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Understanding Exchange Rates and the Euro

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Abstract

This paper investigates the exchange rate movements for EUR/USD, EUR/SEK and EUR/NOK using an OLS regression. Movements are tested against traditional and nontraditional explanatory variables for exchange rate movements. Traditional variables consists of current account, inflation, productivity and interest rate differentials while the nontraditional are equity returns and risk appetite. Results indicate that the nontraditional variables are significant for all currency pairs. Increased equity returns are associated with currency appreciation consistent with previous research. Furthermore is the evidence on the risk appetite variable conclusive on how investors perceive the risk exposure to the currencies. For the EUR/SEK are coefficients of the interest differentials evidence on the effect of the yield curve, suggesting that the currency is driven by expectations on future economic activity such as GDP growth and inflation instead of actual values as tested on the model. Results on the current account variables are coherent with the theory that current account is significant only when a threshold deficit is breached. Overall the results presented indicates that the exchange rates for reserve and non-reserves currencies are explained by different variables.

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1. INTRODUCTION

The foreign exchange market is today the largest market place in the world with a daily turnover of about 4 trillion dollars, 10-15 times larger than the bond and roughly 50 times larger than the equity (Smith 2007). As international trade increases the market grows continuously and has more than two folded since 1995 (Bank for International Settlements 2010). Still explaining nominal exchange rates remains one of the perhaps most intriguing themes in international macroeconomics.

The aim of our report is to understand the euro exchange rate movements against the U.S. dollar, Swedish krona and Norwegian krone by using a regression analysis. Both the euro and the dollar are considered reserve currencies while the krona and krone are non-reserve currencies. Roughly 28 % of the daily turnover in the currency market is trading of the currency pair euro/dollar while euro/krona sums up to about 1 % and euro/krone less than 1 % (Bank for International Settlements 2010). To understand the exchange rates we have used traditional explanatory variables for exchange rate movements. The variables are current account, inflation, productivity and interest rate differentials (Sun & An 2009). Also included are changes in equity returns and risk appetite.

However there is a widespread pessimism in academia that traditional macroeconomic fundamentals are sufficient to explain exchange rate movements in the short- and medium-run (Frankel & Rose 1995). Furthermore are attempts to explain exchange rates complicated by its complex role in the economy as it affects both trade competitiveness and capital flows. Then in turn is trade competitiveness and capital flows affected by exchanges rates creating a circular effect (Meredith 2001).

In 1983 Meese & Rogoff presented an influential paper using forecasting models based on traditional explanatory variables according to asset pricing approach, comparing their predictive ability to a random walk model. The forecasting models tested where flexible-price monetary model (Frenkel-Bilson), the sticky-price monetary model (Dornbusch-Frankel) and the sticky-price asset model (Hooper-Morton). In the Frenkel-Bilson model PPP holds for exchange rates consequently changes in price level translate into exchange rates movements. Additionally interest rate differentials are assumed to reflect expected inflation differentials. To overcome the empirical failure of PPP in the short run the Dornbusch-Frankel allows for sticky prices in the short run consequently slow price movements allowing deviations from purchasing power parity (Moosa 2000). Furthermore the model adds real interest rate differentials as an additional explanatory variable since interest rate differentials are assumed to reflect a shortage of liquidity leading to capital inflows a currency appreciation. The Hooper-Morton model extends the monetary models by adding the effect of changes in the current account balance. The model implies that changes in current account balance changes the expectations of long run real exchange rates, in turn changing the expected nominal exchange rate (Moosa 2000). But none of the models outperformed the random walk model in forecasting the future exchange rates on a short and medium horizon even though their forecasts are based on actual realized values of future explanatory variables. The results from Meese & Rogoff (1983) still remain an important contribution to research on exchange rate movements.

Following the depreciation of the euro against primarily the dollar during the mid to late 90s and early 00s brought a new approach to exchange rate explanation emphasizing on the effect of capitals flows and equity returns. The decline of the euro started even before the introduction and continued into to the early 00s, opposite to the widespread expectation of the creation of a strong euro currency (Meredith 2001). Puzzling about the development was also that the U.S. current account deficit was expanding while the currency appreciated against e.g. the euro, contradicting traditional explanatory variables of exchange rate movements.

In 2001 Meredith published his paper “Why Has The Euro Been So Weak?” followed by a paper by Brooks et al. (2001) also testing capital flows as an explanatory variable. The results from Meredith (2001) suggest that the surge in U.S. equity market capitalization since the mid-90s created a demand chock for the dollar consequently leading to an appreciation. Furthermore the weakness of the euro could be explained by a temporary mismatch of supply and demand of the euro as issuance of euro denominated bonds surged while investors diversified away from the euro. Brooks et al. (2001) test of the dollar versus the euro and yen demonstrate that equity portfolio capital flows relative to current account transactions are becoming more significant in understanding exchange rate movements while interest rate differentials continue to be significant. The underlying drivers of capital flows are according to Brooks et al. (2001) changes in expectations of relative rates of return and portfolio diversification. Additional research on capital flows and exchange rates has been done by Siourounis (2003) and Sun & An (2009). Siourounis (2003) find that an equity-augmented exchange rate model incorporating net cross border equity flows outperforms a random walk in exchange rate predictability in several cases. Furthermore is positive equity returns associated with equity inflows and currency appreciation while an increase interested rate differential (relative to foreign) are consistent with long term uncovered interest rate parity. The results presented by Sun & An (2009) are similar to Brooks et al. (2001) demonstrating the importance of interest rate differentials and capital flows. The main difference is that Sun & An (2009) demonstrate that interest rate differentials are more important for reserve currencies and capital flows more important for non-reserve currencies.

Additional research has been done to understand exchange rates movements in the short run emphasizing on changes in risk appetite. Ranaldo and Söderlind (2007) have tested changes in risk appetite in the equity and bond markets effect on the dollar, euro, yen, pound and the Swiss franc over the period 1993-2006. The currencies where tested by their safe haven and flight-to-quality characteristics for hourly up to weekly changes in risk appetite. Safe haven currencies are assumed to be negatively correlated to risk appetite and flight-to-quality assumes that investors rebalance their portfolios as market risk increases, thereby seeking more secure investments. Ranaldo and Söderlind (2007) main results are that the dollar is positively correlated to risk appetite whereas the Swiss franc and to smaller extent the yen, euro and pound exhibit safe haven characteristics versus the dollar. Furthermore the Swiss franc also appreciates against other currencies as risk appetite decrease.

Given previous research, the contribution of our report is to analyze the euro exchange rate ex post until Q2 2010 and testing apart from traditional fundamental macroeconomic variables also equity returns and risk appetite measured as relative stock index returns and the risk appetite index constructed by SEB. As the previous research available on the risk appetite is limited the variable is tested in both expansion and contraction business cycles using a dummy variable. By testing both the period from 1995 to 2010 and 1999 to 2010 the hypothesis that the introduction of the euro marks a new paradigm is tested. The period 1995-1999 is constructed from a synthetic euro. Furthermore the euro is tested against one reserve currency, the U.S. dollar, and two European non-reserve currencies, the Swedish krona and the Norwegian krone.

Anticipating the results, evidence is found that the risk appetite variable is significant for all currency pairs. The coefficient for the EUR/USD is positive implying that the euro exchange rate relative the dollar is positively correlated with changes in risk appetite. For the EUR/SEK and EUR/NOK is the relationship the opposite for the euro. Furthermore is the current account variable significant for the EUR/USD. The results suggest that the variable becomes significant when the current account deficit breaches a threshold value. For the interest rate differential evidence is found that the EUR/SEK exchange rate is affected by the slope of the relative yield curve suggesting that exchange rates are instead of actual values of GDP and inflation affected by expectations. The relationship is not statistically significant for the EUR/NOK but the coefficient of long and short term interest rates are indicative of the effect of the relative yield curve.

This paper is constructed as follows. The following section presents the theoretical framework used. The third section outlines the empirical analysis where the economic model is presented as well as tests conducted on the data. Results are presented in the fourth section followed by the last section conclusions, summarizing the contribution of this report.

2. THEORY

This section outlines traditional theories explaining exchange rate movements. The aim is to give a short introduction to the model and put emphasis on exchange rate movements. The long term explanations for exchange rate movements are purchasing power parity and Balassa Samuelsson whereas short term explanations are UIP and Portfolio Balance model. More detailed explanations can be found by reading reference literature.

2.1 Purchasing Power Parity

The absolute purchasing power parity (PPP) approach to exchange-rate determination state that long-term equilibrium of exchange rates is determined by the relative price levels (Rosenberg 2003). PPP is based on the law of one price, implying that arbitrage forces will drive the price of an identical bundle of goods in two countries to equality, if measured in the same currency (Pilbeam 2006). This can be expressed as:

$$S_t = \frac{P_t}{P_t^*}$$

Where S_t is the exchange rate, P_t is the price level of a bundle of goods in domestic currency and P_t^* is the price of the same bundle of goods in foreign country measured in foreign currency. A decline in domestic price levels relative to foreign will lead to an appreciation of domestic currency and vice versa. (Pilbeam 2006) Evidence on absolute PPP suggests that it is unlikely to hold in short and medium term because arbitrage in tradable goods may be imperfect due to transaction costs, tariffs and entry and exit barriers (Rosenberg 2003).

Relative PPP is a weaker form of absolute PPP assuming exchange rates are driven by inflation differentials instead of price levels. It can be explained by the following equation:

$$\Delta \ln S_t = \Delta \ln P_t - \Delta \ln P_t^*$$

Where $\Delta \ln S_t$ is equal to the percentage change in the exchange rate, $\Delta \ln P_t^*$ is the domestic inflation rate and $\Delta \ln P_t^*$ is the foreign inflation rate. If the inflation rate in domestic rises while the inflation rate in foreign is held constant, the domestic currency should depreciate relative foreign currency to offset the gap in relative inflation differential. (Pilbeam 2006)

2.2 Balassa Samuelsson model

In the Balassa Samuelsson model the assumption of PPP is assumed to only hold for tradable sector, thereby the real value of the currency is affected by changes in the price level in non-tradable sector. The model implies that an increase in relative labor productivity in the tradable sector should lead to an appreciation of the currency (Pilbeam 2006). The reason is that the productivity differentials are assumed to accrue in the traded sector rather than in non-traded sector. Furthermore the model assumes that wages in both sectors are equal and higher productivity will have a decreasing effect on price levels and an increasing effect on wages. This can be expressed as:

$$Q_{T^*} > Q_T,\ Q_{N^*} = Q_N$$

$$S = \frac{P_T}{P_T^*},\ S \neq \frac{P_N}{P_N^*}$$

$$W_N = W_T,\ W_T^* = W_N^*$$

Where Q_T is productivity in tradable sector, Q_N is productivity in non-traded sector, W_T wages in traded sector, W_N wages in non-traded, P_N Price level in non-tradables sector and P_T prices in the tradable sector. The *-sign represents the richer country. Since the tradable sector in the richer economy is more productive this will lead to a higher relative price ratio of non-tradable goods to tradable goods compared to the poorer country $\sigma^* > \sigma$. This relationship can be explained by:

$$\frac{P_N}{P_T} = \sigma \quad \frac{SP_N^*}{SP_T^*} = \sigma^*$$

$$\sigma^* > \sigma$$

Consequently, since PPP holds for the tradable sector and $\sigma^* > \sigma$, the price level of the rich country's non-tradable sector will exceed the price level of non-tradable sector in the poor. The reason that PPP does not hold for the non-tradable sector is because higher productivity in the tradable sector leads to higher wages in both sectors assuming competition in the labor market between sectors (Pilbeam 2006). This gives an explanation to why price indices are higher in richer countries. Furthermore Balassa and Samuelsson model assumes that a country with a relative productivity increase in the tradable sector will lead to a relative appreciation of the real value of the currency to maintain PPP for tradable sector (Pilbeam 2006). If GDP is used as a measure of labor productivity the following equation can be used to explain productivity differentials effect on the exchange rate:

$$S = \frac{GDP}{GDP^*}$$

or

$$\Delta \ln S = \Delta \ln GDP - \Delta \ln GDP^*$$

2.3 Uncovered interest rate parity

Both purchasing power parity and the Balassa Samuelsson model assume that uncovered interest parity holds. It states that the expected return on a foreign investment should equal the return on a comparable domestic investment (Pilbeam 2006). Due to uncovered exchange rate exposure the actual exchange rate on maturity can differ from the expected, hence the return on the foreign investment is uncertain. An increase in domestic interest rate relative foreign leads to an expected deprecation on the domestic currency and vice versa. The relationship can be explained by the equations:

$$\Delta \ln S^e = \ln(1+i) - \ln(1+i^*)$$

$\Delta \ln S^e$ is the expected change, i the domestic interest rate and i^* the foreign interest rate. The second equation is transformed using the first difference and natural logarithm. For UIP to hold the assumption that domestic and foreign bonds are perfect substitutes needs to be made, implying that investors perceive the investments as having identical risk and that capital is perfectly mobile (Pilbeam 2006).

2.4 Portfolio Balance model

In contrast to UIP the portfolio balance model instead assumes that foreign and domestic assets are not perfect substitutes introducing a risk premium, explaining why UIP does not hold for exchange rate movements (Rosenberg 2003). Investors are assumed to be rational and risk averse under the portfolio balance model, hence investors will require higher expected return on assets carrying additional risk (Pilbeam 2006). The model can be expressed as:

$$\Delta \ln S^e = \ln (1+i) - \ln (1+i^*) + RP$$

$\Delta \ln S^e$ is the expected change, i the domestic interest rate, i^* the foreign interest rate and RP is the change in risk premium. Furthermore investors are expected to be rational and rebalance their portfolio as risk perceptions and risk preference changes. Consequently if a change in risk perceptions occurs e.g. domestic assets becomes more risky relative to foreign there will be a decrease in demand for domestic assets and a depreciation of domestic currency (U. Michael Bergman 2005). Assuming that investors perceive that assets and currencies have risk premiums then a change in risk appetite on the market should affect exchange rates as investors rebalance their portfolios according to their risk preferences. An increase in risk appetite should appreciate relative riskier currencies and vice versa. This effect is often referred to as safe haven or flight to quality (Ranaldo and Söderlind 2007).

Additionally can the existence of a risk premium explain the effect of a current account surplus or deficit on exchange rates. An increase in cumulative current account deficit and net external debt should be regarded as an increase in the risk of a default and thereby investors should require a higher risk premium to hold the assets in the country (Rosenberg 2003).This increased risk will cause the currency to depreciate as demand for assets denominated in the local currency decreases, assuming returns are held constant.

Another explanation to exchange rate movements under the portfolio balance model is equity returns. Stavárek (2005) outlines that a rise in domestic equities returns will have two effects on the currency: one direct and one indirect. As the value of domestic equities rise, investors will increase their holdings of domestic equities at the expense of foreign. The shift in demand and supply will cause the domestic currency to appreciate. The indirect effect implies that higher equity prices results in higher wealth, causing an increase in demand for money. This will push interest rates up and appreciate the domestic currency (Stavárek 2005).

3. EMPIRICAL ANALYSIS

This section is outlined as follows. First the economic model is specified and interpreted according to the theoretical framework. Next section describes the data used in the regression. The third section outline the evolution of dependent variables during the time period and the last section explain tests conducted on the data.

3.1 Economic model

Based on our explanatory variables and economic theory the following economic model was constructed:

$$S = \beta_1 + \beta_2\pi + B_3 GDP + B_4 10Yi + B_5 3Mi + B_6 CA + B_7 EQUITY + B_8 RAI + B_9 RAIE + B_{10} GAP + e_i$$

$S = \ln S_t - \ln S_{t-1}$

$\pi = \Delta \ln \text{Price level} - \Delta \ln \text{Price level}^*$

$GDP = \Delta \ln GDP - \Delta \ln GDP^*$

$10yi = \ln(1+10Y\ \text{yield}) - \ln(1+10Y\ \text{yield}^*)$

$3Mi = \ln(1+3M\ \text{yield}) - \ln(1+3M\ \text{yield}^*)$

$CA = \text{Current account as \% of GDP} - \text{Current account as \% of GDP}^*$

$\text{Equity} = \Delta \ln \text{Stock index} - \Delta \ln \text{Stock index}^*$

$RAI = \ln SEB\ RAI_t - \ln SEB\ RAI_{t-1}$

$RAIE = (\ln SEB\ RAI_t - \ln SEB\ RAI_{t-1})*\text{Dummy variable}$

$GDP\ GAP = (GDP_{actual} - GDP_{potential})/(GDP_{potential})$

The advantage of using a log-linear model is that the slope of coefficients B1-B10 measures the elasticity of changes in exchange rates with respect to the dependent variables, that is, the percentage change in exchange rates for a given change in dependent variables. The exchange rates are expressed as foreign currency per euro, therefore spreads for the dependent variables are calculated by subtracting euro data by foreign data. The interpretation is that if the spread between dependent variables increase with 1% this will result in a percentage change in exchange rate equal to the beta coefficients.

According to relative PPP the beta coefficient for inflation is expected to be negative as an increase in relative inflation should lead to a depreciation of the euro. If absolute PPP is assumed to hold only for the tradable sector and GDP growth is used as a proxy for productivity growth. Then according to the Balassa Samuelsson model an increase in relative productivity should lead to an appreciation of the currency and therefore a positive beta coefficient for GDP.

To understand interest rate differentials effect on the exchange rates, UIP is used. According to UIP an increase in interest rates relative another country should be followed by offsetting currency depreciation, implying a negative beta coefficient. To measure changes in interest rate differentials both 3 month and 10 year nominal rates are used. Previous research on interest rate differentials suggests that real interest rates have more impact on exchange rates than nominal interest rates (Rosenberg 2003). According to the fisher hypothesis is the real rate equal to the nominal rate subtracted by inflation. By testing nominal rates and inflation effect separate in our regression this assumptions is avoided. Thereby if real rates are a more appropriate measure for interest rate differentials a negative beta coefficient for inflation is expected.

The portfolio balance model assumes that interest parity is affected by risk premiums thereby an increase in relative current account should lead to an appreciation of the euro, a positive beta coefficient is expected. Also assumed according to the portfolio balance model is that a surge in relative equity returns will appreciate the currency, consequently the beta coefficient is expected to be positive for equity returns. Furthermore are investors according to the portfolio balance model expected to rebalance their portfolios when risk preferences and risk perceptions changes. Testing changes in risk appetite effect on the exchange rates tests the investors' perception on risk for the currency. A currency that is considered safer to another should then appreciate as investors rebalance their portfolios to safer investments when risk levels increase. Additionally is the effect of changes in risk appetite on exchanges rates tested in both expansion and contraction business cycles using a dummy variable on the RAI variable. The dummy variable is based on OCED expansion business cycles. According to the theoretical framework there are no expectations of the beta coefficient for the RAI variable using an expansion dummy.

To remove unexplained business cycle effects on our regression a GDP gap variable was created with GDP data for OECD countries using a Hodrick Prescott filter. The GDP gap variable is expected to remove excess noise in the regression by removing the business cycle effects from variables left out of our model and effects that are not measurable with the explanatory variables.

3.2 Data description

The creation of the euro in 1999 posed a major limitation selecting time period. Data before 1999 is constructed by using a synthetic euro. Due to this limitation data have been tested for Q1 1995 to Q2 2010 even though a longer period would probably result in more statistically significant results. As the introduction of the euro could represent a new paradigm for the euro exchange rate movements a second time period is used, from Q1 1999 to Q2 2010.
Furthermore the aim is collecting raw data that all variables should be bilateral. According to Brooks (2001) there are three main reasons for looking for bilateral data. First, most policy issues and public concerns appear to be focused on the currency value vis-à-vis global currencies or the currency of important trading partners. Second, when calculation multilateral exchanges rates the weight used has a significant effect on the value. The weights can be insufficient for describing current and future trading patterns, thereby not giving a fair value of the currency. The last reason is that explanatory variables are expected to have less noise when using bilateral data. The frequency of data observations available is limited. For GDP and current account only quarterly data is available. Consequently quarterly data is used for all variables. For each variable there are 62 observations for the time period 1995-2010 and 46 observations for the time period 1999-2010. Transformed variables can be seen in appendix graph A1-A9.

3.2.1 Exchange rates

Measuring changes in exchange rates, bilateral nominal exchange rate data is used. All observations are from OECD and are expressed as monthly averages of daily closing interbank rates on national markets. Data before the introduction of the euro is based on the European Currency Unit (ECU).

3.2.2 Inflation

To measure inflation changes in price indices is used. According to Pilbeam (2006) a problem when doing research on price levels is that countries usually construct price indexes using different weights on goods and services. Harmonized data is used for Sweden, Norway and the euro area, but for U.S. CPI data is used as HCPI is not available. All data is from OECD except HCPI for the euro area that was published and compiled by ECB aggregating indices for individual countries. The quarterly data is averages of monthly data and seasonally adjusted.

3.2.3 Productivity

To measure productivity measures of percentage growth of real GDP growth is used. An alternative measure would be to use real GDP growth per capita. However by using real GDP growth expressed in percentage the same effect is captured. The data is seasonally adjusted and from OECD. For the euro area the real GDP data is compiled by aggregating EA13. Included in EA13 are Austria, Belgium, Finland, France, Germany, Greece, Italy, Ireland, Luxembourg, Netherlands, Portugal, Slovak Republic and Spain. To avoid exchange rate effect on real GDP data it is expressed in local currency. Since percentage growth of real GDP is used when calculating productivity differentials currency effects are removed.

3.2.4 Interest rates

For long term interest spread 10-year government bonds are used. The quarterly data is averages of monthly data published by OECD. For the euro area prior to 2001 the data aggregated from EU11 is weighted by GDP. Included in EU11 are Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain. The data used for constructing short-term interest rate spread is the for the euro area, Sweden and Norway the 3-month interbank rate expressed as quarterly averages of monthly data composed by OECD. For the U.S. the 3-month Fed funds rate published by Federal Reserve is used. Prior to 1999 rates for the euro area are calculated based on aggregated data from EU11, weighted by GDP.

3.2.5 Current account

Multilateral current account data expressed as percentage of GDP is used to compare relative changes in current account. Bilateral current account would be preferable, but bilateral data is only available from 2003 for the euro area. However tests done by Brooks et. al (2001) on exchange rates using bilateral and multilateral current account data demonstrate that the results using bilateral and multilateral are similar. Furthermore the data is seasonally adjusted to remove the effect of short-term fluctuations. All data is from OECD.

3.2.6 Equity Returns

To measure equity returns effect on exchange rates returns on stock indices are used. Broad indices instead of sectors indices were selected to reflect equity returns. The indices used are for U.S the S&P 500 composite, for Sweden the OMXSPI, for Norway the OSEAX and for the euro the EURO STOXX. All data is from OECD.

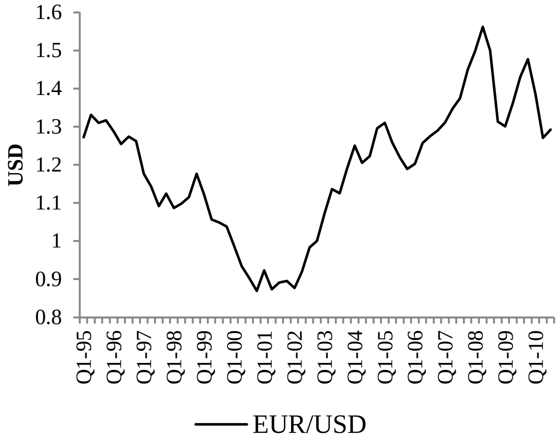
3.2.7 Risk appetite

Measuring market risk appetite is done by using the risk appetite index (RAI) constructed by SEB Merchant Banking. The index is constructed to capture changes in the market risk appetite weighting the following variables: emerging market bond spreads (EMBI) (27%) BAA rated credit spreads (27%), EUR/CHF exchange rate (22%), Chicago Board Options Exchange Market Volatility Index (CBOE VIX) (16%) and gold/silver price ratio (8%) (Olsson 2010). The EMBI is used as it is a proxy for emerging market volatility, uncertainty and risk (Rosenberg 2003). Using Moody’s definition of the lowest investment grade bonds BAA, the spread is constructed as the difference between the highest rated AAA bonds and BAA rated bonds. A larger spread suggests low risk appetite. The CBOE VIX is the implied volatility of S&P 500 index options measuring risk and uncertainty in U.S. equity markets(Rosenberg 2003). Regarding the gold/silver price ratio it is expected to rise as investors are assumed to buy gold when risk appetite decreases. Specific weights have been selected to explain as many major post-1990 financial risk events as possible (FX Ringside). The data used is quarterly averages of daily data. Index 100 equals normal risk and values above indicate high risk appetite and below 100 for low risk appetite. Roughly 50 % of the observations are between 104-98 suggesting deviations from this spectrum are strong signals (Olsson 2010).

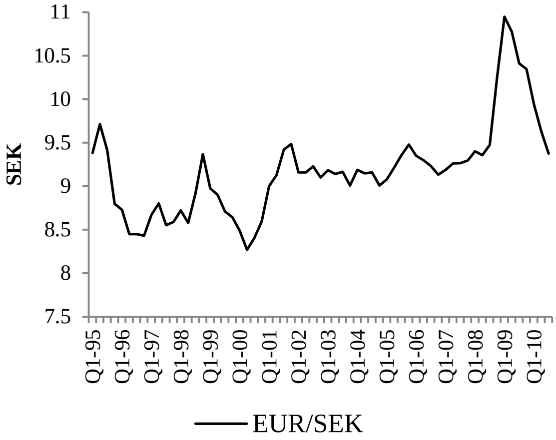
3.3 Evolution of Exchange Rates

In graph 1-3 below are the evolution of the EUR/USD, EUR/SEK and EUR/NOK over the time period 1995 to 2010 presented.

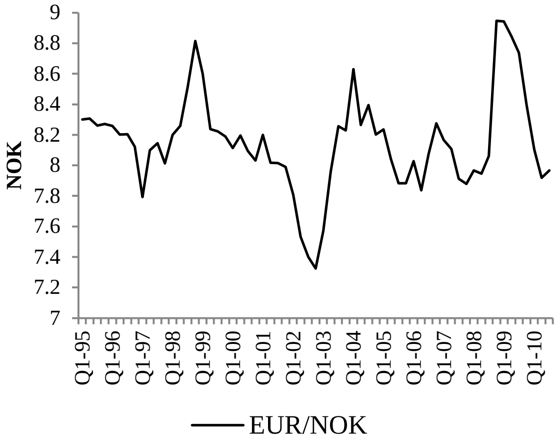
Graph, 1



Graph, 2



Graph, 3



For the EUR/USD it is apparent that the euro weakened consistently against the U.S. dollar from the 1995 to 2001, the trend continued after the introduction of the euro in 1999. After the articles published by Meredith (2001) and Brooks et. al. (2001) concerning euro weakness against the U.S. dollar it is clear that the euro has appreciated considerably. Furthermore the volatility increased significantly during the financial crisis.

The EUR/SEK exchange rate appears to be fluctuating around a mean of roughly 9 SEK per euro with a sharp spike trading at roughly 11 SEK per euro during late 2008 and early 2009 as the financial crisis unraveled . The introduction of the euro in 1999 was associated with a consequent depreciation of the euro that continued until mid-2002 and then reversed into an appreciation to levels around 9 SEK per euro.

As for the EUR/NOK it appears to be the most volatile currency fluctuating around roughly 8 NOK per euro. The value of the euro experienced two fast appreciation followed by a depreciation back to normal levels in 1998 and late 2008 to early 2009 during the financial crisis trading at peak levels of almost 9 NOK per euro. Furthermore did euro depreciate to a bottom level of approximately 7.4 NOK per euro during 2002.

3.4 Test on variables

Since the transformed variables are based on time series data, unit root tests were conducted. Table 1 below show the results from augmented dickey fuller tests made on the explanatory variables. All tests are done using a constant and Akaike Information Criterion (AIC). **Table 1,**

Augmented Dickey Fuller test			
	Currency Pair		
Variable	**EUR/USD**	**EUR/SEK**	**EUR/NOK**
Inflation	-4.86 ***	-7.17 ***	-5.12 ***
Productivity	-3.52 **	-10.79 ***	-3,33 ***
10Y interest rate	-6.12 ***	-6.82 ***	-6.42 ***
3Mi interest rate	-3.52 **	-5.75 ***	-4.24 ***
Current account	-8.78 ***	-8.54 ***	-7.50 ***
Equity returns	-5.18 ***	-5.84 ***	-3.3 **
Risk appetite index	-4.02 **	-4.02 **	-4.02 **

Represent Augmented Dickey Fuller test based on the null hypothesis that there is a unit root, using a constant.

*** denotes significant at 1% level, ** denotes significant at 5% level

As can be seen, the ADF-tests show that the explanatory variables are stationary after being transformed in the first difference.

The regressions are done based on the least square principle. According to the Gauss-Markov theorem is the ordinary least square principle (OLS) best linear unbiased estimators (BLUE) given the assumptions of the classical linear regression model A.1-A.6 (Gujarati 2006). Therefore each regression is tested according to A.1-A.6. The results are presented in table 2 below. The models are also tested if lagging the variables can increase the goodness of fit. Models with the best values are selected by using Akaike Information Criterion. Lagging is done with reference to what seems reasonable according to economic theory.

4. RESULTS

Table 2 below contains the regression results for the euro, reporting the beta coefficients, corresponding std.error, R-square statistics and test results for A.1-A.6 for each currency pair. Result is presented for two sample periods 1995:1-2010:2 and 1999:1-2010:2.

Table 2,

Currency pair	EUR/USD		EUR/SEK		EUR/NOK	
	1995:1-2010:2	1999:1-2010:2	1995:1-2010:2	1999:1-2010:2	1995:1-2010:2	1999:1-2010:2
observations after adjustments	62	46	62	46	62	46
Variable						
Intercept	-0.05 **	-0.07 ***	-0.01	-0.01	0.00	-0.01
	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)
Inflation	-4.02 **	-2.94 *	-0.47	-0.37	-0.42	-0.39
	(1.58)	(1.6)	(0.85)	(1.00)	(0.46)	(0.56)
Productivity	-0.34	0.14	0.68	1.21 ***	-0.30	-0.09
	(0.92)	(0.98)	(0.4)	(0.41)	(0.27)	(0.41)
10Y-interest rate	1.35	4.39 **	-1.97 **	-2.68 **	-1.22	-1.59
	(1.12)	(2.22)	(1.02)	(1.39)	(0.83)	(1.1)
3M-interest rate	0.85	0.23	2.14 ***	2.08 ***	0.63 *	0.88 *
	(0.62)	(0.85)	(0.58)	(0.95)	(0.35)	(0.47)
Current account	1.07 **	1.55 ***	-0.15	-0.15	-0.02	-0.08
	(0.44)	(0.5)	(0.15)	(0.15)	(0.05)	(0.10)
Equity Returns	0.05	0.06 *	0.04 **	0.04 **	0.06 ***	0.07 ***
	(0.03)	(0.04)	(0.02)	(0.02)	(0.02)	(0.02)
RAI	0.29 *	0.51 ***	-0.34 ***	-0.35 ***	-0.43 ***	-0.40 ***
	(0.17)	(0.18)	(0.08)	(0.07)	(0.09)	(0.10)
RAI expansion	0.78	1.04	0.23	0.10	-0.38	-0.70
	(0.75)	(0.73)	(0.4)	(0.38)	(0.49)	(0.55)
GDP GAP	0.38	0.78	-0.56 **	-0.49 **	-0.38 ***	-0.40
	(0.58)	(0.52)	(0.26)	(0.26)	(0.28)	(0.3)
R2	0.44	0.60	0.50	0.57	0.37	0.40
Reset-test	0.10	0.69	1.97	0.53	1.59	2.38
Whites-test	0.85	1.13	0.89	0.56	0.99	1.16
Durbin-Watson	1.59	1.73	2.11	2.13	1.77	1.71
LM-test	0.99	1.24	0.33	1.35	0.56	1.84
Jarque-Berra	0.62	2.90	0.79	0.53	1.12	1.45
Correlation-Matrix	Appendix table A1-A3					

*** denotes significant at 1% level, ** denotes significant at 5% level, * denotes significant at 10% level

Lags: Lagging is done up to 4 periods and the model with best goodness of fit is chosen. Lags used are: EUR/USD (none), EUR/SEK (Inflation 1 period, Productivity 1 period), EUR/NOK (Inflation 1 period, Equity Returns 1 period).

Reset-test: null hypothesis that there is no evidence of misspecification or omitted variables (Two fitted terms is used).

Whites-test: null hypothesis that error-terms are homoscedastic (All tests where made without using cross terms).

Durbin-Watson: null hypothesis that no autocorrelation is present.

LM-test: null hypothesis that no autocorrelation is present.

Jarque-Berra: null hypothesis that error-terms are normally distributed.

For each currency two regressions are done providing a test on whether the introduction of the euro marks a new paradigm. The general result is that the models explanation power $R^{2)}$ rise with 36% for the EUR/USD, 14% for EUR/SEK and 8% for EUR/NOK under the sample period 1999-2000. This implies that the introduction of the euro marks a major shift for the euro exchange rate. Further analysis on variables is done on the sample period 1999:1-2010:2. Test for A.1-A.6 presented in the table 2 above confirm that all the estimators in each regression are BLUE.

Turning to the specific individual results, the first row illustrates the estimates for inflation. The variable is only significant for EUR/USD with a reported negative coefficient which is in line with what is expected according to relative PPP. However the coefficients are negative for EUR/SEK and EUR/NOK but not statistically significant.

The next row presents the estimates for productivity. It is clear that the productivity variable is only statistically significant for the EUR/SEK with a positive beta coefficient consistent with the Balassa Samuelsson model.

The EUR/USD results for interest rate differentials show that the effects of long term interest rates are significant with a positive coefficient. This contradicts UIP as the euro appreciates when the interest rate spreads increase, suggesting an existence of a risk premium according to portfolio balance model. For the EUR/SEK both long and short interest rate are significant with a negative coefficient on long term and positive for short term. The implication is that as the long term interest rate spread increases the euro depreciate but as short term interest rates increases the euro appreciates and vice versa. As the effect of interest rate differentials changes with the maturity of the interest rate this suggest that effect captured is the slope of the relative yield. The argument is further supported as the sum of the coefficient for long term and short term interest rates roughly equals zero. The effect of the relative yield curve suggests that a more negative curve leads to an appreciation of the euro. Furthermore the results for the EUR/SEK yield curve are coherent with recent reports presented by Chen & Tsang (2009). They found that the relative slope of the yield curve predict bilateral exchange rates movements and that it can be used as a forecasting model for one month to two years ahead outperforming the random walk model. The explanation is that according to data from the Survey of Professional Forecasters yield curve factors are highly correlated to expectations about GDP growth and inflation as well as anxiety about a future economic downturn (Chen & Tsang 2009). Furthermore this explains the inability of the GDP and inflation variables to explain exchange rates movements as the currencies are driven by expectations. For the NOK/EUR only short term interest rate differentials are significant with a positive coefficient. The effect of the yield curve is not significant as the long term interest rate is not significant. However the negative coefficient of the long term interest rate is indicative of a potential relative yield curve effect.

The current account variables are according to our results presented above significant only for the EUR/USD. The coefficient is positive implying that an increase in the current account for the euro area relative to the U.S. appreciates and the euro consequently depreciates the U.S. dollar. This is consistent with the portfolio balance model. According to Rosenberg (2003) the insignificance of the current account variable for EUR/SEK and EUR/NOK as well as the significance for the EUR/USD could be explained by a threshold value for current account deficits. Rosenberg (2003) states that the variable only affects exchange rates if the current account deficit for one of the currencies reaches a threshold value. Research done by Mann (1999) and Freund (2000) supports this theory. Mann (1999) found, examining 17 episodes in industrial countries, that a current account deficit reaching 4.2% of GDP triggers exchange rate adjustments. Research done by Freund (2000) suggests that the value triggering exchange rate adjustment should instead be around 4.9%. Examining the current account raw data as percentage of GDP for our four countries shows that the U.S. current account averages a deficit of 4.6 % during the time period. None of the other countries current account breached the threshold value of a 4.2 % deficit of GDP during the time period.

The following row presents that equity returns are significant with a positive coefficient for all currency pairs. The results are consistent with the portfolio balance theory implying that an increase in domestic equity return will appreciate the domestic currency. The significant effect of equity return is consistent with the reports by Meredith (2001) and Brooks et.al. (2001). As new currency pairs are tested in this report, the conclusions that equity returns affect exchange rates can be extended to EUR/SEK and EUR/NOK.

Next, the results for the RAI variable are significant at a one percent level for all currency pairs. For the EUR/USD the coefficient is negative and for the EUR/SEK and the EUR/NOK the coefficient is positive. The implication for the EUR/USD exchange rate is that the euro appreciates when risk appetite increases and depreciates when risk appetite decreases, a positive correlation. As both the euro and the U.S. dollar are considered reserve currencies the U.S. dollar inhabit more safe haven characteristics relative the euro. The relationship contradicts the results presented by Ranaldo and Söderlind (2007) suggesting that the euro exhibit more safe haven characteristics relative the U.S. dollar. For the non-reserve currencies the euro tends to appreciate against the SEK and NOK as risk appetite decreases, a negative correlation. This demonstrates that the euro exhibit more safe haven characteristics relative the non-reserve currencies, the SEK and NOK. According to the portfolio balance model the results for the RAI variable suggest an existence of a risk premium and that investors rebalance their portfolios as risk appetite changes.

The last explanatory variable presented in the table 2 above is the RAI expansion. As the variable is not statistically significant for any of the currency pairs, this conclude that the effect of the RAI does not change over business cycles.

Overall our results show that there are differences in exchange rates between reserve currencies and non-reserve currencies. For the EUR/USD are inflation, current account, long term interest rates and risk appetite significant variables. However for the non-reserves currencies it appears that they instead could be explained by equity returns, risk appetite and the relative yield curve.

5. CONCLUSIONS

Many hypotheses has been advanced in academia to understand and explain exchange rates movements. Early research by Meese & Rogoff (1983) suggested a random walk model test traditional variables while more recent research by e.g. Brooks et.al. Siourounis (2004) have tested and found evidence that exchange rates are affected by using nontraditional variables like equity flows. The contribution of this paper is to explain exchange rates movements of the EUR/USD, EUR/SEK and EUR/NOK using traditional variables including inflation, productivity, interest rates and current account as well as nontraditional variables equity returns and risk appetite for the time period 1999-2010.

This paper documents that a significant variable for understanding exchange rate movements of the EUR/SEK is the slope of the relative yield curve. The implications are that as the slope of the yield becomes more negative relative another country the currency depreciates and vice versa. According to Chen & Tsang (2009) and data from Survey of Professional Forecasters the factors affecting the slope of the relative yield curve are highly correlated to the expectations on future GDP growth and inflation as well as anxiety about a future economic downturn. The significant effect of the relative yield can explain the inability of traditional variables as GDP and inflation are not significant variables for the exchange rate movement. Instead the exchange rates are affected by expectations on traditional variables. Additionally the yield curve effect for the EUR/NOK not statistically significant but the coefficient of the short term and long term interest rates are indicative of a possible relationship.

Also presented are evidence that research done on the effect of equity returns can be extended for the time period 1999-2010 for the exchange rate EUR/USD, EUR/SEK and EUR/NOK. Relative increases in equity returns have a significant effect on exchange rates. Consistent with the portfolio balance model are higher relative equity returns associated with currency appreciation.

Results for the current account variable are only significant for the EUR/USD. However the results are consistent with the theory presented by Rosenberg (2003) that current account deficit become significant for the exchange rate only at a threshold value. Comparing the data for current account deficit as percentage of GDP over the time period clearly shows that the U.S. is the only country that breaches the threshold values presented by Mann (1999) and Freund (2000), 4.2 respectively 4.9 percent. This offers an explanation to the current account variable effect on the tested currency pairs.

The main contribution of this report with regards to previous research is the testing of the risk appetite variable. Results clearly show that the variable is significant at a one percent level for all currency pairs. The coefficients provide evidence on how the exchange rate moves as risk appetite changes. For the EUR/USD the coefficient is positive implying that the euro appreciates during times of increasing risk appetite and depreciate during times of risk appetite declines. If explained from a safe haven perspective it appears that the U.S. dollar exhibit more safe haven characteristics relative the euro. For the EUR/SEK and EUR/NOK is the relationship the opposite, the euro depreciates during times of increasing risk appetite and vice versa.

Overall the results presented indicate that the exchange rates for reserve and non-reserves currencies are explained by different variables. The EUR/USD exchange rate is explained by inflation, current account, long term interest rates and risk appetite, while it appears that the non-reserves currencies could be explained by equity returns, risk appetite and the relative yield curve.

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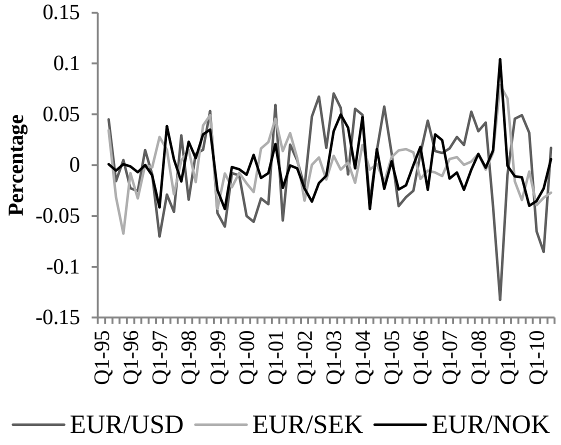
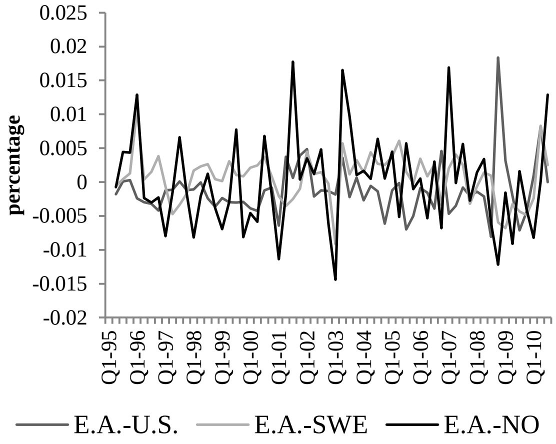
7. APPENDIX

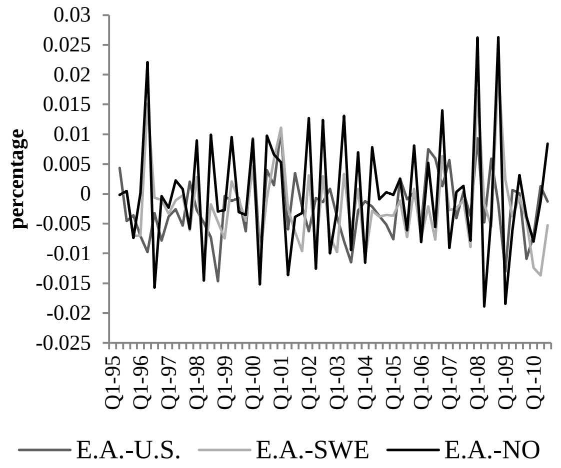
Graph A1, Exchange rates



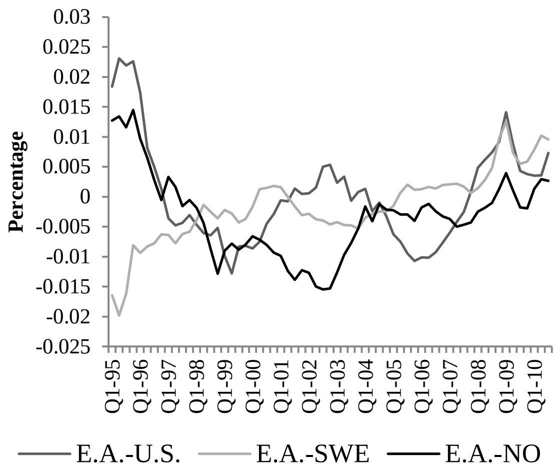
Graph A2, Inflation differentials



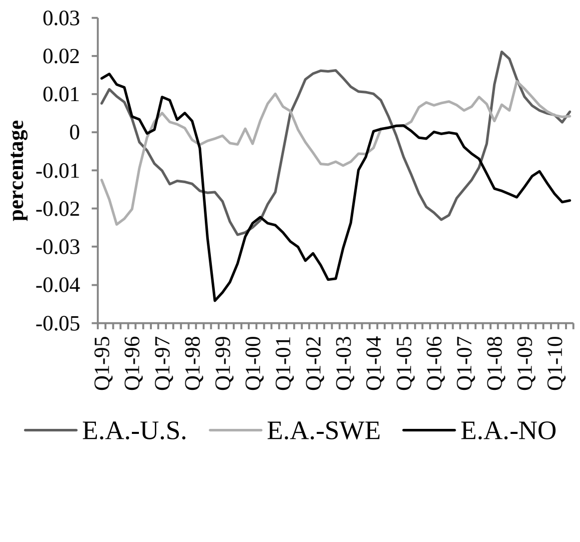
Graph A3, Relative GDP growth



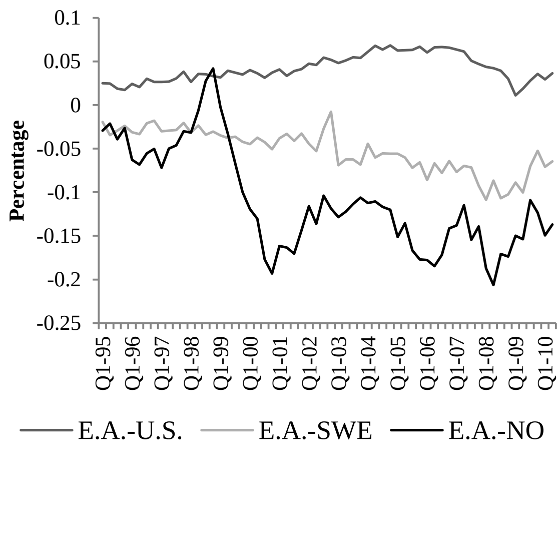
Graph A4, 10Y Interest rate differential



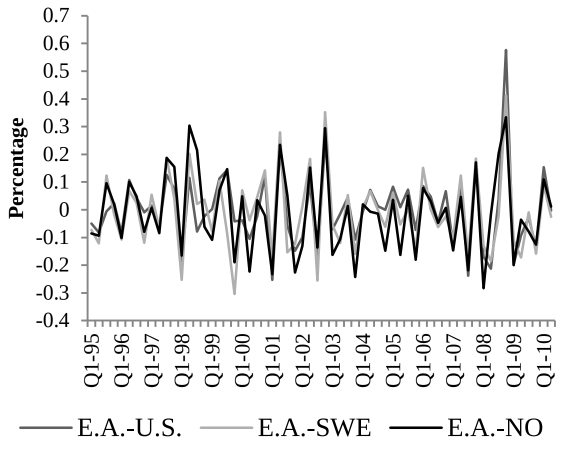
Graph A5, 3M Interest rate differential



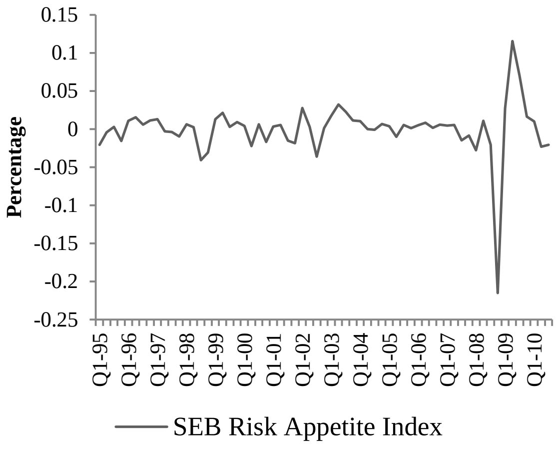
Graph A6, Relative Current account



Graph A7, Relative Equity returns



Graph A8, Risk appetite



Graph A9, GDP GAP

Table A1, EUR/USD correlation matrix

	USD	CPI	GDP	10Yi	3Mi	CA	Equity	RAI	RAI*DH	GAP
USD	1.00	-0.40	0.05	0.12	0.24	0.28	0.03	0.38	0.09	-0.06
CPI	-0.40	1.00	-0.12	0.22	0.29	-0.15	0.09	-0.54	0.10	-0.17
GDP	0.05	-0.12	1.00	-0.13	-0.11	0.25	0.05	-0.07	-0.11	0.40
LS	0.12	0.22	-0.13	1.00	0.73	-0.53	-0.01	-0.04	-0.10	-0.31
SS	0.24	0.29	-0.11	0.73	1.00	-0.11	-0.11	-0.05	-0.11	-0.36
CA	0.28	-0.15	0.25	-0.53	-0.11	1.00	-0.04	-0.02	0.11	0.27
Equity	0.03	0.09	0.05	-0.01	-0.11	-0.04	1.00	-0.14	-0.03	-0.18
VIX	0.38	-0.54	-0.07	-0.04	-0.05	-0.02	-0.14	1.00	0.19	-0.27
VIX*DH	0.09	0.10	-0.11	-0.10	-0.11	0.11	-0.03	0.19	1.00	-0.27
GAP	-0.06	-0.17	0.40	-0.31	-0.36	0.27	-0.18	-0.27	-0.27	1.00

Table A2, EUR/SEK correlation matrix

	SEK	CPI	GDP	10Yi	3Mi	CA	Equity	RAI	RAI*DH	GAP
SEK	1.00	-0.27	0.32	0.17	0.35	-0.17	0.31	-0.44	-0.03	0.03
CPI	-0.27	1.00	-0.17	-0.19	-0.26	0.16	-0.17	0.06	0.05	0.21
GDP	0.32	-0.17	1.00	0.02	0.13	-0.15	0.12	-0.32	-0.09	0.13
10Yi	0.17	-0.19	0.02	1.00	0.79	-0.66	0.08	-0.09	-0.06	-0.01
3Mi	0.35	-0.26	0.13	0.79	1.00	-0.54	0.04	-0.09	-0.07	0.24
CA	-0.17	0.16	-0.15	-0.66	-0.54	1.00	-0.02	0.06	0.18	-0.13
Equity	0.31	-0.17	0.12	0.08	0.04	-0.02	1.00	-0.16	-0.18	-0.10
RAI	-0.44	0.06	-0.32	-0.09	-0.09	0.06	-0.16	1.00	0.19	-0.27
RAI*DH	-0.03	0.05	-0.09	-0.06	-0.07	0.18	-0.18	0.19	1.00	-0.27
GAP	0.03	0.21	0.13	-0.01	0.24	-0.13	-0.10	-0.27	-0.27	1.00

Table A3, EUR/NOK correlation matrix

	NOK	CPI	GDP	10Yi	3Mi	CA	Equity	RAI	RAI*DH	GAP
NOK	1.00	-0.03	-0.06	0.02	0.04	0.02	0.24	-0.46	-0.05	0.00
CPI	-0.03	1.00	-0.05	-0.01	0.11	-0.03	-0.11	0.12	0.05	0.06
GDP	-0.06	-0.05	1.00	-0.25	-0.20	-0.03	0.14	0.11	-0.17	0.13
10Yi	0.02	-0.01	-0.25	1.00	0.80	0.19	-0.01	0.01	-0.02	-0.07
3Mi	0.04	0.11	-0.20	0.79	1.00	0.08	-0.11	0.09	0.01	0.06
CA	0.02	-0.03	-0.03	0.19	0.08	1.00	0.20	0.03	0.07	-0.24
Equity	0.24	-0.11	0.14	-0.01	-0.11	0.20	1.00	-0.39	-0.22	-0.14
RAI	-0.46	0.12	0.11	0.01	0.09	0.03	-0.39	1.00	0.19	-0.27
RAI*DH	-0.05	0.05	-0.17	-0.02	0.01	0.07	-0.22	0.19	1.00	-0.27
GAP	0.00	0.06	0.13	-0.07	0.06	-0.24	-0.14	-0.27	-0.27	1.00