesis that the number cointegrating equations is the figure stated despite the 'true' number being one greater. This occurred where the 'true' number was too high for a VECM in that particular case, so the lower figure had to be quoted instead. The LM and White tests are both $\chi 2$ distributed. Since the multivariate JB test gives multiple test statistics, normality is simply given by N and non-normality as NN. In the two samples that the exchange rate was I(0), cointegration results show NA. Rows in bold refer to instances where no cointegration was observed and, thus, those residual diagnostics are for a stationary VAR which was used to produce a forecast. All other rows are for level VARs which were later transformed into VECMs with the corresponding number of cointegrating equations.

Table 5.2c: Cointegration test results and VAR residual diagnostics (3)

		FB-VAR						DF-VAR						HM-VAR					
		Lags	LM test	JB test	White test	Trace statistic	Cointegrating equations	Lags	LM test	JB test	White test	Trace statistic	Cointegrating equations	Lags	LM test	JB test	White test	Trace statistic	Cointegrating equations
JPY-CAD	1989 - 1996	2	9.912564	NN	164.5951	39.02099	0	2	9.655316	NN	305.5281	61.09745	0	6	47.01963	N	1539.842	14.1716	4
			0.8712		*0.3853*	*0.2594*			*0.9975*		*0.4007*	*0.2032*			*0.1034*		*0.3032*	*0.0783*	
	1997 - 2004	5	18.93394	N	384.3226	43.99226	0	5	24.83071	NN	808.2664	21.4958	2	6	34.05332	NN	1522.649	38.0993	2
			0.2721		*0.7047*	*0.1101*			*0.4719*		*0.0689*	*0.3274*			*0.5615*		*0.4187*	*0.2977*	
	2005 - 2012	4	25.0497	NN	340.4671	26.4617	1	3	28.96142	NN	442.7198	64.11107	0	5	46.15097	NN	1268.555	43.24764	2
			0.069		*0.2065*	*0.1155*			*0.2655*		*0.5877*	*0.1311*			*0.1197*		*0.4273*	*0.1267*	
JPY-CHF	1989 - 1996	6	14.8214	NN	256.1316	8.038771	1	2	16.7745	NN	205.3227	17.09055	1	6	34.30216	NN	971.6321	45.58492	1
			0.096		*0.0972*	*0.4613*			*0.4003*		*0.0948*	*0.6334*			*0.1016*		*0.1669*	*0.0805*	
	1997 - 2004	5	13.00433	NN	407.6519	29.74529	1	4	24.32083	NN	578.9407	40.43347	0	6	36.31044	NN	952.1517	46.99467	1
			0.6724		*0.385*	*0.0507*			*0.5009*		*0.7244*	*0.2074*			*0.067*		*0.2998*	*0.0601*	
	2005 - 2012	4	17.15075	NN	414.8023	9.20822	2	4	27.20856	NN	651.8075	24.14326	2	5	41.65219	NN	1323.953	6.415401	4
			0.3759		*0.0003*	*0.3465*			*0.3455*		*0.0703*	*0.1945*			*0.2383*		*0.1027*	*0.6464*	
JPY-GBP	1989 - 1996	4	12.83034	NN	293.2799	3.31302	3	4	16.8428	NN	565.0058	14.33185	3	4	33.0321	NN	945.2581	6.982251	6
			0.6851		*0.8556*	*0.0687*			*0.8874*		*0.844*	*0.0743*			*0.6105*		*0.9211*	*0.0082*	
	1997 - 2004	4	9.610631	NN	389.9074	11.72754	0	5	23.79798	NN	810.5484	40.15266	0	5	34.4293	NN	809.332	47.16351	1
			0.8862		*0.0045*	*0.9409*			*0.5311*		*0.0617*	*0.2171*			*0.099*		*0.2265*	*0.058*	
	2005 - 2012	6	19.06635	NN	529.7812	3.089084	3	4	30.46615	NN	636.0287	3.897726	4	5	49.52368	NN	1299.341	8.902564	4
			0.2652		*0.0576*	*0.0788*			*0.2073*		*0.1494*	*0.0483*			*0.0661*		*0.2151*	*0.3745*	
JPY-USD	1989 - 1996	5	24.14778	NN	399.7468	29.53878	1	4	18.74788	NN	615.0739	29.62002	2	6	44.89544	NN	1571.504	13.87112	4
			0.0863		*0.4942*	*0.0535*			*0.809*		*0.3261*	*0.0524*			*0.1469*		*0.14*	*0.0865*	
	1997 - 2004	6	11.60103	NN	432.5712	26.96768	1	6	24.57898	NN	877.2545	28.86902	2	6	28.94954	NN	1523.751	4.357643	5
			0.771		*0.9409*	*0.1024*			*0.4862*		*0.7002*	*0.0637*			*0.7917*		*0.4109*	*0.0368*	
	2005 - 2012	6	16.59492	NN	511.9913	26.15457	1	5	24.93133	NN	779.0177	24.88067	2	6	41.36428	NN	1549.013	44.49423	2
			0.4123		*0.1511*	*0.1242*			*0.4662*		*0.2245*	*0.1658*			*0.2479*		*0.2483*	*0.1*	
USD-GBP	1989 - 1996	4	17.01181	NN	323.8407	23.50755	1	4	25.03324	NN	601.723	47.04929	1	5	38.63442	NN	1269.795	14.2101	4
			0.3848		*0.4295*	*0.222*			*0.4605*		*0.4725*	*0.0594*			*0.3515*		*0.4177*	*0.0774*	
	1997 - 2004	5	14.78041	NN	413.729	26.58371	1	4	27.75042	N	653.5676	28.44669	2	5	34.15057	N	1335.274	22.79409	3
			0.5408		*0.3073*	*0.1122*			*0.3195*		*0.064*	*0.0709*			*0.5568*		*0.0689*	*0.2563*	
	2005 - 2012	5	6.03729	NN	197.8742	0.00236	2	5	13.47761	NN	416.446	12.11365	2	6	30.51378	NN	908.2881	45.44429	1
			0.7362		*0.3704*	*0.9591*			*0.6376*		*0.5398*	*0.1516*			*0.2056*		*0.6886*	*0.0828*	

Trace statistics are shaded if cointegration was detected. All other shaded values are significant at the 5% level, with their corresponding p-values in italics underneath. For trace statistics with p-values of less than 0.05, these refer to the null hypothesis that the number cointegrating equations is the figure stated despite the 'true' number being one greater. This occurred where the 'true' number was too high for a VECM in that particular case, so the lower figure had to be quoted instead. The LM and White tests are both $\chi 2$ distributed. Since the multivariate JB test gives multiple test statistics, normality is simply given by N and non-normality as NN. In the two samples that the exchange rate was I(0), cointegration results show NA. Rows in bold refer to instances where no cointegration was observed and, thus, those residual diagnostics are for a stationary VAR which was used to produce a forecast. All other rows are for level VARs which were later transformed into VECMs with the corresponding number of cointegrating equations.

5.3 Granger causality

The causal links between the five macroeconomic variables and the exchange rate were examined by creating level VARs over the entire period in question. Due to the sample size being greater and the focus not being on forecasting, the lag lengths were allowed to increase in order to minimise AIC whilst still satisfying the residual diagnostic checks. Indeed, heteroscedasticity was only removed from the error terms by allowing many more lag terms to be included, although the JPY-AUD was still unable to achieve this. Overall, the results are not very informative, with no clear causality ascertained between the explanatory variables and the exchange rate. However, inflation was shown to Granger cause exchange rates in 7 out of the 15 currency pairs, with the other variables doing so less often and the current account balance doing so only twice. Table 5.3a gives a summary of the Granger causality results whilst table 5.3b provides all of the F-statistics, their p-values and the VAR specifications for each set of tests.

Table 5.3a: Summary of the Granger causality tests

	Causal links detected
Money supply	**3**
Real GDP	**4**
Interest rates	**5**
Inflation	**7**
Current account balance	**2**

5.4 In-sample regression results

The generalised form of the monetary models was estimated for each currency pair over the entire period (1989 – 2013), with the results available in appendices II and III. The findings of the preliminary regressions showed mixed support for the structural models with R^2 values and coefficient significance varying greatly across the samples. It was clear from the results that the DOLS method was able to model the variables more accurately, with R^2 improving significantly for each currency pair compared with the FM-OLS. The most convincing regressions were for AUD-GBP, AUD-USD and CAD-USD, all with R^2 figures of over 0.7

Table 5.3b: Granger causality test results and VAR residual diagnostics (1989 – 2013)

	Money supply	Real GDP	Interest rates	Inflation	Current account balance	VAR specification			
	M does not Granger cause S	Y does not Granger cause S	i does not Granger cause S	π does not Granger cause S	CA does not Granger cause S	Lags	LM test	JB test	White test
AUD-GBP	33.75214	36.26697	45.19807	27.14731	24.47285	18	46.423	NN	4646.58
	0.0135	*0.0065*	*0.0004*	*0.0763*	*0.1401*		*0.1144*		*0.1233*
AUD-USD	21.93136	23.7619	12.16995	23.62905	30.19448	18	32.70333	NN	4625.045
	0.235	*0.163*	*0.8383*	*0.1676*	*0.0356*		*0.6262*		*0.1747*
CAD-AUD	11.27602	20.66061	13.94509	12.76738	22.38564	14	41.43891	NN	3646.561
	0.6642	*0.1107*	*0.4538*	*0.5449*	*0.071*		*0.2454*		*0.0802*
CAD-GBP	17.10452	17.77071	21.49398	38.91425	11.01234	14	26.48861	NN	3611.839
	0.2507	*0.2174*	*0.0896*	*0.0004*	*0.6851*		*0.8765*		*0.1591*
CAD-USD	16.41231	18.59312	10.24253	29.41071	19.55017	16	33.84574	NN	4172.643
	0.4246	*0.2903*	*0.8537*	*0.0213*	*0.2412*		*0.5714*		*0.0599*
CHF-AUD	23.88286	38.40025	35.21393	25.62236	21.36847	18	44.576	NN	4665.723
	0.1589	*0.0034*	*0.0089*	*0.1087*	*0.2612*		*0.1545*		*0.0875*
CHF-CAD	20.07816	16.42458	22.42562	42.08512	11.88594	21	39.15568	NN	5259.597
	0.5163	*0.7453*	*0.3753*	*0.0041*	*0.9426*		*0.3301*		*0.091*
CHF-GBP	18.16683	18.65074	16.73247	41.81457	17.8788	18	30.35388	NN	4692.767
	0.4447	*0.4136*	*0.5416*	*0.0012*	*0.4637*		*0.7337*		*0.0511*
CHF-USD	16.15269	15.65435	14.11793	18.9983	9.926842	10	32.34226	NN	2610.584
	0.0953	*0.11*	*0.1677*	*0.0403*	*0.4469*		*0.6433*		
JPY-AUD	13.55642	21.92655	16.66347	17.30881	28.02768	19	38.32568	NN	4995.035
	0.8089	*0.2879*	*0.6127*	*0.569*	*0.0829*		*0.3644*		*0.0182*
JPY-CAD	13.66944	15.98911	9.271042	24.67278	21.23778	18	20.77118	NN	4684.093
	0.7504	*0.5933*	*0.9531*	*0.1342*	*0.2676*		*0.9801*		*0.0611*
JPY-CHF	25.27271	34.08565	33.68352	36.95595	28.68594	20	25.31721	NN	5185.264
	0.1912	*0.0256*	*0.0283*	*0.0118*	*0.0941*		*0.9082*		*0.075*
JPY-GBP	32.15959	42.46531	41.97506	24.61841	33.02841	17	32.8372	NN	4425.981
	0.0144	*0.0006*	*0.0007*	*0.1036*	*0.0112*		*0.6198*		*0.0637*
JPY-USD	5.712114	13.5267	18.7951	16.30577	14.97813	13	36.89113	NN	3373.753
	0.956	*0.408*	*0.1296*	*0.233*	*0.3087*		*0.4275*		*0.1143*
USD-GBP	30.51444	17.97376	52.27557	57.70899	22.09847	18	35.98802	NN	4640.505
	0.0327	*0.4574*	*0*	*0*	*0.2276*		*0.4692*		*0.1366*

Each currency pair is evaluated over all three sample periods. There were 300 observations for each pair (not including lagged terms being removed). The F-statistics are shaded if the null hypothesis of no causality is rejected. P-values are in italics underneath.

and containing more than 3 significant variables. The least convincing regressions were for JPY-CAD and JPY-USD which gave R^2 figures of less than 0.3. The first Wald test, with the null hypothesis of $\beta_1 = 1$, was rejected for every single currency pair. Based on this, the assumption of first-degree homogeneity in the money supply is probably false. The restriction of $\beta_2 = -1$ was rejected in most cases but could not be rejected by 5 of the FM-OLS models and 4 of the DOLS models[25]. However, joint tests on both restrictions were rejected in all cases, confirming that the unit income elasticity assumption is also likely to be erroneous. This differs from the results of Rapach and Wohar (2002) who found joint significance for the US dollar rates of Australia and Switzerland, as well as for other countries[26]. Nonetheless, they noted insignificant β_1 and β_2 estimates in many cases as well as often not having the correct sign. β_2 was actually insignificant in many of the models in this study, as was β_5 (the coefficient for current account balance). Nevertheless, it was difficult to make an overall decision on whether restrictions to the cointegrating vector should be made, as has been debated widely in the literature. It is, of course, possible to make restrictions based on the in-sample estimates without appealing to any theoretical conditions. Then again, due to the unpersuasive regression estimates and the additional complications associated with restrictions, this study simply used unconstrained models.

5.5 Out-of-sample forecast results

There was a clear distinction between the forecasts with a 1 month horizon and those with 6 and 12 month horizons, which were dominated by the random walk (RW) and random walk with drift (RWD). Overall, the structural models performed poorly. What was perhaps most surprising about the results was the fact that the univariate models outperformed the structural models in all but the 1 month category. For the 6 month forecasts, the ARMA and GARCH models gave very similar results and comfortably dominated the structural models. For the 12 month forecasts, the GARCH model came out as a clear leader amongst the non-random walk models, vastly outperforming all three of the structural models. However, the relative success of the GARCH would not have translated into trading profits, as appendix IV shows. Long or short signals generated by the forecasts would have led to financial losses[27] in all of the models. Furthermore, none of them succeeded at consistently predicting the

[25] β_1 and β_2 are the coefficients for the money supply and real income differentials, respectively.
[26] However, these findings go against those of MacDonald and Taylor (1994) who rejected all of the theoretical restrictions.
[27] Profit and loss is based on a currency trader maintaining their position until the end of the 12 month period.

direction of exchange rate movements, as can be seen in table 5.5a and appendix IV. The GARCH model still dominated for profitability and direction of change predictions, with the combined forecasts losing the most money on average. Interestingly, after the GARCH model, the HM model would have lost the least amount of money despite it consistently producing the largest forecast errors. Table 5.5b gives the average RMSE and MAE values across all 45 samples, with the lowest values in bold, and table 5.5c summarises these results by showing the final rankings of each model based on forecast error. The complete results can be found in appendices VI and VII.

Table 5.5a: Ranking the profitability and direction of change predictions (12 months)

	1st	2nd	3rd	4th	5th	6th
Profitability	GARCH *-9.27%*	HM *-20.37%*	ARMA *-21.48%*	DF *-22.69%*	FB *-32.24%*	Model Averaging *-34.42%*
Direction of change	GARCH *43.90%*	DF & HM *42.22%*		FB *37.78%*	Model Averaging *31.11%*	ARMA *26.67%*

Table 5.5b: Average forecast errors

Horizon	Measure	RW	RWD	ARMA	GARCH	FB	DF	HM	Model Averaging
1 month	RMSE	0.000197	0.000265	0.000199	0.000282	0.000212	0.000199	0.00029	**0.000194**
	MAE	**0.01071**	0.012133	0.010902	0.012286	0.011729	0.011648	0.013514	0.011244
6 months	RMSE	**0.00052**	0.00062	0.000732	0.00072	0.00093	0.000974	0.00176	0.000811
	MAE	**0.01768**	0.019353	0.019766	0.020046	0.022563	0.023259	0.030977	0.021115
12 months	RMSE	**0.00106**	0.001223	0.00163	0.001313	0.002114	0.002008	0.003084	0.001648
	MAE	**0.02532**	0.02706	0.030492	0.027563	0.033067	0.033067	0.041457	0.030317

Table 5.5c: Overall rankings of the models based on forecast error

		Ranking							
Horizon	Measure	1st	2nd	3rd	4th	5th	6th	7th	8th
1 month	RMSE	Model Averaging	RW	DF	ARMA	FB	RWD	GARCH	HM
	MAE	RW	ARMA	Model Averaging	DF	FB	RWD	GARCH	HM
6 months	RMSE	RW	RWD	GARCH	ARMA	Model Averaging	FB	DF	HM
	MAE	RW	RWD	ARMA	GARCH	Model Averaging	FB	DF	HM
12 months	RMSE	RW	RWD	GARCH	ARMA	Model Averaging	DF	FB	HM
	MAE	RW	RWD	GARCH	Model Averaging	ARMA	DF	FB	HM

It is interesting to consider why the most complex structural model (the HM model) was consistently the worst performer over all time horizons, in terms of forecast error. The Occam's razor[28] style argument that simpler models are preferable is usually cited in the forecasting literature, particularly in the context of model averaging. However, AIC and AIC differences (Δ) generally decreased amongst the structural models as the inflation and current account balance terms were added. This disparity between the models' theoretical quality and their forecast performance is a cause for concern. That said, the ARMA and GARCH models were generally allocated a greater quality rating than the structural models, which the forecasts showed to be appropriate. Given this, it seems as though the success[29] of model averaging (relative to the structural models) owes more to the inclusion of the univariate models than to the technique for determining model quality. Table 5.5d summarises the average AIC values, their differences and weights. The complete tables are in appendix VIII.

Table 5.5d: Average AIC, Δ and weights

	ARMA	GARCH	FB	DF	HM
AIC	-5.704	-5.741	5.571	-5.560	-5.61
Δ	0.096	0.070	0.230	0.202	0.192
Weight	21.20%	20.94%	19.83%	20.12%	20.23%

As table 5.5d shows, the weights were essentially the same across the models, roughly equating this process to a naïve strategy of assigning equal weights. Wright (2008) compared his BMA combined forecasts to those of an equal weighting method, for which the mark/euro, pound and yen failed to beat the random walk, with the Canadian dollar being the only exception. This differed from his BMA results where the pound was the only currency to underperform[30]. A key difference with the Bayesian approach is the use of shrinkage parameters. These allow the model weights to deviate from theoretically determined probabilities, in response to the data. In the frequentist tradition, this problem can be overcome by assessing a goodness-of-fit measure in addition to an information criterion, the

[28] Occam's razor in this context refers to the number of parameters in each model. Every endogenous variable added to the structural models comes with extra lagged terms which reduce the models' degrees of freedom.
[29] Relative success in forecast errors, not profitability or direction of change prediction.
[30] This was the case for monthly data. His results for quarterly data showed instances of underperformance in the other currencies.

only real candidate in this instance being the F-statistic. However, since an F-statistic can only be compared across nested models (in this case the structural models), the AIC appears to be the most reasonable measure of quality. Indeed, even amongst the structural models, the F-statistic showed no sign of correlation with forecast accuracy. Likewise, error specifications such as serial correlation, non-normality and heteroscedasticity proved to be inadequate predictors of a model's out-of-sample success whereas Meese and Rogoff noted the tendency of structural models to systematically go off track when serial correlation was allowed for. Other useless predictors of success were the number of lag lengths, the number of significant coefficients and whether or not the structural model was a VECM or stationary VAR. All of the VECM and ARMA specifications can be found in appendix V.

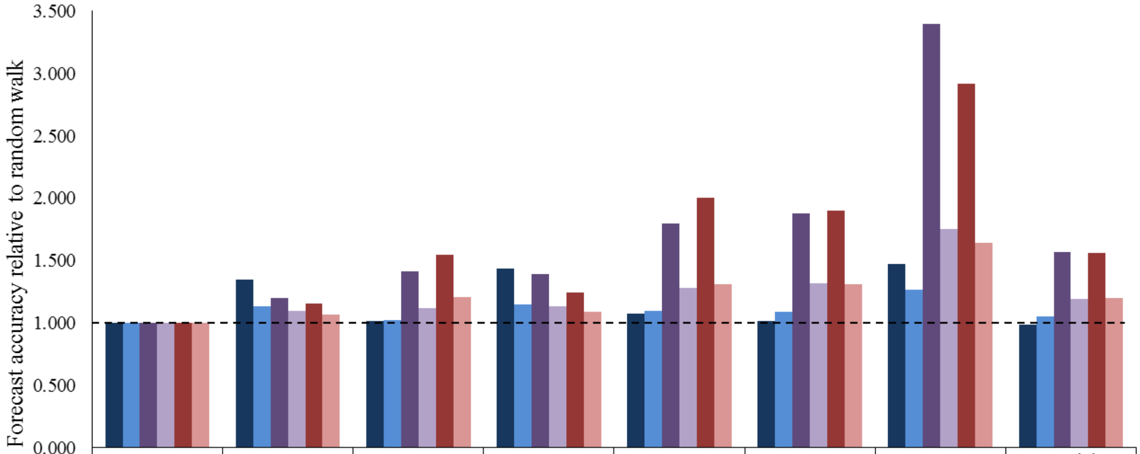
Figure 5.5a gives an overview of how each model compared to the random walk benchmark, with each forecast error divided by that of the random walk. Scores over 1 represent an underperformance, relative to the random walk. The ARMA, DF and combined forecasts performed well for the 1 month category but lost relative accuracy as the time horizon increased. In contrast, the GARCH model actually gained relative accuracy over time, as did the random walk with drift. This was not the case for the 'long' autoregressive (AR) model[31] used by Meese and Rogoff, the forecast of which became relatively worse over the time period. Another interesting result was that the HM model improved significantly between the 6 and 12 month forecasts. Indeed, this phenomenon may have also occurred for the other structural models if the forecast horizon was increased, as the results of Mark (1995) would suggest[32]. The forecasting methodology is certainly an important consideration; particularly in how the sample and forecast periods are determined. Splitting the overall sample into three sub-samples is less effective than using a rolling estimation window over the entire period. As table 5.5e shows, the average forecast error and variance increased for the later time periods. A rolling estimation window, big enough to construct decent models whilst small enough to adjust to structural changes, would have provided a more robust assessment. Figure 5.5b gives an illustrative example of the most accurate forecast, which was the DF model for AUD-GPB (1997-2005).

---

[31] Meese and Rogoff actually used six univariate models, some of which were variants of the long AR. They only reported their long AR results due to worse performances by the others. The 'long' description refers to the longest lag (M) being considered as a function of the sample size (N), where M = N / log N.

[32] Mark (1995) found evidence of exchange rate predictability in the monetary models when the forecast horizon was 3 to 4 years long. However, his study only included the money supply and income differentials, so it is uncertain how the FB, DF and HM models might have fared over a longer period.

Figure 5.5a: Forecast performances relative to the random walk

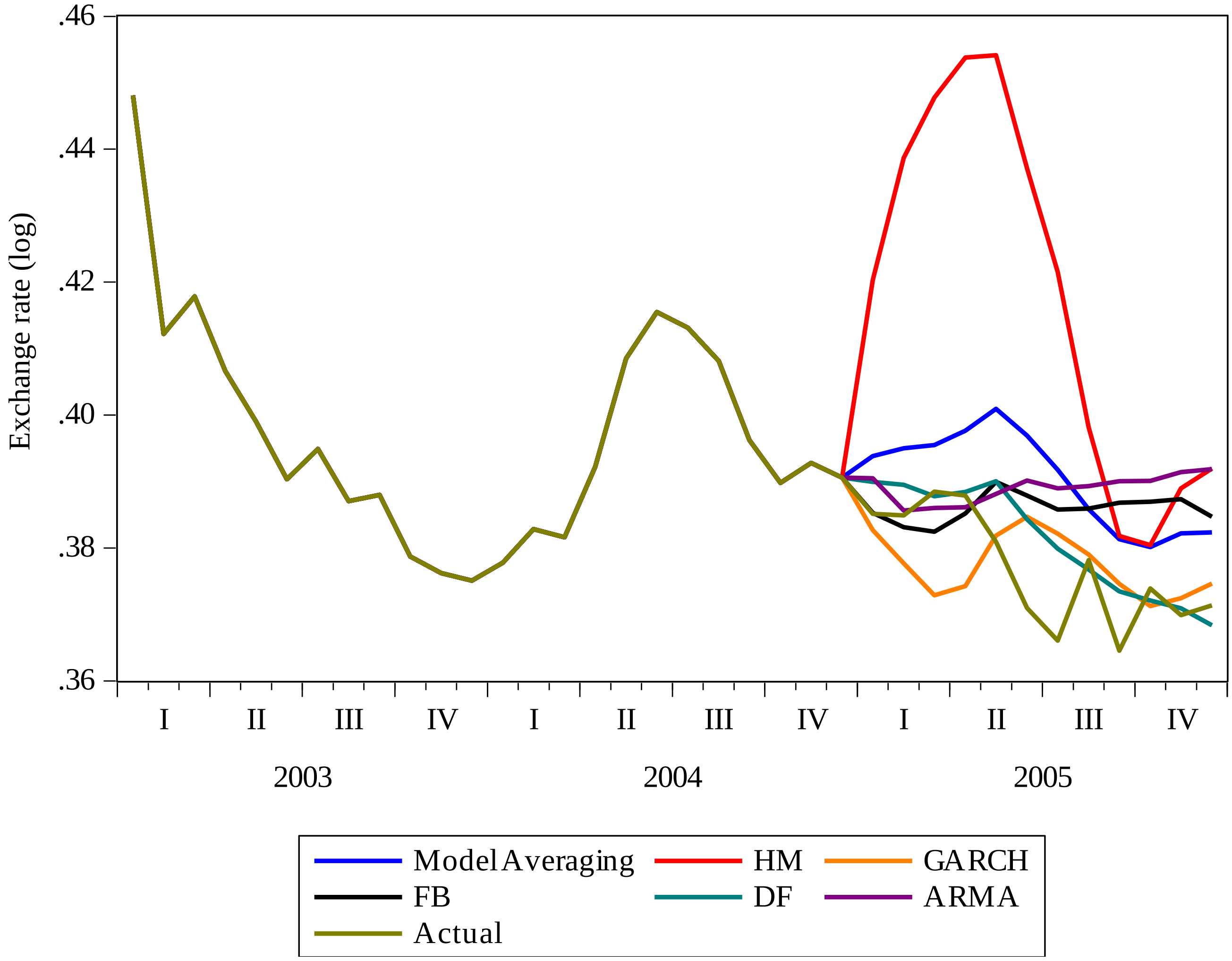


	RW	RWD	ARMA	GARCH	FB	DF	HM	Model Averaging
1 month RMSE	1.000	1.345	1.010	1.431	1.076	1.010	1.472	0.985
1 month MAE	1.000	1.133	1.018	1.147	1.095	1.088	1.262	1.050
6 months RMSE	1.000	1.196	1.411	1.389	1.794	1.878	3.394	1.564
6 months MAE	1.000	1.094	1.118	1.134	1.276	1.315	1.752	1.194
12 months RMSE	1.000	1.157	1.542	1.242	2.000	1.900	2.918	1.559
12 months MAE	1.000	1.069	1.204	1.088	1.306	1.306	1.637	1.197

Table 5.5e: RMSE and variance by forecast period

	RMSE	Variance
1997	0.001254	0.000001
2005	0.001702	0.000006
2013	0.002997	0.000015

Figure 5.5b: AUD-GBP forecasts (1997 - 2005)



6. Conclusion

The purpose of this study was to examine the relationships between macroeconomic variables and exchange rates in the context of monetary models. More specifically, the use of model averaging was considered as a way of overcoming the Meese-Rogoff puzzle - the enigma that modelling economic fundamentals fails to improve upon a random walk forecast. The results from this study show that model averaging could neither improve upon the structural nor the random walk forecasts. Interestingly, the univariate models tended to produce the best out-of-sample forecasts; an ARMA-GARCH(1,1) model with t-distributed errors gave the most consistent performance for 12 month forecasts.

A number of factors could have influenced the final results. Other time-series could be substituted into the models, such as replacing short-term interbank rates with long-term government bond yields. Even with alterations to the data, however, the problem of capturing expectations as opposed to realised values is largely unavoidable. Furthermore, model choice and misspecification may have played a role. The rationale for using VECMs may hold, but there are many possible variations to their construction. More advanced techniques of parameter estimation could have been explored such as allowing for stochastic coefficients[33] or using artificial neural networks[34]. Such innovations have seen some successes in exchange rate forecasting and should be a focus for future research.

Alternatively, the problem may lie with the monetary approach itself. Rossi (2013) surveys the literature and concludes that PPP and the monetary models have had no success at horizons of less than 3 years. The results of this present study, which analysed 135 structural forecasts over a 25 year period, add further evidence to that claim. Regardless of the predictors used, attempting to forecast exchange rates is a precarious task. The number of alterations that could be made to this study go some way in explaining why the exchange rate literature has such disparate findings. Calibrating a model so that it works over a certain time period for particular currency pairs does not guarantee success elsewhere. Despite the amount of research into this topic, it is important to remember that the Meese-Rogoff puzzle may never truly be solved. The possibility still remains that the foreign exchange market is just too efficient and, thus, too unpredictable.

[33] See Schinasi and Swamy (1989)
[34] See Zhang and Hu (1998)

REFERENCES

ANDREWS, D. (1991). Heteroskedasticity and autocorrelation consistent covariance matrix estimation. *Econometrica* 59, 817–854.

AKAIKE, H. (1981). Likelihood of a model and information criteria. *Journal of Econometrics* 16, 3314.

ALLEN, H. and TAYLOR, M. (1990). Charts, noise and fundamentals in the London foreign exchange market. *The Economic Journal*, 49-59.

ALQUIST, R. and CHINN, M. (2008). Conventional and Unconventional Approaches to Exchange Rate Modelling and Assessment. *International Journal of Finance and Economics* 13 (1): 2–13.

BANK FOR INTRERNATIONAL SETTLEMENTS. (2013). *Foreign exchange turnover in April 2013: preliminary global results*. http://www.bis.org/publ/rpfx13fx.pdf

BATES, J. and GRANGER, C. (1969). The combination of forecasts. *Operations Research Quarterly* 20, 451–468.

BILSON, J. (1978a). *The monetary approach to the exchange rate - some empirical evidence*. IMF Staff Papers 25 (March): 48-75.

BILSON, J. (1978b). Rational Expectations and the Exchange Rate. *The Economics of Exchange Rates*, pp. 75-96.

BOX, G. and JENKINS, G. (1970). *Time Series Analysis, Forecasting and Control*. Holden-Day, San Francisco.

BRAUN, P. and MITTNIK, S. (1993). Misspecifications in vector autoregressions and their effects on impulse responses and variance decompositions. *Journal of Econometrics* 59, 319-41.

BURNHAM, K. and ANDERSON, D. (2002). *Model selection and multimodel inference: a practical information-theoretic approach*. Springer.

CHEUNG, Y., CHINN, M. and PASCUAL, A. (2005). Empirical Exchange Rate Models of the Nineties: Are Any Fit to Survive? *Journal of International Money and Finance* 24 (7): 1150–75.

CHEUNG, Y. and LAI, K. (1993). Finite-sample sizes of Johansen's likelihood ratio tests for cointegration. *Oxford Bulletin of Economics and Statistics* 55: 313–328.

CHINN, M. (1989). A Tale of Two Markets: Capital Market Integration and the Determination of Exchange Rates. *International Economics and Financial Markets*, Oxford University Press, pp 193-212.

COFFEY, N., HRUNG, W. and SARKAR, A. (2009). *Capital constraints, counterparty risk, and deviations from covered interest rate parity*. Staff report, Federal Reserve Bank of New York, No. 393.

COOPER, R. (1984). A monetary system for the future. *Foreign Affairs*, 166-184.

CROUSHORE, D. (1998). *Evaluating Inflation Forecasts*. Federal Reserve Bank of Philadelphia, Working Paper No. 98-14.

DICK, C. and MENKHOFF, L. (2013). Exchange rate expectations of chartists and fundamentalists. *Journal of Economic Dynamics and Control* 37(7), 1362-1383.

DIEBOLD, F., GARDEAZABAL, J. and YILMAZ, K. (1994). On Cointegration and Exchange Rate Dynamics. *Journal of Finance* 49 (2): 727–35.

DIEBOLD, F. and MARIANO, R. (1995). Comparing predictive accuracy. *Journal of Business & economic statistics* 13, No. 3, pp. 253-263.

DORNBUSCH, R. (1976). Expectations and exchange rate dynamics. *Journal of Political Economy* 84:1161-76.

DORNBUSCH, R. (1980). Exchange Rate Economics: Where Do We Stand? *Brookings Papers on Economic Activity* 1: 143—85.

FRANKEL, J. (1979). On the mark: A theory of floating exchange rates based on real interest differentials. *American Economic Review* 69 (September) 610-22.

FRANKEL, J. (1981). On the mark: Reply. *American Economic Review* 71, 1075-1082.

FRANKEL, J. (1982). The Mystery of Multiplying Marks: A Modification of the Monetary Model. *Review of Economics and Statistics* 64, pp. 515-519.

FRANKEL, J. and FROOT, K. (1986). Understanding the US dollar in the eighties: the expectations of chartists and fundamentalists. *Economic record* 62(1), 24-38.

FRENKEL, J. (1976). A monetary approach to the exchange rate: Doctrinal aspects and empirical evidence. *Scandinavian Journal of Economics* 76 (May): 200-224.

GRANGER, C. and NEWBOLD, P. (1977). *Forecasting economic time series* (Academic Press, New York).

GROEN, J. (1999). Long Horizon Predictability of Exchange Rates: Is It for Real? *Empirical Economics* 24 (3): 451–69.

GOLDFELD, S. (1973). The Demand for Money Revisited. *Brooking Papers on Economic Activity* No. 3, pp. 577-639.

HAYNES, S. and STONE, J. (1981). On the mark: Comment. *American Economic Review* 71, 1060-1067.

HANSEN, B. (1992). Tests for parameter instability in regressions with I(1) processes. Journal of Business and Economic Statistics 10, 321–335.

HANSEN, P. and LUNDE, A. (2001). *A comparison of volatility models: Does anything beat a GARCH(1,1)?* Working Paper Series No. 84.

HOOPER, P. and MORTON, J. (1982). Fluctuations in the dollar: A model of nominal and real exchange rate determination. *Journal of International Money and Finance* 1:39-56.

INTERNATIONAL MONETARY FUND. (2012). *Annual report on Exchange Arrangements and Exchange Restrictions*. http://www.imf.org/external/pubs/nft/2012/eaer/ar2012.pdf

IVANOV, V. and KILIAN, L. (2005). A practitioner's guide to lag order selection for VAR impulse response analysis. *Studies in Nonlinear Dynamics & Econometrics* 9(1).

JOHANSEN, S. (1991). Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. *Econometrica: Journal of the Econometric Society*, 1551-1580.

KILIAN, L. (1999). Exchange Rates and Monetary Fundamentals: What Do We Learn from Long-Horizon Regressions? *Journal of Applied Econometrics* 14 (5): 491–510.

KIM, S., SHEPHARD, N. and CHIB, S. (1998). Stochastic Volatility: Likelihood Inference and Comparison with ARCH Models. *The Review of Economic Studies* Vol. 65, No.3, pp. 361-393.

KRUEGER, A. (1983). *Exchange-Rate Determination*. Cambridge University Press.

LÜTKEPOHL, H. (1993). *Introduction to Multiple Time Series Analysis*. Second edition, Springer-Verlag, Berlin, pp.118-66.

MACDONALD, R. and TAYLOR, M. (1993). *The Monetary Approach to the Exchange Rate: Rational Expectations, Long-Run Equilibrium and Forecasting*. International Monetary Fund Staff Papers 40 (1): 89–107.

MACDONALD, R. and TAYLOR, M. (1994). The Monetary Model of the Exchange Rate: Long-run Relationships, Short-Run Dynamics and How to Beat a Random Walk. *Journal of International Money and Finance* 13: 276-290.

MARK, N. (1995). Exchange Rates and Fundamentals: Evidence on Long-Horizon Predictability. *American Economic Review* 85 (1): 201–18.

MEESE, R. and ROGOFF, K. (1983a). Empirical Exchange Rate Models of the Seventies: Do They Fit Out of Sample? *Journal of International Economics* 14, 3-24.

MEESE, R. and ROGOFF, K. (1983b). The Out-of-Sample Failure of Empirical Exchange Rate Models: Sampling Error or Misspecification? *Exchange Rates and International Macroeconomics, Chicago*. Chicago University Press and National Bureau of Economic Research.

NEWEY, W. and WEST, K. (1987). A simple, Positive-Definite, Heteroskedasticity and Autocorrelation Consistent Matrix. *Econometrica*, 55, 703-708.

OZCICEK, O. and McMILLIN, W. (1999). Lag length selection in vector autoregressive models: symmetric and asymmetric lags. *Applied Economics* 31(4), 517-524.

PHILIPS, P. and HANSEN, B. (1990). Statistical inference in instrumental variables regression with I(l) processes. *Review of Economic Studies* 57, 99–125.

POIRIER, D. (1973). Applications of Spline Functions in Economics. Madison: unpublished University of Wisconsin Ph.D. thesis.

PUTMAN, B. and WOODBURY, J. (1979). Exchange Rate Stability and Monetary Policy. *Review of Business and Economic Research* Vol. 15, pp. 1-10.

RAPACH, D. and WOHAR, M. (2002). Testing the Monetary Model of Exchange Rate Determination: New Evidence from a Century of Data. *Journal of International Economics* 58 (2): 359–85.

ROSSI, B. (2005). Testing Long-Horizon Predictive Ability with High Persistence, and the Meese–Rogoff Puzzle. *International Economic Review* 46 (1): 61–92.

ROSSI, B. (2013). Exchange rate predictability. *Journal of Economic Literature* 51(4), 1063-1119.

SAVILLE, I. (1980). *Sterling Dollar Rate in the Floating Rate Period: The Role of Money, Prices and Intervention*. Discussion Paper No. 9, Bank of England.

SCHINASI, G. and SWAMY, P. (1989). The out-of-sample forecasting performance of exchange rate models when coefficients are allowed to change. *Journal of International Money and Finance* 8(3), 375-390.

SIMPSON, T. and PORTER, R. (1980). *Some issues involving the definition and interpretation of the monetary aggregates*, in: Controlling monetary aggregates, vol. III, Federal Reserve Bank of Boston conference series no. 23.

STOCK, J. and WATSON, M. (1993). A simple estimator of cointegrating vectors in higher order integrated systems. *Econometrica* 61, 783–820.

STOCK, J. and WATSON, M. (2004). Combination forecasts of output growth in a seven country dataset. *Journal of Forecasting* 23, 405–430.

TAYLOR, M. (2003). Purchasing power parity. *Review of International Economics* 11(3), 436-452.

WOLD, S. (1974). Spline Functions in Data Analysis. *Technometrics* 16:1-11.

WRIGHT, J. (2008). Bayesian Model Averaging and Exchange Rate Forecasting. *Journal of Econometrics* 146, 329-341.

ZHANG, G. and HU, M. (1998). Neural network forecasting of the British Pound/US Dollar exchange rate. *Omega* 26(4), 495-506.

APPENDIX I

Data sources

Variable	Description	Database	Source
S_t (JPY-USD)	Spot exchange rate	Datastream	Bank of England
S_t (USD-GBP)	Spot exchange rate	Datastream	Bank of England
S_t (CHF-USD)	Spot exchange rate	Datastream	Bank of England
S_t (CAD-USD)	Spot exchange rate	Datastream	Bank of England
S_t (AUD-USD)	Spot exchange rate	Datastream	Bank of England
S_t (JPY-GBP)	Spot exchange rate	Datastream	Bank of England
S_t (JPY-CHF)	Spot exchange rate	Bloomberg	Bloomberg BGN
S_t (JPY-CAD)	Spot exchange rate	Bloomberg	Bloomberg BGN
S_t (JPY-AUD)	Spot exchange rate	Bloomberg	Bloomberg BGN
S_t (CHF-GBP)	Spot exchange rate	Datastream	Bank of England
S_t (CAD-GBP)	Spot exchange rate	Datastream	Bank of England
S_t (AUD-GBP)	Spot exchange rate	Datastream	Bank of England
S_t (CHF-CAD)	Spot exchange rate	Bloomberg	Bloomberg BGN
S_t (CHF-AUD)	Spot exchange rate	Bloomberg	Bloomberg BGN
S_t (CAD-AUD)	Spot exchange rate	Bloomberg	Bloomberg BGN
M_t (USA)	M1 money supply	Datastream	U.S. Federal Reserve
M_t (Japan)	M1 money supply	Datastream	Bank of Japan
M_t (UK)	M1 money supply	Datastream	Bank of England
M_t (Switzerland)	M1 money supply	Datastream	Swiss National Bank
M_t (Canada)	M1 money supply	Datastream	Statistics Canada
M_t (Australia)	M1 money supply	Datastream	Reserve Bank of Australia
Y_t (USA)	GDP (constant prices)	Datastream	U.S. Bureau of Economic Analysis
Y_t (Japan)	GDP (constant prices)	Datastream	Cabinet Office, Japan
Y_t (UK)	GDP (constant prices)	Datastream	Office for National Statistics (ONS)
Y_t (Switzerland)	GDP (constant prices)	Datastream	State Secretariat for Economic Affairs
Y_t (Canada)	GDP (constant prices)	Datastream	Statistics Canada (CANSIM)
Y_t (Australia)	GDP (constant prices)	Datastream	Australian Bureau of Statistics
i_t (USA)	Interbank rate (3 month)	Datastream	Reuters
i_t (Japan)	Interbank rate (3 month)	Datastream	British Bankers' Association
i_t (UK)	Interbank rate (3 month)	Datastream	Financial Times
i_t (Switzerland)	Interbank rate (3 month)	Datastream	Swiss National Bank
i_t (Canada)	Interbank rate (3 month)	Datastream	Statistics Canada (CANSIM)
i_t (Australia)	Interbank rate (3 month)	Datastream	Reserve Bank of Australia
π_t (USA)	Annual CPI inflation	Datastream	U.S. Bureau of Labor Statistics
π_t (Japan)	Annual CPI inflation	Datastream	Statistics Bureau, MIC, Japan
π_t (UK)	Annual CPI inflation	Datastream	Office for National Statistics (ONS)
π_t (Switzerland)	Annual CPI inflation	Datastream	Swiss Federal Statistical Office
π_t (Canada)	Annual CPI inflation	Datastream	Statistics Canada (CANSIM)
π_t (Australia)	Annual CPI inflation	Datastream	Australia Bureau of Statistics
CA_t (USA)	Current account balance	Datastream	OECD, *Main Economic Indicators*
CA_t (Japan)	Current account balance	Datastream	OECD, *Main Economic Indicators*
CA_t (UK)	Current account balance	Datastream	OECD, *Main Economic Indicators*
CA_t (Switzerland)	Current account balance	Datastream	OECD, *Main Economic Indicators*
CA_t (Canada)	Current account balance	Datastream	Statistics Canada (CANSIM)
CA_t (Australia)	Current account balance	Datastream	OECD, *Main Economic Indicators*

APPENDIX II

FM-OLS

$$\mathbf{S}_t = \boldsymbol{\beta}_0 + \boldsymbol{\beta}_1(\mathbf{M}_t - \mathbf{M}_t^{*}) + \boldsymbol{\beta}_2(\mathbf{Y}_t - \mathbf{Y}_t^{*}) + \boldsymbol{\beta}_3(\mathbf{i}_t - \mathbf{i}_t^{*}) + \boldsymbol{\beta}_4(\bar{\boldsymbol{\pi}}_t - \bar{\boldsymbol{\pi}}_t^{*}) + \boldsymbol{\beta}_5(\boldsymbol{CA}_t - \boldsymbol{CA}_t^{*})$$

	FM-OLS estimates								
Pair	β0	β1	β2	β3	β4	β5	R squared	β1 = 1	β2 = -1
AUD-GBP	0.144497	0.275914	-0.19027	0.04496	-0.02555	0.000756		NO	NO
	0.070598	0.128919	0.138689	0.004203	0.003379	0.000955	**0.697461**	-5.61659	5.83844
	0.0416	*0.0332*	*0.1711*	*0*	*0*	*0.4291*		*0*	*0*
AUD-USD	4.133981	-0.39871	3.54733	0.002024	-0.01526	0.000528		NO	NO
	0.488223	0.125659	0.4603	0.004917	0.005397	0.000281	**0.708310**	-11.131	9.879059
	0	*0.0017*	*0*	*0.6809*	*0.005*	*0.0613*		*0*	*0*
CAD-AUD	-0.001209	-0.23255	0.259148	-0.0076	0.000714	-3.93E-06		NO	NO
	0.034958	0.12737	0.307833	0.004447	0.004235	1.43E-06	**0.174041**	-9.6769	4.090353
	0.9724	*0.0689*	*0.4006*	*0.0887*	*0.8662*	*0.0063*		*0*	*0.0001*
CAD-GBP	0.255899	-0.28646	-0.28165	0.016968	-0.00633	-5.42E-06		NO	YES
	0.147098	0.19637	0.431697	0.004769	0.005429	1.04E-06	**0.692829**	-6.55122	1.664021
	0.083	*0.1457*	*0.5146*	*0.0004*	*0.2444*	*0*		*0*	*0.0972*
CAD-USD	3.596025	0.486126	1.652258	-0.0007	-0.03388	-7.81E-06		NO	NO
	1.797112	0.07166	1.24109	0.005709	0.008696	1.32E-06	**0.643276**	-7.171	2.137038
	0.0463	*0*	*0.1841*	*0.9026*	*0.0001*	*0*		*0*	*0.0334*
CHF-AUD	0.193399	0.101671	0.378568	-0.0095	0.004534	0.00153		NO	NO
	0.047772	0.065246	0.151065	0.002993	0.00364	0.00098	**0.477507**	-13.7684	9.125673
	0.0001	*0.1202*	*0.0128*	*0.0017*	*0.2139*	*0.1196*		*0*	*0*
CHF-CAD	0.166742	-0.47691	0.673139	-0.0007	-0.00182	-2.35E-09		NO	NO
	0.062945	0.217078	0.223771	0.003969	0.006653	1.06E-06	**0.146292**	-6.80359	7.477017
	0.0085	*0.0288*	*0.0029*	*0.86*	*0.7847*	*0.9982*		*0*	*0*
CHF-GBP	0.261717	0.033368	-7.51E-02	0.02071	-0.03711	0.000638		NO	YES
	0.374766	0.089461	0.561592	0.004754	0.007776	0.000895	**0.672339**	-10.8051	1.64699
	0.4855	*0.7094*	*0.8938*	*0*	*0*	*0.4768*		*0*	*0.1006*
CHF-USD	-1.316536	0.067354	-0.96293	0.014601	-0.02389	-0.00048		NO	YES
	2.155094	0.383383	0.861246	0.007806	0.015509	0.000437	**0.403023**	-2.43268	0.043042
	0.5417	*0.8607*	*0.2645*	*0.0624*	*0.1246*	*0.2738*		*0.0156*	*0.9657*
JPY-AUD	2.757566	-0.67656	1.630476	0.0198	-0.01909	1.20E-06		NO	NO
	0.293273	0.163458	0.477939	0.005301	0.004853	6.78E-07	**0.442197**	-10.2568	5.503795
	0	*0*	*0.0007*	*0.0002*	*0.0001*	*0.0788*		*0*	*0*
JPY-CAD	0.27549	0.329168	3.516211	-0.00995	0.017006	3.03E-07		NO	NO
	1.185205	0.329811	1.867848	0.008358	0.010653	1.19E-06	**0.012172**	-2.03399	2.417868
	0.8164	*0.3191*	*0.0608*	*0.2347*	*0.1115*	*0.7989*		*0.0429*	*0.0162*
JPY-CHF	-0.057367	0.289767	-0.1744	0.031318	0.00805	-1.24E-06		NO	NO
	0.089942	0.153309	0.207683	0.010721	0.008322	8.79E-07	**0.137684**	-4.6327	3.975272
	0.5241	*0.0597*	*0.4017*	*0.0038*	*0.3342*	*0.1599*		*0*	*0.0001*
JPY-GBP	2.046809	-0.09809	-0.11173	0.023883	0.001126	-4.58E-07		NO	NO
	0.359879	0.159032	0.353633	0.0056	0.007667	7.94E-07	**0.523665**	-6.90484	2.511848
	0	*0.5378*	*0.7523*	*0*	*0.8834*	*0.5644*		*0*	*0.0125*
JPY-USD	-1.468642	0.017072	-1.76388	0.013028	-0.01482	7.78E-07		NO	YES
	2.84555	0.091086	1.3831	0.005308	0.009425	1.02E-06	**0.122689**	-10.7912	-0.55229
	0.6062	*0.8515*	*0.2032*	*0.0147*	*0.1169*	*0.4477*		*0*	*0.5812*
USD-GBP	-0.067244	0.076763	-0.27326	-0.0079	-0.0044	-0.00082		NO	YES
	0.598357	0.089894	0.448475	0.004054	0.005385	0.00025	**0.408804**	-10.2703	1.62046
	0.9106	*0.3938*	*0.5428*	*0.0522*	*0.4146*	*0.0012*		*0*	*0.1062*

For each currency pair, the first row of numbers is the coefficient estimates, with their standard errors underneath and p-values in italics. Coefficients estimates are shaded if they are significant at the 5% level. The two columns on the right of the R^2 values are the results of Wald tests with the verdict of the null hypotheses $\beta_1 = 1$ and $\beta_2 = -1$. The first of these figures is the t-statistic with its p-value underneath in italics. The t-statistic is shaded if the null hypothesis cannot be rejected.

APPENDIX III

DOLS

$$\mathbf{S}_t = \boldsymbol{\beta}_0 + \boldsymbol{\beta}_1(\mathbf{M}_t - \mathbf{M}_t^*) + \boldsymbol{\beta}_2(\mathbf{Y}_t - \mathbf{Y}_t^*) + \boldsymbol{\beta}_3(\mathbf{i}_t - \mathbf{i}_t^*) + \boldsymbol{\beta}_4(\bar{\boldsymbol{\pi}}_t - \bar{\boldsymbol{\pi}}_t^*) + \boldsymbol{\beta}_5(\boldsymbol{CA}_t - \boldsymbol{CA}_t^*)$$

	DOLS estimates								
Pair	β0	β1	β2	β3	β4	β5	R squared	β1 = 1	β2 = -1
AUD-GBP	0.149052	0.266048	-0.17291	0.043101	-0.02453	0.000652		NO	NO
	0.048396	0.092817	0.13341	0.002836	0.00332	0.00112	**0.796743**	-7.9075	6.199593
	0.0023	*0.0045*	*0.1961*	*0*	*0*	*0.561*		*0*	*0*
AUD-USD	4.223709	-0.35067	3.538126	0.008075	-0.01832	0.000409		NO	NO
	0.330764	0.10238	0.356667	0.003846	0.004402	0.000182	**0.784492**	-13.1928	12.7237
	0	*0.0007*	*0*	*0.0367*	*0*	*0.0257*		*0*	*0*
CAD-AUD	0.003431	-0.23106	0.295015	-0.01073	0.002336	-3.92E-06		NO	NO
	0.018451	0.08565	0.22184	0.00343	0.00297	1.08E-06	**0.425253**	-14.373	5.837602
	0.8849	*0.0096*	*0.1673*	*0.002*	*0.4446*	*0.0001*		*0*	*0*
CAD-GBP	0.212692	-0.28731	-0.37447	0.015832	0.000809	-5.68E-06		NO	NO
	0.094603	0.137281	0.27902	0.004118	0.003942	8.06E-07	**0.798488**	-9.3772	2.241872
	0.0254	0.0373	0.1807	0.0002	0.8377	0		*0*	*0.0258*
CAD-USD	4.130544	0.448411	2.099569	-0.00216	-0.02885	-7.41E-06		NO	NO
	1.514474	0.056741	1.050716	0.005419	0.007831	1.10E-06	**0.727903**	-9.72116	2.949959
	0.0068	*0*	*0.0467*	*0.6905*	*0.0003*	*0*		*0*	*0.0035*
CHF-AUD	0.123194	0.11985	0.168566	-0.00931	0.009402	0.000756		NO	NO
	0.058995	0.07864	0.198216	0.003008	0.003342	0.001186	**0.613304**	-11.1922	5.895418
	0.0377	*0.1287*	*0.3959*	*0.0022*	*0.0053*	*0.5243*		*0*	*0*
CHF-CAD	0.188926	-0.57136	0.700216	-0.00345	0.000846	9.32E-07		NO	NO
	0.075084	0.206765	0.272134	0.005392	0.007434	1.14E-06	**0.458547**	-7.59974	6.247724
	0.0125	*0.0061*	*0.0106*	*0.5233*	*0.9095*	*0.415*		*0*	*0*
CHF-GBP	0.027682	0.075627	-0.43777	0.017099	-0.02678	0.001132		NO	YES
	0.355519	0.068909	0.53689	0.002907	0.006574	0.000856	**0.775387**	-13.4144	1.047191
	0.938	*0.2734*	*0.4156*	*0*	*0.0001*	*0.1873*		*0*	*0.296*
CHF-USD	-0.95952	0.15636	-0.86044	0.012	-0.02016	-0.0005		NO	YES
	1.513668	0.275185	0.572602	0.004934	0.008609	0.000202	**0.547320**	-3.06572	0.243725
	0.5267	*0.5704*	*0.1341*	*0.0157*	*0.0199*	*0.014*		*0.0024*	*0.8076*
JPY-AUD	2.627201	-0.64332	1.431838	0.017888	-0.01918	4.92E-07		NO	NO
	0.240164	0.166325	0.384459	0.003672	0.003717	7.67E-07	**0.550661**	-9.88017	6.325352
	0	*0.0001*	*0.0002*	*0*	*0*	*0.522*		*0*	*0*
JPY-CAD	0.545194	0.482926	3.87893	-0.01159	0.020508	1.61E-06		NO	NO
	0.875107	0.216739	1.399226	0.007412	0.008602	9.55E-07	**0.233727**	-2.3857	3.486877
	0.5338	*0.0267*	*0.006*	*0.1191*	*0.0178*	*0.0925*		*0.0178*	*0.0006*
JPY-CHF	-0.05671	0.233086	-0.2592	0.023304	0.016686	2.87E-07		NO	NO
	0.059263	0.103124	0.152269	0.010129	0.00543	6.59E-07	**0.418783**	-7.43684	4.86505
	0.3395	*0.0246*	*0.0899*	*0.0222*	*0.0023*	*0.6635*		*0*	*0*
JPY-GBP	2.109056	-0.20555	-0.014	0.026455	0.009088	-1.46E-06		NO	NO
	0.196332	0.113247	0.202135	0.004214	0.007484	6.50E-07	**0.679728**	-10.6453	4.877965
	0	*0.0707*	*0.9449*	*0*	*0.2257*	*0.0258*		*0*	*0*
JPY-USD	0.860123	0.038115	-0.63181	0.008215	-0.0091	3.65E-07		NO	YES
	2.542292	0.083461	1.227159	0.003957	0.008031	1.06E-06	**0.342373**	-11.525	0.300037
	0.7354	*0.6483*	*0.6071*	*0.0389*	*0.2581*	*0.7316*		*0*	*0.7644*
USD-GBP	0.207255	0.050416	-0.47774	-0.00677	-0.00839	-0.00091		NO	YES
	0.539885	0.071568	0.396556	0.002467	0.004275	0.000174	**0.562019**	-13.2682	1.316984
	0.7014	*0.4818*	*0.2294*	*0.0065*	*0.0507*	*0*		*0*	*0.189*

For each currency pair, the first row of numbers is the coefficient estimates, with their standard errors underneath and p-values in italics. Coefficients estimates are shaded if they are significant at the 5% level. The two columns on the right of the R^2 values are the results of Wald tests with the verdict of the null hypotheses $\beta_1 = 1$ and $\beta_2 = -1$. The first of these figures is the t-statistic with its p-value underneath in italics. The t-statistic is shaded if the null hypothesis cannot be rejected.

APPENDIX IV

Direction of change and profit/loss of each trade (12 months)

	Forecast	ARMA	GARCH	FB	DF	HM	MA	ARMA	GARCH	FB	DF	HM	MA
AUD-GBP	1997	0		0	0	1	0	-21.4%		-21.4%	-21.4%	21.4%	-21.4%
	2005	1	0	0	0	1	0	4.9%	-4.9%	-4.9%	-4.9%	4.9%	-4.9%
	2013	0		1	1	1	1	-38.5%		38.5%	38.5%	38.5%	38.5%
AUD-USD	1997	0	1	1	1	1	1	-93.4%	93.4%	93.4%	93.4%	93.4%	93.4%
	2005	1	1	0	0	0	0	18.3%	18.3%	-18.3%	-18.3%	-18.3%	-18.3%
	2013	0	0	0	0	0	0	-323.3%	-323.3%	-323.3%	-323.3%	-323.3%	-323.3%
CAD-AUD	1997	0	0	0	0	0	0	-185.9%	-185.9%	-185.9%	-185.9%	-185.9%	-185.9%
	2005	0	1	0	0	0	0	-148.6%	148.6%	-148.6%	-148.6%	-148.6%	-148.6%
	2013	0	0	0	0	0	0	-272.0%	-272.0%	-272.0%	-272.0%	-272.0%	-272.0%
CAD-GBP	1997	0	0	1	0	0	0	-0.8%	-0.8%	0.8%	-0.8%	-0.8%	-0.8%
	2005	0	1	0	0	0	0	-16.9%	16.9%	-16.9%	-16.9%	-16.9%	-16.9%
	2013	0		0	0	0	0	-18.3%		-18.3%	-18.3%	-18.3%	-18.3%
CAD-USD	1997	0	0	1	1	0	1	-31.9%	-31.9%	31.9%	31.9%	-31.9%	31.9%
	2005	0	1	1	1	1	1	-107.3%	107.3%	107.3%	107.3%	107.3%	107.3%
	2013	1	1	1	0	0	1	24.3%	24.3%	24.3%	-24.3%	-24.3%	24.3%
CHF-AUD	1997	1	1	1	1	1	1	179.8%	179.8%	179.8%	179.8%	179.8%	179.8%
	2005	0	0	0	1	0	0	-69.4%	-69.4%	-69.4%	69.4%	-69.4%	-69.4%
	2013	0	0	0	0	0	0	-356.6%	-356.6%	-356.6%	-356.6%	-356.6%	-356.6%
CHF-CAD	1997	0	0	0	1	1	0	-174.5%	-174.5%	-174.5%	174.5%	174.5%	-174.5%
	2005	1	1	1	1	1	1	334.0%	334.0%	334.0%	334.0%	334.0%	334.0%
	2013	1	1	0	0	1	0	116.8%	116.8%	-116.8%	-116.8%	116.8%	-116.8%
CHF-GBP	1997	0	0	1	0	0	0	-6.0%	-6.0%	6.0%	-6.0%	-6.0%	-6.0%
	2005	0	1	0	0	0	0	-4.4%	4.4%	-4.4%	-4.4%	-4.4%	-4.4%
	2013	1	0	0	1	0	0	1.6%	-1.6%	-1.6%	1.6%	-1.6%	-1.6%
CHF-USD	1997	0	0	0	0	1	0	-31.9%	-31.9%	-31.9%	-31.9%	31.9%	-31.9%
	2005	0	1	0	0	0	0	-107.3%	107.3%	-107.3%	-107.3%	-107.3%	-107.3%
	2013	1	0	1	1	0	0	24.3%	-24.3%	24.3%	24.3%	-24.3%	-24.3%
JPY-AUD	1997	1	0	1	1	1	1	1.8%	-1.8%	1.8%	1.8%	1.8%	1.8%
	2005	0	0	0	1	1	0	-1.7%	-1.7%	-1.7%	1.7%	1.7%	-1.7%
	2013	0	1	1	1	0	1	-0.9%	0.9%	0.9%	0.9%	-0.9%	0.9%
JPY-CAD	1997	0	1	0	0	1	0	-1.8%	1.8%	-1.8%	-1.8%	1.8%	-1.8%
	2005	0	0	1	0	0	0	-3.8%	-3.8%	3.8%	-3.8%	-3.8%	-3.8%
	2013	0	1	0	0	0	0	-2.8%	2.8%	-2.8%	-2.8%	-2.8%	-2.8%
JPY-CHF	1997	0	0	0	0	1	0	-22.4%	-22.4%	-22.4%	-22.4%	22.4%	-22.4%
	2005	0	0	0	0	0	0	-3.5%	-3.5%	-3.5%	-3.5%	-3.5%	-3.5%
	2013	1		0	0	0	0	405.6%		-405.6%	-405.6%	-405.6%	-405.6%
JPY-GBP	1997	0	1	0	1	1	1	-2.4%	2.4%	-2.4%	2.4%	2.4%	2.4%
	2005	0	0	1	1	1	1	-0.9%	-0.9%	0.9%	0.9%	0.9%	0.9%
	2013	0	1	1	1	0	1	-4.9%	4.9%	4.9%	4.9%	-4.9%	4.9%
JPY-USD	1997	0	0	0	0	1	0	-2.7%	-2.7%	-2.7%	-2.7%	2.7%	-2.7%
	2005	1	1	0	0	0	0	3.4%	3.4%	-3.4%	-3.4%	-3.4%	-3.4%
	2013	0	0	0	0	0	0	-5.1%	-5.1%	-5.1%	-5.1%	-5.1%	-5.1%
USD-GBP	1997	1		0	1	1	1	0.0%		0.0%	0.0%	0.0%	0.0%
	2005	0	0	1	1	0	0	-16.5%	-16.5%	16.5%	16.5%	-16.5%	-16.5%
	2013	0	1	1	1	1	1	-3.5%	3.5%	3.5%	3.5%	3.5%	3.5%
		26.67%	43.90%	37.78%	42.22%	42.22%	31.11%	-21.48%	-9.27%	-32.24%	-22.69%	-20.37%	-34.42%

In the first table, each 1 represents a correct directional prediction while a 0 represents a false one. The row underneath the table gives the percentage of correct predictions for every model. MA stands for Model Averaging.

APPENDIX V

VECM and ARMA specifications (1)

		FB-VECM				DF-VECM				HM-VECM				ARMA				
	Period	Lags	LM test	JB test	White test	Lags	LM test	JB test	White test	Lags	LM test	JB test	White test	Lags	LM test	JB test	White test	ARCH test
AUD-GBP	1989 - 1996	5	7.948454	N	464.8353	5	13.01551	N	486.1527	6	20.08088	N	973.0947	4,4	0.245776	N	0.818693	4.376314
			0.9504		*0.4283*		*0.6716*		*0.4132*		*0.7426*		*0.6432*		*0.7827*		*0.6006*	*0.0393*
	1997 - 2004	6	23.40606	NN	483.5928	5	25.8137	NN	844.2226	6	39.79446	NN	1726.177	4,6	0.343562	N	0.975393	1.105512
			0.1033		*0.6927*		*0.4176*		*0.7285*		*0.3049*		*0.4671*		*0.7103*		*0.4756*	*0.2959*
	2005 - 2012	6	24.94576	NN	538.9994	6	25.50097	NN	1000.819	5	35.63148	NN	1488.838	6,2	0.685591	N	0.877677	4.963692
			0.0708		*0.1106*		*0.4346*		*0.1752*		*0.486*		*0.3601*		*0.5068*		*0.5487*	*0.0285*
AUD-USD	1989 - 1996	6	13.57958	NN	500.0609	6	18.37759	NN	519.6355	6	27.80053	NN	1033.907	6,6	1.581696	N	0.410804	0.032702
			0.63		*0.8899*		*0.3023*		*0.8881*		*0.3171*		*0.6325*		*0.2125*		*0.9616*	*0.8569*
	1997 - 2004	5	19.91304	NN	423.7422	6	22.57308	NN	973.3442	5	33.15714	NN	1363.248	0,1	1.141181	N	0.380152	1.133594
			0.2242		*0.4397*		*0.6025*		*0.3751*		*0.6045*		*0.6634*		*0.324*		*0.6848*	*0.2898*
	2005 - 2012	6	16.63554	NN	517.9775	6	27.77032	NN	963.2414	5	45.29293	NN	1477.455	3,5	0.118574	NN	1.05107	1.169361
			0.4096		*0.28*		*0.3185*		*0.4645*		*0.1378*		*0.1769*		*0.8883*		*0.4076*	*0.2825*
CAD-AUD	1989 - 1996	6	13.10053	NN	269.2919	6	12.22736	NN	291.2976	NA	NA	NA	NA	3,2	0.592876	N	0.610116	0.352409
			0.1581		*0.094*		*0.2008*		*0.0449*						*0.555*		*0.7216*	*0.5543*
	1997 - 2004	3	9.575332	NN	199.6413	NA	NA	NA	NA	6	31.3014	NN	1084.134	5,5	30.42401	N	0.490954	1.69266
			0.3859		*0.0001*						*0.1792*		*0.2262*		*0*		*0.8386*	*0.1967*
	2005 - 2012	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3,3	0.996026	N	1.909373	11.33766
															0.3737		*0.0779*	*0.0011*
CAD-GBP	1989 - 1996	NA	NA	NA	NA	4	16.81291	NN	601.5005	6	47.90896	N	1648.963	4,4	0.088865	N	1.396751	0.291407
							0.8885		*0.7871*		*0.0885*		*0.4197*		*0.7664*		*0.2034*	*0.5907*
	1997 - 2004	NA	NA	NA	NA	5	26.27067	N	429.7093	6	36.68529	N	855.093	4,6	25.84847	N	0.392333	0.300712
							0.0503		*0.6282*		*0.0618*		*0.1321*		*0*		*0.9553*	*0.5848*
	2005 - 2012	6	13.58899	NN	547.9982	5	26.46255	NN	811.1869	6	47.37133	NN	1680.903	4,4	1.505961	N	1.430528	0.616355
			0.6293		*0.0678*		*0.3833*		*0.213*		*0.0973*		*0.4892*		*0.2233*		*0.189*	*0.4345*
CAD-USD	1989 - 1996	5	8.823862	N	214.3891	5	12.3622	NN	430.0577	5	31.55094	N	925.2476	1,1	0.376752	N	0.528047	0.247322
			0.4537		*0.295*		*0.7187*		*0.6237*		*0.1714*		*0.2725*		*0.5409*		*0.6642*	*0.6202*
	1997 - 2004	5	11.56536	NN	371.6138	5	21.13487	NN	735.9199	5	38.7274	NN	1353.177	4,2	0.304439	N	1.070464	0.290596
			0.7733		*0.9568*		*0.6851*		*0.8688*		*0.3476*		*0.4249*		*0.5826*		*0.3898*	*0.5912*
	2005 - 2012	6	28.32992	NN	526.291	6	24.59855	NN	979.4509	6	37.42351	NN	1663.087	4,1	0.003212	NN	0.174834	0.050584
			0.0289		*0.2009*		*0.485*		*0.3241*		*0.4036*		*0.3272*		*0.9549*		*0.9829*	*0.8226*

All shaded values are significant at the 5% level, with their corresponding p-values in italics underneath. The LM and White tests are both $\chi 2$ distributed. Since the multivariate JB test gives multiple test statistics, normality is simply given by N and non-normality as NN. In cases where the exchange rate was I(0) or cointegration was not observed, results show NA.

VECM and ARMA specifications (2)

		FB-VECM				DF-VECM				HM-VECM				ARMA				
	Period	Lags	LM test	JB test	White test	Lags	LM test	JB test	White test	Lags	LM test	JB test	White test	Lags	LM test	JB test	White test	ARCH test
CHF-AUD	1989 - 1996	6	14.31471	N	585.0027	6	12.38024	N	596.2408	6	36.57582	N	996.5148	2,3	0.411846	N	1.66413	0.036373
			0.5753		*0.088*		*0.7174*		*0.14*		*0.0633*		*0.436*		*0.6637*		*0.1396*	*0.8492*
	1997 - 2004	6	24.54039	NN	421.3541	5	34.13377	NN	913.7345	6	46.40995	NN	1676.468	5,3	0.465878	N	0.510779	3.025007
			0.0783		*0.4722*		*0.1051*		*0.0388*		*0.1147*		*0.2487*		*0.6293*		*0.8627*	*0.0855*
	2005 - 2012	6	17.9621	NN	558.926	6	20.79645	N	964.9679	5	40.01057	NN	1467.729	3,5	14.80328	NN	0.217626	2.280503
			0.3261		*0.1153*		*0.7039*		*0.4489*		*0.2966*		*0.0623*		*0*		*0.9702*	*0.1346*
CHF-CAD	1989 - 1996	6	18.37358	N	545.9492	6	20.48941	N	566.9488	6	30.61035	N	1023.491	1,1	0.273376	N	0.196562	0.096203
			0.3025		*0.0761*		*0.199*		*0.0757*		*0.2022*		*0.0759*		*0.7614*		*0.8985*	*0.7571*
	1997 - 2004	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6,4	1.407004	N	0.648678	0.00465
															0.2511		*0.7815*	*0.9458*
	2005 - 2012	5	20.86632	NN	535.4016	4	27.0081	NN	765.4521	5	47.71417	NN	1371.531	5,4	2.220792	N	1.244121	0.151532
			0.1837		*0.0086*		*0.3555*		*0.1168*		*0.0916*		*0.2945*		*0.1153*		*0.2768*	*0.698*
CHF-GBP	1989 - 1996	6	25.40365	NN	523.2591	4	21.74191	NN	687.7168	6	1708.151	NN	1708.151	2,3	0.352078	NN	0.144225	9.63E-06
			0.063		*0.6895*		*0.6506*		*0.2204*		*0.3105*		*0.3105*		*0.7042*		*0.9897*	*0.9975*
	1997 - 2004	5	21.06478	NN	440.5864	5	17.3289	NN	451.3757	6	35.22264	N	979.7804	4,4	2.766536	N	0.708729	0.280279
			0.176		*0.4832*		*0.3646*		*0.3436*		*0.0843*		*0.1251*		*0.0689*		*0.6992*	*0.5979*
	2005 - 2012	6	24.80089	NN	603.7899	5	18.09589	NN	877.2189	5	35.25885	NN	1497.225	0,0	1.267589	NN	NA	2.091803
			0.0734		*0.0064*		*0.8383*		*0.1811*		*0.5036*		*0.099*		*0.2864*			*0.1515*
CHF-USD	1989 - 1996	6	34.16922	N	563.4589	4	34.95516	N	736.2778	5	45.61847	N	1340.624	1,1	0.799512	N	0.528047	0.247322
			0.0052		*0.0914*		*0.089*		*0.0206*		*0.1307*		*0.5209*		*0.4528*		*0.6642*	*0.6202*
	1997 - 2004	6	18.01085	NN	503.0959	6	30.37579	NN	972.1337	6	45.42862	N	1716.584	4,2	0.159355	N	1.070464	0.290596
			0.3233		*0.6947*		*0.2105*		*0.6513*		*0.1348*		*0.2617*		*0.853*		*0.3898*	*0.5912*
	2005 - 2012	6	20.67064	NN	562.3762	5	23.03589	NN	857.1837	6	46.39618	N	1659.954	4,1	0.420747	NN	0.174834	0.050584
			0.1915		*0.0967*		*0.5755*		*0.1217*		*0.1149*		*0.347*		*0.6579*		*0.9829*	*0.8226*
JPY-AUD	1989 - 1996	NA	NA	NA	NA	4	14.2389	NN	410.6006	6	33.2549	NN	1039.783	6,2	0.312703	N	0.73217	0.606909
							0.5809		*0.1345*		*0.1248*		*0.5828*		*0.7324*		*0.6782*	*0.4381*
	1997 - 2004	4	23.71102	NN	353.7107	6	21.32344	NN	954.7432	6	45.256	NN	1625.87	2,5	0.217883	N	0.655615	0.299533
			0.096		*0.2931*		*0.6744*		*0.5418*		*0.1387*		*0.5796*		*0.97*		*0.7287*	*0.5855*
	2005 - 2012	NA	NA	NA	NA	NA	NA	NA	NA	6	43.8559	N	1617.623	3,4	0.322383	NN	1.858542	0.146564
											0.1728		*0.1276*		*0.7253*		*0.0777*	*0.7028*

All shaded values are significant at the 5% level, with their corresponding p-values in italics underneath. The LM and White tests are both $\chi2$ distributed. Since the multivariate JB test gives multiple test statistics, normality is simply given by N and non-normality as NN. In cases where the exchange rate was I(0) or cointegration was not observed, results show NA.

VECM and ARMA specifications (3)

		FB-VECM				DF-VECM				HM-VECM				ARMA				
	Period	Lags	LM test	JB test	White test	Lags	LM test	JB test	White test	Lags	LM test	JB test	White test	Lags	LM test	JB test	White test	ARCH test
JPY-CAD	1989 - 1996	NA	NA	NA	NA	NA	NA	NA	NA	5	39.86243	N	1434.02	3,3	0.319525	N	0.827144	0.322466
											0.3023		*0.4503*		*0.7274*		*0.5676*	*0.5716*
	1997 - 2004	NA	NA	NA	NA	5	30.24339	NN	808.5129	5	41.73	NN	1375.001	6,6	0.759626	N	1.611286	0.002764
							0.2153		*0.5081*		*0.2357*		*0.2722*		*0.4715*		*0.1009*	*0.9582*
	2005 - 2012	4	20.96116	NN	379.4038	NA	NA	NA	NA	5	38.2267	N	1355.436	0,6	0.000381	NN	1.875415	0.046327
			0.18		*0.0692*						*0.3686*		*0.408*		*0.9996*			*0.8301*
JPY-CHF	1989 - 1996	6	15.56138	NN	251.0681	4	18.60474	NN	365.0553	6	29.69096	N	973.5109	6,6	1.208034	N	0.500928	0.9173
			0.0766		*0.2988*		*0.2897*		*0.4159*		*0.2361*		*0.3737*		*0.3046*		*0.9173*	*0.5489*
	1997 - 2004	5	17.36624	NN	400.577	NA	NA	NA	NA	5	18.98949	NN	818.4534	3,3	0.133225	NN	1.060942	0.076302
			0.3623		*0.7446*						*0.7976*		*0.4107*		*0.8755*		*0.3985*	*0.783*
	2005 - 2012	6	22.19137	NN	441.9398	4	22.59326	NN	691.6392	6	41.32785	N	1660.85	0,0	0.414404	NN	NA	9.90043
			0.1371		*0.002*		*0.6013*		*0.1906*		*0.2492*		*0.6256*		*0.662*			*0.0022*
JPY-GBP	1989 - 1996	5	15.19161	NN	426.3996	4	34.53146	NN	694.607	5	40.32448	NN	1459.367	1,6	0.58151	NN	1.731127	0.16184
			0.5107		*0.8673*		*0.097*		*0.4437*		*0.2849*		*0.5731*		*0.5613*		*0.1028*	*0.6884*
	1997 - 2004	NA	NA	NA	NA	NA	NA	NA	NA	5	17.80624	NN	873.1591	3,2	0.321225	NN	0.446934	0.556085
											0.8505		*0.061*		*0.7261*		*0.8453*	*0.4578*
	2005 - 2012	4	22.26276	NN	479.2863	4	34.4818	NN	744.2448	5	34.7336	NN	1456.709	2,2	0.173984	NN	1.845371	0.315426
			0.1349		*0.0004*		*0.098*		*0.258*		*0.5288*		*0.2925*		*0.8406*		*0.1124*	*0.5758*
JPY-USD	1989 - 1996	5	23.07394	N	447.2941	4	25.11303	NN	617.9769	5	37.48533	NN	1465.282	6,6	2.117804	NN	0.626611	0.191762
			0.1118		*0.1723*		*0.4561*		*0.8777*		*0.4009*		*0.2407*		*0.1275*		*0.8244*	*0.6626*
	1997 - 2004	6	18.66611	NN	476.8023	6	16.9422	N	984.0937	6	38.34287	NN	1760.921	6,6	0.202254	NN	0.729488	0.475369
			0.2864		*0.7655*		*0.8839*		*0.2876*		*0.3637*		*0.2516*		*0.8173*		*0.7288*	*0.4924*
	2005 - 2012	6	20.45586	NN	503.1477	5	15.77519	NN	761.639	6	34.60997	NN	1671.387	4,4	0.01981	N	1.861982	0.031044
			0.2004		*0.4521*		*0.9214*		*0.8868*		*0.5347*		*0.0925*		*0.9804*		*0.0696*	*0.8605*
USD-GBP	1989 - 1996	4	25.24083	NN	318.9707	5	27.32304	NN	791.4476	5	27.14975	NN	1461.67	6,6	0.903675	NN	1.655655	4.894088
			0.0657		*0.7876*		*0.3399*		*0.3801*		*0.8561*		*0.2619*		*0.4095*		*0.0889*	*0.0296*
	1997 - 2004	5	26.07835	NN	380.8121	5	31.4397	N	751.8839	4	42.37471	N	1190.343	5,4	0.555058	N	1.008738	0.345787
			0.0529		*0.9152*		*0.1749*		*0.9283*		*0.2152*		*0.1194*		*0.5763*		*0.4437*	*0.558*
	2005 - 2012	5	8.532149	NN	228.8404	5	15.33323	NN	459.0343	6	27.91858	NN	891.8328	4,5	1.638199	NN	0.739726	0.873904
			0.4815		*0.2618*		*0.5004*		*0.5039*		*0.3116*		*0.9428*		*0.2009*		*0.6851*	*0.3524*

All shaded values are significant at the 5% level, with their corresponding p-values in italics underneath. The LM and White tests are both $\chi 2$ distributed. Since the multivariate JB test gives multiple test statistics, normality is simply given by N and non-normality as NN. In cases where the exchange rate was I(0) or cointegration was not observed, results show NA.

APPENDIX VI

RMSE results for each forecast (1)

Pair	Period	Horizon	RW	RWD	ARMA	GARCH	FB	DF	HM	Model averaging
AUD-GBP	1989 - 1997	1 month	0.000131	0.0001406	0.0001853	NA	1.38205E-05	**1.976E-06**	1.0022E-05	1.63483E-05
		6 months	0.000148	0.000162	0.000192	NA	0.000118	0.000104	0.000129	**9.68E-05**
		12 months	0.001	0.000861	0.001871	NA	0.00133	0.001453	**0.000818**	0.001321
	1997 - 2005	1 month	2.92E-05	1.94E-08	2.84E-05	6.04E-06	**1.94E-08**	2.30E-05	0.001234	7.50E-05
		6 months	9.17E-05	6.91E-05	7.64E-05	0.000113	6.91E-05	**5.11E-05**	0.003622	0.000232
		12 months	0.000255	0.000167	0.000242	8.83E-05	0.000167	**4.93E-05**	0.002194	0.000225
	2005 - 2013	1 month	0.000135	9.25E-05	0.000133	NA	**7.37E-05**	0.000195	0.000449	0.000124
		6 months	0.000447	0.000495	0.000481	NA	**0.0004**	0.002494	0.005108	0.001008
		12 months	0.001559	0.002762	0.002664	NA	0.001059	0.002763	0.013317	**0.000759**
AUD-USD	1989 - 1997	1 month	0.000161	0.000156	0.000165	0.000103	6.33E-05	7.54E-05	**3.29E-06**	6.97E-05
		6 months	0.000486	0.000456	0.000435	0.000262	0.000161	**0.000123**	0.000145	0.000137
		12 months	0.001771	0.001654	0.001872	0.0015	0.001141	0.000229	**0.000106**	0.00074
	1997 - 2005	1 month	1.79E-05	1.88E-05	1.20E-05	1.10E-05	1.53E-05	1.99E-05	1.16E-05	**1.01E-07**
		6 months	4.44E-05	4.23E-05	4.42E-05	**4.21E-05**	0.000685	0.001468	0.001931	0.000528
		12 months	0.000117	0.000103	0.000115	**0.000102**	0.001708	0.00378	0.004881	0.001439
	2005 - 2013	1 month	3.27E-06	9.68E-06	1.48E-06	1.40E-05	6.56E-06	1.70E-06	1.56E-05	**2.41E-07**
		6 months	**0.000178**	0.00031	0.000195	0.000407	0.000621	0.001632	0.000465	0.000525
		12 months	**0.00167**	0.002496	0.0017	0.003023	0.004571	0.00867	0.003462	0.003912
CAD-AUD	1989 - 1997	1 month	0.000635	0.000643	0.000594	0.000565	0.000773	0.000736	**0.000464**	0.000622
		6 months	0.00023	0.000243	0.000277	0.000251	0.000449	0.000298	**0.000135**	0.000263
		12 months	**0.001091**	0.001164	0.00148	0.001366	0.002223	0.001369	0.001336	0.001527
	1997 - 2005	1 month	0.000125	0.000134	9.59E-05	0.000104	**5.17E-05**	5.36E-05	0.000111	8.16E-05
		6 months	0.000151	0.000173	0.000122	0.000206	0.000122	0.000125	0.000137	**0.000107**
		12 months	0.000471	0.000381	0.000595	**0.000224**	0.001333	0.001249	0.001118	0.000774
	2005 - 2013	1 month	1.08E-05	0.002154	**2.40E-08**	0.000283	1.22E-05	1.12E-06	2.40E-08	2.48E-07
		6 months	0.000245	0.00185	**0.000214**	0.000348	0.00023	0.000278	0.000214	0.000225
		12 months	0.000749	0.001008	0.000542	**0.00043**	0.000593	0.000723	0.000542	0.000592
CAD-GBP	1989 - 1997	1 month	0.001329	0.00137	0.000905	0.000938	0.001347	**0.000191**	0.000208	0.000615
		6 months	0.000441	0.000507	0.000381	0.000338	0.000802	0.001902	0.000703	**0.000253**
		12 months	0.000317	0.000393	0.001144	**0.000272**	0.000694	0.002072	0.000801	0.000389
	1997 - 2005	1 month	3.11E-05	2.79E-05	3.69E-05	6.05E-05	**6.74E-06**	3.52E-05	7.31E-05	3.97E-05
		6 months	**0.000163**	0.000171	0.000187	0.000164	0.000183	0.000406	0.000788	0.000281
		12 months	0.001197	0.001341	0.001343	**0.000864**	0.001476	0.002641	0.003571	0.001885
	2005 - 2013	1 month	6.93E-05	**4.40E-05**	1.18E-04	NA	0.000125	1.33E-04	0.000134	1.23E-04
		6 months	0.000136	**6.42E-05**	7.32E-05	NA	0.000261	0.000397	0.000286	0.00019
		12 months	**0.000335**	0.000734	0.000728	NA	0.000525	0.000709	0.000651	0.000593
CAD-USD	1989 - 1997	1 month	7.93E-05	9.06E-05	5.75E-05	6.56E-05	0.000132	8.40E-05	1.68E-04	**9.29E-06**
		6 months	0.001515	0.001695	0.001653	0.001722	**0.000154**	0.000269	0.000772	0.000696
		12 months	0.00191	0.002284	0.00229	0.002422	**0.000219**	0.00033	0.002332	0.001074
	1997 - 2005	1 month	6.71E-06	3.48E-06	**5.28E-07**	4.26E-06	0.000112	5.76E-05	5.71E-05	3.24E-05
		6 months	0.000452	0.000573	0.000326	0.000248	0.000138	9.78E-05	**7.71E-05**	8.53E-05
		12 months	0.001585	0.002028	0.001566	0.001276	**0.000146**	0.000242	0.000622	0.00059
	2005 - 2013	1 month	2.95E-05	2.02E-05	4.00E-05	3.52E-05	1.27E-06	5.01E-06	**8.50E-08**	2.30E-06
		6 months	8.70E-05	0.000142	0.000156	0.000165	0.00024	0.000141	**6.20E-05**	0.000122
		12 months	**7.03E-05**	0.000123	0.000147	0.000159	0.000173	0.000167	0.00017	8.80E-05

RMSE values in bold represent the lowest value on that row

RMSE results for each forecast (2)

Pair	Period	Horizon	RW	RWD	ARMA	GARCH	FB	DF	HM	Model averaging
		1 month	**6.00E-05**	8.23E-05	0.000284	0.00184	0.00018	0.000134	0.000265	0.000412
	1989 - 1997	6 months	**0.00056**	0.000763	0.001048	0.002692	0.001602	0.001034	0.005034	0.001984
		12 months	0.00079	**0.000715**	0.000862	0.00183	0.001303	0.000992	0.004374	0.001502
		1 month	**0.000246**	0.000276	0.000361	0.000321	0.000396	0.000286	0.00055	0.000375
CHF-AUD	1997 - 2005	6 months	0.000588	0.000768	0.000887	0.000811	0.001176	**0.000581**	0.001643	0.000973
		12 months	0.00098	0.001423	0.001656	0.001505	0.002324	**0.000791**	0.002381	0.001649
		1 month	1.33E-06	**3.10E-07**	4.99E-05	1.65E-05	0.00038	0.000127	0.000228	0.000127
	2005 - 2013	6 months	0.000398	**0.000352**	0.000616	0.00046	0.005129	0.003308	0.003629	0.002051
		12 months	0.001996	**0.001649**	0.003079	0.002246	0.012818	0.009933	0.010534	0.006794
		1 month	0.001084	0.001184	0.001149	0.001144	0.000687	0.000471	**0.000443**	0.00077
	1989 - 1997	6 months	0.001079	0.001426	0.001373	0.001356	0.001418	0.000606	**0.00027**	0.000941
		12 months	0.000995	0.001596	0.001513	0.001482	0.001909	0.000599	**0.000283**	0.001021
		1 month	2.04E-05	0.000708	1.20E-05	**2.26E-06**	0.000105	9.23E-05	0.000297	3.72E-05
CHF-CAD	1997 - 2005	6 months	0.000424	0.000538	0.00017	**0.000135**	0.000179	0.000187	0.000461	0.000157
		12 months	0.002208	0.000822	0.00125	0.000873	0.000888	0.000899	**0.000751**	0.000889
		1 month	2.44E-05	2.27E-05	5.32E-06	7.19E-06	3.51E-05	1.14E-05	**1.95E-06**	9.90E-06
	2005 - 2013	6 months	3.80E-05	**3.36E-05**	5.71E-05	3.89E-05	8.33E-05	0.000655	5.52E-05	3.57E-05
		12 months	0.000388	0.000343	**8.18E-05**	0.000114	0.00082	0.002469	0.000258	0.00044
		1 month	1.44E-05	8.35E-06	5.69E-05	4.70E-05	8.35E-05	3.36E-05	**1.04E-08**	3.57E-05
	1989 - 1997	6 months	0.000254	0.000361	0.000237	0.000229	**9.91E-05**	0.000231	0.00144	0.000312
		12 months	0.000341	0.00059	0.0004	0.000328	**0.000102**	0.000387	0.002249	0.00048
		1 month	0.0001	0.000104	9.48E-05	8.78E-05	**2.92E-05**	8.84E-05	5.56E-05	7.00E-05
CHF-GBP	1997 - 2005	6 months	0.000235	0.000258	0.000242	**0.000205**	0.000223	0.000923	0.000646	0.000387
		12 months	0.000252	0.000294	0.000267	**0.000219**	0.000351	0.001755	0.001491	0.000639
		1 month	0.000171	0.000126	0.000126	0.00018	0.000128	**2.45E-05**	0.000139	0.000114
	2005 - 2013	6 months	0.000206	8.20E-05	8.20E-05	0.000239	0.000192	**2.54E-05**	0.000675	0.000151
		12 months	0.000176	0.00013	0.00013	0.000224	0.000339	**6.85E-05**	0.00146	0.000239
		1 month	7.93E-05	9.06E-05	**5.75E-05**	6.56E-05	0.000297	0.000308	0.001268	0.000271
	1989 - 1997	6 months	**0.001515**	0.001695	0.001653	0.001722	0.002428	0.002191	0.003729	0.002212
		12 months	**0.00191**	0.002284	0.00229	0.002422	0.004162	0.002992	0.004664	0.003152
		1 month	6.71E-06	3.48E-06	**5.28E-07**	4.26E-06	0.000364	0.000265	0.000678	0.000133
CHF-USD	1997 - 2005	6 months	0.000452	0.000573	0.000326	**0.000248**	0.004521	0.003281	0.008271	0.002372
		12 months	0.001585	0.002028	0.001566	**0.001276**	0.015991	0.010424	0.010822	0.006383
		1 month	2.95E-05	2.02E-05	4.00E-05	0.001594	1.21E-05	**1.79E-06**	1.84E-06	7.30E-05
	2005 - 2013	6 months	8.70E-05	0.000142	0.000156	0.000947	9.46E-05	9.76E-05	8.36E-05	**7.54E-05**
		12 months	7.03E-05	0.000123	0.000147	0.001059	7.33E-05	0.000105	0.000171	**6.94E-05**
		1 month	**2.56E-06**	7.02E-06	3.40E-05	8.75E-06	0.00012	0.000252	1.17E-05	5.91E-05
	1989 - 1997	6 months	0.000455	**0.000455**	0.00063	0.000504	0.001283	0.002202	0.001334	0.000968
		12 months	0.000596	**0.000377**	0.000386	0.000749	0.00066	0.001749	0.000814	0.000501
		1 month	3.46E-06	6.35E-06	9.08E-05	0.000117	3.51E-06	0.000175	0.000147	**6.19E-07**
JPY-AUD	1997 - 2005	6 months	0.000197	0.000271	0.000667	0.000645	0.000199	8.82E-05	**7.21E-05**	0.000183
		12 months	0.000628	0.000889	0.001546	0.001523	0.000796	0.00066	**0.000165**	0.000801
		1 month	0.000653	0.000627	0.000666	0.000958	0.000278	**0.000202**	0.000321	0.000468
	2005 - 2013	6 months	0.000952	0.000864	0.002291	0.000841	**0.000224**	0.000231	0.001613	0.000716
		12 months	0.000564	0.0005	0.002414	0.000535	**0.000291**	0.000509	0.001659	0.000428

RMSE values in bold represent the lowest value on that row

RMSE results for each forecast (3)

Pair	Period	Horizon	RW	RWD	ARMA	GARCH	FB	DF	HM	Model averaging
		1 month	0.000806	0.000877	0.000659	0.000637	0.000793	0.000815	**9.57E-06**	0.0005
	1989 - 1997	6 months	0.00048	0.000596	0.000442	0.000378	0.000465	0.000466	0.000509	**0.000317**
		12 months	0.000441	0.000785	0.000558	**0.0003**	0.000677	0.000678	0.000412	0.0004
		1 month	9.11E-05	8.66E-05	6.16E-05	**7.45E-06**	4.44E-05	2.78E-05	0.000242	5.40E-05
JPY-CAD	1997 - 2005	6 months	**0.000187**	0.000201	0.001127	0.000545	0.000267	0.000257	0.000218	0.000359
		12 months	**0.001875**	0.002022	0.004331	0.002442	0.002001	0.002444	0.001989	0.002546
		1 month	0.000476	0.000467	0.000339	0.000481	**0.000257**	0.000571	0.001368	0.000574
	2005 - 2013	6 months	0.001019	0.000971	0.001373	**0.000851**	0.002241	0.001526	0.009685	0.002674
		12 months	0.001283	0.001183	0.002258	**0.000809**	0.003987	0.001678	0.011774	0.003519
		1 month	3.65E-05	3.98E-05	2.07E-05	2.28E-05	1.72E-05	**1.25E-07**	0.000192	1.64E-05
	1989 - 1997	6 months	0.000511	0.000551	**0.000206**	0.000226	0.000321	0.000304	0.002987	0.00039
		12 months	0.000529	0.000568	0.000515	0.000466	0.000731	**0.000382**	0.003571	0.000495
		1 month	0.000181	0.000188	0.000233	0.000237	0.000179	**0.000127**	0.000228	0.0002
JPY-CHF	1997 - 2005	6 months	**0.000134**	0.000154	0.000216	0.000398	0.000495	0.000175	0.000432	0.000327
		12 months	**0.000101**	0.000122	0.000187	0.000586	0.0006	0.00016	0.000425	0.000359
		1 month	0.000712	**0.000692**	0.000692	NA	0.0009	0.001119	0.001358	0.000993
	2005 - 2013	6 months	0.001237	**0.001139**	**0.001139**	NA	0.003305	0.003158	0.006828	0.003228
		12 months	0.002813	**0.00253**	**0.00253**	NA	0.006524	0.005376	0.017822	0.006953
		1 month	0.000237	0.000261	0.000122	0.000107	0.000386	0.000139	**2.54E-05**	0.00013
	1989 - 1997	6 months	0.000309	0.000389	0.000128	0.000124	0.001182	0.000201	0.002122	**0.000103**
		12 months	0.000467	0.000665	0.000397	**0.000256**	0.003426	0.000358	0.003487	0.000299
		1 month	1.38E-05	1.38E-05	2.80E-05	**5.52E-08**	6.04E-05	0.000124	0.00014	4.97E-05
JPY-GBP	1997 - 2005	6 months	**3.27E-05**	3.27E-05	6.20E-05	5.37E-05	7.31E-05	0.000273	0.000534	6.29E-05
		12 months	7.84E-05	7.89E-05	0.000193	0.000159	**6.24E-05**	0.000234	0.000454	7.29E-05
		1 month	0.000486	0.000569	**0.000204**	0.000385	0.000445	0.000754	0.000542	0.000446
	2005 - 2013	6 months	0.001829	0.002461	0.002745	0.001569	**0.000562**	0.000946	0.003566	0.001615
		12 months	0.003743	0.005518	0.005621	0.003191	**0.000658**	0.001074	0.006275	0.002753
		1 month	7.23E-05	7.97E-05	**1.49E-05**	0.000133	4.37E-05	0.000106	0.000199	8.42E-05
	1989 - 1997	6 months	0.000816	0.0009	0.001485	0.001227	0.001152	0.002359	**0.000619**	0.001299
		12 months	0.000855	0.001019	0.003115	0.001324	0.001272	0.002476	**0.000401**	0.001519
		1 month	3.31E-06	**1.61E-06**	1.93E-06	5.47E-06	4.18E-05	0.000145	0.000422	6.40E-05
JPY-USD	1997 - 2005	6 months	0.000161	0.000216	**0.000139**	0.000186	0.001601	0.000842	0.001926	0.000744
		12 months	0.001182	0.00147	**0.000977**	0.001131	0.005431	0.003516	0.004889	0.00283
		1 month	0.000386	0.000427	0.001082	0.000687	**0.000367**	0.000474	0.000569	0.000617
	2005 - 2013	6 months	**0.003607**	0.004085	0.007796	0.007139	0.004819	0.005449	0.004457	0.005887
		12 months	**0.005297**	0.006382	0.013434	0.012492	0.007754	0.008959	0.006908	0.009799
		1 month	**4.81E-05**	5.26E-05	0.00011	NA	0.000111	0.000347	0.000416	0.000231
	1989 - 1997	6 months	0.000208	0.000179	0.000141	NA	0.000369	7.30E-05	0.000119	**6.10E-05**
		12 months	0.000182	0.000144	0.000396	NA	0.000355	5.75E-05	8.85E-05	**5.20E-05**
		1 month	3.69E-06	6.08E-06	**1.09E-08**	6.55E-06	8.59E-06	8.09E-05	2.35E-07	8.29E-06
USD-GBP	1997 - 2005	6 months	0.000152	0.0002	0.000448	0.000191	**5.86E-05**	0.000132	0.000187	0.000128
		12 months	0.000801	0.001036	0.002674	0.000717	**0.000349**	0.000368	0.001145	0.00089
		1 month	3.85E-06	7.66E-06	5.45E-06	6.86E-06	3.38E-05	3.29E-05	**3.82E-07**	1.15E-05
	2005 - 2013	6 months	0.000396	0.000294	**0.000241**	0.000557	0.001461	0.002253	0.001461	0.001014
		12 months	0.000327	**0.000247**	0.000257	0.000523	0.001107	0.001802	0.001164	0.000782

RMSE values in bold represent the lowest value on that row

APPENDIX VII

MAE results for each forecast (1)

Pair	Period	Horizon	RW	RWD	ARMA	GARCH	FB	DF	HM	Model averaging
		1 month	0.011445	0.011858	0.013612	NA	0.003718	**0.001406**	0.003166	0.004043
	1989 - 1997	6 months	0.011041	0.011532	0.012056	NA	0.008778	**0.007593**	0.01062	8.21E-03
		12 months	0.022943	0.02123	0.032526	NA	0.024361	0.025517	**0.021106**	0.025196
		1 month	5.41E-03	**1.39E-04**	5.33E-03	2.46E-03	**1.39E-04**	4.80E-03	0.035135	8.66E-03
AUD-GBP	1997 - 2005	6 months	7.51E-03	6.11E-03	6.12E-03	0.008932	6.11E-03	**5.52E-03**	0.058924	0.013577
		12 months	0.013711	0.010847	0.012873	7.41E-03	0.010847	**5.26E-03**	0.041032	0.013419
		1 month	0.011631	9.62E-03	0.011515	NA	**8.59E-03**	0.01396	0.021197	0.011151
	2005 - 2013	6 months	0.019491	0.019827	0.019811	NA	**0.016932**	0.046313	0.066668	0.028832
		12 months	0.034611	0.044342	0.043709	NA	0.028226	0.050154	0.105362	**0.024884**
		1 month	0.012673	0.012477	0.01285	0.010144	7.96E-03	8.69E-03	**1.82E-03**	8.35E-03
	1989 - 1997	6 months	0.020892	0.020204	0.0198	0.014687	0.009506	**0.008482**	0.010468	0.00898
		12 months	0.037124	0.035845	0.037646	0.032298	0.026574	0.012835	**0.008373**	0.021927
		1 month	4.23E-03	4.34E-03	3.47E-03	3.31E-03	3.91E-03	4.46E-03	3.41E-03	**3.18E-04**
AUD-USD	1997 - 2005	6 months	5.23E-03	5.18E-03	5.18E-03	**5.11E-03**	0.022872	0.034106	0.037207	0.019142
		12 months	0.009041	0.00851	0.008947	**0.00846**	0.03732	0.055572	0.062645	0.033533
		1 month	1.81E-03	3.11E-03	1.22E-03	3.74E-03	2.56E-03	1.30E-03	3.96E-03	**4.91E-04**
	2005 - 2013	6 months	**0.008084**	0.012632	0.00948	0.015244	0.018751	0.03259	0.016187	0.01592
		12 months	**0.031797**	0.040265	0.032691	0.044931	0.055223	0.078586	0.047984	0.050432
		1 month	0.025204	0.025359	0.024374	0.023774	0.027809	0.027135	**0.02155**	0.024933
	1989 - 1997	6 months	0.012044	0.01238	0.013581	0.012605	0.01865	0.014942	**0.009815**	0.013615
		12 months	**0.026863**	0.027768	0.031393	0.029903	0.03991	0.031235	0.028769	0.032059
		1 month	0.011175	0.011592	9.79E-03	0.010187	**7.19E-03**	7.32E-03	0.010528	9.04E-03
CAD-AUD	1997 - 2005	6 months	0.00956	0.010208	0.009222	0.012156	0.010545	0.010631	0.011132	**0.009207**
		12 months	0.017536	0.015877	0.01972	**0.012894**	0.029357	0.028594	0.027723	0.022531
		1 month	3.28E-03	0.046409	1.55E-04	NA	3.49E-03	1.06E-03	**1.55E-04**	4.98E-04
	2005 - 2013	6 months	0.012776	0.040172	0.010649	NA	0.013428	0.011137	**0.010649**	0.011324
		12 months	0.023473	0.025411	0.019104	NA	0.021355	0.021831	**0.019104**	0.02026
		1 month	0.03645	0.037018	0.03008	0.030628	0.036708	**0.013817**	0.014433	0.024803
	1989 - 1997	6 months	0.019085	0.021073	0.01689	0.016346	0.027904	0.039256	0.025208	**0.013414**
		12 months	0.015426	0.017285	0.029087	**0.01459**	0.024941	0.043036	0.027436	0.017281
		1 month	5.58E-03	5.28E-03	6.07E-03	7.78E-03	**2.60E-03**	5.93E-03	8.55E-03	6.30E-03
CAD-GBP	1997 - 2005	6 months	0.010792	0.011142	0.011743	**0.010216**	0.011309	0.015896	0.02182	0.014048
		12 months	0.02823	0.02983	0.030118	**0.024066**	0.031238	0.042326	0.050307	0.035948
		1 month	8.33E-03	**6.63E-03**	1.09E-02	1.04E-02	0.011168	1.15E-02	0.011556	1.11E-02
	2005 - 2013	6 months	0.010755	**7.20E-03**	8.15E-03	0.009229	0.014711	0.01846	0.015114	0.012356
		12 months	**0.01546**	0.019757	0.019969	0.017059	0.019408	0.022776	0.021251	0.019685
		1 month	8.90E-03	9.52E-03	7.58E-03	8.10E-03	0.011474	9.17E-03	1.30E-02	**3.05E-03**
	1989 - 1997	6 months	0.036474	0.038622	0.037913	0.038743	**0.010835**	0.01395	0.025744	0.023952
		12 months	0.041674	0.045663	0.045576	0.046916	**0.012428**	0.015097	0.043183	0.029995
		1 month	2.59E-03	1.86E-03	**7.27E-04**	2.06E-03	0.01059	7.59E-03	7.56E-03	5.69E-03
CAD-USD	1997 - 2005	6 months	0.017942	0.020239	0.014642	0.012489	0.010437	9.23E-03	**6.82E-03**	7.13E-03
		12 months	0.034662	0.039257	0.03337	0.02981	**0.010986**	0.013629	0.020004	0.019617
		1 month	5.44E-03	4.49E-03	6.33E-03	5.93E-03	1.13E-03	2.24E-03	**2.92E-04**	1.52E-03
	2005 - 2013	6 months	8.46E-03	0.010822	0.011393	0.011653	0.012351	0.008433	**6.00E-03**	0.008825
		12 months	7.71E-03	0.009583	0.010923	0.011349	0.009896	0.010433	0.01036	**7.66E-03**

MAE values in bold represent the lowest value on that row

MAE results for each forecast (2)

Pair	Period	Horizon	RW	RWD	ARMA	GARCH	FB	DF	HM	Model averaging
		1 month	**7.75E-03**	9.07E-03	0.01684	0.042892	0.013428	0.011587	0.016277	0.020302
	1989 - 1997	6 months	**0.020346**	0.024968	0.030005	0.050712	0.03775	0.028986	0.066009	0.042662
		12 months	**0.024165**	0.024459	0.027225	0.038309	0.032408	0.027908	0.058143	0.034912
		1 month	**0.015693**	0.016599	0.019007	0.017909	0.019891	0.016925	0.023447	0.019363
CHF-AUD	1997 - 2005	6 months	0.022538	0.02571	0.027734	0.026481	0.031344	**0.021789**	0.037443	0.028793
		12 months	0.029586	0.035477	0.038315	0.036514	0.045005	**0.026269**	0.046463	0.038347
		1 month	1.16E-03	**5.57E-04**	7.06E-03	4.06E-03	0.019486	0.011279	0.015095	0.011263
	2005 - 2013	6 months	0.014248	**0.013949**	0.017233	0.015698	0.060756	0.045855	0.048159	0.034688
		12 months	0.036686	**0.033695**	0.045444	0.039184	0.101789	0.087108	0.09	0.070845
		1 month	0.032931	0.034406	0.033895	0.03383	0.026218	0.021695	**0.021055**	0.027753
	1989 - 1997	6 months	0.03213	0.037294	0.036558	0.036328	0.036814	0.023737	**0.014651**	0.030064
		12 months	0.028926	0.038517	0.037393	0.036965	0.042156	0.021326	**0.014737**	0.030011
		1 month	4.52E-03	0.026603	3.46E-03	**1.50E-03**	0.010264	9.61E-03	0.017228	6.10E-03
CHF-CAD	1997 - 2005	6 months	0.014684	0.021091	0.010271	**0.008999**	0.010567	0.011774	0.019164	0.010015
		12 months	0.038307	0.025951	0.028633	**0.023874**	0.024539	0.025068	0.024483	0.024345
		1 month	4.94E-03	4.77E-03	2.31E-03	2.68E-03	5.93E-03	3.37E-03	**1.40E-03**	3.15E-03
	2005 - 2013	6 months	4.94E-03	**4.61E-03**	6.15E-03	5.31E-03	7.00E-03	0.021488	6.31E-03	4.74E-03
		12 months	0.01514	0.014148	**7.33E-03**	0.008418	0.02251	0.04302	0.012265	0.016039
		1 month	3.79E-03	2.89E-03	7.54E-03	6.85E-03	9.14E-03	5.80E-03	**1.02E-04**	5.97E-03
	1989 - 1997	6 months	0.013891	0.016757	0.013686	0.013319	**8.92E-03**	0.013123	0.033519	0.015797
		12 months	0.016367	0.022099	0.018003	0.016132	**0.008713**	0.017646	0.043879	0.019951
		1 month	0.010009	0.010196	9.74E-03	9.37E-03	**5.41E-03**	9.40E-03	7.46E-03	8.37E-03
CHF-GBP	1997 - 2005	6 months	0.014761	0.015418	0.015074	0.01385	**0.01341**	0.027517	0.022187	0.018223
		12 months	0.01553	0.016751	0.016013	**0.014503**	0.017599	0.039121	0.035211	0.023991
		1 month	0.013074	0.011204	0.011204	0.013403	0.011296	**4.95E-03**	0.011777	0.010661
	2005 - 2013	6 months	0.014014	7.47E-03	7.47E-03	0.015166	0.013458	**4.56E-03**	0.024259	0.012094
		12 months	0.011763	0.009599	0.009599	0.013902	0.016853	**6.60E-03**	0.035759	0.014447
		1 month	8.90E-03	9.52E-03	**7.58E-03**	8.10E-03	0.017231	0.01754	0.035613	0.016459
	1989 - 1997	6 months	**0.036474**	0.038622	0.037913	0.038743	0.04718	0.044925	0.059063	0.044996
		12 months	**0.041674**	0.045663	0.045576	0.046916	0.061528	0.052798	0.066236	0.054007
		1 month	2.59E-03	1.86E-03	**7.27E-04**	2.06E-03	0.019071	0.016294	0.026039	0.011535
CHF-USD	1997 - 2005	6 months	0.017942	0.020239	0.014642	**0.012489**	0.061483	0.052938	0.084947	0.044601
		12 months	0.034662	0.039257	0.03337	**0.02981**	0.11267	0.09219	0.099578	0.073037
		1 month	5.44E-03	4.49E-03	6.33E-03	0.039931	3.48E-03	**1.34E-03**	1.36E-03	8.54E-03
	2005 - 2013	6 months	8.46E-03	0.010822	0.011393	0.029541	9.14E-03	8.24E-03	**7.48E-03**	8.25E-03
		12 months	7.71E-03	0.009583	0.010923	0.031493	7.64E-03	0.00869	0.010038	**7.42E-03**
		1 month	**1.60E-03**	2.65E-03	5.83E-03	2.96E-03	0.010975	0.01588	3.42E-03	7.69E-03
	1989 - 1997	6 months	0.018374	**0.018199**	0.01955	0.019539	0.027775	0.04063	0.029543	0.023145
		12 months	0.022106	0.017025	0.014416	0.024778	0.016422	0.038088	0.022699	**0.014323**
		1 month	1.86E-03	2.52E-03	9.53E-03	0.01082	1.87E-03	0.013212	0.012131	**7.87E-04**
JPY-AUD	1997 - 2005	6 months	0.012408	0.014715	0.024012	0.023821	0.012358	**7.91E-03**	7.96E-03	0.011117
		12 months	0.022013	0.026298	0.036151	0.035948	0.024296	0.020913	**0.011239**	0.023886
		1 month	0.025552	0.025031	0.025797	0.030954	0.016674	**0.01422**	0.017906	0.021636
	2005 - 2013	6 months	0.027199	0.025697	0.044907	0.026437	0.012978	**0.012522**	0.037575	0.024163
		12 months	0.020025	0.018102	0.04647	0.019853	**0.012993**	0.019365	0.038989	0.017648

MAE values in bold represent the lowest value on that row

MAE results for each forecast (3)

Pair	Period	Horizon	RW	RWD	ARMA	GARCH	FB	DF	HM	Model averaging
		1 month	0.028395	0.029618	0.025679	0.025244	0.028159	0.02855	**3.09E-03**	0.022358
	1989 - 1997	6 months	0.018662	0.020517	0.018617	0.017757	0.018206	0.018227	**0.015634**	0.016847
		12 months	0.017956	0.024689	0.020616	**0.014501**	0.022704	0.022718	0.01581	0.017362
		1 month	9.55E-03	9.31E-03	7.85E-03	**2.73E-03**	6.66E-03	5.28E-03	0.015569	7.35E-03
JPY-CAD	1997 - 2005	6 months	**0.01163**	0.011911	0.028421	0.017581	0.012942	0.011882	0.013071	0.014217
		12 months	**0.034337**	0.035621	0.057195	0.041042	0.036028	0.038711	0.035266	0.040589
		1 month	0.021817	0.021609	0.018425	0.021931	**0.016031**	0.02389	0.036987	0.023961
	2005 - 2013	6 months	0.029637	0.028912	0.034405	**0.027932**	0.041475	0.036869	0.093379	0.048639
		12 months	0.034014	0.032667	0.044887	**0.027458**	0.058241	0.039285	0.105148	0.056993
		1 month	6.04E-03	6.31E-03	4.55E-03	4.78E-03	4.15E-03	**3.54E-04**	0.013863	4.05E-03
	1989 - 1997	6 months	0.017196	0.018127	**0.011325**	0.011676	0.014186	0.014016	0.047265	0.014543
		12 months	0.01849	0.019199	0.017999	0.017358	0.021431	**0.016696**	0.051744	0.01838
		1 month	0.013465	0.01371	0.015252	0.015391	0.013382	**0.011285**	0.0151	0.014156
JPY-CHF	1997 - 2005	6 months	**0.009658**	0.010515	0.012929	0.017436	0.019799	0.011341	0.019074	0.016089
		12 months	**0.008284**	0.009127	0.011976	0.022439	0.022887	0.01082	0.019293	0.017523
		1 month	0.026687	0.026308	**0.026308**	NA	0.030004	0.033454	0.03685	0.031508
	2005 - 2013	6 months	0.033156	0.031831	**0.031831**	NA	0.052345	0.051703	0.075776	0.052396
		12 months	0.048592	0.046132	**0.046132**	NA	0.075168	0.069015	0.121852	0.077248
		1 month	0.015407	0.016156	0.011067	0.010342	0.019649	0.011772	**5.04E-03**	0.011419
	1989 - 1997	6 months	0.015165	0.01663	0.009236	0.00957	0.032555	0.01353	0.04078	**0.008571**
		12 months	0.015864	0.019608	0.013178	0.013314	0.051506	0.01399	0.053208	**0.01265**
		1 month	3.71E-03	3.71E-03	5.29E-03	**2.35E-04**	7.77E-03	0.011138	0.011822	7.05E-03
JPY-GBP	1997 - 2005	6 months	**5.36E-03**	5.36E-03	6.71E-03	5.63E-03	7.48E-03	0.015847	0.02217	6.77E-03
		12 months	**6.74E-03**	6.76E-03	0.011167	0.00968	6.90E-03	0.013964	0.019457	7.11E-03
		1 month	0.02205	0.02386	**0.014279**	0.019614	0.021105	0.027467	0.023281	0.021119
	2005 - 2013	6 months	0.040022	0.046356	0.045881	0.03705	**0.022409**	0.029848	0.054995	0.037863
		12 months	0.056733	0.068495	0.06798	0.052354	**0.02189**	0.029695	0.074576	0.049072
		1 month	8.50E-03	8.93E-03	**3.86E-03**	0.011526	6.61E-03	0.01029	0.014105	9.18E-03
	1989 - 1997	6 months	0.025494	0.026989	0.034096	0.031926	0.029951	0.044034	**0.022053**	0.032517
		12 months	0.025477	0.028255	0.049654	0.033145	0.030902	0.046058	**0.015526**	0.035297
		1 month	1.82E-03	**1.27E-03**	1.39E-03	2.34E-03	6.47E-03	0.012057	0.020531	8.00E-03
JPY-USD	1997 - 2005	6 months	0.010336	0.012075	**0.009805**	0.011875	0.03624	0.027451	0.042269	0.025529
		12 months	0.0277	0.031179	**0.025039**	0.027551	0.06539	0.052148	0.064598	0.046893
		1 month	0.019658	0.020662	0.032892	0.026218	**0.01916**	0.021778	0.023848	0.024839
	2005 - 2013	6 months	**0.0567**	0.060213	0.083488	0.079206	0.064358	0.069058	0.063511	0.07211
		12 months	**0.07001**	0.076534	0.110594	0.106173	0.08372	0.0902	0.079997	0.094433
		1 month	**6.93E-03**	7.26E-03	0.010509	NA	0.010537	0.018623	0.020395	0.015213
	1989 - 1997	6 months	0.01379	0.012769	0.011526	NA	0.018698	**6.06E-03**	0.009276	6.55E-03
		12 months	0.011883	0.010724	0.017637	NA	0.018089	**6.10E-03**	7.84E-03	6.25E-03
		1 month	1.92E-03	2.47E-03	**1.05E-04**	2.56E-03	2.93E-03	8.99E-03	4.85E-04	2.88E-03
USD-GBP	1997 - 2005	6 months	0.00902	0.010923	0.016008	0.009612	**5.78E-03**	0.011078	0.010367	0.007117
		12 months	0.023196	0.02673	0.042423	0.021475	**0.015062**	0.017315	0.027791	0.023386
		1 month	1.96E-03	2.77E-03	2.33E-03	2.62E-03	5.82E-03	5.74E-03	**6.18E-04**	3.40E-03
	2005 - 2013	6 months	0.017385	0.014833	**0.011985**	0.020756	0.034869	0.043155	0.033718	0.028534
		12 months	0.015333	0.013874	**0.013145**	0.019757	0.028932	0.038317	0.029116	0.02345

MAE values in bold represent the lowest value on that row

APPENDIX VIII

AIC, Δ and weights (1)

		AIC					Δ					Weight				
		ARMA	GARCH	FB	DF	HM	ARMA	GARCH	FB	DF	HM	ARMA	GARCH	FB	DF	HM
AUD-GBP	1989 - 1997	-5.444024		-5.336897	-5.350671	-5.310149	0		0.107127	0.093353	0.133875	26.06%		24.70%	24.87%	24.37%
	1997 - 2005	-5.601999	-5.605695	-5.478855	-5.553734	-5.584552	0.003696	0	0.12684	0.051961	0.021143	20.37%	20.41%	19.15%	19.88%	20.19%
	2005 - 2013	-5.647188		-5.750146	-5.882419	-5.767074	0.235231		0.132273	0	0.115345	23.59%		24.83%	26.53%	25.05%
AUD-USD	1989 - 1997	-6.407566	-6.458912	-6.346076	-6.329554	-6.327963	0.051346	0	0.112836	0.129358	0.130949	20.33%	20.86%	19.72%	19.55%	19.54%
	1997 - 2005	-5.680596	-5.660163	-5.673453	-5.696405	-5.558668	0.015809	0.036242	0.022952	0	0.137737	20.26%	20.06%	20.19%	20.42%	19.06%
	2005 - 2013	-5.028439	-5.210485	-4.95992	-5.012589	-5.155445	0.182046	0	0.250565	0.197896	0.05504	19.53%	21.40%	18.88%	19.38%	20.81%
CAD-AUD	1989 - 1997	-6.532614	-6.575729	-6.351417	-6.340661	-6.214747	0.043115	0	0.224312	0.235068	0.360982	21.29%	21.76%	19.45%	19.34%	18.16%
	1997 - 2005	-6.309106	-6.29698	-6.173611	-6.107503	-6.142498	0	0.012126	0.135495	0.201603	0.166608	21.04%	20.91%	19.66%	19.02%	19.36%
	2005 - 2013	-6.008615		-5.744219	-5.793354	-5.734481	0		0.264396	0.215261	0.274134	27.43%		24.03%	24.63%	23.91%
CAD-GBP	1989 - 1997	-5.669407	-5.653841	-5.468955	-5.753244	-5.669191	0.083837	0.099403	0.284289	0	0.084053	20.24%	20.09%	18.31%	21.11%	20.24%
	1997 - 2005	-6.245758	-6.096205	-5.892763	-6.336312	-6.347039	0.101281	0.250834	0.454276	0.010727	0	20.56%	19.08%	17.23%	21.51%	21.63%
	2005 - 2013	-6.131942	-6.075753	-5.862631	-5.884794	-5.935267	0	0.056189	0.269311	0.247148	0.196675	21.57%	20.97%	18.85%	19.06%	19.55%
CAD-USD	1989 - 1997	-5.542556	-5.590839	-5.383749	-5.315868	-5.305722	0.048283	0	0.20709	0.274971	0.285117	21.14%	21.66%	19.53%	18.88%	18.78%
	1997 - 2005	-5.867189	-5.836481	-5.910444	-5.744979	-5.728638	0.043255	0.073963	0	0.165465	0.181806	20.49%	20.18%	20.94%	19.28%	19.12%
	2005 - 2013	-5.375844	-5.396139	-5.504314	-5.678654	-5.652312	0.30281	0.282515	0.17434	0	0.026342	18.56%	18.75%	19.79%	21.59%	21.31%
CHF-AUD	1989 - 1997	-5.250356	-5.15216	-4.993506	-5.124505	-5.145364	0	0.098196	0.25685	0.125851	0.104992	21.19%	20.17%	18.64%	19.90%	20.11%
	1997 - 2005	-5.409537	-5.291974	-5.224061	-5.281513	-5.119352	0	0.117563	0.185476	0.128024	0.290185	21.47%	20.25%	19.57%	20.14%	18.57%
	2005 - 2013	-5.763378	-5.770232	-5.65344	-5.674403	-5.65223	0.006854	0	0.116792	0.095829	0.118002	20.61%	20.68%	19.51%	19.71%	19.49%
CHF-CAD	1989 - 1997	-5.410791	-5.328142	-5.05637	-5.072163	-5.042189	0	0.082649	0.354421	0.338628	0.368602	22.36%	21.45%	18.73%	18.87%	18.59%
	1997 - 2005	-5.947215	-5.872641	-5.76395	-5.687458	-5.732262	0	0.074574	0.183265	0.259757	0.214953	21.50%	20.71%	19.61%	18.88%	19.31%
	2005 - 2013	-5.475054	-5.486072	-5.418722	-5.386273	-5.305593	0.011018	0	0.06735	0.099799	0.180479	20.61%	20.72%	20.03%	19.71%	18.93%
CHF-GBP	1989 - 1997	-6.213202	-6.33537	-5.944894	-6.022902	-5.867359	0.122168	0	0.390476	0.312468	0.468011	21.33%	22.68%	18.65%	19.40%	17.94%
	1997 - 2005	-6.534015	-6.411445	-6.177516	-6.251042	-6.118828	0	0.12257	0.356499	0.282973	0.415187	22.43%	21.10%	18.77%	19.47%	18.23%
	2005 - 2013	-5.749032	-6.155896	-5.752285	-5.78987	-6.036627	0.406864	0	0.403611	0.366026	0.119269	18.51%	22.69%	18.54%	18.89%	21.37%

AIC, Δ and weights (2)

		AIC					Δ					Weight				
		ARMA	GARCH	FB	DF	HM	ARMA	GARCH	FB	DF	HM	ARMA	GARCH	FB	DF	HM
CHF-USD	1989 - 1997	-5.542556	-5.590839	-5.290492	-5.241523	-5.16117	0.048283	0	0.300347	0.349316	0.429669	21.77%	22.31%	19.20%	18.73%	17.99%
	1997 - 2005	-5.867189	-5.836481	-5.834396	-5.844228	-5.729004	0	0.030708	0.032793	0.022961	0.138185	20.45%	20.14%	20.12%	20.22%	19.08%
	2005 - 2013	-5.375844	-5.396139	-5.870736	-5.840189	-6.057311	0.681467	0.661172	0.186575	0.217122	0	16.78%	16.95%	21.50%	21.17%	23.60%
JPY-AUD	1989 - 1997	-5.311555	-5.450507	-5.144332	-5.24865	-5.204316	0.138952	0	0.306175	0.201857	0.246191	20.37%	21.84%	18.74%	19.74%	19.31%
	1997 - 2005	-5.428624	-5.471783	-5.121839	-5.128095	-5.283461	0.043159	0	0.349944	0.343688	0.188322	21.41%	21.88%	18.37%	18.43%	19.91%
	2005 - 2013	-4.783324	-4.978566	-4.625132	-4.510463	-4.587693	0.195242	0	0.353434	0.468103	0.390873	20.81%	22.94%	19.23%	18.15%	18.87%
JPY-CAD	1989 - 1997	-5.56168	-5.50771	-5.501418	-5.494299	-5.397594	0	0.05397	0.060262	0.067381	0.164086	20.70%	20.15%	20.08%	20.01%	19.07%
	1997 - 2005	-5.492073	-5.631279	-5.271045	-5.315863	-5.16122	0.139206	0	0.360234	0.315416	0.470059	21.14%	22.66%	18.93%	19.36%	17.92%
	2005 - 2013	-5.209541	-5.306779	-5.167682	-4.928698	-5.556511	0.34697	0.249732	0.388829	0.627813	0	19.66%	20.64%	19.25%	17.08%	23.38%
JPY-CHF	1989 - 1997	-5.804352	-5.861423	-5.873738	-5.809307	-6.025904	0.221552	0.164481	0.152166	0.216597	0	19.29%	19.85%	19.97%	19.34%	21.55%
	1997 - 2005	-5.472176	-5.542583	-5.240201	-5.21075	-5.216772	0.070407	0	0.302382	0.331833	0.325811	21.35%	22.11%	19.01%	18.73%	18.79%
	2005 - 2013	-5.387379		-5.26385	-5.188173	-5.195468	0		0.123529	0.199206	0.191911	26.64%		25.04%	24.11%	24.20%
JPY-GBP	1989 - 1997	-5.722772	-5.915282	-5.40227	-5.35106	-5.521015	0.19251	0	0.513012	0.564222	0.394267	21.33%	23.49%	18.17%	17.72%	19.29%
	1997 - 2005	-5.512632	-5.541203	-5.389681	-5.287971	-5.319987	0.028571	0	0.151522	0.253232	0.221216	21.02%	21.33%	19.77%	18.79%	19.09%
	2005 - 2013	-5.358674	-5.435228	-5.358783	-5.362477	-5.260257	0.076554	0	0.076445	0.072751	0.174971	20.03%	20.81%	20.03%	20.07%	19.07%
JPY-USD	1989 - 1997	-5.771448	-5.677239	-5.494659	-5.563389	-5.504871	0	0.094209	0.276789	0.208059	0.266577	21.73%	20.73%	18.92%	19.59%	19.02%
	1997 - 2005	-5.676648	-5.640239	-5.407136	-5.750814	-5.880976	0.204328	0.240737	0.47384	0.130162	0	20.00%	19.63%	17.47%	20.75%	22.15%
	2005 - 2013	-6.009243	-6.080241	-5.969738	-5.9494	-5.906796	0.070998	0	0.110503	0.130841	0.173445	20.25%	20.99%	19.86%	19.66%	19.24%
USD-GBP	1989 - 1997	-5.673701		-5.588568	-5.734064	-5.853319	0.179618		0.264751	0.119255	0	24.49%		23.47%	25.24%	26.79%
	1997 - 2005	-6.523659	-6.54386	-6.278857	-6.274485	-6.295863	0.020201	0	0.265003	0.269375	0.247997	21.41%	21.63%	18.95%	18.90%	19.11%
	2005 - 2013	-5.952358	-5.968336	-5.772476	-5.835366	-5.801338	0.015978	0	0.19586	0.13297	0.166998	20.87%	21.03%	19.07%	19.68%	19.35%