Do Forecasters use Monetary Models?

An Empirical Analysis of Exchange Rate Expectations

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Abstract

Do financial market analysts use structural economic models when forecasting exchange rates? This is the leading question analysed in this paper. In contrast to other studies we use expectations instead of realised data. Therefore we analyse the implicit structural models forecasters have in mind when forming their exchange rate expectations. Using expected short- and long-term interest rates and business expectations as explanatory variables we estimate latent structural models to explain expected exchange rates. A special hypothesis is whether exchange rate expectations are formed according to monetary models. The currencies included in the study are US dollar, British pound, Japanese yen, French franc and Italian lire, each defined against the German mark.

A major finding of the analysis is that expected GDP is the most important variable (from the set of our variables) for the determination of exchange rate expectations. For the DM/US dollar expectations a Mundell-Fleming type model is compatible with the data. This means, that increasing interest rates will lead to an appreciation of the corresponding currency. The opposite result have been found for French franc and Italian lire where high expected interest rates indicate a weak currency.

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I. Introduction

Monetary exchange rate models have long been in the centre of the economic theory of exchange rate behaviour. The influential paper of (Meese and Rogoff, 1983) where the authors show that most structural exchange rate models cannot outperform a simple random walk, has stimulated a vast amount of empirical work that tried to reconcile monetary exchange rate models with observed exchange rate data. One important strand of research focuses on the analysis of exchange rate expectations using survey data.[3] Most of these studies have tested different hypotheses of expectation building as e.g. whether expectations are rational, adaptive, regressive or extrapolative. Other studies analysed heterogeneity of exchange rate expectations.[4]

Our study differs from these studies in at least three major respects: 1. We explore the relationships between expectations on exchange rates and expected fundamentals. This means that we are analysing only the relationships between expected variables without using realisations. 2. We are using categorical survey data instead of the usually used continuous expectations. This has consequences for the estimation method and the formulation of the model. 3. We are estimating structural models instead of single equations. Therefore we can cope with a potential simultaneity bias that could occur in a single equation model.

The aim of this paper is to investigate the significance of expected macroeconomic fundamentals for expected exchange rates, i.e. we try to identify the structure of the exchange rate model professional analysts have in mind when forecasting exchange rates. We concentrate on those relationships proposed by monetary exchange rate models. Although this class of models did not perform very well in explaining and forecasting exchange rates, monetary exchange rate models still seem to build the basis for the explanation of exchange rate behaviour both in academics and in more popular comments on foreign exchange markets. Put differently, the expected fundamental variables used to explain expected exchange rates in our estimations, namely GDP, short-term and long-term interest rates, are tested for their significance

[3] A survey on survey data studies published until 1991 can be found in Takagi (1991).

[4] In addition to Takagi (1991) see e.g. (Frankel and Froot, 1988) and MacDonald (1990) and MacDonald (1992) for tests on the rationality of exchange rate forecasts and (MacDonald and Marsh, 1996) who investigate the heterogeneity of currency forecasters.

in explaining exchange rate expectations and in addition we test whether the signs of the (significant) variables are in accordance with monetary models. For this analysis it is only of minor importance whether monetary models are successful in forecasting exchange rates. We instead try to find out whether monetary models are at least implicitly used by professional analysts to form exchange rate expectations.

There is still a lively discussion amongst academic economists whether new econometric methods could perhaps find a better fit between macroeconomic and particularly monetary variables and exchange rates. Recent publications e.g. (MacDonald and Taylor, 1994), MacDonald (1999) and (Husted and MacDonald, 1999) show that this is not a hopeless task. Husted and MacDonald for example use panel data to estimate monetary exchange rate models for international currencies defined against the US dollar, the German mark and the Japanese yen. Especially for the German mark exchange rates the authors find that "the monetary approach equations also turned in a good performance" (p. 237).

Still more important for our study is that recent surveys amongst currency traders find clear evidence that economic fundamentals are important variables to assess future developments of exchange rates.[5] According to the survey conducted by (Cheung and Chinn, 1999) about 25% of the currency traders use fundamental data as trading advice. The economic variables that are believed to be important for future exchange rate movements are especially unemployment (as a proxy for GDP), inflation and interest rates. In the ZEW survey, which is the database used in our study, the participants are mostly financial market analysts with an academic background in economics and not traders. Therefore we believe that economic variables and particularly those included in monetary exchange rate models should be of significantly higher importance than in the survey of Cheung and Chinn.

Although there is a vast amount of publications on exchange rate expectations to our knowledge only one publication, Taylor (1989), uses categorical data. Taylor aggregates the individual data to receive the average expectation of the survey respondents. He uses the aggregate expectations to test for rationality and the influence of uncertainty on the expected mean. In contrast we are using the individual data to get insights into the formation process of expectations.

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[55] See Menkhoff (1997), Menkhoff (1998) and (Cheung and Chinn, 1999).

The major difference of our study compared to all other publications in this field is that we are using only expectations both for the exchange rates to be explained and for the fundamental variables that have been chosen as explanatory variables. Our results therefore can shed light on the economic structure financial analysts have in mind when forecasting exchange rates.

We are analysing the expectations for the US dollar, Pound Sterling, Japanese yen, French franc and Italian lire exchange rates defined against the German mark. The database for the expectations data used in this study is the ZEW financial market survey. This database provides us with information on original expectations of German financial market analysts from December 1991 on. [6]

The results of the estimations show that the structure of the DM/US dollar expectations are compatible with Mundell-Fleming type models. This means that an expected increase in US interest rates leads to the expectation of a dollar appreciation. Interestingly, the results for French franc and Italian lire show just the opposite influence of expected interest rates on exchange rate expectations. Concerning these two currencies an increase in expected interest rates means the expectation of a weak currency. For the two exchange rates, British pound and Japanese yen the results give no clear indication of the underlying structural model. The results show that expected foreign GDP growth is the most important single factor for exchange rate expectations.[7] The second important factor are the expectations on foreign short- and long-term interest rates. The results show a clear asymmetry between domestic and foreign variables: With the exception of the US dollar and partly the Italian lire and the French franc the expected German fundamentals seem to be relatively unimportant compared to the influence of foreign variables.

The study is organised as follows: Chapter 2 gives a description of the data. Chapter 3 describes the theoretical exchange rate models as well as the estimation approach. The results of the estimations are presented and interpreted in chapter 4. Chapter 5 concludes.

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[6] For more detailed information on the database see chapter II.

[7] As we are analysing exchange rates against the German mark, „foreign“ is defined from the point of view of Germany.

II. Data

Since December 1991, the Centre for European Economic Research (ZEW) has been conducting a business survey amongst German financial analysts. Experts of approximately 350 enterprises participate each month, including around 220 banks, 40 investment funds, 60 insurance companies and 30 industrial companies. Respondents belong to the board, or to the finance, research, asset management or economics department. The respondents are asked to prevail their medium term[8] expectations for important international financial markets with regard to the economic situation, inflation rate, short- and long-term interest rates, stock markets and exchange rates. The countries covered are Germany, USA, Japan, United Kingdom (UK), France, and Italy. The answers given are qualitative assessments of the underlying latent variables using the three categories ”increase”, ”stay approximately the same (no change)” and ”decrease”. In addition a ”don’t know” category can be chosen. For the empirical work the qualitative answers are coded ”decrease” = 1, ”no change” = 2, ”increase” = 3. The ”don’t know” category is dropped. The observation period of each wave is 14 days, but later responses are also included in this study.

This study makes use of the expectations for the gross domestic product (GDP), short- and long-term interest rates and inflation rates of Germany, USA, Japan, UK, France and Italy as well as the relevant exchange rate expectations. The total observation period is December 1991 to December 1997 which gives 73 waves.[9] A preselection regarding the frequency of the response was not performed. A total of 596 enterprises have participated in the survey. The resulting unbalanced panel consists of about 21.700 observations, depending on the variable analysed.[10]

Descriptive statistics for all variables used are given in table 1. A mean of 2 of a categorical variable means that the respondents expected on average no change of this variable in the future. If the mean is lower than 2 a decrease was expected on

[8] The respondents are asked for their expectations for the next six months.

[9] For the exchange rate expectations of the French franc and the Italian lire the data series start in August 1993. Therefore we have 53 waves for the analysis of the expectations of these two exchange rates.

[10] For the French franc and the Italian lire the observations amount to approximately 16.000 and 15.600, respectively.

average, while a value above 2 is consistent with an expected increase. The variances of the categorical data are very similar. This is also true for variables such as long term interest rates and exchange rates which in reality have a much higher variance than e.g. inflation rates or GDP.

Table 1: Descriptive Statistics of Expectations Data

Expectation	Variable	No. Obs.	Mean	Std. dev.	Decrease	No Change	Increase
GDP	Germany	22.401	2.31	0.70	14%	41%	45%
	USA	21.926	2.21	0.60	10%	60%	31%
	Japan	21.381	2.40	0.62	7%	45%	48%
	UK	21.417	2.16	0.55	8%	67%	25%
	France	21.190	2.36	0.59	6%	52%	42%
	Italy	20.289	2.21	0.60	9%	60%	31%
Inflation	Germany	22.380	1.83	0.73	37%	43%	20%
	USA	21.868	2.46	0.56	3%	47%	50%
	Japan	20.953	2.18	0.53	6%	69%	25%
	UK	21.163	2.35	0.63	9%	48%	43%
	France	21.013	2.07	0.55	12%	69%	19%
	Italy	20.030	2.08	0.67	19%	54%	45%
Short-term interest rates	Germany	22.378	1.66	0.71	48%	38%	14%
	USA	21.869	2.46	0.63	7%	39%	53%
	Japan	21.120	2.10	0.58	12%	65%	23%
	UK	21.171	2.09	0.73	22%	46%	32%
	France	21.039	1.71	0.69	43%	44%	13%
	Italy	20.024	1.72	0.69	42%	44%	14%
Long-term interest rates	Germany	22.385	1.95	0.77	33%	40%	28%
	USA	21.941	2.43	0.66	10%	38%	53%
	Japan	21.103	2.23	0.61	10%	57%	33%
	UK	21.219	2.10	0.71	20%	49%	31%
	France	21.070	1.88	0.74	34%	44%	22%
	Italy	20.055	1.86	0.73	34%	45%	21%
Exchange rates	DM/USD	22.139	2.62	0.63	8%	22%	70%
	DM/YEN	21.348	1.95	0.72	28%	49%	23%
	DM/UKP	21.582	2.11	0.68	18%	53%	29%
	DM/Franc	16.055	2.02	0.49	11%	76%	13%
	DM/Lire	15.674	2.04	0.64	19%	59%	22%

III. Description of the Theoretical and Empirical Models

Monetary exchange rate models are one of the most popular classes of structural models for the explanation of exchange rates. These models try to explain exchange rates using domestic and foreign monetary aggregates, interest rates and economic growth. In our study we want to analyse whether professional financial market analysts employ monetary exchange rate models to forecast future exchange rates. If the analysts believe in the validity of monetary models or at least if they implicitly use these models to formulate their exchange rate forecasts, we should find similar structures in their expectations. In addition, we analyse whether our estimates could be interpreted in the light of Mundell-Fleming type models.

The basis of monetary exchange rate models is the assumption of purchasing power parity:

(1) $$s_t = p_t - p_t^*$$

s_t is the exchange rate (DM price for foreign currency), p_t is the domestic and p_t^* is the foreign price level. All variables are in logs. Equation 1 can be reformulated in expectations i.e. if a forecaster believes that equation 1 is true then the equation should hold in realisations but also in expectations: $E_t(s_{t+x}) = E_t(p_{t+x}) - E_t(p^*_{t+x})$. Here E_t is the conditional expectations operator which indicates that expectations are formed in period t for the variables *s*, *p* and p^* in period $t+x$.[11] The forecast horizon is given by *x*.

The monetary exchange rate models assume the following money demand functions (* denotes foreign variables):

(2) $$m_t^d = p_t + b \cdot y_t - g \cdot r_t \quad \text{and} \quad m_t^{d*} = p_t^* + b^* \cdot y_t^* - g^* \cdot r_t^*$$

The variable *y* is real income (in logs) and *r* is the nominal interest rate. The money demand functions imply homogeneity of degree one in prices.

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[11] The expectation of future values is conditioned on information known in period t (= I_t). Therefore the expectation operator could be written in detail as $E_t(\,.\,) = E_t(\,.\mid I_t)$.

Combining equation 1 and the money demand equations and assuming money market equilibrium we get the flexible-price monetary model:[12]

(3) $$s_t = m_t - m_t^* - b \cdot y_t + b^* \cdot y_t^* + g \cdot r_t - g^* \cdot r_t^*$$

Here *m* is money supply expressed in logs.

A basic assumption of the flexible-price monetary model is that changes in the relative supply of monies lead to adjustments of prices and thereby influences the exchange rate. A rise in domestic GDP e.g. will increase money demand and ceteris paribus domestic prices will decline and thus causing an appreciation of the domestic currency (= decrease of s_t). An increase in the domestic interest rate ceteris paribus causes a depreciation because the higher interest rate reduces domestic demand for money.

Dornbusch (1976) suggested a monetary exchange rate model with sluggish price adjustment. The resulting equation of the sticky-price monetary model for the determination of the exchange rate is:[13]

(4) $$s_t = m_t - m_t^* - b \cdot y_t + b^* \cdot y_t^* - d \cdot r_t + d^* \cdot r_t^* + c \cdot inf_t - c^* \cdot inf_t^*$$

The flexible-price and the sticky-price monetary models differ in two respects. First, the coefficients of the nominal interest rates in one model have the opposite sign than in the other model. Second, the sticky-price model includes the long term expectations of inflation (*inf, inf**) as additional variables. The long run solution for the exchange rate in the sticky-price model is equal to the flexible-price model, but the sluggish adjustment of prices causes temporary overshooting of the exchange rate compared to the long run equilibrium. The sign and the significance of the coefficients attached to the interest rates and the long term inflation expectations are therefore the major criteria to discriminate between the flexible-price and the sticky-price model.

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[12] See e.g. Isard (1995: 134-140), for a description of different monetary exchange rate models.

[13] See Isard (1995: 134-135) for the derivation of the sticky-price monetary model.

To test the theoretical models we estimate (4) using the ZEW expectations data. In the survey we ask for the expected future changes of these variables. Therefore, and due to the categorical nature of the data the series are stationary and can be directly used for econometric estimations.

In the estimation we use domestic and foreign business expectations as proxies for y_t and y_t^*. The business expectations behave very similar as future real GDP growth and can therefore be used as a proxy for the real income variable in the estimation. The effects of the nominal interest rates (r_t, r_t^*) on the exchange rate is in most studies estimated using short-term interest rates. The use of short-term interest rates is due to the interpretation of monetary models as equilibrium models for the money market. In our empirical analysis we therefore also employ expectations for future short-term interest rates to estimate the interest rate effect on exchange rates.

In most empirical studies long-term inflation expectations (inf_t, inf_t^*) are represented by long-term interest rates, since assuming rational expectations long-term interest rates should capture the bond market expectations of future inflation. In our study we also choose the expectations for long term interest rates as a proxy for expected long-term inflation and not the expectations on inflation. This is because respondents to the ZEW survey prevail their medium-term inflation expectations (next 6 months). Hence, this variable will not capture the expected long-term trend of inflation.[14] However expectations for long-term interest rates of the ZEW survey could be a good proxy for long-term inflation, because the respondents should take into account their expectations for inflation in the more distant future when forecasting long-term interest rates.

In the theoretical models (3) and (4) monetary supply is an important variable for the exchange rate determination. Unfortunately the ZEW survey does not cover the

[14] A direct estimation of PPP (eq. 1) using the expectations for inflation from the ZEW survey resulted in coefficients with signs opposite to the theoretical model for all three currencies. The coefficient for domestic inflation has a negative sign for all five currencies whereas the coefficient of foreign inflation has a positive sign and both coefficients are highly significant for all exchange rates under consideration. The wrong signs should be attributable to the short horizon of the inflation expectations. Therefore inflation expectations are rather a proxy for expected future changes in short term interest rates than an indicator for the expected long term trend of inflation. This can be seen by looking at the (polychoric) correlation coefficients between expected inflation and expected short-term interest rates which are at least 0.5 for all countries included in our study.

expectations of future changes in money supply. Therefore the effect of this variable cannot be taken into account in the estimation. Money supply has not been included in the monthly ZEW survey because of severe doubts concerning the usefulness of money supply expectations. Money supply would have been usually expected to increase in the coming 6 months by a majority of respondents (if not by all of them). Therefore, a categorical variable „expected future change in money supply“ would have nearly no variability and could therefore not be used for statistical inference. As a consequence the effect of neglecting this variable should have no major impact on the quality of the estimations of the other coefficients.

In addition to the two monetary models described above we also test whether a Mundell-Fleming type model is compatible with the data. In the Mundell-Fleming Model an increase in GDP may result in either an exchange rate appreciation or a depreciation. It is therefore not possible to derive a hypothesis on the coefficients of domestic and foreign expected GDP in equation 4. But the coefficients of expected short- and long-term interest rates can be used to discriminate between the Mundell-Fleming model and monetary models: An expected increase (decrease) in domestic short- and long-term interest rates causes capital inflows (outflows) and hence an appreciation (depreciation) of the currency. This is just the opposite relationship as postulated by the flexible-price monetary model. While the coefficients of the short term interest rates have the same sign both in the sticky-price model and the Mundell-Fleming model, the coefficients of the long-term interest rates should have the opposite sign. The signs of the coefficients of long-term interest rate expectations therefore can therefore be used to discriminate between the sticky-price model and the Mundell-Fleming model.

The resulting specification of the estimation equation for the exchange rates in terms of the variables of the ZEW survey is:

$$\textbf{(5)} \qquad s_t = \beta \cdot y_t + \beta^* \cdot y_t^* + \delta \cdot rs_t + \delta^* \cdot rs_t^* + \lambda \cdot rl_t + \lambda^* \cdot rl_t^*$$

where y_t are the expectations of future GDP growth, rs_t is the expected short term interest rate and rl_t the expected long term interest rate. Using (5) to test for the three theoretical models the estimated coefficients should reveal the following signs:

Table 2: The Coefficients of the Parameters in the Structural Models

	β	β^*	δ	δ^*	λ	λ^*
Flexible-price monetary model	-	+	+	-	0	0
Sticky-price monetary model	-	+	-	+	+	-
Mundell-Fleming model	?	?	-	+	-	+

Equation (6) shows the general structure of the estimation model. *Y** is the vector of the latent endogenous variables, *X* represents the matrix of the exogenous variables, *K*, *B* and *P* are the matrices of the coefficients and ε is the vector of the disturbance terms.

(6) $$Y^* = K + B \cdot Y^* + P \cdot X + \varepsilon$$

The elements of *Y** are latent expectations variables that can be identified from the survey data. The 9x9-Matrix *B* contains the simultaneous effects between the expectations variables.[15] Table 3 shows the elements of Matrix *B*. According to equation (5) we assume that expectations for short- and long-term interest rates and GDP expectations contribute to the explanation of the expected exchange rate (= first row of table 3: *b1, b3, b9, b12, b15, b17*). The subsequent rows of table 3 show the assumed simultaneous relationships between the explanatory variables. Matrix B has a basic structure which is equal for all countries: expected GDP growth influences expected inflation (*b2, b4*) and expected inflation has impacts on short- and long-term interest rate expectations (*b5* - *b8*). It is assumed that short-term interest rates will influence long-term interest rates (*b11, b14*) and both can effect growth expectations (*b10, b13, b16, b18*).

But there are also some differences in the structure of Matrix B between countries. We assume that the expectations of US variables influence expectations for the German variables (coefficients "USA" in table 3) and that expectations on German variables influence the expectations on French and Italian variables (coefficients "F/I" in table 3). The estimates of these coefficients have been all highly significant

[15] In Matrix B the expectations of domestic and foreign inflation are included in addition to the variables of equation (5). The reason is that expectations of inflation are highly correlated with the expectations for short- and long-term interest rates. The inclusion of inflation expectations should therefore improve the estimation of the whole system.

with the expected positive sign. In case of DM/British pound and DM/Japanese yen we did not assume these cross-country effects between Germany and UK or Japan, because empirical tests did not result in significant parameter estimations for these cross-country effects.

Table 3: Simultaneous Effects (Matrix *B*)

	s	**gdp**	**gdp***	**p**	**p***	**rs**	**rs***	**rl**	**rl***
Exchange rate (s)	0	**b1**	**b3**	0	0	**b9**	**b12**	**b15**	**b17**
Domestic business expectations (gdp)	0	0	USA	0	0	**b10**	0	**b16**	0
Foreign business expectations (gdp*)	0	F/I	0	0	0	0	**b13**	0	**b18**
Domestic inflation (p)	0	**b2**	0	0	USA	0	0	0	0
Foreign inflation (p*)	0	0	**b4**	F/I	0	0	0	0	0
Domestic short term interest rates (rs)	0	0	0	**b5**	0	0	USA	0	0
Foreign short term interest rates (rs*)	0	0	0	0	**b7**	F/I	0	0	0
Domestic long term interest rates (rl)	0	0	0	**b6**	0	**b11**	0	0	USA
Foreign long term interest rates (rl*)	0	0	0	0	**b8**	0	**b14**	F/I	0

Matrix *B* is estimated together with matrix *P* which contains the coefficients of the exogenous variables *X*. As we use pooled data (across time and respondents) we assume that the structure of the model (= matrix *B*) is constant over time and that the respondents are all equal. This means that the estimated model shows the structure between the variables as an average of all respondents.

In our study the only true exogenous variables are time dummies i.e. we define one dummy variable for each point in time ($d_i = 1$ if $i = t$ and $d_i = 0$ otherwise, $i,t = 1,...,72$).[16] These dummy variables capture the effects of exogenous influences on the intercept that are common to all respondents e.g. a shift in the level of expectations

[16] In case of French franc and Italian lire we define 52 time dummies, which is due to the smaller amount of waves available.

due to a change in economic policy at time *t*. The dummy variables are represented by matrix *X*.

The ZEW survey asks each month for the expectations of the next 6 months. This causes an overlapping data problem: by construction of the data we get a moving average process in the residuals of order 5. To overcome this problem we split our data sample into 6 non-overlapping sub-samples. The first sub-sample contains data for month *t* and month *t+6* for all time periods starting in December, whereas the second sub-sample starts in January and so on until sub-sample 6. Therefore all estimations have to be carried out six times, one time for each sub-sample.

The estimations have been carried out using the econometric software package MECOSA.[17] In equation (6) the vector *Y** contains the latent expectations. These continuous variables represent the true but unknown expectations of the respondents of the ZEW survey. The relationship between the latent expectations and the observed ordered categorical variable Y is controlled by the two threshold parameters α_1 and α_2:

$$\textbf{(7)} \qquad \begin{array}{rcl} Y_t^* \geq \alpha_2 & : & Y_t = 3 \\ \alpha_1 \leq Y_t^* \leq \alpha_2 & : & Y_t = 2 \\ Y_t^* < \alpha_1 & : & Y_t = 1 \end{array}$$

The threshold parameters have to be estimated together with the coefficient matrices *B* and *P*. A basic assumption of the estimation procedure is that the residuals ε of equation (6) are normally distributed with mean zero and variance-covariance matrix Ω: $\varepsilon \approx N(0,\Omega)$.

The estimation procedure of MECOSA includes three separate steps: in the first step the thresholds are estimated together with the reduced form coefficients and the reduced form error variances for each equation by maximum likelihood.[18] The

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[17] MECOSA is the abbreviation of MEan and COvariance Structure Analysis. The estimation approach of MECOSA is a generalisation of LISREL type models. The programme is based on the software package GAUSS. For a description of MECOSA and the estimation procedures see (Sobel and Arminger, 1992: 40, 44-45) and Arminger (1997: 200-202).

[18] In the estimation the lower threshold α_1 is set to zero, while a constant and the upper threshold α_2 are estimated for each latent variable. An alternative restriction would be to estimate both thresholds but to exclude the constant. One of these restrictions has to be chosen for

estimated equations in the first step are therefore: $Y^* = \text{A1} + \text{A2} \cdot X + \text{A3} \cdot \varepsilon$. The parameters A1, A2 and A3 are: $\text{A1} = (I - B)^{-1} \cdot K$, $\text{A2} = (I - B)^{-1} \cdot P$ and $\text{A3} = (I - B)^{-1}$.

In step 2 the program estimates the reduced form variance covariances matrix $(I - B)^{-1} \cdot \Omega \cdot (I - B)'^{-1}$. In our case of only qualitative variables the variances are restricted to be one. This is a necessary condition for identification. The covariances are therefore equal to the polychoric correlation coefficients between the categorical variables.[19] Step 2 is also estimated by maximum likelihood. In step 3 the structural parameters of equation (6), *K, B, P* and Ω, are estimated by a minimum distance approach.

IV. Results of the Estimations

The following tables 4 (a) – 4 (e) show the estimated parameters of the exchange rate equations and their significance level for all five currencies and all six sub-samples.

Table 4: Results of the Exchange Rate Equation (First Row of Matrix *B*)
($s_t = \beta \cdot y_t + \beta^* \cdot y_t^* + \delta \cdot rs_t + \delta^* \cdot rs_t^* + \lambda \cdot rl_t + \lambda^* \cdot rl_t^* + u_t$ **)**

(a) Expected German mark / US dollar

Sub-Samples	**gdp**	**gdp***	**rs**	**rs***	**Rl**	**rl***
Dec./June	0.0043	0.195***	-0.047*	0.081***	-0.112***	0.099***
Jan./July	-0.009	0.163***	-0.0796***	0.102***	-0.144***	0.0575*
Febr./Aug.	-0.01*	0.184***	-0.083***	0.096***	-0.074**	0.0538
Mar./Sept.	-0.037	0.163***	-0.078***	0.110***	-0.028	0.060*
April/Oct.	0.008	0.125***	-0.064**	0.115	-0.01***	0.085**
May/Nov.	0.032	0.175***	-0.077***	0.135***	-0.067**	0.065*

Significance levels of one-sided tests: *** = 1%, ** = 5%, * = 10%

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identification of the parameters. The resulting estimations of the coefficient matrices *B*, *P* and Ω are not influenced by the choice of the identification restriction.

[19] For more information on the concept of polychoric correlations and their estimation see (Poon and Lee, 1987). The polychoric correlation measures the (linear) relationship between two categorical variables. The resulting value can be interpreted just like the usual correlation coefficient between two real-valued variables.

(b) Expected German mark / Japanese yen

Sub-Samples	**gdp**	**gdp***	**rs**	**rs***	**Rl**	**rl***
Dec./June	-0.0256	0.1039***	-0.0186	0.103***	0.0214	-0.0276
Jan./July	-0.0458**	0.1076***	0.0177	-0.0255	0.005	0.0573
Febr./Aug.	-0.0286	0.1599***	0.003	0.037	-0.0934***	-0.0318
Mar./Sept.	-0.0329	0.1222***	0.0229	0.0458	0.0350	0.0240
April/Oct.	-0.0287	0.091***	-0.0459*	0.0734**	0.0298	0.0002
May/Nov.	-0.0042	0.0805***	0.0388	0.0554*	-0.0103	0.0268

Significance levels of one-sided tests: *** = 1%, ** = 5%, * = 10%

(c) Expected German mark / British pound

Sub-Samples	**gdp**	**gdp***	**Rs**	**rs***	**Rl**	**rl***
Dec./June	-0.0412***	0.1463***	0.0043	0.0252	-0.023	0.0255
Jan./July	-0.0397**	0.1345***	0.0342	0.0718***	-0.0409	0.0028
Febr./Aug.	0.0113	0.1352***	-0.0425	0.0666**	-0.0409	-0.0144
Mar./Sept.	-0.0279	0.1397***	0.0018	0.0556**	-0.0111	0.0141
April/Oct.	-0.0452**	0.1912***	0.0033	0.0463*	-0.0206	0.0013
May/Nov.	-0.0178	0.1754***	-0.0541**	0.0854***	-0.0418*	-0.0135

Significance levels of one-sided tests: *** = 1%, ** = 5%, * = 10%

(d) Expected German mark / French franc

Sub-Samples	**gdp**	**gdp***	**Rs**	**rs***	**Rl**	**rl***
Dec./June	0.048	0.06	0.777	-0.099	0.31***	-0.34***
Jan./July	-0.151**	0.338***	0.002	0.128***	0.1415**	-0.1489**
Febr./Aug.	-0.004	0.076	-0.187***	0.116**	0.054	-0.0801
Mar./Sept.	-0.079	-0.138**	0.034	-0.082*	-0.083	0.073
April/Oct.	-0.032	0.1196*	0.170***	-0.104**	0.025	-1.177***
May/Nov.	-0.102	0.189***	0.125**	-0.178***	0.142**	-0.187**

Significance levels of one-sided tests: *** = 1%, ** = 5%, * = 10%

(e) Expected German mark / Italian lire

Sub-Samples	**gdp**	**gdp***	**Rs**	**rs***	**Rl**	**rl***
Dec./June	-0.098**	0.157***	0.028	0.052	0.17***	-0.318***
Jan./July	-0.108***	1.191***	0.017	0.059	0.115***	-0.277***
Febr./Aug.	-0.032	1.085**	0.026	0.079*	1.213**	-0.359***
Mar./Sept.	-0.100***	1.193***	0.093***	0.026	0.071*	-0.205***
April/Oct.	-0.06**	0.159***	0.121***	0.026	0.041	-0.258***
May/Nov.	-0.09***	0.216***	0.064*	0.054	0.162***	-0.284***

Significance levels of one-sided tests: *** = 1%, ** = 5%, * = 10%

The results give a clear picture about the strong significance of expected foreign GDP growth (= gdp*). This variable is the most important explanatory factor out of the set of variables used in our study. In nearly all estimated equations the coefficient of gdp* is significant at the 1%-level and shows the correct sign: an expected increase (decrease) in foreign GDP induces an appreciating (depreciating) currency vis-à-vis the German mark. Remarkably, the expectation on the German GDP has a significantly smaller influence on exchange rate expectations.

Concerning the identification of structural exchange rate models the results are mixed. The only clear results are from the DM/US dollar equations: for all sub-samples the signs of the estimated coefficients are compatible with a Mundell-Fleming type model. This means that an expected increase (decrease) in US short- or long-term interest rates relative to German interest rates leads to an expected appreciation (depreciation) of the US dollar.

For the Japanese yen and the British pound only expected changes in the foreign short-term interest rates seem to be of some importance (in addition to foreign GDP). For example, an increase in Japanese or British short-term interest rates is expected to induce an appreciation of the yen and the pound, respectively. This result is in accordance with both the sticky-price model and the Mundell-Fleming model, but cannot discriminate between the two approaches.

For the French franc and the Italian lire the results for the interest rate expectations in nearly all cases show just the opposite result: a widening of the interest rate differentials vis-à-vis Germany leads to a depreciation of the currency. This result is in sharp contrast to the estimations for dollar, yen and pound. The reason for these

different results could be the EMS membership of franc and lire: increases in interest rate differentials to Germany mostly occurred in situations of a weak franc or lire. The signs of the coefficients are in line with uncovered interest rate parity where interest rate differentials are a compensation for an expected future devaluation of the currency.

V. Conclusions

In this study we have analysed the relationships between important fundamental variables (short- and long-term interest rates, GDP) and the exchange rates DM/US dollar, DM/Pound Sterling, DM/Japanese yen, DM/French franc and DM/Italian lire. In contrast to other studies we made use of only expectations data instead of realisations of the relevant variables. Therefore, the focus of our study is on the latent structural equations the respondents of the ZEW survey might have in mind when forecasting future exchange rates. The economic hypotheses tested in this study are whether popular structural models could be compatible with the results of the estimated parameters. The alternative models considered in this study are the flexible-price monetary model, the sticky-price monetary model and the Mundell-Fleming model.

The results show that expected foreign GDP growth is the most important single variable used in our study. For all currencies considered an expected increase (decrease) in foreign growth leads to an expected appreciation (depreciation) of the currency vis-à-vis the German mark. This result is compatible with all structural exchange rate models considered in this study. Interestingly, the results also show a clear asymmetry: the expected German GDP growth has a much weaker influence on exchange rate expectations than the expected foreign GDP.

For the US dollar a Mundell-Fleming type model is compatible with the estimations: an expected increase in interest rate differentials relative to Germany induce an appreciation of the US dollar. For British pound and yen the expected interest rates are relatively unimportant. Only foreign short-term interest rates seem to have some stronger influence on the exchange rate expectations. Concerning these two currencies both the Mundell-Fleming model and the sticky-price monetary model are supported by the results. Just the opposite results have been found for the French franc and the Italian lire. Here an expected widening of the interest rate differentials indicates the expectation of a weak currency. This result is compatible with

uncovered interest rate parity. It seems that the EMS participation of these two currencies has significantly influenced the expectations of the financial market analysts.

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