THIRD COUNTRY EFFECTS OF THE EUROPEAN UNION ON THE

MONETARY MODEL OF EXCHANGE RATE NEWS

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THIRD COUNTRY EFFECTS OF THE EUROPEAN UNION ON THE MONETARY MODEL OF EXCHANGE RATE NEWS

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MONETARY MODEL OF EXCHANGE RATE NEWS

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Rachel Michele Allen, daughter of John and Carol Allen, was born on August 31, 1982, in Birmingham, Alabama. She graduated from Mountain Brook High School in 2000. She attended The University of Alabama the same year, and graduated with a Bachelor of Science degree in Commerce and Business Administration in 2004. She entered Graduate School, Auburn University, in August 2004 were she held a graduate teaching assistantship.

THESIS ABSTRACT

THIRD COUNTRY EFFECTS OF THE EUROPEAN UNION ON THE

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This thesis investigates third country effects in the monetary model of exchange rate news. The goal of this thesis is to determine whether the country chosen as the third country makes a difference. US variables as the third country in the monetary model of exchange rate news have been shown to have a significant effect on the model. This thesis examines whether the European Union has had a similar effect on the pound-sterling/dollar and yen/dollar exchange rates. This hypothesis is empirically tested by adding EU macroeconomic variables to the monetary model of exchange rate news. The EU does not affect the pound sterling/dollar and yen/dollar exchange rates, leading to the conclusion that the country chosen as the third country in the monetary model of exchange rate news affects model estimation.

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CHAPTER I

INTRODUCTION

Exchange rates, by nature, are volatile and difficult to predict. They tend to be much more volatile in the short run than the macroeconomic time series used to predict their movements, making short run forecasting difficult. Fundamental-based models over long-run horizons have proven to be much more effective, yet for foreign investors whose performance is evaluated over relatively short spans of time, long-run forecasts do not provide much useful information. Medium-run models, like the monetary model of exchange rates, would likely provide the most useful information for fund manager but these models might be influenced by macroeconomic variables (Rosenberg, 2003). The influences of macroeconomic variables on bilateral exchange rate models and third country effects on these models will be the focus of this thesis.

Various theories have been developed to explain exchange rate movements. A widely employed class of exchange rate models is known as the asset market approach which assumes perfect capital mobility, so the exchange rate adjusts instantaneously to equilibrate the international demand for stocks and national assets as in Frankel (1993). This theory is contrary to the belief that exchange rate behavior could be explained in terms of clearing international trade flows of goods and services.

One popular version of the asset approach is the simple monetary approach by Frenkel (1976), Johnson (1976), Dornbusch (1976), and Bilson (1978) where the exchange rate is determined by the relative demand and supply of money. Another version of the asset-market model is the portfolio balances approach by Frankel (1982, 1983) where the exchange rate is determined by supply and demand for all financial assets as developed by Hoffman and Schlagenhauf (1985) There are many different variations on these approaches reviewed by Frankel (1983), such as the flexible-price monetary model of Frenkel and Bilson (1987), the sticky-price monetary model[1] of Dornbusch (1976) and Frenkel (1976, 1981), and the sticky-price asset model[2] of Hooper and Morton (1982). These models provide a basis for explaining exchange rate movements but have had limited empirical success.

The monetary approach is utilized in the present thesis. It was developed in the late 1970s after the collapse of the Bretton Woods system. The Bretton Woods system kept the dollar convertible to other currencies at a fixed rate of $35 per ounce of gold, which defined the dollar as standard international currency. Other currencies were pegged at exchange rates against the dollar. An excessive balance-of-payments deficit in the US, sharp increase in US money supply, and doubts about the liquidity of international currencies led to the collapse of the Bretton Woods system in 1972 as discussed by Rivera-Batiz and Rivera-Batiz (1994). Both the $/£and $/¥ exchange rates were thereafter allowed to float as discussed by Chrystal and MacDonald (1995).

The monetary model assumes money market equilibrium, equating demand and supply of both the home and foreign money. There was early optimism for this approach

[1] This model allows for short-run deviations from purchasing power parity (PPP) which Suggests that the prices of goods in countries will tend to equate under floating exchange rates so that people would be able to purchase the same quantity of goods in any country for a given sum of money

[2] This model incorporates long-run PPP level movements by assuming the movements take place in response to current account deficits or surpluses.

but it has had little success in effectively predicting movements in exchange rates

Rosenberg (2003) states that, "…the monetary approach is widely regarded as an incomplete theory of exchange rate determination because it ignores other important explanatory variables…".

It has been suggested by Frenkel (1981) that the volatility of exchange rates could be caused by unanticipated news that affects interest rates. If the foreign-exchange market is operating efficiently, all information available would be conveyed in current prices. Expectations regarding future exchange rates should accurately be reflected in the forward exchange rate. In markets of this nature all new information is immediately reflected in price changes eliminating any profit from speculative investment.[3]

This property implies that fluctuations in the market are due to new information that cannot be predicted, news not reflected in the forward rate. Frenkel (1981) shows that predicted changes in exchange rates account for a very small fraction of the actual changes (p 674) meaning the bulk of the movement in exchange rates is due to news. Exchange rate news is defined as the difference between the spot and forward exchange rate at time t, and news in the macroeconomic explanatory variables is defined as the difference between the actual and some optimally predicted value at time t.

A recent paper by Jackson, Thompson, and Zheng (2005) explores how a third country added to the monetary model of exchange rates news could have an effect on exchange rate news. If investors in countries hold foreign bonds, third country news

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[3] The foreign-exchange market is characterized by volatile and unpredictable movements in price; characteristics shared by auctions and organized asset markets. (Frenkel 1981)

added to the model can affect other variables. They find that the “third country” news does have an effect on exchange rate news when the third country is the United States.

The present question is whether these results hold for other countries. For instance does euro news have an effect on the ¥/$ and £/$ exchange rates? To answer this question I will replicate the tests of Jackson, Thompson and Zheng with the Eurozone[4] as the “third country”.

The purpose of the present study is to determine if the euro has an effect on the UK pound-sterling/US dollar (£/$) and Japanese yen/US dollar (¥/$) bilateral exchange rates. The ¥/$ exchange rate is examined to see if the exchange rate between two countries not involved directly in the EU would be affected by the economic activity of the EU. The £/$ exchange rate is chosen because of United Kingdom’s decision to not adopt the euro as it national currency and the major role the pound plays in international financial markets.

The UK joined the European Community, a political and economic group of countries, in 1973. The Maastricht Treaty of 1993 officially established the European Union (EU) as an economic and monetary union, but also provided an opt-out clause for the UK. The UK withdrew from the Exchange Rate Mechanism (ERM) in October 1992. The ERM is the system for controlling exchange rates within the European Monetary System (EMS) that fixed member countries currencies against each other within a narrow

[4] Eurozone is the subset of European Union member states which have adopted the Euro as their official currency, creating a currency union. Eurozone member countries include: Austria, Belgium, Finland, France (except pacific territories using CFP franc), Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain.

band of fluctuation based on a central European Currency Unit (ECU). By the summer of 1992 German interest rates had reached nearly 10%. During that time output in the United Kingdom had declined nearly 4% and unemployment had topped 10%. Maintaining a fixed parity with the deutsche mark would require the UK to tighten monetary policy (US Government, 1994). This led to the UK's decision to drop out of the ERM and allow their exchange rate to float.

The euro was launched as the single European currency in January 1999, with the UK choosing to not adopt it as its national currency but to stay with the pound-sterling. The UK has not ruled out adopting the euro in the future depending on the success of the EU and the economic benefits of switching, which remain to be seen. This thesis will test whether the economic activity of the EU and the change-over to the euro had any effect on the £/$ exchange rate.

The Eurozone will be added as the third country to the monetary model of exchange rate news to see whether Eurozone variables affect the £/$ and ¥/$ exchange rate models. The affect of the Eurozone on the £/$ and ¥/$ will be tested by adding Eurozone income, interest rates, and money supply to the traditional monetary model of exchange rate news. Ordinary least squares regressions will determine whether the Eurozone variables affect the model.

CHAPTER II

REVIEW OF LITERATURE

This section presents and discuses literature relative to the monetary model of exchange rates, the overall usefulness of the monetary model is discussed, as well as possible reasons for the model's shortcomings. The volatile nature of exchange rate movements and the importance of news in explaining these movements is discussed , as well as the importance of third country news.

Meese and Rogoff's (1983a) early work on post-Bretton Woods exchange rate modeling remains on the forefront of the exchange rate literature. They find that it is difficult to explain and predict major-currency exchange rate movements, and that monetary models at horizons up to one year could not out-perform the simple random walk model. They suggest that a possible cause of the models poor performance is the instability of money demand and/or slow convergence to purchasing power parity (PPP).

In a companion study Meese and Rogoff (1983b) investigated the poor performance of exchange rate models, including the monetary model of exchange rates. They first use vector autoregressions (VAR) to identify the factors that influence the exchange rate over short versus long horizons using US to foreign relative money supplies, relative outputs, short-term and long-term interest rate differentials, and US and foreign trade balances. The US-UK VAR shows that own innovations in the exchange rate, the UK and US trade balances, and the long-term interest differential account for most of the forecast error variance. The VAR results also shows that own innovations in exchange rates explain a large portion of the forecast error variance at one-month and three-month forecast horizons, while innovations in the rest of the variables become relatively more important at horizons of one and three years. Meese and Rogoff also examine the predictive ability of structural models with constrained coefficients in explaining the exchange rate out of sample. They find that the structural models fail to forecast out of sample as well as the random walk model at horizons of up to twelve months. They suggest that the failure of the exchange rate models may be the result of volatile time-varying risk premiums, volatile long-run real exchange rates, and poor measurement of inflationary expectations or money demand specifications.

Husted and MacDonald (1998) encounter limited success with the monetary approach. They determine that to establish a suitable long-run relationship between exchange rates and macroeconomic variables, a period of around one hundred years should be studied. However, doing this involves using data from before the float, an important regime change, and accounting for this regime change is difficult. Their solution to this problem is to use panel data sets for the recent float to increase the span of data. To control for the potential non-stationary of the data a Levin and Lin unit root test, the panel equivalent to an augmented Dickey-Fuller statistic, is conducted. The US dollar, German mark, and Japanese yen bilateral exchange rates are examined in their study. Four different panel data sets are used; an international dollar-based data set, a European sample against both the US dollar and the German mark, and an international data set based on the Japanese yen.

Husted and MacDonald first formulated individual country estimates of the cointegrating vectors using the two-step estimator of Engle and Granger, known as two-step MAER cointegration. They also include standard augmented Dickey Fuller residual-based t-ratio test statistics and a Phillips-Perron t-ratio which has a non-parametric correction for serial correlation and heteroscedasticity. They find that there is no evidence of cointegration in the US-based bilaterals and one incidence of cointegration in both the DM-based bilaterals, and the Japanese-based bilaterals. The results of the two-step cointegration show that the US-based models have the lowest proportion of correctly signed coefficients. All of the foreign and domestic variables have less than half of the models with the correct signs. The Japanese and German-based models have much more success. In both the Japanese and German samples, home money supply, and foreign income and interest rates have a high portion of correctly signed coefficients.

The panel data exhibited results superior to those of the individual country estimates. Four estimators are used to test the usefulness of the panel estimates. They include: OLS with fixed effects; maximum likelihood estimates with fixed effects and a common AR1 process specified for the error term; maximum likelihood with fixed effects and an AR1 process which differs across individual units; and a maximum likelihood estimator which allows fixed effects. There is evidence of significant long-run relationships for all the panel combinations, especially the DM-based relationships. Overall, 90 out of a total 144 coefficients are correctly signed. The DM-based results have far more correct signs than does the US and yen-based results. The US and Japanese variables are wrongly signed in the DM-based system. Husted and MacDonald attributed the success of the German system to the fact that the central bank placed greater emphasis on money market developments during the sample period, and that the German simple sum aggregates are less prone to financial deregulation than US aggregates.

Husted and MacDonald estimate an error correction model (ECM) to check for the presence of cointegration. They find that the exchange rate regime makes a difference to the adjustment to equilibrium after a disturbance. Their results show that currencies on quasi-fixed regimes adjustment faster to the currency that they are anchored to, which in this case is the DM, and also relative to the currency to which they are floating, which is the US dollar.

There is little evidence of significant long-run relationships when looking at the single equation estimates but when the panel data sets are used evidence of a significant long-run relationship for all the panel combinations are found. The DM-based relationships showed the highest percentage of correct signs on the monetary coefficients, with the US and yen-based show evidence of significant long-run relationships as well. One explanation of the performance of the DM relationships is that a lot of the European countries are managed on DM-based system during the period studied, so the coordination of monetary policies across countries could affect the success of the monetary model of exchange rates.

Frenkel (1981) investigates the efficiency of the foreign exchange market and the role to which news plays in explaining exchange rate movements. He begins by testing whether the forward exchange rate is an unbiased forecast of the exchange rate. To do this he regresses the log of the spot rate on the log of the forward rate,

$$e_t^{jk} = \alpha + \beta \, f_{t-1}^{jk} + \varepsilon_t \qquad (1)$$

where e_t^{jk} is the log of the spot rate, and f_{t-1}^{jk} is the log of the forward rate. If the forward rate is an unbiased forecast of the spot rate the constant term should not differ significantly from zero, and the slope coefficient should not differ significantly from one. Frenkel tests the bias of the $/£, $/franc, and $/DM exchange rates from 1973-1979. The individual hypotheses that the constant term does not differ significantly from zero, and the slope coefficient does not differ significantly from unity can not be rejected for the $/DM exchange rate, but are rejected for the $/franc and $/£ exchange rates. However, the joint hypothesis that the constant is zero and the slope coefficient is one can not be rejected for all three exchange rates.

Frenkel then analyzes the efficiency of the foreign exchange market with the idea that the spot exchange rate should reflect all currently available information. If the forward exchange rate reflects all information available at time t-1, then it should also reflect all information for time t-2, and additional lagged values. To test the efficiency of the market, Frenkel adds the lagged value of the forward rate to equation (1), for the three exchange rates used previously. The coefficient for the lagged value for all three equations does not differ significantly from zero, and the Durbin-Watson statistic indicates that the hypothesis that there is first-order autocorrelation present in the model is rejected, leading to the conclusion that the market for the $/franc, $/£, and $/DM exchange rates are operating efficiently.

Frenkel then tests whether it is unanticipated rather than anticipated changes in interest rates that are associated with changes in exchange rates. He finds that interest rate news is significant and positively correlated with exchange rate news for the $/£ exchange rated between 1973 and 1979, an inflationary period. The interest rate differential for the same period is not significant, implying that unanticipated changes in the exchange rate are at least partially due to innovations in the interest rate differential in periods of inflation.

Hoffman and Schlagenhauf (1985) examine the effect of news conveyed through unanticipated shocks in explanatory variables using a variety of exchange rate models, including the monetary, flow, real interest rate differential, overshooting, synthesis, and portfolio balance approaches. The $/franc, $/£, $/DM, and $/¥ exchange rates from 1973-1981 are examined. They applied an approach designed by Abel and Mishkin (1983) to test for market efficiency,

$$s_t - f_{t-1} = (X_t - Z_{t-1}\gamma)\beta + Z_{t-1}(\gamma - \gamma^*)\beta + \varepsilon_t \qquad (2)$$

where s_t is the spot exchange rate, f_{t-1} is the forward exchange rate, X_t is the vector of variables relevant to the determination of the spot rate, Z_{t-1} is the vector of variables that are relevant to the determination of X_t, β is a vector of coefficients, and ε_t is a white noise error term. The addition of $Z_{t-1}(\gamma - \gamma^*)\beta$ allows the testing of joint hypothesis of forward exchange market efficiency and investor rationality. γ is the matrix of structural coefficients weights that determine the stochastic structure of X_t. Rationality requires that γ coincides with the weights employed by investors in formulating their conditional forecasts of X_t. If this is not true, $\gamma^*$is an alternative “non-rational” matrix of weights that is implicitly employed by investors in forecasting futures X_t. They use a univariate fourth-order autoregressive process that they assume replicates rational investor expectations to form a forecast. They find that in most cases, this process generates white noise residuals.

Hoffman and Schlagenhauf, when using monthly data, find that the monetarist and real interest rate differential approaches are the best models to explain exchange rate movements. They find no evidence of a link between relative money shocks and exchange rates. However, unanticipated movements in real interest rates and relative income shocks are both significant in explaining movements in spot exchange rates. Using the R^2 criterion to compare the monetarist and portfolio balances models, one finds that the portfolio-balances specification is superior for the $/franc and $/¥ exchange rates, while the monetarist model is superior for the $/£ and $/deutsch-mark exchange rates.

When using quarterly data, the explanatory power of the equations fell dramatically. The real interest rate differential formulation is the superior equation possibly due to the significance of unanticipated changes in the real interest rate. Income shocks show less significance when monthly data is used, but their sign is generally consistent with the asset model.

Hoffman and Schlagenhauf also conduct joint rationality/efficiency tests to examine whether the weights assigned by economic agents are consistent with the parameter estimates in the model. For the quarterly data, no models show significant evidence against the rationality/efficiency assumption. However, both the $/franc, $/£ model reject the hypothesis for the portfolio balances approach. The $/franc also model rejects the hypothesis for the flow model. This is good news for the monetary model, as it held the rationality/efficiency assumption, and preformed well when compared to other models of exchange rates.

Jackson, Thompson, and Zheng (2005) theorize that the shortcomings of the monetary model are due to the omission of third country or ‘outside’ news from the model. The monetary model can be extended to include a third country by including the effects on interest rates of agents holding bonds belonging to a country other than the two directly involved in the exchange rate. There is also a potential influence of money supply and income news from the third country on the exchange rate. They also investigate the possible effects of unanticipated changes in the trade balance, government budget deficit, employment rate, and expected inflation on the exchange rates as a matrix of independent variables. They develop an ex ante measure of news through a procedure called a Saurman filter[5]. Only information available up to time t-1 is used to forecast the value for time t. The difference between the actual value and the forecasted value for time t is the measure of news. The $C/DM, DM/¥, and DM/£ models of exchange rates are examined with the US as the third country.

The news models without the US added fails to produce many significant coefficients, supporting the hypothesis of efficient markets and rational expectations. They find no significant variables at the 5% level. At the 10% level, money supply news in the $C/DM, interest rate news in the DM/£, and income news in the DM/¥ are significant.

When the US is added to the models as the third country, all the US news variables are significant at the 5% level in every model. There are no new variables significant for the other countries. Also, the addition of trade balance, government budget deficit, employment rate, and expected inflation news failed to explain any exchange rate

[5] Named for its creator D.S. Saurman. Jackson, Thompson and Zheng (2005)

news when US news is added to the model. Clearly, US news can explain some portion of exchange rate news, implying inefficiency in the market and a potential for arbitrage profit.

CHAPTER III

THEORETICAL MODEL

This section develops the simple model of the monetary model of exchange rate news. First, the simple monetary model of exchange rates is derived. Next, a third country is allowed to enter the model. Then, the model of exchange rate news is formulated by defining the process by which the variables are forecasted and presenting the news variables that will be modeled. Finally, the actual models to be estimated will be developed.

THE SIMPLE MONETARY MODEL OF EXCHANGE RATES:

The basis of the monetary model is the money market in equation (3) where all money that is supplied is demanded in both the home and foreign country. Real money supply is the exogenous nominal money supply, M, divided by the price level, P, (4). Money demand is an increasing function of domestic income, Y, and a decreasing function of the interest rate, r in (5). As income rises, demand for money increases due to the increased demand for liquidity in (5). If interest rates rise, the demand for money falls because people will want to buy bonds rather than hold it in cash due to increased returns. The model is stated

$$M_s = M_d \qquad (3)$$

$$M_s = M/P \qquad (4)$$

$$M_d = L(Y, r) \qquad (5)$$

By substitution,

$$M/P = L(Y,r) \tag{6}$$

By manipulation we obtain an equation for price levels,

$$P^{1,2} = M^{1,2}/L(Y^{1,2},r^{1,2}) \tag{7}$$

where 1 indicates home country and 2 indicates the foreign country.

Cassel (1916) points out that according to the quantity theory of money, the general price level varies in direct proportion to the quantity of money circulating in a country. Therefore, the rate of exchange between two countries must vary as the quotient of their respective circulating media. Cassel acknowledges that the quantity of money is generally not exactly known, and facts relating to the increase of the circulation are not known. However, it is possible to prove that the advance of the general price level is proportional to the increase of the money in circulation, so price increases can be used as an expression of inflation. Therefore, the exchange rate can be expressed as a ratio of home and foreign price levels.

This idea is known as purchasing power parity (PPP), a key assumption in constructing the monetary model of the exchange rate. If the PPP relationship does not hold, profits could be made by simply moving goods across borders. According to PPP, the price level in the home country equals the price level in the foreign country multiplied by the exchange rate, and a proportionality factor, γ,

$$P^1 = \gamma E^{12} P^2 \tag{8}$$

where E^{12} is the exchange rate between countries 1 and 2.

Rearranging (8) we can write an equation for exchange rates as a function of relative prices,

$$E^{12} = P^1/\gamma P^2 \quad (9)$$

Substituting (7) into (9), the exchange rate is a function of income, interest rates, and money supply of both the home and foreign countries,

$$E^{12} = L^2(Y^2,r^2)M^1/L^1(Y^1,r^1)M^2 \quad (10)$$

Demand is given by the Cagan (1956) functional form

$$L = AY^{\beta} \exp(\gamma r) \quad (11)$$

where A is a constant term, β is the income elasticity of money demand, and γ is the semi-elasticity of money demand with respect to interest rates. Taking the logarithm of both sides,

$$l = a + \beta y - \gamma r \quad (12)$$

where the lower case l, a, m, and y indicate the logarithm of their uppercase values. Taking the logarithm of (6) gives

$$l = m - p$$

Which is substituted into (12) to generates

$$m_j - p_j = a_j + \beta_j y_j - \gamma_j r_j,\ j=1,2 \quad (13)$$

for Country j.

Solving for price gives the equation,

$$p_j = -a_j - \beta_j y_j + \gamma_j r_j + m_j$$

Taking the logarithm of PPP in (8) and substituting produces,

$$e_t^{12} = (a^2 - a^1) + (m_t^{\,1} - m_t^2) + (\beta^2 y_t^{\,2} - \beta^1 y_t^{\,1}) + \gamma^1 r_t^{\,1} - \gamma^2 r_t^{\,2} + \varepsilon_t \quad (14)$$

for the two country model, where ε_t is a white noise disturbance term. This is the model that can be tested using ordinary least squares regression for the significance of money supply, income, and interest rates. According to the theory β_2, γ_1 and should be positive, and β_1, γ_2 should be negative.

FORMULATING NEWS VARIABLES:

The monetary model of exchange rate news is the focus of this thesis. Since traditional monetary models of exchange rate determination have had much success in forecasting variations in exchange rates it has been suggested that market fluctuations are due to new information that cannot be predicted, 'news'. In developing this model, accurate measures of news must be obtained for the exchange rates, income, interest rates, and money supply.

INCOME, INTEREST RATE, AND MONEY SUPPLY NEWS:

Developing a news version of income, interest rates, and money supply can be complicated. News is by definition unexpected. Therefore, by definition money supply, income, and interest rate news is the difference between forecasted and actual value. To forecast these variables a univariate time series technique, like an ARIMA model, can provide the best forecast. An *ex ante* rather than *ex post* measure of news will be used because it best replicates the process by which an economic agent would predict future values of these variables.

Measuring news *ex post* estimates the appropriate ARIMA model using data from the entire sample; the residuals from the model are the news measure. This does not provide an accurate measure of news in that it assumes the economic agent would know information at the beginning of the sample period that would not actually be available until the end of the sample period. While including data from the entire sample would be the simpler way to forecast the series, it would provide a misleading measure of news.

In contrast, an *ex ante* measure of news includes only past data in the forecast of individual observations. This method assumes the economic agent at time t-1 knows all relevant information up to and including that of period t-1, but knows nothing of period t. This method, while much more tedious than an *ex post* estimation, provides an accurate reflection of the forecasts made by economic agents.

A rolling ARIMA process is used to produce these forecasts. This process involves a combination of autoregressive, integrated, and moving average series that includes only prior data to forecast the next component of a series. To explain this process one must begin with the moving average series (MA). The MA process is used to smooth time series data. A moving average process regresses the variable on the error term and subsequent lags of the error term

$$Y_t = \varepsilon_t + \sum_{q=1}^{n} \beta_q \varepsilon_{t-q} \qquad (15)$$

where q is the number of lagged values of the error, representing the order of moving average.

The forecasted value for X_{n+1} is

$$f_{n,1} = \beta(X_n - f_{n-1,1}) \qquad (16)$$

The autoregressive process (AR) regresses the variable on lagged values of itself to produce a smooth series.

$$X_t = \sum_{p=1}^{n} \alpha_p X_{t-p} + \varepsilon_t \qquad (17)$$

where ε_t is zero-mean white noise error term and p is the number of lags, also symbolizing the order of autoregressive dimension.

The forecast value for X_{n+h} is

$$f_{n,p} = \alpha^{p} X_{n}. \tag{18}$$

The autoregressive-moving average mixes both processes so that

$$X_t = \sum_{p=1}^{n} \alpha_p X_{t-p} + Y_t, \tag{19}$$

The autoregressive-moving average model is symbolized by ARMA(p,q).

Wold's theorem states that any stationary series is composed of a self-deterministic portion and a moving average portion of infinite order (Jackson, Thompson, and Zheng 1005). If the data is not stationary, differencing the data will often produce a stationary series. If the data is differenced the model becomes an ARIMA(p,d,q) model where d is the order of differencing.

Estimation of the ARIMA process requires three steps:

(1) Identification: Values of p, d, and q are determined by examining the correlation and partial correlation plot

(2) Estimation: Values of α and β are estimated

(3) Diagnostic checking: The model is tested to determine if the residuals resemble a white noise process using a chi-square test.

The values are forecast until the diagnostic check shows that the residual is not white noise, meaning there is something left in the model to forecast. The model then has to be re-identified to account for the new information, then and re-estimated.

For the purpose of this thesis a process of the "rolling" ARIMAs, called a "Saurman filter" will produce an accurate forecast of the variables (Jackson, Thompson, and Zheng 2005). The ARIMA process uses the first 20 observations to forecast the 21st observation, and then includes in the actual value of the 21st observation to forecast the 22nd observation. The process continues until all of the observations have been forecast, or until the process fails to produce a white noise residual in which case it is, re-specified, re-estimated and run again until all observations have been forecasted.

There are 130 total observations, the first 20 are the 'hold out' group that is used to forecast the next, and subsequent observations. This gives a total of 110 forecasted observations.

Results of the rolling ARIMA process are presented in Table 1. To produce a forecast of US interest rates that replicates one that might be used by a financial professional, an AR (1) process is used for the first eight observations, from the first of quarter 1977 to the fourth quarter of 1978 (recall that the forecast begins with the 21st observation). After this point there is a regime change so the last 102 observations are estimated using an AR (6) process.

US money supply is estimated with an AR (1) process for the first 5 observations. There is then a change in the data which requires an ARI (5, 1) process to estimate the next 101 observations. From this point an ARIMA (5, 1, 5) process is used to estimate the remaining observations.

The US GDP data series contains multiple regime changes, making it a difficult series to forecast. The first 18 observations are forecast with an ARI (1, 1) process. The next 17 are forecast by an ARI ((8), 1) process. An ARI ((8 10), 1) process forecasts the next 20 observations. Observations 76-88 are forecast using an ARIMA ((9), 1, 1) process, then the following 30 with an ARIMA ((1 8 9 10), 1, 1) process. The last 12 observations are forecast with an ARIMA ((1 2 8 9 10 12), 1, 1) process.

UK interest rates are forecast with an AR (1) process for observations 21-95. The regime change after this point required an AR (2) process to forecast the last 35 observations.

UK money supply is forecast with an AR (1) process for only the first 5 observations. Then an ARIMA (1, 4, 1) process is used to forecast the next 62 observations. At this point there is another regime change so an ARIMA (4, 1, 1) process is used for the next 38 observations. A small change employs the use of an ARIMA (4, 2, 2) process for the next 4 observations. The final observation is forecast with an ARI (1, 1) process.

Like UK money supply, UK GDP is forecast with an AR (1) process for only the first 5 observations. The next 33 are forecast with an ARI (7, 1) process, and the last 72 are forecast with an ARI (8, 1) process.

EU interest rates are forecast with an AR (2) process for the first 62 observations. The last 48 are forecast with an ARI (2, 1) process.

Like UK money supply, EU money supply is forecast with an AR (1) process for only the first 4 observations. The remaining observations are forecast with an ARIMA (1, 4, 1) process.

An ARI (1, 1) process is used to forecast the first 21 EU GDP observations. Observations 42-53 are forecast with an ARI (4, 4) process. An ARI (4, 5) process is then used to forecast the next 37 observations. The next 20 observations are forecasted with an ARI ((4), (4), 2) process, and the final 20 observations are forecast with an ARIMA ((4), (4), 2, 1) process.

The entire set of 110 observations is forecast with an AR (2) process for Japanese interest rates.

Japanese money supply forecast for the first 21 observations is an ARI (1, 4) process. The next 40 observations are forecast with an ARI (3, 4, 3) process. The last 49 observations are forecast with an ARIMA (3, 4, 3) process.

Finally, Japanese GDP is forecast with an ARI (1, 1) process for the first 40 observations, and an ARI (2, 1) process for the final 70 observations.

Table 1
ARIMA Forecasting Process

Country	Variable	ARIMA Process
US	Interest Rate	AR (1) Observations 21-28
		AR (6) Observations 28-130
	Money Supply	AR (1) Observations 21-26
		ARI (5,1) Observations 27-128
		ARIMA (5,1,5) Observations 129-130
	GDP	ARI (1,1) Observations 21-38
		ARI ((8),1) Observations 39-55
		ARI ((8 10),1) Observations 56-75
		ARIMA ((9),1,1) Observations 76-88
		ARIMA ((1 8 9 10),1,1) Observations 89-118
		ARIMA ((1 2 8 9 10 12),1,1) Observations 119-130
UK	Interest Rate	AR (1) Observations 21-95
		AR (2) Observations 95-130
	Money Supply	AR (1) Observations 21-25
		ARIMA (1,4,1) Observations 26-87
		ARIMA (4,1,1) Observations 88-125
		ARIMA (4,2,2) Observations 126-129
		ARI (1,1) Observation 130
	GDP	AR (1) Observations 21-25
		ARI (7,1) Observations 26-58
		ARI (8,1) Observations 59-130
EU	Interest Rate	AR (2) Observations 21-82
		ARI (2,1) Observations 82-130
	Money Supply	AR (1) Observations 21-25
		ARIMA(1,4,1) Observations 26-130
	GDP	ARI (1,1) Observations 21-41
		ARI (4,4) Observations 42-53
		ARI (4,5) Observations 54-90
		ARI ((4)(4),2) Observations 91-110
		ARIMA ((4)(4),2,1) Observations 111-130
Japan	Interest Rate	AR (2) Observations 21-130
	Money Supply	ARI (1,4) Observations 21-41
		ARI (5,4) Observations 42-81
		ARIMA (3,4,3) Observations 82-130
	GDP	ARI (1,1) Observations 21-60
		ARI (2,1) Observations 61-130

The forecast values are used to obtain a measure of news for the final model. The actual measure of news is the difference between the actual and forecast values of the data. Accordingly, money supply news is given by

$$m_t^* = m_t - E_{t-1}(m_t) \tag{20}$$

where m_t is the log money supply, and $E_{t-1}(m_t)$ is the one period ahead forecast of money supply in period t-1. Income news is given by

$$y_r^* = y_t - E_{t-1}(y_t) \tag{21}$$

where y_t is the of log GDP, and $E_{t-1}(y_t)$ is the one period ahead forecast of GDP in period t-1. Interest rate news is given by

$$r_r^* = r_t - E_{t-1}(r_t) \tag{22}$$

where r_t is interest rates, and $E_{t-1}(r_t)$ is the one period ahead forecast of interest rates in period t-1.

EXCHANGE RATE NEWS:

Formulating a news variable for the exchange rate is fairly straightforward. Exchange rate news is the difference between the spot exchange rates and forward exchange rate. The forward exchange rate is an unbiased forecast of the spot exchange rate, and is relied upon for investment and trade purposes by investors and traders. The one period forward rate is preferred, because it contains the most up-to-date information on the expected exchange rate. The one period forward rate contains all information up to and including period t-1. The one period forward exchange rate is theoretically an unbiased forecast of the future spot rate, so that

$$E_{t-1}(e_t^{12}) = f_{t-1}^{12} \qquad (23)$$

where e is the spot exchange rate, f is the forward exchange rate, and 1 and 2 are the home and foreign countries, respectively.

To test whether the forward exchange rate is an unbiased forecast of the spot rate, the method used by Frenkel (1981) will be utilized. Recall that for this test the log of the one month forward rate is regressed on the log of the spot exchange rate,

$$e_t^{12} = \alpha + \beta f_{t-1}^{12} + \varepsilon_t \qquad (24)$$

If the forward rate is an unbiased forecast of the spot rate the constant term should not differ significantly from zero,

$H_O: \alpha = 0$

versus

$H_A: \alpha \neq 0$

and the slope coefficient should not differ significantly from one,

$H_O: \beta = 1$

versus

$H_A: \beta \neq 1$

Furthermore, if the market is operating efficiently the error terms from (24) should not be serially correlated.

The results of these tests for the £/\$ and ¥/\$ exchange rates are in Table 2. When examining the £/\$ three month forward rate, the null hypothesis that the intercept is zero, and the null hypothesis that the slope coefficient is one cannot be rejected, indicating that it is an unbiased forecast of the ¥/\$ spot rate. In the case of the ¥/\$ one-month forward rate, the null hypotheses that the intercept is zero and the slope coefficient is one can also not be rejected leading to the conclusion that the forward rate is an unbiased forecast of the ¥/$ spot rates.

Table 2
Forward Exchange Rate Efficiency

	Intercept	Slope
£/$	0.00	1.01
t-ratio[a]	0.02	0.37
¥/$	0.06	0.99
t-ratio[b]	1.50	1.22

[a] H_O: Intercept = 0
H_A: Intercept ≠ 0
[b] H_O: Slope = 1
H_A: Slope ≠ 1

The Durbin-Watson (DW) statistic for the ¥/$ model (1.72)[6] rejects the null hypothesis of first order autocorrelation, meaning the forward rate is an efficient forecast of the spot exchange rate. There is no significant evidence of first order autocorrelation in the £/$ model based on the DW statistic (1.71). The R-squared for the ¥/$ model is 0.99, and 0.97 for the £/$ model signifying a strong fit of both models. We infer then that the forward rate is an appropriate forecast of both the £/$, and ¥/$ exchange rates.

Exchange rate news is given by,

$$e_t^{12*} = e_t^{12} - f_{t-1}^{12} \tag{25}$$

The 'news' version of the model is therefore given by,

$$e_t^{12*} = (a^{2*} - a^{1*}) + (m_t^{1*} - m_t^{2*}) + (\beta_2 y_t^{2*} + \beta_1 y_t^{1*}) + \gamma_1 r_t^{1*} + \gamma_2 r_t^{2*} + \varepsilon_t \tag{26}$$

[6] The DW upper bound is 1.74 and the lower bound is 1.72

THIRD COUNTRY EFFECTS:

In the traditional view of the monetary model, third country effects cancel each other out so the exchange rate remains unchanged. According to Jackson, Thompson, and Zheng (2005), the canceling out effects can be seen by assuming money market equilibrium in the third country is given by

$$M_3/P_3 = A_3Y^{\beta}{}_3 \exp(\gamma_3 r_3) \qquad (27)$$

so that

$$p_3 = -a_3 + m_3 - \beta_3 y_3 \qquad (28)$$

where p, m, and y indicate the logarithms of their uppercase counterparts. Then making use of (14) for exchange rates between countries 1 and 3

$$e_t^{13} = (a^3 - a^1) + (m_t^{\,1} - m_t^3) + (\beta_3 y_t^{\,3} - \beta_1 y_t^{\,1}) + \gamma_1 r_t^{\,1} - \gamma_3 r_t^{\,3} + \varepsilon_t \qquad (29)$$

and countries 2 and 3

$$e_t^{23} = (a^3 - a^2) + (m_t^{\,2} - m_t^3) + (\beta_3 y_t^{\,3} - \beta_2 y_t^{\,2}) + \gamma_2 r_t^{\,2} - \gamma_3 r_t^{\,3} + \varepsilon_t \qquad (30)$$

Triangular arbitrage of exchange rates requires that

$$\begin{aligned} s^{12} &= s^{13} - s^{23} = (p^1 - p^3) - (p^2 - p^3) = (p^1 - p^2) + (p^3 - p^3) \\ &= (a^2 - a^1) + (m^1 - m^2) + (\beta^2 y_t^2 - \beta^1 y_t^1) + (\gamma^2 r_t^2 - \gamma^1 r_t^1) \\ &+ (a^3 - a^3) + (m^3 - m^3) + (\beta^3 y_t^3 - \beta^3 y_t^3) + (\gamma^3 r_t^3 - \gamma^3 r_t^3) + \varepsilon_t \end{aligned} \qquad (31)$$

Clearly, the last four terms are zero, making (27) equal to (14). The third country would have no effect on the bilateral exchange rate between countries 1 and 2.

According to Jackson, Thompson, and Zheng (2005), a third country can be allowed to enter the model by assuming economic agents hold bonds from the third country. The simple model it is assumed that residents of Country 1 and 2 hold only domestic money and domestic bonds. It is more likely that they hold assets from a variety of foreign countries. Assuming that residents of each country hold foreign and third country bonds in addition to domestic money and bonds would give the aggregate asset demand for Country j as

$$A_j = M_j + A_j^1 + A_j^2 + A_j^3 \tag{32}$$

Thus the demand for money in Country j is given by

$$L_{j,t} = A_{j,t}^{\beta_j} \exp(\gamma_{j,1} r_{1,t} + \gamma_{j.2} r_{2,t} + \gamma_{j,3} r_{3,t}) \quad j\text{=1,2,3} \tag{33}$$

Money market equilibrium in the j^{th} country implies that the logarithm of the domestic price level is given by

$$p_{j,t} = -a_j + m_{j,t} - \beta_j y_{j,t} - \gamma_{j,1} r_{1,t} - \gamma_{j,2} r_{2,t} - \gamma_{j,3} r_{3,t} \tag{34}$$

By manipulation, an equation for the exchange rate news between countries 1 and 2 is obtained

$$e_t^{12*} = (a^{2*} - a^{1*}) + (m_t^{1*} - m_t^{2*}) + (\beta_2 y_t^{2*} + \beta_1 y_t^{1*}) + \gamma_1 r_t^{1*} - \gamma_2 r_t^{2*} + \gamma_3 r_t^{3*} + \varepsilon_t \tag{35}$$

According to Jackson, Thompson and Zheng (2005), the third country money market equilibrating mechanism requires that third country interest rate news and money supply news also enter the model. To see this, consider an unexpected increase in Country 3's income. An increase in Y_t^3 increases the demand for cash balances in Country 3, which increases the interest rate in Country 3. The higher interest rate would attract a person to buy Country 3's bonds over Country 1 or Country 2's bonds, which causes a decrease in money demand and thus an increase in aggregate demand and the price level for both countries. This increase in the price level will result in an unexpected increase in the exchange rate between Countries 1 and 2. Similarly, an unexpected increase in Country 3's money supply would decrease Country 3's interest rate, and thus decreasing the exchange rate between Countries 1 and 2. The inclusion of Country 3's income and money supply generates the empirical model,

$$e_t^{12*} = \alpha_1 + \alpha_2 m_t^{\ 1} + \alpha_3 m_t^{\ 2} + \alpha_4 m_t^{\ 3} + \alpha_5 y_t^{\ 1} + \alpha_6 y_t^{\ 2} + \alpha_7 y_t^{\ 3} + \alpha_8 r_t^{\ 1} + \alpha_9 r_t^{\ 2} + \alpha_{10} r_t^{\ 3} + \varepsilon_t \quad (36)$$

EMPIRICAL MODELS:

The two country news version of the empirical model is given by,

$$e_t^{12*} = \delta_1 + \delta_2 m_t^{\ 1*} + \delta_3 m_t^{\ 2*} + \delta_4 y_t^{\ 1*} + \delta_5 y_t^{\ 2*} + \delta_6 r_t^{\ 1*} + \delta_7 r_t^{\ 2*} + \varepsilon_t \quad (37)$$

The models to be tested are as follows:

Model 1: $e_t^{21*} = \delta_1 + \delta_2 m_t^{\ 1*} + \delta_3 m_t^{\ 2*} + \delta_4 y_t^{\ 1*} + \delta_5 y_t^{\ 2*} + \delta_6 r_t^{\ 1*} + \delta_7 r_t^{\ 2*} + \varepsilon_t$ (38)

which is the simple monetary model of exchange rate news,

Model 2: $e_t^{21*} = \alpha_1 + \alpha_2 m_t^{\ 1*} + \alpha_3 m_t^{\ 2*} + \alpha_4 m_t^{\ 3*} + \alpha_5 y_t^{\ 1*} + \alpha_6 y_t^{\ 2*} + \alpha_7 y_t^{\ 3*} + \alpha_8 r_t^{\ 1*} + \alpha_9 r_t^{\ 2*} + \alpha_{10} r_t^{\ 3*} + \varepsilon_t$ (39)

which includes the third country variables, and

Model 3: $e_t^{21*} = \varphi_1 + \varphi_2 m_t^{\ 1*} + \varphi_3 m_t^{\ 2*} + \varphi_4 m_t^{\ 3*} + \varphi_5 y_t^{\ 1*} + \varphi_6 y_t^{\ 2*} + \varphi_7 y_t^{\ 3*} + \varphi_8 r_t^{\ 1*} + \varphi_9 r_t^{\ 2*} + \varphi_{10} r_t^{\ 3*} + \delta_{11}\text{Dummy} + \varepsilon_t$ (40)

which includes a dummy variable for the period after the third quarter of 1992, at the time the UK left the EMS, to see if that decision has any effect on the £/$ exchange rate. Where the superscript 1 signifies a US variable, 2 signifies a UK variable when testing the £/$ exchange rate, and a Japanese variable when examining the ¥/$ exchange rate, and 3 signifies a Eurozone variable.

These models will be run using an ordinary least squares (OLS) regression to estimate the coefficients. The OLS estimators are the most efficient linear unbiased estimators of the true parameter values in that they have the minimum variance of all linear unbiased estimators (Pindyck and Rubinfeld 1998).

CHAPTER IV

DATA

This section presents and discusses the data used in this paper. First, the bilateral exchange rates are presented. Next, the data that is used as a measure of income, interest rates, and money supply, and the source of this data is discussed. Finally, the interchangeability analysis by which a proxy for EU income and interest rates is chosen is explained.

EXCHANGE RATES:

Data from the first quarter of 1972 to the second quarter of 2004 is used in this thesis. The ¥/$ and £/$ bilateral exchange rate figures come from the International Monetary Fund Statistics (IMF) website. The ¥/$ one month and £/$ three month forward exchange rates are extracted from DataStream, which acquires these figures from Reuters.

INCOME, INTEREST RATES, AND MONEY SUPPLY:

As a measure of income, seasonally adjusted gross domestic product (GDP) is used for the UK and Japan, and not seasonally adjusted GDP for the US, all in logarithms. To measure interest rates, the Treasury bill rate is used for the US and UK, and the lending rate[6] is used for Japan. Money[7] is used as a measure of money supply for the US and Japan, while money plus quasi-money is used for UK, all in logarithms.

[6] The interest charged by the financier on the amount financed
[7] 'Money' as defined by the IMF

Data on these variables and the ¥/$ and £/$ spot exchange rates are obtained from the IMF website.

INTERCHANGEABILITY ANALYSIS:

To determine if the EU has an effect on the ¥/$ and £/$ bilateral exchange rates, EU income news, money supply news, and interest rate news are added to the monetary model of exchange rate news. The IMF provides data on Euro Area M1[8] dating back to 1972, which will be used as a measure of money supply. However, there is no EU income or interest rate data dating from the present back to 1972, the period of interest. There is data available on EU GDP, seasonally adjusted in billions, for the first quarter of 1998 to third quarter of 2004, and EU government bond yield from the first quarter of 1994 to the third quarter of 2004. Since quarterly data is used there are not enough observations to provide a reliable analysis of the EUs effect on the ¥/$ and £/$exchange rates. A proxy for EU income and interest rates must then be found for use in the analysis. A European country which has data available for the time period of interest would be the most appropriate choice for a proxy. There is available French seasonally adjusted GDP data, and three-month Treasury bill data for the time period studied. As well, there is data on German GDP, seasonally adjusted, and the lending rate available for this period. The process to determine which country should be used for which variable involves an interchangeability analysis to determine which is the more suitable proxy.

In obtaining a suitable proxy, the question of empirical interchangeability arises. Jackson and Dunlevy (1982) present three criteria for interchangeability. The weakest

[8] M1 is defined as currency and checking accounts deposits

criterion is rank correlation criterion which states that adequate proxies must have identical rankings for corresponding observations. Testing this criterion involves calculating Spearman's rank correlation coefficient R_s, for pairwise combinations of alternative proxies. If these proxies are adequate, a high positive R_s would be expected.

The second criterion, simple correlation criterion, involves pairwise simple correlation of alternative proxy series. This suggests that high, preferably perfect, correlation between alternative measures being considered is a necessary condition for them to be interchangeable.

The last and strongest criterion, and the one used in this paper, is the orthogonal regression criterion. The necessary and sufficient condition for interchangeability is that the alternative measures must be perfectly correlated in their logarithms and strictly proportional.

If alternative measures are perfectly correlated and if

$$Y_1 = AY_2^{\beta} \qquad (41)$$

then Y_1 increases less than, exactly, or more than proportionally to Y_2, as β is less than, equal to, or greater than unity. In log-linear for equation (41) is

$$y_1 = a + \beta y_2 \qquad (42)$$

where the lowercase letters indicate the log of their uppercase counterparts.

The first instinct would be to estimate β in (42) by ordinary least squares regression (OLS). However, the OLS regression assumes causality, implying EU income is determined by the proxy, which may not be the case. Proportionality rather than causality is desired when determining if a variable is a suitable proxy for income.

Jackson and Dunlevy (1982) point out that estimating (42) by OLS may introduce problems with errors in variables and contradictory distributional assumptions.

A more appropriate approach to estimating (42) is orthogonal least squares (ONLS) which minimizes the perpendicular distance from the actual values and fitted line, rather than the vertical or horizontal distance minimized in OLS. Minimizing the perpendicular distance is preferred because it assumes proportionality rather than causality.

The hypothesis being tested for interchangeability by ONLS is

H_O: $\beta_p = 1$

versus

H_A: $\beta_p \neq 1$

where β_p is the true ONLS regression slope,

$$\beta_p = [(\sigma_{22} - \sigma_{11}) + \sqrt{(\sigma_{11} - \sigma_{22})^2 - 4\sigma_{12}^{\ 2}}\ ]/2\sigma_{12} \tag{43}$$

where σ_{ij} is the covariance of variables i and j.

The test statistic for the null hypothesis follows a chi-squared distribution with 1 degree of freedom, and is characterized by,

$$\chi^2(1) = n[l_1\alpha'_{10}S^{-1}\alpha_{10} + (1/l_1)\alpha'_{10}S\alpha_{10} - 2] \tag{44}$$

where n is the sample size, S is the covariance matrix of variables i and j, l_1 is the consistent estimate of λ_1, the largest eigenvector of S_1, which is given by

$$\lambda_1 = [(\sigma_{22} - \sigma_{11}) + \sqrt{(\sigma_{11} - \sigma_{22})^2 - 4\sigma_{12}^{\ 2}}\ ]/2\sigma_{12} \tag{45}$$

Jackson and Dunlevy (1982) show that under the null hypothesis α_{10} is specified as

$$\alpha_{10}' = [1/\sqrt{1+\beta_p^2}, \beta_p / \sqrt{1+\beta_p^2}] \quad (46)$$

or

$$\alpha_{10}' = [\sqrt{2}/2, \sqrt{2}/2] \quad (47)$$

The χ^2 test will be used to determine which variable would be the best proxy.

Since French and German income and interest rates could presumably be used as proxies for EU income and interest rates, the question posed is which country's data is best suited for the model. To decide which country should be used data from both countries are used to estimate equation (42) by ONLS, and then compute the χ^2 value from equation (44). If one country fails to reject the null hypothesis that β_p equals one according to the χ^2 value, that countries data can be used as a one for one proxy for the EU data. However, if both countries reject the null hypothesis that β_p equals unity according to the χ^2 value, the data series with the β_p value closest to one is chosen as the proxy. That countries data is then divided by the obtained value of β_p. The transformed series will then be used as the proxy.

French GDP, in logarithms, is first tested as for its interchangeability. The results are presented on Table 3. The obtained βp value is 0.87, and the resulting χ2 value is 415.86 is measured against the critical value of 16.79. French GDP therefore rejects the null hypothesis that the slope estimator does not differ significantly from one.

Table 3
Interchangeability analysis

Country	Statistic	Income	Interest Rate
France	β_p	0.87	0.84
	$\chi^2(1)$	415.86	50.39
Germany	β_p	0.47	0.52
	$\chi^2(1)$	3206.4	89.08

German income, in logarithms, is then tested to determine if it is a better fit as a proxy for EU income. The obtained β_p value is 0.47 and the chi-squared value for is 3,206.41, which clearly rejects the null hypothesis, and is much higher than the chi-squared obtained in the French test. It is then concluded that German GDP is the less stable of the two estimates, and French GDP should be used instead.

Since the slope for French GDP is not one, it cannot be used as a one for one substitution. Instead French GDP has to be divided by the ONLS slope estimate of 0.87 for all observations, based the equation estimate for EU income in (41).

The same process is repeated to obtain a proxy for EU interest rates. French and German data is again examined as possible proxies. French interest rates are first tested for interchangeability. Results are shown on Table 3. β_p equals 0.84 and the chi-squared value when French interest rates are tested is 50.39, which rejects the null hypothesis that the slope coefficient does not differ significantly from one.

When testing German interest rates, β_p equals 0.32 and the chi-squared value is 89.08, which also rejects the null hypothesis, and is higher than the French value. Therefore, French interest rates will be used as the proxy for EU interest rates. Since the slope coefficient does differ significantly from zero, EU interest rate data will be divided by the slope coefficient, 0.84, for all observations.

CHAPTER V

EMPIRICAL RESULTS

This chapter presents and discusses the results of the econometric analysis of the traditional monetary model of exchange rate news, the third country news model, and the dummy model. The statistical significance and of the individual coefficient estimates and the interpretation of their significance is discussed. The estimators from each model are thoroughly analyzed to ensure that they are the best linear unbiased estimators. The analysis includes tests for the joint significance of the news coefficients, autocorrelation, model specification, and multicolinearity.

TRADITIONAL MONETARY MODEL OF EXCHANGE RATE NEWS:

Table 4 shows the results of the OLS estimation of Model 1, the monetary model of the £/$ and ¥/$ exchange rates.

If the market is operating efficiently, the coefficients in Model 1 should not differ significantly from zero. This is tested by the hypothesis,

Ho: $\delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = 0$

versus

H_A: at least one $\delta_j \neq 0$

This hypothesis is tested using an F-test. The corresponding F-statistic is at the bottom of Table 4. If the F-statistic is higher than the critical value, the null hypothesis is rejected.

Table 4
Monetary Model of Exchange Rate News

Variable	£/$	£/$ NW	¥/$	¥/$ NW
Intercept	0.00	0.00**	0.02*	0.02*
r^{US}	-0.00	-0.00	-0.00	-0.00
r^{UK}	0.01**	0.01*		
r^{JA}			-0.00	-0.00
m^{US}	0.37*	0.37*	-0.01	-0.01
m^{UK}	-0.03	-0.03		
m^{JA}			-0.06	-0.06
y^{US}	0.02	0.02	1.47	1.47
y^{UK}	0.69**	0.69*		
y^{JA}			1.38	1.38
Adj R^2	.07	0.07	-0.00	-0.01
DW	1.87	1.88	1.80	1.80
F-tests[A]	2.33	2.33	0.84	0.84

* Significant at the 5% level
** Significant at the 10% level
[A] $F_{critical}(6,100) = 2.19$ @ $\alpha = 0.05$

The obtained F-ratio for the £/$ model is 2.33, which rejects the null hypothesis that all coefficients are simultaneously zero at the alpha level of 0.05. This indicates that the there is some news present in the model that does effect £/$ exchange rate news. Specifically, the news variable or variables that affect exchange rate news are US money supply, UK income and UK interest rate news. US money supply news is significant at the 5% level and UK income news and interest rate news at the 10% level. The significance of news in this model implies that the market is not operating efficiently and/or there are not rational expectations.

The F-ratio for the ¥/$ model is 0.84, which fails to reject the null hypothesis that the coefficients are simultaneously zero. Only the intercept term in the model is significant. The lack of significance of the news variable coefficients indicates that this market is operating efficiently.

In the interest of completeness, hypothesis tests are run to check for the joint significance of any form of money supply, income, and interest rates news in both exchange rate models. The null hypothesis that the coefficients on both home and foreign money supply news, income news, and interest rate news are concurrently zero,

Ho: $\delta_a = \delta_b = 0$

versus

H_A: $\delta_a \neq 0$ or $\delta_b \neq 0$

will be tested, where subscript *a* designates a matrix of the three home country news variables and subscript *b* designates a matrix of foreign news variables.

Results of the joint significance tests for the £/$ and ¥/$ models are in Table 5. Both the income and interest rates tests for the ¥/$ model fail to reject the null hypothesis that the coefficients are simultaneously zero, meaning no form of income news or interest rate news has an effect on the exchange rates. However, money supply rejects the null hypothesis, meaning there is money supply news from at least one country affecting £/$ exchange rate news. Each joint significance test for the ¥/$ fail to reject the null hypothesis for all three macroeconomic variables, supporting the previous findings that there is no form of income, interest rate, or money supply news that has an influence of ¥/$ exchange rate movements.

Table 5
Joint Significance Test

Variable	£/$ [d]	¥/$ [d]
Income	1.6	2.31
Interest Rate	2.17	0.23
Money Supply	2.72	0.04

[d] $F_{critical}(3,100) = 2.72$ @ $\alpha = .05$

Autocorrelation could be an issue. The presence of autocorrelation means that the error terms from the regression are not independent from one period to the next. This results from a non-scalar covariance matrix. When autocorrelation is present the estimators remain unbiased but are inefficient. The Durbin-Watson (DW) statistic checks for the presence of first order autocorrelation in time series models. In the case of the £/$ model, the DW statistic rejects the null hypothesis of first order autocorrelation, while the DW statistic for the ¥/$ model falls in the area of indecision.

To ensure that autocorrelation is not a problem, a Newey-West correction is applied. A Newey-West correction for autocorrelation uses the variance estimator

$$V(\underline{b}) = (X'X)^{-1}[S_0 + \sum_{l=1}^{L}\sum_{i=l+1}^{n}(1-\frac{l}{L+1})e_i e_{i-l}(\underline{x}_i \underline{x}_{i-l}' + \underline{x}_{i-l}\underline{x}_i')](X'X)^{-1} \quad (44)$$

where according to Greene (2003)

$$L \approx T^{1/4} \tag{45}$$

and T is the number of observations. This correction will be run for both exchange rates with L = 3.

The results from this correction are presented on Table 4. The Newey-West correction does not change the coefficients in the £/$ or the ¥/$ model and the DW statistic remains unchanged, so first order autocorrelation and is not present in either model.

A Ramsey RESET test is used to test for errors in model specification for Models 1 and 2 for both exchange rates. The test involves running the model as is, saving the predicted values, then adding the squared, cubed, and fourth degree values of the predicted values to the original model. An F-test is then run for the hypothesis,

H_0: No model misspecification

versus

$H_{A:}$ Model misspecification

A rejection of the null hypothesis could result from omitted variables, irrelevant variables, incorrect functional form, measurement errors, or simultaneity. The RESET test does not indicate which type of specification error is present.

The Ramsey RESET test produces an F-ratio of 0.36 for the £/$ model. This is compared against the critical F(3,94) value of 2.70. Since the obtained value is less than the critical value, the model fails to reject the null hypothesis of correct model specification.

The RESET test for the ¥/$ model generates an F-ratio of 1.11, a value smaller than the critical value of 2.70. The null hypothesis of correct model specification is therefore not rejected for this model as well.

THIRD COUNTRY NEWS MODEL:

Model 2 includes the EU news variables and results of the OLS estimation of this model are in Table 6.

In the same model, the UK income news coefficient and interest rate news coefficient are significant at the 10% level while the US money supply news coefficient is no longer significant. Since none of the coefficients on EU variables are statistically significant and no new variable's coefficient's are found to be significant, it can be said that EU news has no effect on £/$ exchange rate news.

There are no significant coefficients in the ¥/$ model, suggesting that EU news has no effect on ¥/$ exchange rate news.

What, if any, impact the EU news has on the model is tested by the hypothesis,

Ho: $\alpha_4 = \alpha_7 = \alpha_{10} = 0$

versus

H_A: $\alpha_4 \neq 0$ or $\alpha_7 \neq 0$ or $\alpha_{10} \neq 0$

If the null hypothesis is rejected, third country news does have an effect on unanticipated movements in exchange rates, and Model 1 is not correctly specified.

Table 6
Third Country News Model

Variable	**£/$**	**£/$ NW**	**¥/$**	**¥/$ NW**
Intercept	0.00	0.00**	0.02*	0.02*
r^{US}	-0.00	-0.00	-0.00	-0.00
r^{UK}	0.00**	0.00*		
r^{JA}			-0.00	-0.00
r^{EU}	-0.00	-0.00	0.00	0.00
m^{US}	0.40	0.40**	0.12	0.12
m^{UK}	-0.03	-0.03		
m^{JA}			-0.05	-0.05
m^{EU}	-0.03	-0.03	-0.07	-0.07
y^{US}	-0.13	-0.13	1.40	1.40
y^{UK}	0.68**	0.68*		
y^{JA}			1.40	1.40*
y^{EU}	0.13	0.13	0.07	0.07
Adj R^2	0.05	0.05	-0.03	-0.03
DW	1.88	1.87	1.78	1.78
F-tests[B]	1.64	1.64	0.60	0.60

* Significant at the 5% level
** Significant at the 10% level
[B] $F_{critical}(9,100) = 1.97$ @ $\alpha = .05$

The hypothesis that the EU news coefficients are simultaneously zero is tested using an F-test. The F-ratio for the £/$ model is 0.34 compared to the critical F-value (3,100) of 2.73. The model clearly fails to reject the null hypothesis that the EU coefficients are simultaneously zero. The F-ratio for the ¥/$ model is 0.17, which is measured against the same critical value and also reject the null hypothesis. These results coupled with the lack of significant coefficients indicates that EU news has no effect on either £/$ or ¥/$ exchange rate news.

The DW statistic is again used to test for the presence of first order autocorrelation. For the £/$ model the DW statistic is 1.88, which falls in the rejection region for the null hypothesis that first order autocorrelation is present. The DW for the ¥/$ model is 1.78 which falls in the indecision region.

To again ensure that autocorrelation is not a problem in these models, a Newey-West correction is run for the £/$ and ¥/$ models and results are in Table 6. The Newey-West correction for the £/$ model changes the significance level of both UK income and interest rate news from 10% to 5%. US money supply is shown to be significant at the 10% level. The change in significance indicates a possible presence of first order autocorrelation.

The application of the Newey-West correction for the ¥/$ model made Japanese income significant at the 5% level. The significance of income suggests that there is first order autocorrelation in this model as well.

The Ramsey RESET test is run as well for both exchange rates models. The test for the £/$ model produces an F-ratio of 0.43 which is compared against the critical F-statistic of 2.70. Since the F-ratio is smaller than the critical value, the model fails to reject the null hypothesis of correct model specification.

The RESET test for the ¥/$ model generates an F-ratio of 1.37, which is again compared against the critical value of 2.70. Like the £/$ model, the null hypothesis of correct model specification cannot be rejected.

DUMMY MODEL

Model 3 will be run using an ordinary least squares regression for the £/$ exchange rate. The dummy is used to test whether the UK's decision to leave the ERM in October 1992 has an effect the £/$ exchange. The significance of the dummy would indicate that there is a change in the exchange rate after the third quarter of 1992 that needs to be accounted for in the model. This is tested by the hypothesis

Ho: $\delta_{11} = 0$

versus

H_A: $\delta_{11} \neq 0$

The model is not run for the ¥/$ exchange rate because there is no reason to believe that the crisis of the EMS would affect that exchange rate.

Results from the OLS estimation of Model 3 are presented on Table 7. The hypothesis that the coefficient on the dummy variable does not differ significantly from zero cannot be rejected at any level of significance indicating the crisis of the EMS does not affect the £/$ exchange rate news.

Table 7
Dummy Model

Variable	£/$
Intercept	0.00
r^{US}	-0.00
r^{UK}	0.00**
r^{EU}	-0.00
m^{US}	0.41
m^{UK}	-0.03
m^{EU}	-0.02
y^{US}	-0.13
y^{UK}	0.68**
y^{EU}	0.13
Dummy	0.01
Adj R^2	0.05
DW	1.88
F-tests	1.58^C

* Significant at the 5% level
** Significant at the 10% level
c $F_{critical}(10,100) = 1.93$ @ $\alpha = .05$

MULTICOLINEARITY:

The presence of multicolinearity in the models increases the standard errors creating a greater chance of a type II error. To check for the presence of multicolinearity auxiliary regressions are run for the US, UK, and Japanese news variables. Auxiliary regressions take one of the dependent variables from the model and estimate the coefficients using OLS estimation. A high R^2 in a regression indicates that there is information contained in one or more of the dependent variables that explains movements in the variable being modeled.

The US money supply news and EU money supply news models both had high R^2 values. After examining the significant variables in these models, it is clear that US money supply news and EU money supply news are highly correlated. This could be why US money supply news if found to be insignificant in the third country news model, after finding it to be significant in the traditional monetary model of exchange rate news £/$ model. However, it is highly unlikely that these results affected the estimators of interest in this study.

CHAPTER VI

SUMMARY AND CONCLUSION

The aim of this research is to test the effect the EU has had on the £/$ and ¥/$ bilateral exchange rates by adding EU income, interest rates, and money supply to the monetary model of exchange rate news. Chapter I introduces the monetary model of exchange rates and the concept of 'news' and why it is of interest when studying models of exchange rate behavior.

Chapter II reviews the literature relevant to this thesis. Meese and Rogoff (1983) show that the monetary model of exchange rates fails to out perform the simple random walk model. Husted and MacDonald (1998) found more success with the monetary model when examining the data in a panel rather than time series. It could be argued that the simple fact that they were examining a much larger amount of data could be the reason for their improved results. Frenkel (1981) argues that it is unanticipated movements in the variables that are of interest, not the movements in general. Jackson, Thompson, and Zheng (2005) examine the influence of third country or 'outside' news on the monetary model of exchange rate news.

Chapter III presents the theory relevant to the monetary model of exchange rate news. First the simple monetary model where the exchange rate is given as a function of home and foreign income, interest rates, and money supply, is developed. News is then introduced into the model. Exchange rate news is defined as the difference between the spot and forward exchange rate, an unbiased predictor of the spot rate. Income, interest rate, and money supply news is defined as the difference between forecasted and actual values. A process of rolling ARIMAs is used to obtain *ex ante* forecasts that accurately replicate the process by which economic agents make forecasts. A third country is then allowed to enter the model by including the effects of agents holding the third country bonds. The third country money market equilibrating mechanism requires that third country income and money supply are also included in the model. The three models tested were presented and explained.

Chapter V discusses the source of the data employed and the interchangeability analysis used to select a suitable proxy. French income and interest rates are found to be best suited as a proxy for EU income and interest rates.

Chapter IV details the results of the econometric analysis. Table 8 summarizes the results of the OLS estimation of the coefficients in Models 1 and 2 for the £/$ and ¥/$ exchange rates, and Model 3 for the £/$ exchange rate. Model 1 one was tested for market efficiency and rational expectations using OLS estimation of the coefficients. The £/$ model contains significant UK interest rate and income news and US money supply news. There is market information available that can be used to predict exchange rate movements. When there is information present that is not reflected in current prices arbitrage profits are possible. In this model, news accounts for variations in the exchange rate that might not be detected in the monetary model of exchange rates.

Table 8
Summary Results

Variable	Model 1 £/$	Model 2 £/$	Model 3 £/$	Model 1 ¥/$	Model 2 ¥/$
Intercept	0	0	0	0.02*	0.02*
r^{US}	0.00	0.00	0.00	0.00	0.00
r^{UK}	0.01**	0.00**	0.00**	-	-
r^{JA}	-	-	-	0.00	0.00
r^{EU}	-	0.00	0.00	-	0.00
m^{US}	0.37*	0.40	0.41	-0.01	0.12
m^{UK}	-0.03	-0.03	-0.03	-	-
m^{JA}	-	-	-	-0.06	-0.05
m^{EU}	-	-0.03	-0.02	-	-0.07
y^{US}	0.02	-0.13	-	1.47	1.40
y^{UK}	0.69**	0.68**	-	-	-
y^{JA}	-	-	-	1.38	1.40
y^{EU}	-	0.13	-	-	0.07

* Significant at the 5% level
** Significant at the 10% level

The ¥/$ model does not contain any significant variables indicating that all information available is reflected in the forward exchange rate. This market is operating efficiently eliminating the opportunity for arbitrage profits.

Model 2 determines the significance of EU news variables. In the £/$ and ¥/$ models EU news is not significant. News relating to EU income, interest rates, and money supply added as third country variables to the monetary model of exchange rate news does not help to explain £/$ or ¥/$ exchange rate news. These results indicate that third country news need not be considered when attempting to explain or predict exchange rate movements, but when coupled with the results of Jackson, Thompson, and Zheng (2005) suggest that the country chosen as the third country in the monetary model of exchange rate news affects the model estimation. In addition, the failure to include relevant variables implies model misspecification.

Jackson, Thompson, and Zheng (2005) find that the US news does have an effect on the $C/DM, DM/¥, and DM/£ exchange rates. One possible reason that the EU has no effect as the third country while the US does could be the relatively young life of the EU. The addition of the third country in the news model rests on investors holding the third countries bonds, but EU bonds have only been available for a small portion of the sample period. It is possible that the interest rates on EU bonds held by US, UK, and Japanese investors is insignificant with regards to international investment. If for instance an increase in EU interest rates does not attract a significant number of buyers from the US, UK and Japan to sell their domestic bonds and buy EU bonds the effects of the EU on the model would cancel out.

The use of France as a proxy for the EU presents a possible shortcoming of the tests and could be a reason that EU news variables have no effect. It is possible that the news proxies did not accurately reflect the behavior of the EU over that time period, resulting in inaccurate model estimations.

In modeling exchange rate behavior, examining news provides valuable information about the market being examined and possible inefficiencies in the market. The effectiveness of the monetary model of exchange rate news when a third country is added to the model depends on the investment behavior of citizens of countries 1 and 2. If their money demand is not affected by changes in third country variables, it is unlikely that third country news will affect the exchange rate between other countries.

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