Expectations and Exchange Rates

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Abstract

A large empirical literature in international finance has tried to explain currency movements in terms of macroeconomic variables. In general, this approach has not led to satisfactory results. We argue in this paper that much of the existing literature on the topic has an important shortcoming: it focuses on the realized values of macroeconomic variables, whereas recent research (see e.g. Engel and West, 2004) suggests that changes in expectations of macroeconomic variables should be of much greater importance.

We thus investigate how such changes in expectations – as measured by the monthly poll of forecasters in the Economist magazine – help to explain exchange rate movements. The forecasts are based on estimates by financial market participants and include expectations of output growth, inflation, and the current account/GDP ratio. We find that changes in expectations do indeed significantly affect the bilateral exchange rates of the countries we investigated, providing evidence for our view that expectations as opposed to realizations of macroeconomic variables are the main drivers of exchange rate movements.

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1 Introduction

A vast literature in finance has tried to model the behavior of exchange rates as a function of changes in macroeconomic fundamentals. In the 1970s, when researchers turned to investigate this question empirically, they were initially quite successful: starting with Frenkel (1976), a significant number of researchers demonstrated that various models of exchange rates yielded significant parameter estimates for realized macroeconomic variables. A majority of these papers were based on the monetary approach to the exchange rates.

However, after the 1970s, when macroeconomic fluctuations decreased in magnitude, it became increasingly difficult to obtain significant parameter estimates for monetary models of the exchange rate. The seminal paper of Meese and Rogoff (1983a) tested a number of exchange rate models that were commonly used at the time by their ability to predict out-of-sample. They found that, even though the parameter estimates for some of these models were significant, they could not outperform a random walk in out-of-sample predictions.

For almost a decade, the negative results of Meese and Rogoff (1983a, 1983b) could not be conclusively overturned. [1] However, during the 1990s, the use of econometrically more sophisticated methods such as vector error correction models could improve on a random walk. MacDonald and Taylor (1993, 1994) for example established that monetary models can serve as a useful guide for the long-run equilibrium of exchange rates. Clarida and Taylor (1997) showed that the term structure of forward exchange premia contains predictive information for the future spot exchange rate. They extended their work to allow for a non-linear adjustment to the long-run equilibrium in Clarida, Sarno, Taylor and Valente (2002). Still, many researchers are sceptical about the generality of these results.

On the very short horizon, it has been established that the announcement of macroeconomic news has an instant and significant effect on exchange rates in real time data that is consistent with the predictions of monetary models of the exchange rate (see e.g. Andersen et al., 2003). However, it is unclear whether this effect persists systematically over longer periods.

One of the reasons for the otherwise poor performance of macroeconomic fundamentals as predictors of exchange rates is that exchange rates are forward-looking, i.e. they depend to a large extent on expectations about the future. As Engel and West (2004) point out, a large part of the fluctuations in exchange rates must thus be attributed to changes in expectations. Another problem of the approach used in much of the literature employing macroeconomic fundamentals to predict exchange rates is that they assume that all macroeconomic variables are instantaneously available after they have been realized. However, GDP data for instance take a long time to be compiled, and often are revised even years after the first publication date. Using the updated historical version of such time series includes information that was not available at the time the data was realized and can therefore distort estimation results (see e.g. Faust,

[1] For a detailed survey of the related literature see for example Neely and Sarno (2002).

Rogers and Wright, 2003).

Our objective in this study is to demonstrate that changes in expectations regarding macroeconomic variables, such as growth, prices and current account balances, have an important effect on exchange rates.

2 Model

The dependence of exchange rates on expectations is most clearly stated by the asset market approach to exchange rates, as developed by Frenkel (1976) and Mussa (1976). This approach is based on the notion that the current exchange rate is related to various macroeconomic variables and the future exchange rate:

$$s_t = \beta x_t + \delta E_t [s_{t+1}]$$

where $0 < \delta < 1$ is the dependence of the exchange rate on its expected future value, $E_t [\cdot]$ is the expectations operator given all information available at time t, β is a vector of structural parameters, and x_t is a vector of macroeconomic fundamentals, or relative fundamentals of the two countries involved. The fundamentals can involve future output, interest rates, money, prices etc. Accordingly, a solution for the spot exchange rate s_t in the absence of bubbles can be obtained in the form of a net present value relationship:

$$s_t = \sum_{i=0}^{\infty} \delta^i E_t [\beta x_{t+i}] \tag{1}$$

The exact parametric form of δ and βx_t depends on the chosen theoretical model. The simplest flexible and sticky price monetary models both yield a specification along the lines of equation (1) that includes the money supply and output. Another possible model that yields equation (1) assumes an economy in which the central bank follows a Taylor rule that partially targets the level of exchange rates, so that the macroeconomic fundamentals also contain the price level and inflation, as developed e.g. in Engel and West (2005b). Still another approach asserts that the current account balance has an important impact on the exchange rate. We take an agnostic approach as to the exact specification of macroeconomic fundamentals and do not assume a specific form for equation (1) in this paper.

The change in exchange rates according to equation (1) can be decomposed into two parts:

$$\begin{aligned} \Delta s_t &= \sum_{i=0}^{\infty} \delta^i \{E_t [\beta x_{t+i}] - E_{t-1} [\beta x_{t-1+i}]\} = \\ &= -E_{t-1} [\beta x_{t-1}] + \sum_{i=0}^{\infty} \delta^i \{E_t [\beta x_{t+i}] - \delta E_{t-1} [\beta x_{t+i}]\} \end{aligned}$$

As Engel and West (2004) discuss, $\delta \to 1$ for short time horizons.[2] This allows us to rewrite an approximation for the change in the spot exchange rate as

$$\Delta s_t \approx -E_{t-1}\left[\beta x_{t-1}\right] + \sum_{i=0}^{\infty} \Delta E_t \left[\beta x_{t+i}\right] \tag{2}$$

In the following, let us assume that this equation holds with equality. We also have to assume that $x_{t+i} \to 0$ as $i \to \infty$ so that the exchange rate is defined. The first term of the expression, $-E_{t-1}\left[\beta x_{t-1}\right]$, represents the "rational expectation change" in the exchange rate. If there is for example an interest rate differential between the two countries under investigation, then uncovered interest rate parity implies that the exchange rate will appreciate from the perspective of the country with the lower interest rate, and this will be captured by the first term. The second term captures changes in expectations, which are – with rational expectations – by definition unexpected. Analytically, this follows from the law of iterated expectations:

$$E_{t-1}\left[\Delta E_t\left[\beta x_{t+i}\right]\right] = E_{t-1}\left[E_t\left[\beta x_{t+i}\right]\right] - E_{t-1}\left[\beta x_{t+i}\right] = 0$$

Given rational expectations, we can thus express the expected change in the spot exchange rate as

$$E_{t-1}\left[\Delta s_t\right] = E_{t-1}\left[-\beta x_{t-1}\right]$$

Note that we do not drop the expectations operator from the term $E_{t-1}\left[-\beta x_{t-1}\right]$, since some of the variables in x may be observable only with a lag, or may be subject to revisions.

A perhaps striking implication of equation (2) is that the actual realization of x_{t-1} does not matter for the level of the exchange rate, or – more precisely – it matters only to the extent that it changes expectations regarding future values of x_t.

In the following, we describe the data set we use to measure expectations. We then impose various assumptions on the structure of expectations and use these to estimate equation (2).[3]

3 Description of Data

For our measure of expectations, we use the Economist's poll of forecasters. This poll is conducted at the beginning of every month and has been consecutively published since

[2] In a simple calibration exercise, Engel and West find that both the monthly δ resulting from a standard monetary model of the exchange rate and from a model incorporating a central bank that follows a Taylor-rule is greater than 0.99.

[3] A number of commentator have suggested that we investigate whether the inclusion of macroeconomic expectations allows us to improve upon the results on the forecastability of exchange rates by Meese and Rogoff. However, this paper takes the view that changes in macroeconomic expectations are immediately incorporated in the pricing of exchange rates. The theoretical framework for exchange rates that we use precludes any impact of current changes in expectations on future changes in exchange rates.

August 1991 in the section "Economic and Financial Indicators" in the last few pages of the Economist magazine. The set of forecasters consists of the Economist Intelligence Institute plus roughly 20 international banks from all major financial centers, and can thus be thought of as representative of the views of financial markets. The exact list of forecasters varies over time as some institutions disappear, e.g. through mergers, and new financial institutions are included in the poll.[4] In total, our data set contains 180 monthly observations from August 1991 until June 2006.

The data consist of yearly expectations of GDP growth $y_{s,s+12}$, consumer price inflation $\pi_{s,s+12}$, and of the current account balance as a percentage of GDP $b_{s,s+12}$. In the current section, let us denote the vector of macroeconomic forecasts $x_{s,s+12} = (y_{s,s+12},\ \pi_{s,s+12},\ b_{s,s+12})'$, where $x_{s,s+12}$ will be augmented by other variables in the following sections. We have collected data from July 1991 to February 2005. From December 1993 on, the Economist also publishes the range $\left[y^L_{s,s+12}, y^H_{s,s+12}\right]$ of all institutions' forecasts for GDP growth.

In our estimations, we use data for six industrial economies: Great Britain, Canada, Germany/the EMU area, Japan, Switzerland, and the United States. Germany's exchange rate and macroeconomic fundamentals are continued by the respective values for the Euro area starting in January 1999.[5]

The polls performed in January and February of every year contain the forecasts for data of the previous and the current calender year, i.e. at the beginning of January the poll consists of $E_t\left[x_{t-12,t}\right]$ and $E_t\left[x_{t,t+12}\right]$ and in February of $E_t\left[x_{t-13,t-1}\right]$ and $E_t\left[x_{t-1,t+11}\right]$. Note that an expression like $E_t\left[x_{t-13,t-1}\right]$ is still a forecast, even though the variables are already realized, since some of the data in x is collected with a lag and may be subject to revisions at a later time. For March to December, the forecasts pertain to the current and the following calender year, i.e. for March $E_t\left[x_{t-2,t+10}\right]$ and $E_t\left[x_{t+10,t+22}\right]$ and similarly for all other months. This changing relative forecasting horizon significantly complicates our analysis, as we will discuss in the next section.

A graphical example for our measure of expectations is given in figure 3, which presents expected US growth for 2004, the expected US current account/GDP ratio for 2004 and US consumer price inflation for 2004 as predicted by the Economist's monthly poll of forecasters from March 2003 to February 2005. Note that all of the data points are predictions for the same period of time, i.e. for the calender year of 2004. However, they differ since the information set of forecasters was continuously updated. As can be seen in the first graph, for example, forecasters became increasingly optimistic about US growth for 2004 during the year of 2003. However, over the course of 2004, their forecasts declined slightly from the peak. Different patterns can be observed for the

[4]The list of forecasters for August 1991 is Barclays de Zoete Wedd, EIU, Goldman Sachs, Hoare Govett, James Capel, Kredietbank, Long-Term Credit Bank, Merrill Lynch, Morgan Stanley, Nomura, Nordbanken, Paribas, Salomon Brothers, Scotiabank, Shearson Lehman Brothers, Toronto Dominion Bank, UBS Phillips & Drew, S.G. Warburg, and Williams de Broe. In February 2005, it included ABN Amro, Deutsche Bank, EIU, Goldman Sachs, HSBC Securities, KBC Bank, J.P. Morgan Chase, Morgan Stanley, Decision Economics, BNP Paribas, Royal Bank of Canada, Citigroup, Scotiabank, and UBS.

[5]Running separate regressions for Germany and the Euro area with aggregated EMU data did not yield significantly different results.

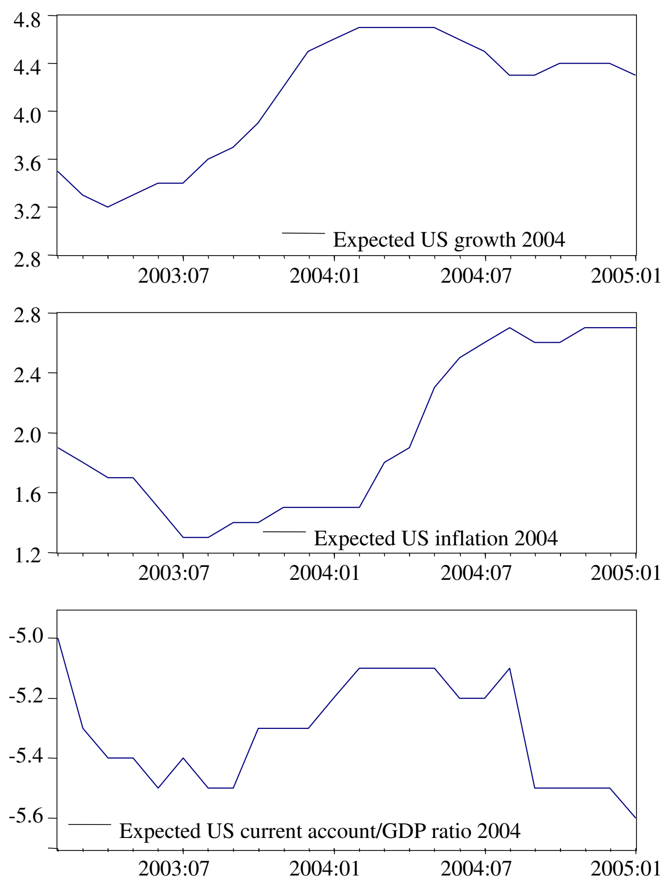

Figure 1: Expectations on US growth in 2004, the US current account/GDP ratio 2004 and US consumer price inflation in 2004 as predicted by the Economist's monthly poll of forecasters from March 2003 to February 2005.

forecasts of the current account and consumer price inflation.

One interesting feature of our data is described in table 1: One might suppose that expectations about growth or inflation are rather stable over time, especially when an average over a large number of forecasters is taken. In fact, however, we can observe that the (rounded) average of forecasts moves for most countries and series by at least one tenth of a percentage point in 40 – 72% of all months, as described in table 1. This suggest that there is enough variability in the data to run monthly regressions on it. Note that all of our expectational variables are martingales, i.e. their expected future value equals – by the law of iterated expectations – their current value:

$$E_{t-1}\left[E_t\left(x_s\right)\right] = E_{t-1}\left[x_s\right], \quad s > t$$

In addition to the data from the Economist's poll of forecasters, we also include the 12-month LIBOR interest rates from the British Bankers' Association in our data set, since it is well known that interest data have important explanatory power for exchange rates, i.e. in order to avoid an omitted variable bias. For our measure of exchange rates, we use download the end-of-month values from the IMF's International Financial Statistics. Since these series were not available until the the end of January 2005, we supplement them with data from the official exchange rates published by the Federal Reserve Bank of New York for the last few months. In the following, we will use logged values for our measure of exchange rates.

We do not have a variable for expectations of money supply in our data set. However, to an important extent these are determined by expectations about central banks' monetary policy strategy in conjunction with expectations about macroeconomic variables such as inflation and output, as captured for example by a Taylor rule. We acknowledge that this omission might possibly introduce a bias in our parameter estimates, but we would like to point out that our goal in this paper is not to analyze the exact relationship between changes in macroeconomic expectations and in exchange rates, but rather to show that expectations are an important determinant of the exchange rate.

In order to investigate whether our time series contain a unit root, we perform Augmented Dicker-Fuller and Phillips-Perron tests on the realized time series of output, inflation, the capital account/GDP ratio, which we obtain from the IFS, and on our interest rates data. We present the test statistics for all countries and variables for the case of the Phillips-Perron test with a constant in table 2. The tests indicate that all of the variables in our data are approximately $I(1)$, with some exceptions for certain country-variable pairs, which we disregard in order to have a consistent data structure across countries. As a result of this finding and because of our intention to be agnostic with respect to the exact structural model underlying the exchange rate process, we will include the levels and first differences of our variables in the following regressions.

4 Estimation Strategy

4.1 Synthetic Uniform Forecasting Horizon

As we discussed above, a major difficulty with our data set is that the relative forecasting horizon of our data varies according to the calender month. One way to cope with this problem is to assume that given the expected fundamentals $E_t\left[x_{s,s+12}\right]$ over a certain calender year $[s, s+12]$ with $s \geq t$, the "synthetic" forecasted fundamentals $E_t^*\left[x_{m,m+1}\right]$ for each month $m \in [s, s+12]$ equal the entire year's forecast, i.e.

$$E_t^*\left[x_{m,m+1}\right] = E_t\left[x_{s,s+12}\right] \tag{3}$$

Note that we use the asterisk here to distinguish synthetic expectations from observed expectations. For example, if growth for 1991 was expected to be 4.8%, then we assume that expected annualized growth for every single month in 1991 was 4.8%.

This assumption does not describe the precise way in which economic fundamentals behave, and therefore it cannot describe the way that expectations are formed without an error. However, it is a useful simplification that allows us to define a regression equation using all of our available observations. The resulting parameter estimates will exhibit some bias, but the procedure will nonetheless allow us to determine with a sufficient degree of certainty whether there is a relationship between changes in expectations of macroeconomic variables and exchange rates. We will discuss various ways of how to address the shortcomings of this approach below.

Assumption (3) yields an easy way to calculate a synthetic forecast that is of common horizon for each month of the year. This common horizon can be at most as long as the horizon of the month with the shortest forecasting horizon among all months, i.e. February. (Recall that the forecasts of February of a given year are for the macroeconomic fundamentals between January and December of the past year and of the current year.) We can for example use all available months and calculate a synthetic 11-month forecast $E_t^*\left[x_{t,t+11}\right]$ as an appropriately weighted average between the given two years of forecasts.

For January and February, we can use (3) to find $E_t^*\left[x_{t,t+11}\right] = E_t\left[x_{t,t+12}\right]$ and $E_t^*\left[x_{t,t+11}\right] = E_t\left[x_{t-1,t+11}\right]$, which are the forecasts for the current year. For March, we set $E_t^*\left[x_{t,t+11}\right] = \frac{10}{11}E_t\left[x_{t-2,t+10}\right] + \frac{1}{11}E_t\left[x_{t+10,t+22}\right]$, and so forth. In general, we can write our naïve 11-month forecast as $E_t^*\left[x_{t,t+11}\right] = f_1 E_t\left[x_{Y(t,1)}\right] + f_2 E_t\left[x_{Y(t,2)}\right]$, where $Y(t,1)$ and $Y(t,2)$ are the two years for which forecasts are published in the respective month and f_1 and f_2 are the number of months that the forecasting period is part of the respective year. In addition to the forecast for growth, inflation, and the current account we also include the 11-month interest rate in $E_t^*\left[x_{t,t+11}\right]$.

We also need to make an assumption on how changes in the 11-month forecast affect changes in the forecasts beyond that period, which are also included in the infinite sum of equation (2). Again, our data limitations force us to make a rather simplistic assumption here and assume that consecutive 11-month forecasts follow a $VAR(1)$ process with parameter A, where we assume that the characteristic roots of A are less than one in absolute value:

$$E_t^*\left[x_{t+11,t+22}\right] = AE_t^N\left[x_{t,t+11}\right] \tag{4}$$

It can be easily seen that this implies

$$s_t = \sum_{i=0}^{\infty} E_t\left[\beta x_{t+i}\right] = \sum_{j=0}^{\infty} \beta E_t^*\left[x_{t+11\cdot j,\ t+11\cdot(j+1)}\right] = \beta\left(I-A\right)^{-1} E_t^*\left[x_{t,t+11}\right]$$

In order to estimate the effects of a change in this 11-month forecast of fundamentals on exchange rates, we can estimate the following equation:

$$\Delta s_t = \gamma \Delta E_t^*\left[x_{t,t+11}\right] + \varepsilon_t \tag{I}$$

where s_t is the log of the exchange rate, $\gamma = \beta\left(I-A\right)^{-1}$ and ε_t is an error term. As discussed above, we do not make any a-priori assumptions on whether the changes in our expectational variables should enter our regressions in level or difference terms. In order to test this, our first regression included the levels and differences of the expectations of our four macroeconomic variables $\Delta \log y_t$, $\Delta \log p_t$, b_t, and r_t plus a constant. We performed estimations for all exchange rates with respect to the USD, using as explanatory variables the differences between the macroeconomic fundamentals of the US and the respective other country.

The results of these regressions are shown in table 3. We find that changes in expectations about relative growth rates have a significant effect on the CHF/USD and JPY/USD rates. In the given specification, expected changes in price levels have slightly higher explanatory power than expected changes in inflation rates. Expectations on the relative current account balance have a somewhat significant effect on the CAD/USD rate. Finally, the coefficients on changes in relative interest rates are significant for all currencies except the JPY, which is consistent with the findings in the existing literature.

We thus re-run the regressions, dropping for each macroeconomic variable either the level or the differences, depending on which one of the two had more significant parameter estimates in the previous regression. We call this specification II. The results are presented in panel (i) of table 4. Now, many more variables are significant. As before, changes in growth expectations affect the JPY/USD and CHF/USD rates. Expectations about inflation differentials can be found to be significant for the CAD/USD, DEM/USD or EUR/USD respectively, and CHF/USD exchange rates, and at a 10% level of significance for the JPY/USD rate. Expected differences in current accounts are significant for all currencies but the British Pound. Finally, changes in the interest rate differential have a significant impact on the GBP/USD, CAD/USD, DEM/USD or EUR/USD rates respectively, and with a lower degree of significance on the CHF/USD rate.

Note that all parameter estimates that we report have been multiplied by 100 for convenience. Hence the coefficient for growth differentials in the 'JPY' column, for example, means that a 1% increase in the expected growth differential between the United States and Japan entails on average a depreciation of the JPY by 1.60%.

We would like to point out that all estimated parameters of our expectational variables have a positive sign, which is in line with the predictions of standard monetary models of the exchange rate. A change in the expected relative growth rates of two country raises relative money demand in the faster growing country and therefore its exchange rate. In a country with a credible monetary authority, rise in the inflation differential will induce a relative future monetary tightening, which boosts the exchange rate. An increase in the relative current account surplus appreciates the currency of the country with the rising surplus so as to bring the current account back towards equilibrium.

The reaction of the exchange rate to a change in relative short term interest rates reflects interest rate parity for most countries: A (relative) rise in the interest rate implies an immediate appreciation, which will be followed by a period of depreciation towards the country's long run equilibrium exchange rate so as to equalize expected returns on all currencies. For Canada, however, the sign of the coefficient on the interest rate is of opposite sign and very significant. This can be interpreted as evidence that Canada's central bank includes a target for the exchange rate in its policy function. If the Canadian dollar shoots above its target, the central bank lowers interest rates and vice versa, which yields the observed sign.

We also run estimations for two sub-samples of our data set, for 1991:7 to 1998:12 and for 1999:1 to 2005:2. The cut-off point coincides with the launch of the European Monetary Union and the replacement of the Deutsche Mark with the Euro in our sample. The results for the two sub-samples are presented in panels (ii) and (iii) of table 4.

In the first part of our sample period, none of the expectational variables is significant except for the Canadian inflation differential. This is the case even though all of the parameter estimates are of the correct sign and none of them differs significantly from our full sample estimates. At the same time, the parameter estimates for changes in the interest rate are just as significant as for the full sample, and in the currencies where the interest rate is highly significant, the R^2-statistic reaches values close to 40%.

This pictures is inverted in the second sub-period in panel (iii). The interest rate plays an insignificant role in all countries for that period, whereas a large number of macroeconomic variables are significant. Also, the estimated parameters do not significantly differ from the ones over the full period. It thus seems that the importance of macroeconomic variables increased over time.

As an alternative to using our synthetic 11-month forecast, we drop all February observations so that the remaining observations each contain at least one full year of expectations. Then we run a regression on a synthetic 1-year forecast, which we construct along the lines described above. Consequently,

$$\Delta s_t = \gamma \Delta E_t^* \left[x_{t,t+12} \right] + \varepsilon_t \tag{II}$$

As a result, the number of observations we can include in our estimations drops from 164 to 149. Estimation with the same set of levels and differences of our macroeconomic variables as the previous specification II yields roughly similar results, as shown in table 5. As discussed above, all the parameter estimates for our macroeconomic fundamentals are still positive and they do not significantly deviate from what was estimated using our synthetic 11-month forecasts. There are some changes in the level of significance of some country-variable pairs, but these are not very large.

4.2 GMM Estimation

So far, the coefficients in most of our regressions were of the right sign, but not always very significant. One of the reasons for this might be the size of our sample. We thus proceeded by restricting all coefficients for macroeconomic fundamentals to be the same across all countries that we have included:

$$\Delta s_t^c = \gamma \Delta E_t^* \left[x_{t,t+11}^{US} - x_{t,t+11}^c \right] + \varepsilon_t^c \tag{III}$$

Note that in this setup, the error terms $\varepsilon_t^c, \varepsilon_t^d$ of two different countries will be correlated, since all bilateral dollar exchange rates contain shocks to the US economy. We thus employed a GMM procedure that allowed us to take these correlations into account. Since our vector x_t contains for explanatory variables, we can easily identify four moment conditions for every country c:

$$\bar{m}^c = E\left[\left(x_{t,t+11}^{US} - x_{t,t+11}^c \right) \varepsilon^c \right] = (0,0,0,0)$$
$$\text{where } \varepsilon^c = \Delta s_t^c - \gamma \Delta E_t^* \left[x_{t,t+11}^{US} - x_{t,t+11}^c \right]$$

Since we have 5 country pairs versus the US, this yields 20 moment conditions in total. We set $S_1 = I$ and iterate the minimization problem $\gamma_n = \arg\min \bar{m}(\gamma)' S_n^{-1} \bar{m}(\gamma)$, where we update the weighting matrix $S_{n+1} = Var(\bar{m}(\gamma_n))$ after each step using the Newey-West autocorrelation consistent estimator of the variance, until the estimated parameters converge to a constant.

Our results for the full sample are given in panel (i) of table 6. We find that all four parameters are strongly significant at the 5% level and, with the exception of inflation differentials, at the 1% level. A Chi^2-test of the over-identifying restrictions of our regression shows that the restrictions imposed by our model cannot be rejected.

A one percentage point increase in expected growth differentials causes on average a 1.51% appreciation of the exchange rate of a country. Each percentage point of expected inflation differentials leads to a 0.17% increase in the exchange rate. A one percent divergence in the expected current account/GDP ratio causes a 0.03% appreciation of the exchange rate. Finally, a one percent increase in the interest differential causes a 1.07% decrease in the exchange rate. This negative sign might again be interpreted as evidence that the involved central banks consider the exchange rate in their interest rate rules.

Upon splitting our data into sub-samples, our results do not change much. In our first sub-sample from 1991 to 1998, panel (ii), all expectational variables remain strongly significant, even at the 1% level, and are insignificantly different from the estimates for the full sample. The parameter on the interest rate becomes significantly more negative.

A different picture emerges from panel (iii), which shows the estimation results for our second sub-sample, 1999 to 2005. Aside from the parameter on changes in the relative growth differentials, which remains remains strongly significant at the 1% level, all parameter estimates are significantly different from panel (i). The coefficients on inflation and current account differentials become insignificant; the parameter estimate of the interest rate differential becomes significantly positive, which might reflect that central banks reacted less to exchange rates in that period and let interest parity work.

4.3 Refining Expectations With Historical Data

In making the two assumptions (3) and (4) above, we disregarded an important part of our available information. Let us first turn our attention to assumption (3), that all months in a given year are equal. When we use this to calculate the expectation of the last n months of the current year of forecasts $[s, s+12]$, the variables of the previous months are already realized, and some of them may already be known. Denote $l \geq 0$ the lag at which data becomes available, and $s < t-l < s+12$. Then the total expectation for the calender year is a weighted average of the already known realized variables and the expected realizations of the remainder:

$$E_t\left[x_{s,s+12}\right] = \frac{(t-l-s)\, x_{s,t-l} + (s+12-t+l)\, E_t\left[x_{t-l,s+12}\right]}{12}$$

This allows us to refine our expression for the expectation of the remaining months $[t-l, s+12]$ as[6]

$$E_t\left[x_{t-l,s+12}\right] = \frac{12 E_t\left[x_{s,s+12}\right] - (t-l-s)\, x_{s,t-l}}{12-(t-l-s)} \tag{5}$$

The problem with assumption (4) is that in most of our observations, we have forecasts that reach beyond the 11-month horizon (12 month horizon for specification II). In effect, we truncated all forecasts to the shortest forecasting horizon in our data set, which was the 11-month forecast in February for specification I (12-month forecast in January for specification II). We could improve upon this situation by including for every observation the longest forecast possible. However, let us still assume a $VAR(1)$ process for the yearly expectations beyond that date here. Then we can write the exchange rate as

$$s_t = \sum_{i=0}^{\infty} E_t\left[\beta x_{t+i}\right] = \beta E_t\left[x_{t-l,s+12}\right] + \beta\left(I-A\right)^{-1} E_t\left[x_{Y(t,2)}\right]$$

[6]Another alternative to using assumption (3) on the homogeneity of all monthly expectations would be to split our sample into quarterly or semi-annual sub-samples and assume that monthly expectations are only equal within the given quarter/half-year. This could better account for the heterogeneous forecasting horizon. The extreme form of this would be to estimate separate parameters for each calender month, i.e. to run for example regression I only with January data instead of our synthetic expectations, then only with February data etc. However, due to the low number of observations in our sample, parameter estimates using this approach were mostly insignificant. We thus do not pursue this approach here further.

For the change in exchange rates, this yields

$$\Delta s_t = \beta \left\{ E_t \left[x_{t-l,s+12} \right] - E_{t-1} \left[x_{t-l-1,s+12} \right] \right\} + \\ + \beta \left(I - A \right)^{-1} \left\{ E_t \left[x_{Y(t,2)} \right] - E_{t-1} \left[x_{Y(t-1,2)} \right] \right\}$$

For all months except March, $Y(t,i) = Y(t-1,i)$. We can thus re-express the change in the exchange rate for these months as

$$\Delta s_t = \beta \left\{ E_t \left[x_{t-l,s+12} \right] - E_{t-1} \left[x_{t-l-1,s+12} \right] \right\} + \beta \left(I - A \right)^{-1} \Delta E_t \left[x_{Y(t,2)} \right]$$

This allows us to run the following regression, dropping all observations of February (where our maximum forecasting horizon is only 11 months) and March (where $Y(t,i) = Y(t-1,i) + 1$):

$$\Delta s_t = \beta \left\{ E_t \left[x_{t-l,s+12} \right] - E_{t-1} \left[x_{t-l-1,s+12} \right] \right\} + \gamma \Delta E_t \left[x_{Y(t,2)} \right] + \varepsilon_t$$

In order to calculate the forecasts $E_t \left[x_{t-l,s+12} \right]$ for the remaining months of each year according to (5), we have to determine the lag l at which data on realized macroeconomic variables becomes available. According to information on the latest macroeconomic data in the statistical part of the Economist, consumer prices are updated with a lag of one month in Britain, the Euro area, Switzerland, and the United States, and with a two month lag in Canada and Japan. GDP data is only available quarterly and is published at a lag of two to six months, depending on the country, i.e. the total monthly lag is between two and eight months. The current account balance is updated monthly in Germany and the Euro area at a lag of three months, and quarterly in all the other countries with a total lag between five to seven months.

However, when calculating $E_t \left[x_{t-l,s+12} \right]$, we found that for the lag length determined above, our time series of expectations for the remaining months of each year fluctuated wildly towards the end of the calender year (to the extent of +/− 30%), as an increasing amount of historical data became available for that year. This probably reflects the problem that it is not clear what information set the forecasters are using to compile their predictions. On the one hand, some of the forecasters might not have used the most up-to-date information for their forecasts before being polled by the Economist, i.e. their information set might not contain all publicly available information. On the other hand, forecasters might have some private information that allows them to predict better than the first official announcement of macroeconomic variables, which is subject to frequent later revisions, i.e. their information set could actually contain data that is not in the public information set. In addition, it is not clear how representative the Economist's poll of forecasters is and whether the Economist's way of aggregating individual market participants' forecasts is consistent with the way that the market aggregates individual beliefs.

It is thus uncertain whether we should use the first announcement of macroeconomic variables (from the Economist magazine) or the most recent revision thereof (from IFS). None of the two approaches enabled us to compile satisfactory time series that would allow us to perform meaningful regressions according to equation (4.3).

4.4 Test of Rational Expectations

As we have seen above, our model was able to significantly explain an important part of the fluctuations in exchange rates. However, some of the estimated parameters in individual country regressions were insignificant. In addition, as we just discussed, there was some indication that the expectational data we used was not always up-to-date, since we could not combine expected and recently realized data to build a meaningful time series. Let us thus investigate the quality of the forecasts we are using. As discussed above in section 2, rational expectations have to be martingales, since there would be a way to improve upon the forecasts otherwise. This means in particular, that any past data should not be able to explain future changes in expectations.

We use this property to test whether our forecasts from the Economist can be regarded as rational expectations. For this purpose, we estimate for every country a VAR with one lag containing the changes in all of our forecasted variables ($\Delta y^c,\ \Delta\pi^c,\ \Delta b^c$), past changes in interest rates Δr^c and past changes in exchange rates Δe^c for the given country c, as well as growth forecasts for the US Δy^{US} (in the case of our model for the US, we include growth forecasts for Germany/the EMU here). If expectations are rational, then we should not be able to reject the null hypothesis that all estimated parameters are jointly zero.

Table 8 shows the F-statistics for this test. In general, we can reject the hypothesis that changes in forecasts are unpredictable for some variable in every single country. It seems that growth forecasts exhibit especially significant deviations from rational expectations, with the only exception of Great Britain, the home country of the Economist magazine. But even there, the forecast of changes in the current account does not pass our test. We thus have to conclude that our measure of expectations from the Economist's poll of forecasters does not contain perfectly rational expectations. Still, these are the expectations collected from a significant number of financial market participants, and it might not be a surprise that these are not always perfectly rational.

5 Conclusions

According to the monetary approach to the exchange rate, macroeconomic variables should be expected to have a strong influence on the movements of exchange rates. However, the empirical literature on the subject has not been very successful at detecting such a relationship, especially at a monthly or quarterly horizon.

Our paper argued that this failure might be due to the fact that expectations rather than realizations of macroeconomic variables are the driving forces behind exchange rate movements. We tested the hypothesis that changes in expectations have a significant impact on exchange rates using expectations of growth, inflation, and current account/GDP ratios for six industrial countries from the Economist's poll of forecasters.

Our results indicated that there is indeed a significant link between these variables and exchange rate movements for most countries in our sample. However, the link is weak for some country-variable pairs. Also, our results still leave a large fraction of exchange rate variability unexplained.

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Table 1: Percentage of months in which the expectations on growth $\Delta E[y]$, inflation $\Delta E[p]$, and the current account/GDP-ratio $E[b]$ for the current (1) and next year (2) change in the Economist's poll of forecasters.

	$E[\Delta y_1]$	$E[\Delta y_2]$	$E[\Delta p_1]$	$E[\Delta p_2]$	$E[b_1]$	$E[b_2]$
UK	54.47%	53.86%	50.81%	53.25%	62.40%	65.45%
CA	62.40%	54.47%	50.20%	47.76%	67.89%	63.62%
EU	50.20%	56.91%	40.45%	42.89%	47.76%	51.42%
JP	65.45%	67.28%	39.84%	47.15%	42.89%	55.69%
CH	56.30%	57.52%	44.72%	50.81%	72.15%	66.67%
US	55.69%	56.91%	42.28%	58.74%	47.76%	58.13%

Table 2: Phillips-Peron unit root tests with a constant testing the stationarity of the exchange rate (e), the LIBOR interest rate (r), logged output (y), the current account balance (b) and the price level (p). The null hypothesis of a unit root is rejected if the t-statistic is less than the critical value, which is -2.880 for the 5% level and -3.473 for the 1% level for the given case. Values in brackets are the p-values that the hypothesis of a unit root cannot be rejected.

		e	r	y	b	p
UK	I(1)	-1.834472	-2.555291	0.573939	-3.824776	-3.820994
		(0.3628)	(0.1045)	(0.9886)	(0.0034)	(0.0034)
	I(2)	-11.59525	-14.83541	-18.08486	-28.11406	-12.48662
		(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0000)
CA	I(1)	-1.856158	-2.407543	0.574922	-1.448579	1.423335
		(0.3524)	(0.1412)	(0.9886)	(0.5569)	(0.9991)
	I(2)	-12.00489	-13.72819	-15.55674	-13.37462	-10.66775
		(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
EU	I(1)	-1.232113	-2.004318	-0.630403	-3.276197	-2.907935
		(0.6600)	(0.2849)	(0.8592)	(0.0178)	(0.0467)
	I(2)	-10.71859	-10.07714	-13.09192	-21.02935	-9.921833
		(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
JP	I(1)	-2.429147	-0.955608	-0.232628	-2.680396	0.179981
		(0.1354)	(0.7648)	(0.9304)	(0.0800)	(0.9705)
	I(2)	-11.95275	-6.857552	-12.80603	-11.62636	-10.66952
		(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
CH	I(1)	-1.483032	-5.880012	-0.074498	-8.541866	-3.689919
		(0.5399)	(0.0000)	(0.9491)	(0.0000)	(0.0051)
	I(2)	-10.82563	-10.66269	-12.79124	-41.95156	-10.98948
		(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0000)
US	I(1)	0.029334	-2.136342	0.244887	-0.765149	1.681535
		(0.9577)	(0.2309)	(0.9746)	(0.8255)	(0.9996)
	I(2)	-6.780202	-9.006951	-16.90449	-12.52178	-14.71939
		(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Table 3: Regression results of specification I: Change in logged bilateral exchange rates on relative macroeconomic fundamentals and a constant c. All parameter estimates have been multiplied by 100. The t-values for all estimate parameters are in brackets; * marks significance at the 10%-level, ** at the 5% and *** at the 1% level. The last three lines contain the R^2 and adjusted R^2 statistics as well as the p-value of the F-test that all parameters are zero.

	GBP	CAD	DEM/EUR	JPY	CHF
c	0.3892	0.3399	0.4428	-1.7330	0.0080
	(0.8722)	(0.921)	(0.6005)	(-1.4568)	(0.0099)
$y^{US} - y^{C}$	-0.1001	0.0113	-0.2171	-0.3809	-0.0355
	(-0.4066)	(0.0431)	(-0.863)	(-1.4567)	(-0.1087)
$\Delta(y^{US} - y^{C})$	0.3356	0.5371	0.8579	1.873**	2.007**
	(0.3988)	(0.7287)	(1.2541)	(2.2737)	(2.0757)
$\pi^{US} - \pi^{C}$	0.3573	0.0992	-0.2269	0.4812	-0.3784
	(0.7915)	(0.2957)	(-0.2282)	(0.8411)	(-0.4138)
$\Delta(\pi^{US} - \pi^{C})$	1.0789	0.6914	0.6955	-0.3126	1.1801
	(0.9023)	(0.8315)	(0.3794)	(-0.1715)	(0.7497)
$b^{US} - b^{C}$	0.1869	0.1000*	0.0941	-0.0161	0.0303
	(1.2399)	(1.7255)	(0.8413)	(-0.0867)	(0.3629)
$\Delta(b^{US} - b^{C})$	-0.2774	0.1992	1.9277	0.5267	0.8099
	(-0.3481)	(0.4763)	(1.6319)	(0.3135)	(0.9334)
$r^{US} - r^{C}$	0.0904	0.1594	0.2636	0.2779**	0.3664
	(0.5943)	(1.3394)	(1.1523)	(2.0188)	(1.3964)
$\Delta(r^{US} - r^{C})$	1.9359***	-1.272***	3.2826***	0.8059	1.4467*
	(5.5689)	(-4.4447)	(3.7861)	(0.9777)	(1.769)
R^2	21.31%	16.52%	15.17%	8.36%	8.97%
R^2 adjusted	17.22%	12.19%	10.76%	3.53%	4.24%
Prob(F)	0.00001	0.00041	0.00113	0.09504	0.06430

Table 4: Regression results of specification II: Change in logged bilateral exchange rates on selected relative macroeconomic fundamentals. All parameter estimates have been multiplied by 100. The t-values for all estimated parameters are in brackets; * marks significance at the 10%-level, ** at the 5% and *** at the 1% level. The last two lines present the R^2 and adjusted R^2 statistics.

(i) Full sample period: 1991:7 - 2005:2

	GBP	CAD	DEM/EUR	JPY	CHF
$\Delta(y^{US} - y^{C})$	0.3232	0.5119	0.7235	1.3938*	1.9584**
	(0.3988)	(0.7115)	(1.0709)	(1.7786)	(2.1244)
$\pi^{US} - \pi^{C}$	0.5005	0.3579**	0.8308**	0.5983*	0.7922**
	(1.3369)	(2.373)	(2.2735)	(1.8227)	(2.0404)
$b^{US} - b^{C}$	0.0920	0.0619**	0.1675**	0.2705**	0.0974**
	(1.0143)	(2.0689)	(2.189)	(2.0093)	(2.2644)
$\Delta(r^{US} - r^{C})$	1.9919***	-1.2175***	3.0505***	0.6926	1.4437*
	(6.0112)	(-4.4219)	(4.067)	(0.847)	(1.8369)
R^2	20.50%	15.06%	12.52%	4.44%	7.26%
R^2 adjusted	19.00%	13.46%	10.87%	2.62%	5.51%

(ii) First part of sample period: 1991:7 - 1998:12

	GBP	CAD	DEM	JPY	CHF
$\Delta(y^{US} - y^{C})$	0.437	0.6332	0.11960	1.3359	1.3282
	(0.3515)	(0.8732)	(0.1573)	(1.0233)	(0.9572)
$\pi^{US} - \pi^{C}$	0.1892	0.3073***	0.56010	0.9426	0.6412
	(0.3701)	(2.6675)	(1.0561)	(1.5241)	(1.3149)
$b^{US} - b^{C}$	0.1508	0.0829	0.4093	0.53020	0.1111
	(0.7218)	(1.0957)	(1.4383)	(1.6603)	(1.4578)
$\Delta(r^{US} - r^{C})$	3.3853***	-1.4016***	3.7778***	0.8891	1.8555*
	(7.3424)	(-6.9837)	(4.5727)	(0.793)	(1.9287)
R^2	39.18%	36.33%	20.47%	4.04%	6.64%
R^2 adjusted	37.05%	34.11%	17.69%	0.61%	3.38%

(iii) Second part of sample period: 1999:1 - 2005:2

	GBP	CAD	EUR	JPY	CHF
$\Delta(y^{US} - y^{C})$	0.8827	0.0159	3.7181***	1.9179*	3.1809**
	(0.8982)	(0.0119)	(2.7542)	(1.8669)	(2.5954)
$\pi^{US} - \pi^{C}$	0.9093*	0.6055	2.6168***	0.8947*	2.2442**
	(1.7711)	(1.1424)	(3.8988)	(1.7027)	(2.4346)
$b^{US} - b^{C}$	0.0944	0.0652	0.3263***	0.3379*	0.2143**
	(1.0172)	(1.6368)	(3.6101)	(1.7928)	(2.6089)
$\Delta(r^{US} - r^{C})$	0.5876	1.3556	0.0617	0.7096	-0.3119
	(1.3639)	(1.0149)	(0.0373)	(0.5108)	(-0.1929)
R^2	8.63%	4.25%	22.29%	9.53%	15.03%
R^2 adjusted	4.66%	0.09%	18.91%	5.59%	11.34%

Table 5: Regression results of specification II using a 12-month synthetic forecasting horizon: Change in logged bilateral exchange rates on selected relative macroeconomic fundamentals. Note that all parameter estimates have been multiplied by 100 for convenience. The t-values for all estimate parameters are in brackets; * marks significance at the 10%-level, ** at the 5% and *** at the 1% level. The last two lines present the R^2 and adjusted R^2 statistics.

	GBP	CAD	DEM/EUR	JPY	CHF
$\Delta(y^{US} - y^{C)}$	0.9294*	0.5825	0.4010	0.5682	1.5743**
	(1.6772)	(1.1694)	(0.8588)	(1.3072)	(2.392)
$\pi^{US} - \pi^{C}$	0.5953*	0.3066*	0.9144**	0.6971**	0.7081*
	(1.6901)	(1.965)	(2.3872)	(2.0671)	(1.8054)
$b^{US} - b^{C}$	0.1330	0.0696**	0.208**	0.3209**	0.1059**
	(1.4314)	(2.2289)	(2.5455)	(2.3007)	(2.3952)
$\Delta(r^{US} - r^{C})$	1.9123***	-1.2346***	2.9845***	1.0307	1.8885**
	(5.8265)	(-4.3997)	(3.839)	(1.1936)	(2.3469)
R^2	22.51%	16.14%	12.84%	4.69%	9.22%
R^2 adjusted	20.92%	14.42%	11.05%	2.70%	7.35%

Figure 1: Expectations on US growth in 2004, the US current account/GDP ratio 2004 and US consumer price inflation in 2004 as predicted by the Economist's montly poll of forecasters from March 2003 to February 2005.