School of Economics and Management, Lund University
Department of Economics
Second year master thesis
Spring 2011

Does the explanatory power of the monetary prediction models change during times of financial crisis? - A study of the Swedish krona.

Date:
2011-10-10

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Abstract

This study compares how the Swedish krona, valued in four different currencies, changes during times of financial crisis with non-crisis periods. Then out-of-sample predictions are made based on the flexible-price model. The predictions are made for the one period time horizon using the most recent information available at that time. This is done by re-estimating the parameters for every new observation that becomes available by using rolling regressions. These predictions are then compared to a benchmark based on no-change values. The results are mixed and even though the benchmark could not be beaten in this study, the evidence indicates that it is possible.

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Introduction

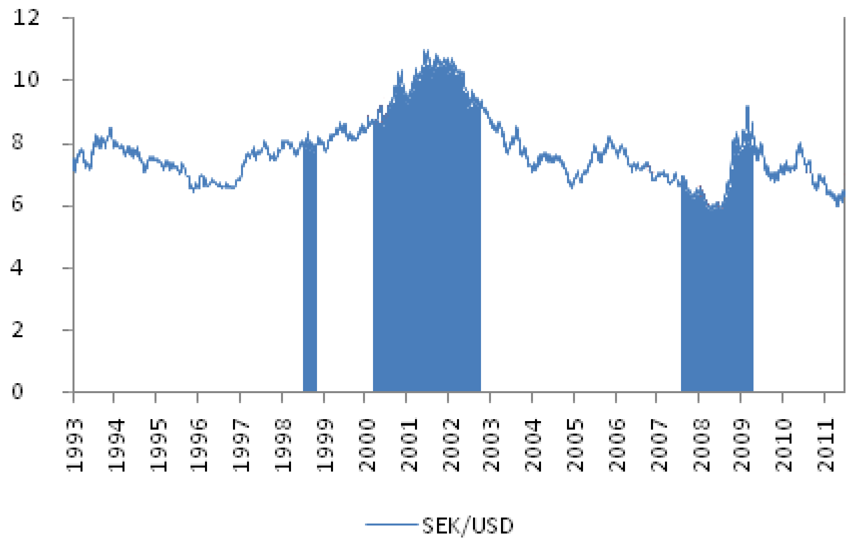
"It is particularly important that the exchange rate is 'correctly priced' since it simultaneously affects the prices of all foreign assets, goods, and factors of production." - *Froot and Thaler (1990)*

Between 23 of April 2008 and 4 of March 2009 the US dollar appreciated against the Swedish krona by 57%. During this time there had been no significant change in the difference of inflation or interest rates between the countries. The only apparent reason for the depreciation was that a full-blown financial crisis was taking place in the world. It does make sense that during times of crisis investors and speculators turn to safe havens because uncertainty increases in the market (Pilbeam, 2006). But ironically this crisis started off in the US. So it seems that in times of financial crisis, no matter where it originated, there is an increased demand for large currencies like the US dollar. And if this is the case in general then one would be able to use this information to better predict exchange rate fluctuations (Choi et al. 2010). And better predictions lead to a more stable exchange rate today.

There are many different theories on how a change in value of a currency comes about. According to the now famous Efficient Market Hypothesis (EMH) by Eugene Fama (1970), the price of an asset in an efficient market reflects all available information at that point in time. This means that the value of the Swedish krona today is a perfect reflection of all available information today. When new information becomes available, the value of the currency will change instantly. This fact would make predictions impossible. Fortunately, the EMH has proven to not always hold. When testing the currency pairs for auto-correlation and cross-correlation the test shows that they exhibit both. This establishes evidence against the weak and semi-strong forms of EMH respectively and is discussed further in the next section. Another theory is represented by the uncovered interest parity (UIP) condition which defines that a change in valuation will come about when the interest rates of two countries are unequal. The argument is that if this was not true then an arbitrage opportunity would arise. Yet another famous theory is the purchasing power parity (PPP) theory which states that if the price of a basket of the same goods are unequal for two countries then the exchange rate must be valued in such a way that relative value of those goods are the same. Otherwise there would be arbitrage.

Using a monetary model derived from the basic money demand function and based on the assumptions of UIP and PPP this thesis tries to come up with a model that can make accurate predictions. Unlike stocks, currencies do not tend to follow a distinct trend. Instead they fluctuate around a constant mean. For this reason one needs to focus on what causes the fluctuations instead of what causes trends. The monetary model used is therefore extended with more explanatory variables to try and take advantage of the apparent negative correlation between times of financial crisis and periods of appreciation of large currencies (Choi et al. 2010) as illustrated in the following graph:

Graph 1: SEK/USD during times of financial crisis



The SEK/USD pair seems to fluctuate around eight kronor per dollar with tendencies of strong appreciations of the dollar during times of financial crisis (marked in blue). This graph also shows that the series seem to exhibit short-term auto-correlation. As mentioned above this is a clear violation of the EMH. Another question arises from these findings, namely if the market is not efficient, is this because the market doesn't function properly or for other reasons like a risk premium? Assuming that it is a risk premium, one could also assume that it is the risk premium that increases during times of financial crisis.

By introducing a variable that represents crisis periods the hope is that this will not only capture the aforementioned correlation but also the associated risk premium. The variable is added to the monetary flexible-price model in the form of a dummy variable.

The result of this study is that a crisis dummy has a significant effect when it comes to predicting certain currency pairs. Which currency pairs depends on how big the currencies are that are in the pair. To get the best result it needs to be a big one together with a small one. Because of the uncertainty times of crisis bring to the market, small currencies are "abandoned" for the "bigger", "safer" ones, making the former depreciate and the latter appreciate. However when it comes to making predictions it proved to be very difficult to beat the benchmark of “no-change” i.e. the value of tomorrow is best predicted with the value of today. But although the benchmark couldn’t be beaten, including information about times of financial crisis improved the model somewhat.

The structure of this thesis is as follows. First, a brief summary of the different theories are presented and then the methodology for making predictions is explained and tested. Then the data are presented and an attempt is made to test the theories. Lastly a short analysis of the results and a concluding discussion are presented.

The failure of exchange rate models

Fama (1970) writes about three versions of the EMH. When applied to the foreign exchange market the weak form of EMH states that the value of a currency is reflected by all available information of past values. In the semi-strong version the value of a currency does not only reflect past values but all public information. In the strong version it also includes all non-public information. This means that even if one had inside information from all the central banks in the world one still would not be able to predict the exchange rate. What makes the concept of an efficient market even more confusing is that a market may be “efficient” in the sense of not being predictable but fails to bring about the correct value that reflects supply and demand (Shiller, 1989). To show that the market isn’t effective and hence can be predicted to some degree an attempt is made here to disprove the weak and semi-strong version of the EMH. This is done by testing the currency pairs for auto-correlation and cross-correlation respectively (Wickremasinghe, 2001).

The first pair to be examined is the SEK/USD one, looking at a correlogram of the series there seem to be strong evidence of autocorrelation, even if one regresses a trend on the series the Durbin-Watson value, being close to zero, shows signs of strong autocorrelation. Similar results are shown for the rest of the pairs as well. This would be evidence against the weak form of the efficient market hypothesis. Even for shorter time periods, one of only three months, the Durbin-Watson statistic still indicates a positive autocorrelation. It is only in the very short run that this is no longer true. For a time period of seven days the Durbin-Watson statistic and a correlogram no longer indicates autocorrelation. An explanation for the autocorrelation is given by Mazzoli and Barducci (2009). The reason is herding behavior, some investors take the decision in this period and the rest follow in the next. Looking instead on a cross-correlogram (appendix c) for the SEK/USD and SEK/EUR pairs with a frequency of 1 day, it shows that recent values of the SEK/USD pair have less to no effect on the SEK/EUR pair, but the more distant the lag the more effect it has. This is consistent with theories claiming that the market is efficient (EMH) and hence unpredictable in the short run but becomes more predictable as the time period for the prediction moves further away in time from the prediction date.

Comparing the SEK/USD and SEK/GBP in a cross-correlogram shows that there is strong positive correlation on all leads and lags, this is also true for the EUR/USD and SEK/USD pair which show even stronger correlation (almost 1) at all leads and lags, this would imply that not only does the SEK move at the same time in the same direction against the dollar as the EUR does, it does it with almost the same relative amount as well. Comparing instead the SEK/USD and the SEK/AUD the correlogram shows strong negative correlation on all leads and lags. These are evidences against the semi-strong form of the EMH. This is because a lagged value of a currency has a significant effect on the present value of another currency, making predictions possible.

The absolute version of PPP can be explained as the law of one price but for a basket of goods. The law of one price states that if a hamburger costs two kronor in Sweden and an equal burger cost one dollar in the US then the exchange rates should be set to two kronor per dollar. This is unlikely to hold because of transportation costs and tariffs on trade etc (Pilbeam, 2006). A more commonly used version is the relative version of PPP:

$$\%\Delta S = \%\Delta P - \%\Delta P^{*} \quad (1)$$

where the percentage change of the exchange rate is explained by the difference of the percentage change of prices between the two countries in the currency pair. The consumer price indices are not included in any regression run in this thesis. Instead they are only used here to give support to why PPP couldn't be used to make predictions. The base year has been changed so that they all have the same base year of 2005. The series consist of 20 years of monthly data, from 1991 to 2011. The data shows a higher inflation during this time in the US than in Germany and Sweden, it also shows that the Swedish and German inflation have been almost the same with only a slightly higher inflation in Germany. If PPP were to hold, than the exchange-rate data would show a depreciation of both the euro and the US dollar equivalent to the inflation difference. For the whole time period the inflation in the US was 57,86% and 29,1% for Sweden, that is a difference of 28,76. However the US dollar only depreciated by 11,53% during the same time period. This is not surprising since it is commonly known that PPP tend not to hold for countries which are not geographically close to one another (Banerjee et al. 2005). Looking instead on Germany and Sweden, Germany showed a slightly higher inflation for the period with a difference in inflation of only 6,3. During the same period the depreciation of the Euro was almost 4%. One could argue that the rest of the difference is because of risk aversion among investors. The gain that could be acquired from a slightly undervalued krona is not enough to compensate for the risk of taking a long position in a small vulnerable currency. So even if PPP was not to hold at all times the difference is captured in the risk premium which in turn is captured by the crisis dummy. The reason why PPP is discussed here is because it is important to emphasis why PPP theory and the model for PPP is not used to make predictions. Even though some claim that PPP does hold when panel data is used instead of testing pair wise, it is most likely due to a bad method being used when testing for unit-roots in the panel data (Banerjee et al. 2005).

Theory

In order to make predictions, a basic model has to be derived. In this case the derivation used is one described by Pilbeam (2006). The derivation is done by assuming the conventional money demand function:

$$m - p = \eta y - \sigma r \quad (2)$$

Where m is the domestic money stock, p is the domestic price level, y is the domestic real income and r is the nominal domestic interest rate. What this equation states is that the demand for real money (m-p) is given by the domestic real income (y) and the interest rate (r). The reason why there is a negative sign in front of the coefficient for the interest rate is simply because the opportunity cost of holding money becomes greater with higher interest rates. Here an assumption is made that foreign and domestic bonds are perfect substitutes so that UIP holds:

$$E\dot{s} = r - r* \quad (3)$$

where Es is the expected rate of depreciation of the home currency. Assuming that PPP holds then:

$$s = p - p* \quad (4)$$

where s is the exchange rate. Substituting equation (2) for the domestic and foreign market into equation (4) and rearranging gives:

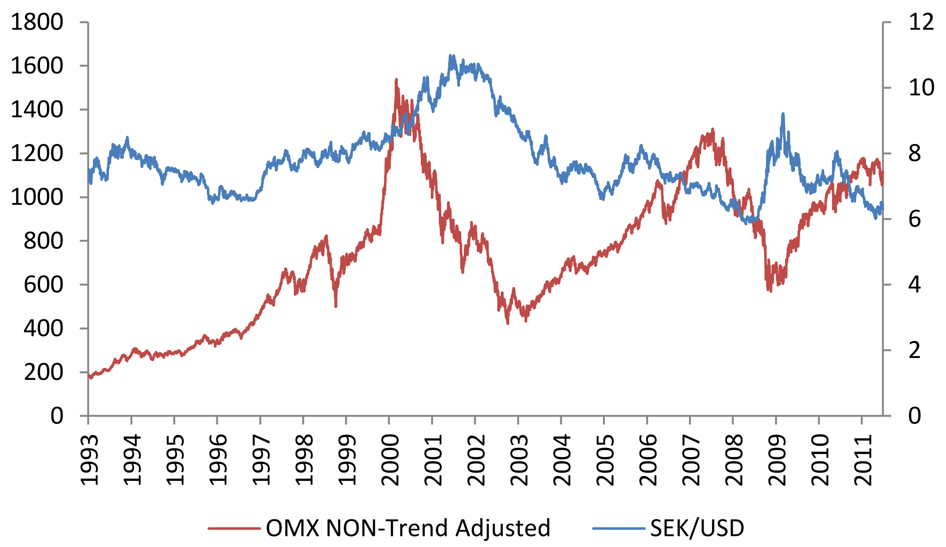
$$s = (m - m^*) - \eta(y - y^*) + \sigma(r - r^*) \quad (5)$$

This is the basic flexible-price monetary model. An increase in relative money supply leads to an increase in price, and if PPP holds that means a depreciation of the exchange rate. An increase in relative levels of national income, assuming the money stock and interest rates are held constant, leads to a decrease in prices and a appreciation of the currency.

Methodology

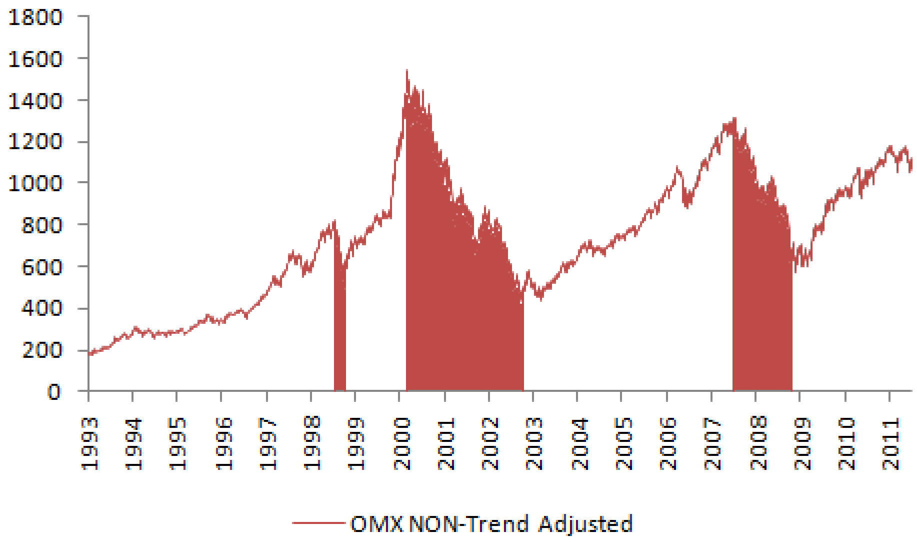
Here PPP is assumed to hold, as has been shown above this is a strong assumption because if this would be the case then predictions would be entirely based on the relative inflation between the countries of the exchange rate pair. However instead of using variables based on the consumer price indices for the different countries, price levels are estimated using money supply, interest rates and GDP. In times of financial crisis, the currencies of small export dependent countries tend to get hit harder when aggregate world demand falls (Choi et al. 2010). Because of this, investors tend to "flee" to bigger more stable currencies, and there is, at present, no bigger currency than the US dollar. An appreciating dollar could also have another explanation, that the US dollar does not follow the conventional rules of supply and demand. This is because the US dollar is used as a reserve currency and that most commodities are traded in US dollars, this increases the demand for the dollar and also makes it more sticky and resilient than other currencies. This would explain why PPP does not hold in this case since demand for the dollar is driven up for other reasons than what is ordinary for other currencies. That is why it is important to indentify periods of financial crisis and take this into account. Therefore a crisis dummy is created to identify these periods. The crisis dummy was created to capture the correlation between steep decline in the Swedish stock market index, the OMX-100, and the value of the SEK/USD pair. The argument being that the US dollar is a safe haven for currency traders.

Graph 2: Nominal OMX-index together with the SEK/USD pair



What this graph shows is that in times of financial crisis, i.e. when the red line has a steep decline, the dollar seems to gain in strength at first but then slowly return to its "natural mean", this is very evident at the 2009 mark. What can be a bit contradicting here is that in the period between 2003 and 2007 the dollar depreciated continuously but at the same time the index of the Swedish stock exchange continued to rise. In theory a depreciating dollar should put pressure on the Swedish export market, however, the United States is not the only country that Sweden exports to and even though some goods are traded in dollar the Euro has a bigger impact on the Swedish export since its biggest trading partner is located in Europe (Germany). To identify these periods of financial crisis, a dummy variable is created based on periods of steep decline between a high mark and a low mark of the OMX index:

Graph 3: OMX index with times of financial crisis highlighted



To test for the suitability of a random-walk predictor each currency pair is differentiated and tested for stationarity. Then an in-sample prediction is made based on the no-change and random walk models. This is done for both the short- and long-term for ordinary periods, non-crisis periods and periods of financial crisis respectively. Those predictors are later used as benchmarks for the models derived from the monetary model. Then a regression is run using the basic monetary model presented in the theory. The model is then extended with additional variables. To determine which variables are to be added, one needs to turn to economic theory. In the economic literature there are several fundamental variables which are supposed to affect the exchange rate in either a direct or indirect way (Pilbeam, 2006). The first long term model that is run is the flexible-price model:

$$s_{t+1} = \beta_1(m_t - m_t^*) - \beta_2(y_t - y_t^*) + \beta_3(r_t - r_t^*) + \epsilon_t \quad (6)$$

It is then extended to also include net export (in proportion of GDP) and the crisis dummy:

$$s_{t+1} = \beta_1(m_t - m_t^*) - \beta_2(y_t - y_t^*) + \beta_3(r_t - r_t^*) + \beta_4(x_t/GDP_t) + \beta_5(x_t^*/GDP_t) + \beta_6 CD_t + \epsilon_t \quad (7)$$

The reason why net export should have an effect on the value of the exchange rates is simply because an increase in relative net export means an increase in relative demand for goods. Since these goods are paid for in domestic currency there is an increase in demand for the home currency compared to that of the foreign one if the export gap increases. In the last step the model is extended one more time to allow each variable to interact with the crisis dummy separately:

$$\begin{aligned} s_{t+1} = {} & \beta_1(m_t - m_t^*) - \beta_2(y_t - y_t^*) + \beta_3(r_t - r_t^*) + \beta_4(x_t/GDP_t) + \beta_5(x_t^*/GDP_t) + \beta_6 CD_t \\ & + \beta_7(m_t - m_t^*) \cdot CD_t - \beta_8(y_t - y_t^*) \cdot CD_t + \beta_9(r_t - r_t^*) \cdot CD_t \\ & + \beta_{10}(x_t/GDP_t) \cdot CD_t + \beta_{11}(x_t^*/GDP_t) \cdot CD_t + \epsilon_t \quad (8) \end{aligned}$$

The variables included here are (all in logs except for the interest rates and net exports): Net export (x/GDP) in proportion to GDP, gross domestic product (y), interest rate (r), money supply (m) and a dummy for periods of financial crisis (CD). Equations (6)-(8) shows the general models used in this thesis. In order to make predictions the monthly data set of 218 observations is first split in half. Then observations 1-109 of the explanatory variables are regressed upon the 2-110 observations of the currency pair variable, this is done to get parameter values which represent how the explanatory variables affect the currency pair in the next period. This window is then expanded one month at a time until there are no more observations left. For each time period an estimate is made of what the value of the currency pair will be in the future by using the estimated coefficients. These are then multiplied with the values of the explanatory variables of today to get an estimate of the value of the currency pair of tomorrow. This is done for all three models for all four of the currency pairs. Because of the multicollinearty problem created in equation (8) by including each variable twice one more model, a reduced one, is created which is unique for each currency pair. This model is tested down from the general model in equation (8) to include only those variables that are statistically significant and not highly correlated with other explanatory variables. All of the above models are long-run models that try to explain how a change in the mean of the series comes about.

To be able to test predictions for the short run as well four new models are created based on those reduced models. These short-run models are created by taking the first difference of all variables except for the crisis dummy which is simply lagged one period instead. To correct for short term deviations from the long run a new variable is added to create a so called error correction model. This variable is the residuals from the long term model that has been lagged one period and is included in the models as $\hat{u}_{t-1}$. These short-run models differ from the long-run models in that they explain how the slope of the currency series is affected by changes in the slopes of the explanatory variables.

Two benchmarks are created to be able to compare the prediction models to the most basic of prediction models. The first one, the no-change predictor, is simply the value of the previous period of the series that is trying to be predicted. The second one, the random walk predictor, is created using a random number generator for normal distributions using the same mean and standard deviation as the currency pair. Then the value from the previous period of that currency is multiplied with the randomly generated number to create a prediction for this period.

Lastly the forecasting errors from these models are compared to each other and to the prediction errors of the forward rate, no-change and random walk prediction using the root mean squared error (RMSE) to see which model performs the best.

$$RMSE = \sqrt{\frac{\sum\left(n_i - E(n_i)\right)^2}{n}} \quad (9)$$

Technical Analysis

Another method of making predictions is technical analysis. It is not used here but worth mentioning. It is usually performed entirely based on previous values of the series at different time frames. Technical analysis can be a powerful tool when it comes to predicting any type of time series but is more interesting from a statistical point of view rather than an economical.

Data

All the data collected for this thesis stem from DataStream. The forward rate is the Reuters closing price for the overnight rate. The interest rates are the seven day average of the repo rate.

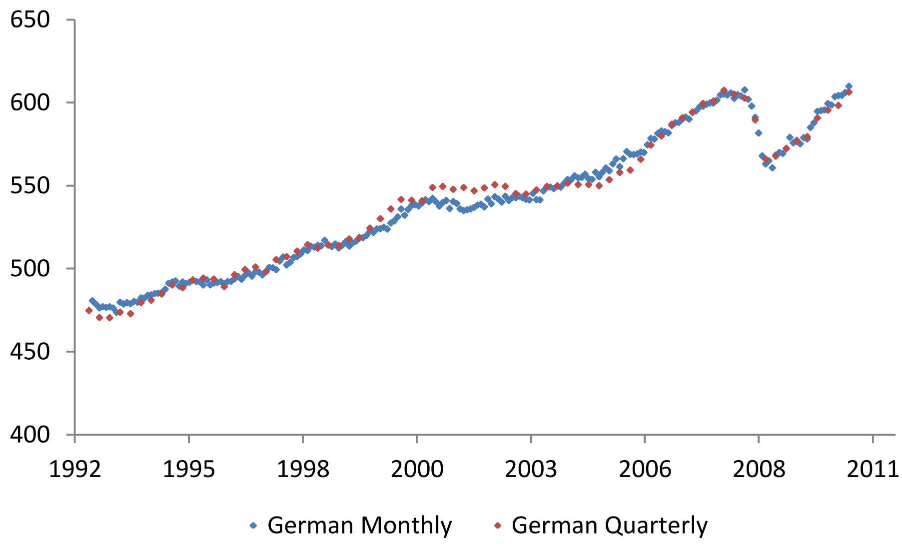
Exchange rates are all enumerated in Swedish kronor except for one pair, the Euro/USD. This inclines an underlying assumption that if a currency depreciates against the SEK and another currency enumerated in SEK remains unchanged during that same time period then the first currency needs to depreciate by the same relative amount against the second currency, if this wouldn't be true then arbitrage opportunities would occur. The pairs that are used in this thesis are the SEK/USD, SEK/EUR, SEK/AUD, SEK/GBP and the EUR/USD. Where SEK is the Swedish krona, EUR is the Euro, AUD is the Australian Dollar, GBP is the Great Britain Pound (sterling) and USD is the United States Dollar. The pairs do not follow a normal distribution, instead they seem to follow a chi-squared distribution where longer periods of sub-mean values are common but not far from the mean, while higher than mean values are uncommon but much more extreme. It has however previously been shown that non-normal leptokurtic series are common in exchange rates (Tucker & Pond, 1988 and Kearns & Pagan, 1997). Other variables also included in this thesis are import, export, industrial production, unemployment rate, consumer price index and money supply.

Because some data aren't available in daily periods and regressions cannot be run on series of different lengths one needs to either convert the more frequent daily data into less frequent quarterly averages or try and artificially fill the void in the less frequent data to match the number of observations from the more frequent daily data. In the first case the number of observations is reduced from almost 5000 to 73. This is obviously not ideal since if one wants to include lots of explanatory variables in the model then the degrees of freedom becomes critically low and instead causes a loss of power. Another problem with this method is that a lot of usable information which is available in the daily data gets discarded. In the second case the problem is to choose a method to fill in for the missing observations. There are many different ways of doing this, but to keep it simple a compromise is made to use monthly data instead of daily. Fortunately the only variable that isn't available in monthly data is GDP where instead a regression model is used to approximate monthly GDP values:

$$GDP_t = \beta_1 + \beta_2 INDUSTRIAL\ PRODUCTION_t + \beta_3 IMPORT_t + \beta_4 EXPORT_t + \beta_5 UNEMPLOYMENT_t + \beta_6 TREND_t + \epsilon_t \quad (10)$$

This model uses quarterly data to get an estimate of the coefficient values which are then used for the monthly data to create a new monthly GDP series. This approach is very accurate with an R^2 ranging between 0,985 and 0,999 for the different countries. Unfortunately there was no industrial production index available for Australia. Instead the monthly GDP data for Australia is created through interpolation of the quarterly GDP data. To illustrate how accurate the predicted values are to the actual values both series have been plotted in the same graph, this one showing the least accurate prediction of the four, namely the German one, the rest can be found in the appendix:

Graph 4 Actual and predicted GDP for Germany



The coefficients from the GDP regressions (appendix f) show that the variable with the biggest effect on the GDP is the industrial index. After that comes export which surprisingly has a negative sign in front of its coefficient. This would suggest that an increase in export leads to a decrease in GDP. This might have to do with some kind of lagged effect i.e. if export is high in the present period this might not show in the GDP statistics until next period. All of the explanatory variables except for the British unemployment rate contained a unit-root. But in all cases a co-integration vector was found (appendix g).

To avoid spurious results of the other regressions each variable is tested for a unit-root:

Table 1

P-Values of Unit Root Test				
Variable	SEK/USD	SEK/GBP	SWE/GER	SEK/AUD
m-m*	0,4376	0,0453	0,5375	0,9982
y-y*	0,8676	0,9612	0,9983	0,4608
r-r*	0,0039	0,0272	0,1188	0,0775

Table 2

P-Values of Unit Root Test					
Variable	USA	UK	Germany	Australia	Sweden
x	0,7215	0,4871	0,7547	0,2182	0,8238

As can be seen from the tables above the null hypothesis of a unit root can only be rejected in two cases. This is not very surprising since these series are trending in absolute values with the exception of interest rates. But the interest rate case probably has to do with the number of observations here. Because the null of a unit root cannot be rejected, further tests will have to be done to make sure these variables are co-integrated.

Analysis

The biggest problem using samples to try and build a good prediction model for the short run is that it is hard to emulate the market sentiment at that particular point in time. Sentiment that might be based on rumors that never realize.

Running the models from equations (6) to (8) for all the pairs and testing them for co-integration shows that the probability of falsely rejecting a null of a unit root in the residuals is as good as zero (appendix g). But another problem arises when the regressions are run, several variables are not statistically significant enough to explain the movements of the currency pair. For the flexible-price model all variables are significant for all currency pairs except for one. The interest rate differential does not seem to have any explanatory power of the SEK/EUR currency pair. This might be because the German interest rate was used and not an aggregate rate for the whole euro zone. Extending the models to include net export and a crisis dummy (see equation (7)) makes some variables insignificant. That were previously not. This also indicates that the net export and crisis dummy should be included. Extending the models once more to include the interaction variables shows that a lot of variables are highly statistically insignificant. A quick look at the correlation matrices (appendix d) shows that several explanatory variables are highly correlated with each other. This is expected when using a dummy as an interaction variable. The reason is because when the value of the dummy is zero, the interacted variables also become zero creating perfect correlation. However it is not good if the variables are correlated through the interaction variable and directly with each other at the same time. Because of this each model is changed so as to minimize multicollinearity, for example the SEK/GBP pair model is changed so that (m-m*)*CD and (x-x*)*CD are removed from the equation and instead of regressing the net export as a proportion of GDP for the home country and foreign country separately the latter is deducted from the former to instead create a new variable. These new reduced models are presented in table 3 below.

The estimated coefficients from the regressions are presented in appendix f. The crisis dummy seems to have little effect explaining the fluctuations of the SEK/AUD pair. This is because the AUD is one of the currencies that also experience high depreciation during financial crisis. If the SEK depreciates against a large currency like the USD and the AUD also depreciates against the USD by a similar relative amount then the SEK/AUD remains more or less unchanged. So the crisis dummy does not have a strong effect on that pair. When using the flexible-price model the money supply has the biggest effect on the pairs. After expanding the model it seems that the net export and crisis dummy have a bigger effect. However it is hard to say in which magnitude. Because even though net export has a bigger coefficient, the numbers are not in log value but in absolute value as a part of GDP. But if net export increases by one percent of GDP above that of the other country, that certainly seems to have a large effect on the currency pair. When the full model from equation (8) is used, the interaction variable representing GDP times the crisis dummy has a big effect on the exchange rate pairs. This is probably because a country that can withstand a decline in its GDP during a time of financial crisis is very strong financially and therefore has a higher demand for its currency.

One reason for the poor performance of some of the models used here is that PPP is assumed to hold when this is usually not the case. Another reason is that contrary to a common method used by other authors (Pilbeam, 1991) this thesis does not assume that the fundamental variables on the right hand side of the equation can be perfectly predicted. Because of this the estimated coefficients are multiplied with the values in time t instead of t+1.

Table 3: Long term models

Currency Pair	Explanatory Model used	RMSE	RMSE Benchmark	R2	R2 Benchmark
SEK/USD	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)+β_4(x)+β_5(x*)+β_6(CD)+β_7(m-m*)*CD-β_8(y-y*)*CD+β_9(r-r*)*CD+β_{10}(x)*CD+β_{11}(x*)*CD	0,08512	0,03045	0,75012	0,961652
	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)+β_4(x)+β_5(x*)+β_6(CD)	0,12561	0,03045	0,44635	0,961652
	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)	0,14532	0,03045	0,27618	0,961652
	β_1(m-m*)+β_2(r-r*)+β_3(x-x*)+β_4(CD)+β_5(m-m*)*CD-β_6(y-y*)*CD	0,08143	0,03045	0,72725	0,961652
SEK/AUD	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)+β_4(x)+β_5(x*)+β_6(CD)+β_7(m-m*)*CD-β_8(y-y*)*CD+β_9(r-r*)*CD+β_{10}(x)*CD+β_{11}(x*)*CD	0,06216	0,02137	0,34165	0,892505
	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)+β_4(x)+β_5(x*)+β_6(CD)	0,06832	0, 02137	0,25025	0,892505
	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)	0,07046	0, 02137	-0,1056	0,892505
	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)-β_4(y-y*)*CD	0,06597	0, 02137	0,24427	0,892505
SEK/GBP	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)+β_4(x)+β_5(x*)+β_6(CD)+β_7(m-m*)*CD-β_8(y-y*)*CD+β_9(r-r*)*CD+β_{10}(x)*CD+β_{11}(x*)*CD	0,06838	0,02042	0,80092	0,959796
	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)+β_4(x)+β_5(x*)+β_6(CD)	0,072	0,02042	0,70321	0,959796
	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)	0,09785	0,02042	0,21243	0,959796
	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)+β_4(x-x*)+β_5(CD)-β_6(y-y*)*CD+β_7(r-r*)*CD	0,06793	0,02042	0,75311	0,959796
SEK/EUR	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)+β_4(x)+β_5(x*)+β_6(CD)+β_7(m-m*)*CD-β_8(y-y*)*CD+β_9(r-r*)*CD+β_{10}(x)*CD+β_{11}(x*)*CD	0,05686	0,01422	0,33451	0,926352
	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)+β_4(x)+β_5(x*)+β_6(CD)	0,05474	0, 01422	0,26917	0,926352
	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)	0,05091	0, 01422	0,24547	0,926352
	β_1(m-m*)-β_2(y-y*)+β_3(x-x*)+β_4(CD)+β_5(m-m*)*CD	0,05738	0, 01422	0,29479	0,926352

Table 4: Short term models

Currency Pair	Explanatory Model used	RMSE	RMSE Benchmark	R2	R2 Benchmark
SEK/USD	β_1(m-m*)+β_2(r-r*)+β_3(x-x*)+β_4(CD)+β_5(m-m*)*CD-β_6(y-y*)*CD +β_7($\hat{u}_{t-1}$)	0,03091	0,03353	0,056194	0,117399
SEK/AUD	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)-β_4(y-y*)*CD +β_5($\hat{u}_{t-1}$)	0,02212	0,02859	0,068267	0,028476
SEK/GBP	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)+β_4(x-x*)+β_5(CD)-β_6(y-y*)*CD+β_7(r-r*)*CD +β_8($\hat{u}_{t-1}$)	0,02052	0,02752	0,065709	0,016221
SEK/EUR	β_1(m-m*)-β_2(y-y*)+β_3(x-x*)+β_4(CD)+β_5(m-m*)*CD +β_6($\hat{u}_{t-1}$)	0,01401	0,01801	0,110677	0,046237

Table 5: Benchmark tests (averages)

Variable	RMSE Crisis	RMSE Total
No change	0,102437038	0,059902158
Random Walk	1,062029989	1,072925144
Forward Rate	0,043083636	0,04382764

From table 3 it is clear that the model used in equation (8) does suffer from multicollinearity. In all cases an equally good model or in two cases an even better model in terms of RMSE can be created using half or less amount of explanatory variables. Equation (8) is a good model in the sense that it explains more of the economic background of the effect that a period of financial crisis brings about on the explanatory variables. However in terms of creating a pure prediction model it is not necessary to include all of the variables as can be seen in the table above. The reason for this is simply because the correlations between some of the variables are very high which makes it unnecessary to include them both. This correlation is created to a big extent by the fact that the crisis periods are relatively short and when the dummy is multiplied with the rest of the variables this creates several series containing mostly zeros and then a few observations with actual numbers. Looking at the performance of these models it seems that the model explaining the SEK/USD pair is the one that is the most accurate. This is found by dividing the benchmark with the models RMSE for each currency pair. This is because the values of the RMSE for a model can only be compared to other RMSE values of the same currency pair and the benchmark for that currency. One cannot compare an absolute RMSE value for a model trying to explain a certain currency pair directly with another model trying to explain a different currency pair. This is because the absolute value of the mean and variance for the exchange rate series are different. And hence if the RMSE value is the same for two different models explaining two different currency pairs then the model explaining the currency pair with the higher mean and variance is the better one even though the RMSE value is the same. Therefore the results for the models explaining each of the currency pairs are analyzed separately. The most surprising results are shown when looking at the models explaining the SEK/EUR pair. Here the most basic model is the one that has the most explanatory power according to RMSE. Neither the crisis dummy nor the net export improves the explanatory power of the models. One of the reasons why the models has such a bad explanatory power could be because all of the variables on the right hand side of the equation are based on values from the German economy but on the left hand side the euro represents all the countries of the euro zone.

Table 4 shows some very surprising results. It seems that in the short run these models become a lot better at outperforming the benchmark. What the short term model does is that it explains how much the change of the currency will change based on a change in change of the explanatory variables. One reason for the surprising result could be that the error correction term used here was created from a long term regression that was run for the entire period, this was done for simplicity. However this means that the error correction term contains information about things that have not yet occurred. This is not a major problem since the error term, like the rest of the variables, is included gradually. But if one were to run a long term regression for each time the window is expanded, then the results might have come out differently. Another fact that might pose a problem is that the benchmark is no longer no change in the sense that it assumes that the value of tomorrow equals the value of today. Instead the no change benchmark now means that the change in value since last period should be the same as the change in value between this period and the next. Compared to the "original" meaning of no change (when absolute level value is used) i.e. it will not change at all! So it might not only have been the model that has become more accurate. It might as well be the benchmark which has become less accurate. One could instead create a new benchmark based on the average change stating that the change for any period should be equal to the average of the entire period.

Focusing on table 5 now, it shows the average RMSE for all the currency pairs. Unlike the RMSE's in table 3 and 4 the RMSE's in table 5 are for all observations and not just for the second half of the series. What is worth noting here is that the no change predictor becomes a lot worse during times of financial crisis, while the random walk predictor actually improves. This would be an indication that in times of crisis, the currency series becomes more random and hence less predictable. The no-change predictor on the other hand becomes a lot better during non-crisis periods. This is intuitive since the market doesn't move as often or as big during non-crisis periods, making the no-change predictor almost perfect at times. Using the overnight forward rate it outperformed both the no-change and random walk predictors during both periods of crisis and non-crisis. But surprisingly, the forward rate improves during times of crisis. This is somewhat contradictive but suggests that the currency pairs have stronger trends during times of crisis making them easier to predict at those times. This would be a support of including a crisis dummy to indentify these periods. That the no change predictor becomes a lot worse during those times suggests that changes occur either more often or are bigger than usual. The random walk model seems to be a very bad predictor, even though it performs slightly better during times of crisis than it does for non-crisis times, it is only marginally better. It is however still far from being anywhere close to the real value. The fact that the forward rate can outperform the other models should be seen as a strong indication that predictions are possible in the short run. What should be noted here is that the random walk predictor is created assuming a normal distribution. However as shown in the data section these series are not normally distributed instead they tend to have a chi-squared distribution, this should be one reason why the random walk predictor performs so poorly.

What also needs to be mentioned is the fact that the crisis dummy was created using a totally subjective measure; being a strong decline in the OMX-index. However the alternative would have been to create a measure using standard deviations from the mean of the currency series, this would however end up being just as subjective because one has to choose the size of the rolling window used to calculate the standard deviation and one would also have to choose a value of which the standard deviation has to exceed for the period to be considered a crisis period.

Conclusion

The reason why it should be easier to do long run predictions is because the expected value of a zero sum game is equal to the mean of the series. And the only things that can shift the series from its mean are the fundamental variables which the series are based on. This is probably why it has been shown to be easier to beat the random walk and no change predictions in the (very) long run (making predictions further than only one period ahead) using a model based on fundamental variables. But this does not mean that the random walk and no-change prediction models cannot be beaten in the short run which has been shown here. Because it was shown in the test for EMH that the currency pairs exhibit autocorrelation and cross-correlation among each other it would be interesting to set up a model that includes the lagged values of the exchange rates and to include the other currency pairs as explanatory variables or at least include the explanatory variables of other pairs that have high correlation with the pair trying to be explained. It might also be useful to try and predict the explanatory variables as well, if these can be accurately predicted then the prediction of the exchange rate will become more accurate as well since predicting the value of the exchange rate in the next period using the next periods explanatory variables is easier than using this periods values. It would also make sense to relax the assumptions of purchasing power parity and the uncovered interest parity. Another variable that might have helped explain the currency fluctuations during financial crisis is the foreign currency reserve that each country holds. The reason for using the reserve as an explanatory variable would be to see if it gets used during times of financial crisis. For example a country could decide to use its reserve to try and avoid a too steep depreciation of the currency to keep the economy stable. What one also could have done to extend the analysis is to try and predict several periods ahead instead of what is done in this paper which focuses on trying to predict one period ahead. It should theoretically be easier to beat the no change prediction the further you are trying to predict, however since the currency pairs fluctuate around a constant mean one might end up with the case that the period one is trying to predict coincides with a retraction of the series back to the value that the no change predictor was based on, making it a perfect match. Therefore the no change predictor as a benchmark has to be argued to be a biased predictor in the sense that its accuracy depends on the sample period chosen. If the sample for example only consisted of observations of a very "calm" period the no change predictor would perform better than for a time of large frequent fluctuations. To summarize the findings of this thesis it seems that beating the no change predictor when making one period ahead predictions is difficult but possible. Even though the models used here were not successful (except for the ECM) at beating the no change predictor, the forward rate shows that it can be consistently beaten for the one period horizon. More importantly the crisis dummy has a significant effect when it comes to making predictions. If however one were to do real time predictions then the dummy would not be able to be created the way it was created here. Since a steep decline in OMX would only be visible in hindsight. That the financial crisis started in the US and still the US Dollar appreciated against smaller currencies is not a general case. It is only because the dollar is the world's biggest currency. If instead the crisis had originated in a smaller economy then the currency of that country would have depreciated against the US dollar (as long as it was a floating currency). So if a better way can be found to recognize a financial crisis at an early stage. That information could be used to make better predictions.

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Appendix

App. A Durbin-Watson test

Durbin-Watson statistic for different currency pairs for the full dataset period (20 years), constant and trend included in the regression:

SEK/EUR: 0.010190414717708, SEK/US: 0.003265121939138031, SEK/AUS: 0.01411944562442888, SEK/GBP: 0.003825339957237661, EUR/US: 0.001878912856131392

App. B Unit root test for currency series

Results of a unit root test on the first difference for each of the currency pairs. They all reject the null of a unit root with a p-value of 0,0001.

App. C Cross-Correlograms for currency pairs:

Correlations

Variable	SEK/USD	SEK/AUD	SEK/GBP	SEK/EUR	EUR/USD
SEK/USD	1	-0,256527	0,69794	-0,030551	0,934721
SEK/AUD	-0,256527	1	-0,268945	0,405201	-0,361566
SEK/GBP	0,69794	-0,268945	1	-0,012859	0,672392
SEK/EUR	-0,030551	0,405201	-0,012859	1	-0,373008
EUR/USD	0,934721	-0,361566	0,672392	-0,373008	1

SWE_US,SWE_EUR(-i)	SWE_US,SWE_EUR(+i)	i	lag	lead
		0	-0.0144	-0.0144
		1	-0.0164	-0.0151
		2	-0.0182	-0.0155
		3	-0.0198	-0.0158
		4	-0.0214	-0.0161
		5	-0.0229	-0.0163
		6	-0.0244	-0.0162
		7	-0.0260	-0.0163
		8	-0.0276	-0.0163
		9	-0.0293	-0.0164
		10	-0.0309	-0.0167
		11	-0.0325	-0.0170
		12	-0.0340	-0.0171
		13	-0.0355	-0.0173
		14	-0.0371	-0.0175
		15	-0.0385	-0.0177
		16	-0.0399	-0.0178
		17	-0.0414	-0.0180
		18	-0.0430	-0.0181
		19	-0.0445	-0.0183
		20	-0.0460	-0.0183
		21	-0.0475	-0.0183
		22	-0.0490	-0.0184
		23	-0.0505	-0.0185
		24	-0.0518	-0.0186
		25	-0.0532	-0.0186
		26	-0.0546	-0.0187
		27	-0.0559	-0.0187
		28	-0.0572	-0.0188
		29	-0.0585	-0.0191
		30	-0.0598	-0.0194
		31	-0.0610	-0.0197
		32	-0.0622	-0.0199
		33	-0.0635	-0.0201
		34	-0.0650	-0.0204
		35	-0.0664	-0.0206
		36	-0.0678	-0.0207

SWE_US,SWE_UK(-i)	SWE_US,SWE_UK(+i)	i	lag	lead
		0	0.7106	0.7106
		1	0.7092	0.7092
		2	0.7078	0.7078
		3	0.7066	0.7066
		4	0.7054	0.7056
		5	0.7041	0.7046
		6	0.7029	0.7035
		7	0.7015	0.7024
		8	0.7001	0.7013
		9	0.6986	0.7003
		10	0.6971	0.6993
		11	0.6956	0.6984
		12	0.6941	0.6976
		13	0.6927	0.6966
		14	0.6912	0.6956
		15	0.6898	0.6946
		16	0.6883	0.6937
		17	0.6868	0.6928
		18	0.6853	0.6919
		19	0.6839	0.6910
		20	0.6824	0.6901
		21	0.6810	0.6894
		22	0.6795	0.6885
		23	0.6780	0.6876
		24	0.6766	0.6867
		25	0.6752	0.6858
		26	0.6739	0.6849
		27	0.6724	0.6840
		28	0.6711	0.6832
		29	0.6696	0.6822
		30	0.6682	0.6813
		31	0.6670	0.6804
		32	0.6657	0.6796
		33	0.6644	0.6788
		34	0.6630	0.6779
		35	0.6616	0.6771
		36	0.6602	0.6763

SWE_US,SWE_AUS(-i)	SWE_US,SWE_AUS(+i)	i	lag	lead
		0	-0.2888	-0.2888
		1	-0.2899	-0.2895
		2	-0.2908	-0.2900
		3	-0.2918	-0.2904
		4	-0.2928	-0.2907
		5	-0.2936	-0.2908
		6	-0.2945	-0.2909
		7	-0.2955	-0.2910
		8	-0.2965	-0.2910
		9	-0.2975	-0.2911
		10	-0.2986	-0.2912
		11	-0.2996	-0.2914
		12	-0.3004	-0.2914
		13	-0.3012	-0.2916
		14	-0.3020	-0.2916
		15	-0.3028	-0.2917
		16	-0.3037	-0.2916
		17	-0.3047	-0.2915
		18	-0.3056	-0.2913
		19	-0.3063	-0.2912
		20	-0.3071	-0.2909
		21	-0.3077	-0.2905
		22	-0.3085	-0.2903
		23	-0.3093	-0.2902
		24	-0.3101	-0.2901
		25	-0.3108	-0.2901
		26	-0.3114	-0.2902
		27	-0.3118	-0.2903
		28	-0.3122	-0.2904
		29	-0.3127	-0.2906
		30	-0.3131	-0.2907
		31	-0.3133	-0.2908
		32	-0.3135	-0.2909
		33	-0.3138	-0.2911
		34	-0.3140	-0.2914
		35	-0.3143	-0.2916
		36	-0.3147	-0.2917

SWE_US,EUR_US(-i)	SWE_US,EUR_US(+i)	i	lag	lead
		0	0.9342	0.9342
		1	0.9343	0.9329
		2	0.9335	0.9316
		3	0.9328	0.9303
		4	0.9321	0.9291
		5	0.9314	0.9279
		6	0.9307	0.9266
		7	0.9300	0.9252
		8	0.9292	0.9238
		9	0.9284	0.9225
		10	0.9276	0.9212
		11	0.9268	0.9199
		12	0.9261	0.9187
		13	0.9253	0.9173
		14	0.9244	0.9160
		15	0.9236	0.9146
		16	0.9228	0.9133
		17	0.9219	0.9118
		18	0.9210	0.9104
		19	0.9201	0.9090
		20	0.9192	0.9077
		21	0.9183	0.9062
		22	0.9175	0.9047
		23	0.9166	0.9032
		24	0.9157	0.9017
		25	0.9149	0.9002
		26	0.9140	0.8987
		27	0.9131	0.8972
		28	0.9122	0.8958
		29	0.9113	0.8943
		30	0.9103	0.8929
		31	0.9093	0.8915
		32	0.9084	0.8901
		33	0.9074	0.8886
		34	0.9065	0.8871
		35	0.9055	0.8856
		36	0.9046	0.8841

App. D Correlation matrices:

Correlation Table for SEK/GBP

Variable	SEK/GBP	m-m*	y-y*	r-r*	x	x*	Crisis Dummy	(m-m*)*CD	(y-y*)*CD	(r-r*)*CD	(x)*CD	(x*)*CD
SEK/GBP	1	0,06699	-0,178931	-0,564654	0,423524	-0,494776	0,457642	0,500201	0,449388	-0,265449	0,414048	-0,369826
m-m*	0,06699	1	-0,833888	0,256308	-0,734181	0,711353	-0,035559	0,029167	-0,04451	0,010535	-0,11613	0,158833
y-y*	-0,178931	-0,833888	1	-0,116144	0,525878	-0,455788	0,122212	0,054333	0,133739	-0,109776	0,191101	-0,218431
r-r*	-0,564654	0,256308	-0,116144	1	-0,537244	0,431564	-0,180083	-0,180463	-0,180499	0,328048	-0,136841	0,112061
x	0,423524	-0,734181	0,525878	-0,537244	1	-0,87802	0,113831	0,07258	0,118633	0,005823	0,19438	-0,22306
x*	-0,494776	0,711353	-0,455788	0,431564	-0,87802	1	-0,238081	-0,197726	-0,242266	0,100514	-0,30068	0,333732
Crisis Dummy	0,457642	-0,035559	0,122212	-0,180083	0,113831	-0,238081	1	0,985295	0,999645	-0,735528	0,959744	-0,902718
(m-m*)*CD	0,500201	0,029167	0,054333	-0,180463	0,07258	-0,197726	0,985295	1	0,980883	-0,730936	0,908693	-0,831859
(y-y*)*CD	0,449388	-0,04451	0,133739	-0,180499	0,118633	-0,242266	0,999645	0,980883	1	-0,736587	0,963871	-0,90903
(r-r*)*CD	-0,265449	0,010535	-0,109776	0,328048	0,005823	0,100514	-0,735528	-0,730936	-0,736587	1	-0,622728	0,550011
(x)*CD	0,414048	-0,11613	0,191101	-0,136841	0,19438	-0,30068	0,959744	0,908693	0,963871	-0,622728	1	-0,978416
(x*)*CD	-0,369826	0,158833	-0,218431	0,112061	-0,22306	0,333732	-0,902718	-0,831859	-0,90903	0,550011	-0,978416	1

Correlation Table for SEK/USD

Variable	SEK/USD	m-m*	y-y*	r-r*	x	x*	Crisis Dummy	(m-m*)*CD	(y-y*)*CD	(r-r*)*CD	(x)*CD	(x*)*CD
SEK/USD	1	0,480977	-0,445336	-0,064759	-0,104923	-0,183408	0,361427	0,369949	0,357926	-0,052807	0,234577	-0,380944
m-m*	0,480977	1	-0,356637	-0,475207	0,490457	-0,752293	0,522923	0,52581	0,522274	-0,028475	0,49146	-0,536048
y-y*	-0,445336	-0,356637	1	0,081324	0,094052	0,191416	0,214842	0,210809	0,217571	0,108482	0,305001	-0,209696
r-r*	-0,064759	-0,475207	0,081324	1	-0,414456	0,443053	-0,11977	-0,12032	-0,119294	0,429242	-0,051087	0,11096
x	-0,104923	0,490457	0,094052	-0,414456	1	-0,879374	0,113831	0,113176	0,114865	0,156784	0,19438	-0,140292
x*	-0,183408	-0,752293	0,191416	0,443053	-0,879374	1	-0,251079	-0,252416	-0,251041	-0,014916	-0,269179	0,27757
Crisis Dummy	0,361427	0,522923	0,214842	-0,11977	0,113831	-0,251079	1	0,999904	0,999986	-0,01094	0,959744	-0,986739
(m-m*)*CD	0,369949	0,52581	0,210809	-0,12032	0,113176	-0,252416	0,999904	1	0,99985	-0,012403	0,959007	-0,987911
(y-y*)*CD	0,357926	0,522274	0,217571	-0,119294	0,114865	-0,251041	0,999986	0,99985	1	-0,009864	0,960701	-0,986694
(r-r*)*CD	-0,052807	-0,028475	0,108482	0,429242	0,156784	-0,014916	-0,01094	-0,012403	-0,009864	1	0,139516	-0,00488
(x)*CD	0,234577	0,49146	0,305001	-0,051087	0,19438	-0,269179	0,959744	0,959007	0,960701	0,139516	1	-0,97196
(x*)*CD	-0,380944	-0,536048	-0,209696	0,11096	-0,140292	0,27757	-0,986739	-0,987911	-0,986694	-0,00488	-0,97196	1

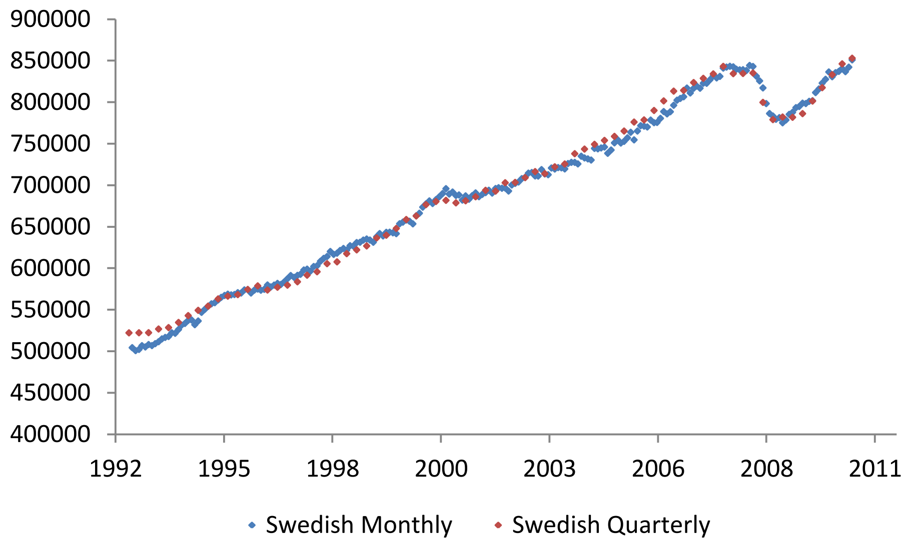
Correlation Table for SEK/AUD

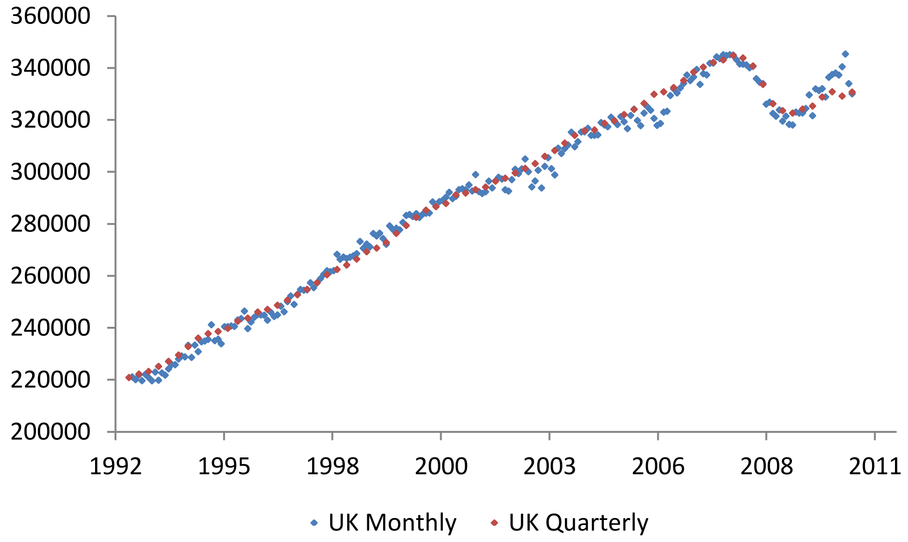
Variable	SEK/AUD	m-m*	y-y*	r-r*	x	x*	Crisis Dummy	(m-m*)*CD	(y-y*)*CD	(r-r*)*CD	(x)*CD	(x*)*CD
SEK/AUD	1	-0,576287	-0,601476	-0,429837	0,321135	-0,579673	-0,18011	0,090825	-0,184802	0,043403	-0,091979	-0,282611
m-m*	-0,576287	1	0,847807	0,802932	-0,755321	0,82558	-0,203681	0,294642	-0,197421	0,290377	-0,269081	0,061109
y-y*	-0,601476	0,847807	1	0,616424	-0,657546	0,753335	0,092932	-0,025705	0,099238	-0,04297	0,029858	0,202216
r-r*	-0,429837	0,802932	0,616424	1	-0,820553	0,633054	-0,075198	0,120353	-0,073871	0,199043	-0,094659	0,069069
x	0,321135	-0,755321	-0,657546	-0,820553	1	-0,686287	0,113831	-0,181541	0,108015	-0,149971	0,19438	-0,063001
x*	-0,579673	0,82558	0,753335	0,633054	-0,686287	1	0,037856	0,148146	0,04949	0,24385	-0,093329	0,464458
Crisis Dummy	-0,18011	-0,203681	0,092932	-0,075198	0,113831	0,037856	1	-0,951993	0,999708	-0,822366	0,959744	0,729914
(m-m*)*CD	0,090825	0,294642	-0,025705	0,120353	-0,181541	0,148146	-0,951993	1	-0,945979	0,896942	-0,981897	-0,49912
(y-y*)*CD	-0,184802	-0,197421	0,099238	-0,073871	0,108015	0,04949	0,999708	-0,945979	1	-0,819177	0,954062	0,742085
(r-r*)*CD	0,043403	0,290377	-0,04297	0,199043	-0,149971	0,24385	-0,822366	0,896942	-0,819177	1	-0,840359	-0,307769
(x)*CD	-0,091979	-0,269081	0,029858	-0,094659	0,19438	-0,093329	0,959744	-0,981897	0,954062	-0,840359	1	0,563615
(x*)*CD	-0,282611	0,061109	0,202216	0,069069	-0,063001	0,464458	0,729914	-0,49912	0,742085	-0,307769	0,563615	1

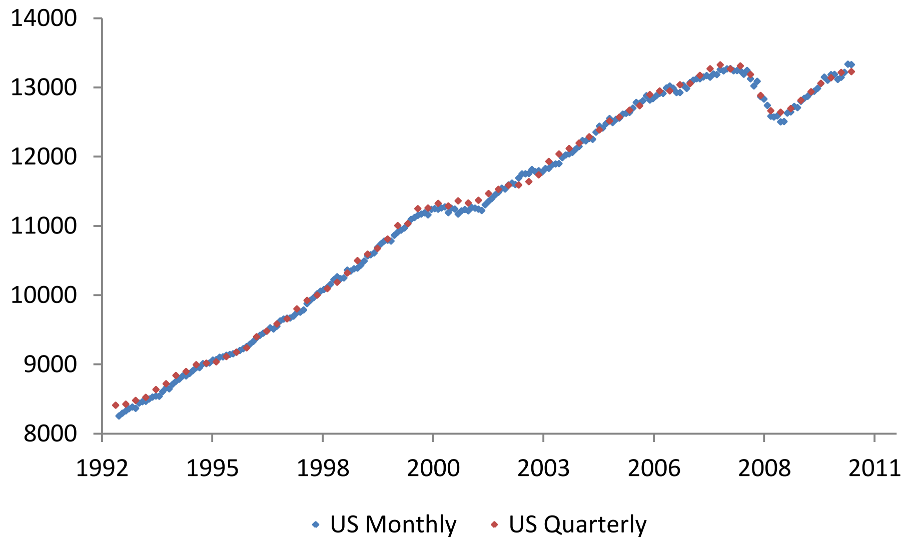
Correlation Table for SEK/EUR

Variable	SEK/EUR	m-m*	y-y*	r-r*	x	x*	Crisis Dummy	(m-m*)*CD	(y-y*)*CD	(r-r*)*CD	(x)*CD	(x*)*CD
SEK/EUR	1	-0,179163	0,438831	-0,232314	0,391967	0,473903	-0,060484	-0,06013	-0,058992	0,114808	0,021173	0,116863
m-m*	-0,179163	1	0,116359	-0,113376	0,314775	0,045149	0,218122	0,236453	0,21665	0,213271	0,208056	0,086741
y-y*	0,438831	0,116359	1	-0,664637	0,899649	0,87158	0,230891	0,226864	0,232804	-0,054421	0,288251	0,342696
r-r*	-0,232314	-0,113376	-0,664637	1	-0,62579	-0,570597	-0,316548	-0,312695	-0,316732	0,256203	-0,29632	-0,23111
x	0,391967	0,314775	0,899649	-0,62579	1	0,858893	0,113831	0,113688	0,115651	0,021166	0,19438	0,26073
x*	0,473903	0,045149	0,87158	-0,570597	0,858893	1	0,217911	0,213006	0,221449	0,035429	0,346378	0,502177
Crisis Dummy	-0,060484	0,218122	0,230891	-0,316548	0,113831	0,217911	1	0,999373	0,999976	-0,101319	0,959744	0,779557
(m-m*)*CD	-0,06013	0,236453	0,226864	-0,312695	0,113688	0,213006	0,999373	1	0,999249	-0,085508	0,959076	0,773377
(y-y*)*CD	-0,058992	0,21665	0,232804	-0,316732	0,115651	0,221449	0,999976	0,999249	1	-0,102094	0,961411	0,783704
(r-r*)*CD	0,114808	0,213271	-0,054421	0,256203	0,021166	0,035429	-0,101319	-0,085508	-0,102094	1	-0,060938	-0,004869
(x)*CD	0,021173	0,208056	0,288251	-0,29632	0,19438	0,346378	0,959744	0,959076	0,961411	-0,060938	1	0,908959
(x*)*CD	0,116863	0,086741	0,342696	-0,23111	0,26073	0,502177	0,779557	0,773377	0,783704	-0,004869	0,908959	1

App. E GDP prediction graphs:







App. F Regression results:

SEK/USD

Long term models	eq 6	p-value	eq 7	p-value	eq 8	p-value	reduced	p-value
m-m*	0,680455	0	0,609276	0	0,420547	0	0,50022	0
y-y*	-0,195263	0,0055	-0,100311	0,3809	0,079724	0,3686		
r-r*	0,012679	0,0006	0,004496	0,1869	0,003589	0,2343	0,006852	0,0026
x			-4,06162	0	-1,736478	0,013		
x*			-3,110311	0,0299	-0,915149	0,4267		
crisis dummy			0,025966	0,1486	8,973545	0,0439	19,73375	0
(m-m*)*crisis					1,590706	0	1,328503	0
(y-y*)*crisis					-3,767	0,0003	-6,151928	0
(r-r*)*crisis					0,025218	0,0014		
(x)*crisis					-4,33489	0,0601		
(x*)*crisis					-0,856709	0,8361		
x-x*							-0,73847	0
adjusted R^2	0,269411		0,43323		0,737993		0,720788	
Nr of Obs	217		217		217		217	
DW	0,06994		0,099138		0,372901		0,385173	
BIC	-1,504342		-1,69798		-2,369586		-2,405962	

Δ(SEK/USD)

Short term model	reduced	p-value
Δ (m-m*)	0,055293	0,6658
Δ (r-r*)	-0,001896	0,8052
Δ (x-x*)	0,988985	0,1825
crisis dummy	0,003497	0,3675
Δ ((m-m*)*crisis)	-0,411001	0,1457
Δ ((y-y*)*crisis)	0,028141	0,9614
$\hat{u}_{t-1}$	-0,097489	0,0007
adjusted R^2	0,056194	
Nr of Obs	216	
DW	1,360269	
BIC	-4,33523	

SEK/EUR								
Long term models	eq 6	p-value	eq 7	p-value	eq 8	p-value	reduced	p-value
m-m*	-0,069884	0,0001	-0,039666	0,0702	-0,072438	0,0044	-0,071984	0,003
y-y*	0,369967	0	0,345762	0	0,375255	0	0,374339	0
r-r*	0,002582	0,314	0,001532	0,6628	-0,00124	0,7401		
x			-0,588263	0,0997	-0,662427	0,0828		
x*			0,669548	0,0258	0,580427	0,1338		
crisis dummy			-0,017317	0,0554	12,18276	0,0255	-0,74038	0,0043
(m-m*)*crisis					-0,021176	0,7296	0,115742	0,0053
(y-y*)*crisis					-1,714498	0,0223		
(r-r*)*crisis					0,005894	0,7274		
(x)*crisis					3,923231	0,0135		
(x*)*crisis					0,701798	0,5856		
x-x*							-0,641378	0,0278
adjusted R^2	0,238416		0,251855		0,302205		0,281488	
Nr of Obs	217		217		217		217	
DW	0,099584		0,108157		0,116127		0,113567	
BIC	-3,144424		-3,10197		-3,071662		-3,162449	

Δ(SEK/EUR)		
Short term model	reduced	p-value
Δ (m-m*)	-0,067568	0,0473
Δ (y-y*)	-0,170901	0,2304
Δ (x-x*)	1,07993	0,0013
crisis dummy	0,005727	0,0043
Δ ((m-m*)*crisis)	-0,002728	0,024
$\hat{u}_{t-1}$	-0,049911	0,0236
adjusted R^2	0,110677	
Nr of Obs	216	
DW	1,750278	
BIC	-5,555503	

SEK/GBP								
Long term models	eq 6	p-value	eq 7	p-value	eq 8	p-value	reduced	p-value
m-m*	0,440276	0	0,768522	0	0,666188	0	0,678166	0
y-y*	2,460688	0	2,000726	0	2,146067	0	2,0469	0
r-r*	-0,038073	0	-0,020341	0	-0,025765	0	-0,019589	0
x			0,718576	0,0761	-0,081691	0,8253		
x*			-5,004669	0	-5,042016	0		
crisis dummy			0,036515	0,0002	2,700428	0,0009	2,66086	0
(m-m*)*crisis					0,020257	0,901		
(y-y*)*crisis					-3,148961	0,0001	-2,968455	0
(r-r*)*crisis					0,025814	0,0018	0,021458	0,0051
(x)*crisis					2,845563	0,04		
(x*)*crisis					2,917991	0,1494		
x-x*							2,300937	0
adjusted R^2	0,205069		0,696181		0,791259		0,746051	
Nr of Obs	217		217		217		217	
DW	0,191241		0,403744		0,586651		0,459082	
BIC	-1,935834		-2,8374		-3,112757		-2,996656	

Δ(SEK/GBP)		
Short term model	reduced	p-value
Δ (m-m*)	0,040678	0,6616
Δ (y-y*)	-0,13111	0,256
Δ (r-r*)	-0,005433	0,3596
crisis dummy	-0,00142	0,6117
Δ ((y-y*)*crisis)	0,026082	0,1567
Δ ((r-r*)*crisis)	0,003877	0,567
Δ (x-x*)	1,27555	0,0182
$\hat{u}_{t-1}$	-0,079419	0,0051
adjusted R^2	0,065709	
Nr of Obs	216	
DW	1,855195	
BIC	-4,880414	

SEK/AUD								
Long term models	eq 6	p-value	eq 7	p-value	eq 8	p-value	reduced	p-value
m-m*	-0,429988	0	-0,505899	0	-0,419714	0	-0,490884	0
y-y*	1,485409	0	1,492935	0	1,643084	0	1,486069	0
r-r*	0,010599	0,0104	0,013091	0,0019	0,004336	0,3871	0,015192	0
x			-0,364551	0,2898	-1,425592	0,0008		
x*			0,012147	0,9574	-1,22615	0,0018		
crisis dummy			-0,103187	0	1,264902	0,2282		
(m-m*)*crisis					0,201058	0,2241		
(y-y*)*crisis					-1,647122	0,1188	-0,101017	0
(r-r*)*crisis					-0,035733	0,0969		
(x)*crisis					4,351693	0,0004		
(x*)*crisis					2,470415	0,0034		
x-x*								
adjusted R^2	-0,115943		0,23248		0,309691		0,233625	
Nr of Obs	217		217		217		217	
DW	0,14702		0,271004		0,332562		0,26581	
BIC	-2,267314		-2,581346		-2,587393		-2,62299	

Δ(SEK/AUD)		
Short term model	reduced	p-value
Δ (m-m*)	-0,050124	0,5528
Δ (y-y*)	-0,371144	0,1802
Δ (r-r*)	-0,014608	0,0466
Δ ((y-y*)*crisis)	-0,001841	0,8784
$\hat{u}_{t-1}$	-0,089497	0,0015
adjusted R^2	0,068267	
Nr of Obs	216	
DW	1,749155	
BIC	-4,55779	

GDP

Variabel	Sweden	p-value	Germany	p-value	US	p-value	UK	p-value
Constant	381779,4	0	341,1487	0	5882,302	0	131737	0
Industrial production index	2240,412	0	1,804252	0	39,36355	0	1330,422	0
Import	2,597114	0,0012			0,014257	0	5,039213	0
Export	-1,870491	0,1159			-0,020541	0	-6,075059	0
Unemployment	-2102,186	0,0388	-0,490406	0,3297	-3,801775	0,8268	-2587,939	0,001
Trend	2822,247	0	0,993081	0	50,5805	0	1066,822	0
Trade Balance			-0,205978	0,5682				
adjusted R^2	0,993496		0,984521		0,998582		0,992855	
Nr of Obs	74		74		74		74	
DW	0,385716		0,299122		1,118725		0,665766	
BIC	21,16519		6,260416		11,3003		19,27644	

ln(GDP)

Variabel (all in logs)	Sweden	p-value	Germany	p-value	US	p-value	UK	p-value
Constant	12,82352	0	4,902207	0	8,138234	0	10,97125	0
Industrial production index	0,463973	0	0,297983	0	0,287913	0	0,283715	0
Import	0,266661	0			0,112902	0	0,184118	0,0001
Export	-0,40874	0			-0,13881	0	-0,161335	0
Unemployment	-0,021832	0,017	-0,020864	0,0499	-0,031841	0,0034	-0,071623	0
Trend	0,005475	0	0,00138	0	0,005202	0	0,004036	0
Trade Balance			0,016437	0,0044				
adjusted R2	0,995953		0,984676		0,998715		0,997094	
Nr of Obs	74		74		74		74	
DW	0,794011		0,352991		1,134986		0,469211	
BIC	-6,158684		-6,31888		-7,379296		-6,718292	

App. G Co-integration tests and additional unit-root test:

(P-value indicates the probability of falsely rejecting the null hypothesis of a unit root.)

Co-Integration tests

Currency Pair	Explanatory Model used	P-value
SEK/USD	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)+β_4(x)+β_5(x*)+β_6(CD)+β_7(m-m*)*CD-β_8(y-y*)*CD+β_9(r-r*)*CD+β_{10}(x)*CD+β_{11}(x*)*CD	0
	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)+β_4(x)+β_5(x*)+β_6(CD)	0,0004
	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)	0,0072
	β_1(m-m*)+β_2(r-r*)+β_3(x-x*)+β_4(CD)+β_5(m-m*)*CD-β_6(y-y*)*CD	0
SEK/AUD	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)+β_4(x)+β_5(x*)+β_6(CD)+β_7(m-m*)*CD-β_8(y-y*)*CD+β_9(r-r*)*CD+β_{10}(x)*CD+β_{11}(x*)*CD	0
	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)+β_4(x)+β_5(x*)+β_6(CD)	0
	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)	0,0002
	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)-β_4(y-y*)*CD	0
SEK/GBP	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)+β_4(x)+β_5(x*)+β_6(CD)+β_7(m-m*)*CD-β_8(y-y*)*CD+β_9(r-r*)*CD+β_{10}(x)*CD+β_{11}(x*)*CD	0
	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)+β_4(x)+β_5(x*)+β_6(CD)	0
	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)	0,0165
	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)+β_4(x-x*)+β_5(CD)-β_6(y-y*)*CD+β_7(r-r*)*CD	0
SEK/EUR	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)+β_4(x)+β_5(x*)+β_6(CD)+β_7(m-m*)*CD-β_8(y-y*)*CD+β_9(r-r*)*CD+β_{10}(x)*CD+β_{11}(x*)*CD	0,0023
	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)+β_4(x)+β_5(x*)+β_6(CD)	0,0065
	β_1(m-m*)-β_2(y-y*)+β_3(r-r*)	0,01
	β_1(m-m*)-β_2(y-y*)+β_3(x-x*)+β_4(CD)+β_5(m-m*)*CD	0,0073

GDP Co-Integration tests	Explanatory Model used	P-value
GDP UK	β_1+β_2(industrial production index)+β_3(import)+β_4(export)+β_5(unemployment)+β_6(trend)	0,0003
GDP GERMANY	β_1+β_2(industrial production index)+β_3(import)+β_4(export)+β_5(unemployment)+β_6(trend)	0,0066
GDP Sweden	β_1+β_2(industrial production index)+β_3(import)+β_4(export)+β_5(unemployment)+β_6(trend)	0,0017
GDP US	β_1+β_2(industrial production index)+β_3(import)+β_4(export)+β_5(unemployment)+β_6(trend)	0

P-Values of Unit Root Test for GDP series

Variable	UK	Germany	Sweden	US
industry production index	0,7141	0,8994	0,9091	0,9173
import	0,9994	0,7494	0,9958	0,9842
export	0,981	0,7494	0,9864	0,9914
unemployment	0,029	0,3546	0,3285	0,4939