# Investor sentiment in the dollar market: longer-term, mean-reverting expectations

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**Abstract:**

How can longer-term exchange rates show behavior towards equilibrium, when professionals form consistently false expectations? We apply a fresh perspective on this puzzle by analyzing sentiment. First, long-horizon regressions show that professionals' sentiment contains valuable information in forecasting exchange rate returns for time horizons of more than two years but does not contain information at usually examined shorter time horizons. Second, sentiment is anchored in a stable fashion to PPP. Third, this anchorage is weak when PPP nearly holds but becomes strong the farther exchange rates deviate from PPP. Thus, professionals' expectations closely match facts of empirical exchange rate research.

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Keywords: Exchange rates, investor sentiment, long-horizon regression, threshold VECM

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## 0. Introduction

Foreign exchange markets, such as the dollar market, seem to be characterized by a separation along the time horizon (Frankel and Rose, 1995, p.1718). At shorter-term time horizons, up to one or two years, there reigns the "exchange rate disconnect" (Obstfeld and Rogoff, 2000). At longer-term horizons, however, exchange rates appear being linked with economic fundamentals (Sarno and Taylor, 2002). Unfortunately, this long-term tendency of exchange rates towards equilibrium—revealed in empirical exchange rate modeling—has never been matched by any direct observation of professionals' behavior. On the contrary, empirical evidence shows that professionals' exchange rate expectations are poor whatever dimension is considered.[1] This leaves us with a puzzle: where does long-term equilibrium come from if professional forecasts are characterized by "expectational errors" (Frankel and Froot, 1987, p.150)? Our paper provides a surprising contribution by analyzing exchange rate expectations data from a new angle, i.e. research on sentiment in financial markets:[2] professionals form valuable longer-term, mean-reverting expectations.

Researchers have always been dissatisfied with the finding of consistently false expectations of market professionals. We argue that this result is most likely caused by a joint hypothesis problem, i.e. next to "poor" expectations, "inappropriate" measurement could also cause this result.[3] Accordingly, we would ask what could influence professionals' exchange rate expectations (and how should it be

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[1] In fact, MacDonald (2000) surveys the literature since the seminal work by Frankel and Froot (1987) and states consistent violations of unbiasedness and orthogonality, i.e. rationality, of professionals' exchange rate expectations. Thus, it seems "hard to avoid the conclusion that [this finding] implies some form of irrationality among market participants" (p.94).

[2] See e.g., Baker and Wurgler, 2006, Brown and Cliff, 2005, Coakley and Fuertes, 2006, Lee, Jiang and Indro, 2002.

[3] There may be other reasons as well, such as Peso problems or learning (see e.g., MacDonald, 2000, Sercu and Vinaimont, 2006).

measured)? According to our reading of the literature, one may draw three conclusions from empirical work, which we see as established facts at present stage of knowledge (see e.g., Sarno, 2005): first, exchange rate expectations derived from economic fundamentals ought to be long-term oriented. Second, the anchor for these expectations should consider the purchasing power parity (PPP), and, third, more distance of exchange rates from PPP leads to stronger mean-reversion expectations. In the following, we provide evidence for justifying these three established facts before we test whether they are reflected in professionals' expectations.

The core insight, as it seems to us, appears to be that professional forecasters in foreign exchange markets, who rely on fundamental economic concepts, cannot seriously expect to predict successfully exchange rates in the short run.[4] There is overwhelming evidence that exchange rate models fail over shorter-term time horizons (see recently Cheung, Chinn and Garcia Pascual, 2005). At the same time, evidence has accumulated that exchange rates are linked to fundamentals over longer-term horizons, (early contributions include MacDonald and Taylor, 1994, Mark, 1995). Following these studies, exchange rate expectations of any time horizon might be influenced by longer-term considerations. Accordingly, the analysis of survey expectations should allow for longer-term anchorage.[5]

With regard to fundamental anchorage, the debate on PPP has experienced a complete reversal during the 1990s as earlier rejection of the PPP-hypothesis is replaced by gradual acceptance (Taylor and Taylor, 2004). In the beginning, the tendency of exchange rates moving towards PPP was seen as a very long-run phenomenon. However, the implicit half-life of adjustment towards PPP found in empirical studies has remarkably decreased due to more refined methods of examination from five or

[4] Professionals also apply other instruments to forecast exchange rates, such as technical and (order) flow analysis, which are indeed used in shorter-term horizons than fundamental analysis (see e.g., Gehrig and Menkhoff, 2006).

[5] There is, indeed, early evidence in Frankel and Froot (1987) of longer-run regressive expectations. However, even these twelve months expectations are "false" when compared to respective exchange rate realizations.

six years (Rogoff, 1996) down to one or two years only (Coakley and Fuertes, 2000, Imbs et al., 2005).[6] Thus, PPP has gained even more importance for real world forecasting.

As another recent development, research has provided deeper insights into the adjustment process towards fundamental equilibrium. Previous studies have found that the speed of mean-reversion depends on the deviation of exchange rates from the equilibrium level (Coakley and Fuertes, 2006, show analogous dynamics in equity markets). Close to the equilibrium, adjustment is slow if existent at all, whereas speed towards equilibrium is higher outside such a band. This finding holds for various modeling approaches, including an exponential smooth transition autoregressive (ESTAR) adjustment towards PPP (Taylor, Peel and Sarno, 2001, Kilian and Taylor, 2003) and a Markov switching approach (Sarno and Valente, 2006). It follows that exchange rate expectations should reflect the distance of the price from its equilibrium level.

We test whether these three established facts concerning exchange rates—i.e. long-term validity of fundamentals, anchorage on PPP and impact of present price distance from PPP—are reflected in exchange rate expectations. The analysis is based on professional expectations, arisen from a monthly survey of the Center for European Economic Research at Mannheim (ZEW). This survey, which started in December 1991 and queries on average about 300 financial market professionals in Germany, has established as a standard source for analysis, featured e.g., by Bloomberg and Reuters.

We examine the first fact by applying long-horizon regressions that allows identifying information value in expectations over all time horizons. In particular, we follow Brown and Cliff's (2005) recent simulation technique. Accordingly, qualitative expectations are condensed into a sentiment indicator in the way that the relative share of upwards expectations minus downwards expectations is calculated. Our application of this approach to exchange rates shows that sentiment becomes more valuable with increasing time horizon: it is useless in the shorter run of say one year—

[6] Coakley et al. (2005) further evidence in favour of relative PPP.

consistent with conventional wisdom—but it significantly contains valuable information for time horizons of more than two years.[7]

This result motivates to uncover the determinants of the exchange rate sentiment by applying a vector error correction model (Johansen, 1995). Therefore, we test determinants derived from common exchange rate models, e.g., interest rates, moneys and growth rates (see Sarno and Taylor, 2002). In fact, we reveal one long-term cointegration relation on sentiment that comprises a set of exchange rate fundamentals, inter alia inflation and interest rates, which in turn indicates overall importance of PPP.

Finally, to test for possible non-linear effects that actual exchange rates bear on sentiment, we apply a threshold vector error correction model, akin to the one introduced by Hansen and Seo (2002). This approach allows testing the above-mentioned facts two and three, i.e. mean-reversion and threshold effects. Interestingly, we find long-term expectations of mean-reversion towards PPP. When we consider different regimes, mean-reversion is weak in a band where actual exchange rates are close to PPP. However, if actual exchange rates are farther away from PPP—i.e. in regime 2—mean-reversion becomes strong and increases with the magnitude of fundamental misalignment.

We conclude that professionals' exchange rate expectations—in the form of sentiment—seem to reflect three established facts of exchange rate research: they are long-term oriented, show anchorage on PPP and are mean-reverting. We do not speculate on causation, i.e. whether exchange rate sentiment contributes to the formation of exchange rate dynamics or whether it reflects anticipation of existing dynamics. However, we want to emphasize, that our findings contribute towards understanding the apparent puzzle of contemporaneous long-term exchange rate equilibrium and professionals' seemingly irrational attitude.

The paper is structured as follows: Section 1 describes the data used here. Section 2 examines sentiment's potential forecasting contribution of future exchange rate returns. In Section 3, determinants of the foreign exchange market sentiment are analyzed, Section 4 explicitly allows for threshold effects in this setting. Section 5 summarizes main findings.

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[7] Recently Ang, Bekeart and Wei (2006) find that surveys forecast better future US inflation than several other models, e.g., ARIMA models or derived term structure measures.

## 1. Data

Our analysis is based on the well-established monthly financial market survey of the Centre for European Economic Research (ZEW) in Mannheim, Germany. Compared to other surveys of financial market professionals, the ZEW's survey structure is conventional (e.g., similar to Consensus Forecasts, London) but participation is large with about 300 responses.

The ZEW collects every month numerous economic and financial forecasts with a time horizon of six months. For this purpose, the ZEW conducts a standardized questionnaire via fax, where responses are usually processed on the last Friday of each month. About 75 percent of participants are working in the financial sector. Among these financial professionals, analysts represent the main fraction; however, traders, portfolio managers and senior bankers are included in the sample as well. Participants outside the financial sector work in finance or accounting departments and thus are likewise familiar with financial market developments. The ZEW survey asks respondents to give their qualitative expectations, i.e. up, down or no change. This sort of data fits perfectly to generate a bull-bear spread, which is a common measure in the financial community. We follow Brown and Cliff (2005) in applying this measure:

$$\text{SENTIMENT} = \text{UP} - \text{DOWN} \tag{1}$$

Sentiment is analyzed for the main foreign exchange market, i.e. the market linking the two largest economic areas in the world, US-dollar/euro (D-mark/US-dollar until 1998, respectively). In order to ensure continuity we take the reverse of the euro's present notation, i.e. from 1999 we use the euro/US-dollar exchange rate. Accordingly, "Up" contains the relative amount of participants, who forecast a stronger US-dollar vis-à-vis the euro and vice versa in respect of "Down". Both numbers are measured in relation to the number of all participants, who participated at the particular forecast, thus sentiment yields zero, when upwards and downwards expectations exactly equalize each other.[8]

We cover the period from December 1991, i.e. the survey's introduction, to August 2005, which sums up to a total of 165 observations. In addition to the sentiment series, further data is necessary for

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[8] Unless all participants expect either up or down, sentiment outcomes range between one and minus one. However, if everybody would expect up (down), sentiment correspond to one (minus one).

the analysis. Thus, we use US-dollar/euro and D-mark/US-dollar end of the month rates from the Deutsche Bundesbank. Both time series, i.e. sentiment and exchange rate, are shown in Figure 1 for the period of investigation. Moreover, as changes in the US-dollar may be related to other determinants beyond sentiment we need to control for such variables, too. Hence, it seems self-evident to consider fundamental variables, which are used in standard exchange rate models. Taking the monetary model as the reference model, these variables are the following: differences between the euro zone (Germany until 1998, respectively) and the US with regard to changes in money or income and levels of interest rates. In detail, we take a broader definition of money, i.e. M3, and a narrower one, M2. To proxy income growth on a monthly basis we rely on industrial production; additionally quarterly GDP is interpolated to get a monthly frequency. With respect to interest rates, we take six months Libor money market rates. In order to consider Frankel's (1979) real interest rate variation of the monetary model, we also incorporate long-term bond rates. Finally, and somewhat more pragmatic, we control for variables beyond this reference model. First, inflation differences are often seen being less distorted proxies for actual price trends than money aggregates. Second, the monthly trade balance is often assessed as a further exchange rate determinant (Obstfeld and Rogoff, 1995) and, third, capital flows reach beyond money market instruments or bonds—captured by respective interest rates—and might therefore include equity market returns (Hau and Rey, 2006).[9] However, before we run our analysis, we have to examine the time series properties of the variables underlying our interest, wherefore we consult standard unit-root tests (e.g., Augmented Dickey-Fuller, Philips-Perron as well as KPSS test). These tests provide somewhat mixed results, depending on the particular procedure as well as the period of investigation (see Table 1). Hence, persistent behavior characterizes at least the level series of the variables.[10]

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[9] Financial market series, i.e. interest rates and equity indices, are taken from EcoWin, whereas M2, M3, industrial production, GDP, CPI inflation and trade balance, stem from IMF's International Financial Statistics.

[10] However, corresponding differences of the time series are stationary, so we can exclude definitely dealing with I(2)-ness in the data.

## 2. Forecasting contribution of sentiment

In investigating professional's expectations formation, studies have taken time horizons literally—here six months—and did not find any forecasting ability. We allow, however, for diverse time horizons' relevance of expectations in respect to future exchange rates and find forecasting value in sentiment, but only in longer time horizons. The usefulness of expectations in predicting future exchange rates has been assessed very critically in the past. To cut a long story short, there is no forecasting power in consensus exchange rate expectations, in the usual way, by relying on a priori defined time horizons (MacDonald, 2000). The same result applies to our data set as we show in Appendix A, which indicates that the ZEW survey respondents behave like respondents of other surveys.[11] The new perspective draws on long-horizon regressions, which allows us to test sentiment's future exchange rate relevance on a bulk of different time horizons—from one month up to 60 months. In doing so, we follow the simulation procedure of Brown and Cliff (2005), who investigate the US equity market using bootstrap techniques.

$$r_t^k = \alpha^k + \Theta^{k\prime} \cdot \mathbf{z}_t + \beta^k \cdot S_t + \varepsilon_t^k \tag{2}$$

We regress k-period future average returns of the euro/US-dollar, $r_t^k$, on a vector of control variables, $z_t$, and on sentiment, $S_t$. Variables in the control vector include all those exchange rate determinants discussed in Section 2. Thus, the question we follow, does sentiment contain information value beyond a wide set of possibly relevant fundamentals? The methodological difficulty of this approach is twofold. First, there is a problem arising from overlapping observations. Since we calculate average returns of sequential periods, we obtain a moving average process of the dimension of the specific period in the error term, $\varepsilon_t^k$. Using Newey-West standard errors would be a way out, but due to our relatively small sample size, this correction entails small power and so turns out being not appropriate (see e.g., Hodrick, 1992). Second, the persistent behavior of some of the regressors as well as the regressand must be considered. The regressors appear as stochastic processes, possibly influenced by innovations that are correlated with the disturbance term $\varepsilon$ in (2). Corresponding

[11] This stretches out to the analyses of rationality of expectations: respondents at the ZEW survey show the same pattern as identified in other studies (see Menkhoff et al., 2006, analyzing a somewhat shorter sample than us).

estimations would be biased, even though the regressors are predetermined, and hence, spurious regression results could be the outcome (see Stambaugh, 1999). Therefore, significance levels of estimates of long-horizon regressions will most likely increase no matter if economic relations exist actually. In consequence of that, the overlapping of fractions of the sample alters the stochastic order of the variable and generates the persistency in the regressand (see Valkanov, 2003).[12] Following Brown and Cliff (2005), we deal with this issue by applying a bootstrap simulation technique, under the null hypothesis of no predictability. Hence, we run 10,000 repetitions in order to derive simulated distributions of the estimates, which in turn allow us to calculate accurate test statistics, on which our following analysis is based.

Results presented in Table 2 reveal an interesting pattern. In the short run, we reproduce the conventional finding that expectations do not contain valuable forecasting information, i.e. sentiment does not contribute to explaining future exchange rates at time horizons up to 12 months. However, by increasing the horizon, corresponding coefficients as well as probability values indicate that the specific time horizon matters. At approximately 24 to 30 months, sentiment shows some information contribution in order to predict subsequent returns in the euro/US-dollar. Strikingly, from month 32 upwards, corrected beta coefficients from sentiment turn out being statistically significant at the five percent level.

Thus, we receive our first finding: sentiment contains valuable information in forecasting longer-term exchange rates. This fits well in the established fact number one of the introduction, that fundamentals explain exchange rates in the longer run. It seems noteworthy that sentiment is of value, even when we control for well-known exchange rate fundamentals. Interestingly, it does not contain information in the shorter run, even not as a contrarian indicator.

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[12] Ferson et al. (2003) show that even if the regressand does not undergo high persistency, spurious regression could occur, while the variables are statistically independent.

## 3. Determinants of sentiment

We have seen that sentiment has some forecasting value at longer-term time horizons—so, where does it come from? In this section we analyze possible economic and purely time series determinants of sentiment. We find that sentiment changes in a way as if professionals would adhere to the insight from long-term exchange rate modelling, i.e. established fact number two: they orientate their expectations towards PPP. Due to the data characteristics we use a standard vector error-correction model (VEC model) to explain sentiment, which we formulate in terms of differences in the following, where we restrict the constants into the cointegration space:[13]

$$\Delta x_t = \Pi \cdot x_{t-1} + \Gamma_1 \cdot \Delta x_{t-1} + \varepsilon_t \qquad (3)$$

$$\text{with } \Pi = \alpha \cdot \beta' ,$$

$$\text{with } \varepsilon_t \sim N_p(0, \Sigma) \quad \text{and } t = 1, \ldots, T$$

Vector $X_t$ contains the endogenous variables of the system, in which we consider all variables mentioned in Section 2, inter alia interest rates, growth etc. Our objective here is to find a data set, which delivers best model-fit and specification properties in order to explain sentiment. To check for correct model specification, we run residual tests and picture results in Table 3. Multivariate maximum-likelihood-tests do not reveal autocorrelation, but autoregressive heteroskedasticity of order three and five. Furthermore, residuals do not seem to be normally distributed; however, asymptotic results are robust to some sort of heteroskedasticity and non-normality (see Johansen, 1995 and 2006). Identifying the rank of the VEC model, we run Johansen's Trace tests, which show, that our model underlies one long-term relation (see results in Table 4). Assuming the chance, that one variable of $X_t$ generates a unit-root in this multivariate system we consult respective LR-tests. Results in Table 5

[13] For robustness, we consider specifications with non-restricted constants. The latter are not significant and do not change qualitatively short-term as well as long-term relations. Testing for seasonality effects via including seasonal dummies, again, estimates do not show any sensibility.

show clearly that the long-term relation does not constitute one endogenous variable being stationary.[14]

Table 6 presents the results of the VEC model.[15] Regarding the long-term relation, it turns out, that all variables of $X_t$ appear significant. Relative inflation and bond rate affect sentiment positively. We associate the influence from bond rates on sentiment with future inflation expectations. Moreover, the exchange rate correlates negatively with sentiment, which points to mean-reversion behavior of the latter. Turning to the short-term dynamics, next to sentiment only the relative bond rate significantly error-corrects. Nevertheless, the magnitudes of corresponding alpha-coefficients seem rather small, which consequently puts the economic significance into question. Furthermore, concerning short-term coefficients from the lagged sentiment, we see that sentiment has only short run impact on itself, which indicates that sentiment is not a short-term force of the exchange rate. Looking at sentiment's significant short-term determinants, sentiment is negatively affected by the relative bond rate and positively by the euro/US-dollar, unlike in the steady-state relation. Whereas we see latter relation in conjunction with the well-known phenomena of extrapolative expectations in foreign exchange markets, the positive short-term affect arising from the relative bond rate seems to be in line with a short-term relation between interest and exchange rate (Frankel, 1979).

Summing up, sentiment shows some kind of extrapolative behavior in the short run, while mean-reversion dominates its long-run relation with the exchange rate. In addition to that, interest rates influence sentiment in two different ways, depending on the time horizon. However, the minor economic significance of sentiment's error-correction indicates that nonlinear behavior of sentiment may remain.

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[14] Selecting the lag-length of the cointegrated VEC model, we rely again on LR-tests, which show a lag of one being sufficient. We do not show corresponding results in order to save space.

[15] Accordant attempts using different variable sets appeared to be less fruitful than the one we finally consider in vector $X_t$. However, further estimation results will be provided upon request.

## 4. Threshold effects in sentiment's behavior

Following the idea of different speeds of sentiment's reaction on exchange rate misalignments, we are going to analyze how sentiment mean-reverts in a nonlinear setting using a regime-switching model. Hereunto we set up a threshold vector error-correction model (threshold VEC model), where sentiment depends on exchange rate deviations from long-term PPP.

The third established fact we are going to consider in this section has been modeled e.g., by Kilian and Taylor (2003). They suspect that in a market with heterogeneous beliefs, consensus' anticipation of exchange rate mean-reversion grows the larger its misalignment from fundamentals (see also Taylor and Taylor, 2004, p. 148). Relying on our previous results, we assume one cointegration relation, on which sentiment error-corrects.[16] Next to sentiment and the bond rate difference, the long-term relation contains the inflation difference and the actual exchange rate (see Table 6). We incorporate the latter two variables into a regressive term, which comprises the difference between actual exchange rate and corresponding fair PPP value.[17] Our procedure is motivated by Frankel's (1979) hybrid model, in which next to a regressive PPP term, the bond rate difference determines exchange rate expectations. By implementing the latter variable, he extends the sticky-price monetary exchange rate model by longer-term inflation expectations (proxied by bond rates).[18] In spirit of Kilian and Taylor (2003), sentiment should error-correct stronger, the higher exchange rate's deviation from long-term PPP. Hence, we draw on Hansen and Seo's (2002) regime-switching model, which integrates cointegration analysis and uses an exogenous threshold variable (see Appendix B).[19] Since recent studies in nonlinear exchange rate modeling show symmetric behavior of exchange rates, irrespective of being above or below fair values (see e.g., Taylor, Peel and

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[16] In fact, the linear VEC analysis of section four does not indicate another cointegration relation (see Table 4).

[17] We estimate also the accordant linear VEC model and obtain identical results as in Table 6.

[18] MacDonald and Marsh (1997) consider balance of payment equilibrium conditions, that's why they integrate the interest rate differential in an augmented PPP model. So in their setting, exchange rate expectations show up as being determined by a PPP term as well as interest rates, too.

[19] Seo (2003) uses this model in order to test the expectation hypothesis concerning the yield curve of interest rates. Indeed, he is able to show significant nonlinear mean-reversion in the term structure, arising from threshold effects in the adjustment to an existing cointegration relation.

Sarno, 2001, Kilian and Taylor, 2003), we use symmetric thresholds and measure accordant variable in absolute terms. Hence, we handle two regimes; in regime 1, exchange rates are in line with corresponding fundamentals, whereas in regime 2, exchange rate deviations from fundamentally fair values are comparatively huge (Hansen and Seo, 2002). Our model shows up as follows:

$$\Delta x_t = \begin{cases} \Pi^{(1)} \cdot x_{t-1} + \Gamma_1^{(1)} \cdot \Delta x_{t-1} + \varepsilon_t & \text{if} \quad z \leq \gamma \\ \Pi^{(2)} \cdot x_{t-1} + \Gamma_1^{(2)} \cdot \Delta x_{t-1} + \varepsilon_t & \text{if} \quad z > \gamma \end{cases} \tag{4}$$

$$\text{with } \Pi^{(1)} = \alpha^{(1)} \cdot \beta^{(1)\prime}, \; \Pi^{(2)} = \alpha^{(2)} \cdot \beta^{(2)\prime},$$

$$\text{with } \varepsilon_t \sim N_p(0, \Sigma) \quad \text{and} \quad t = 1, \ldots, T$$

Except for above-imposed nonlinear elements, we proceed like in the previous section, whereas vector $X_t$ comprises the US-dollar sentiment, the regressive term and the difference of bond rates. Since we follow the idea that sentiment is subject to nonlinear (symmetric) mean-reversion, depending on exchange rate's misalignment from fundamentals, we choose the regressive PPP term measured in absolute values as being our threshold variable, *z*. Hence, the latter identifies in connection with the endogenously generated threshold, γ, the current regime. Depending on the threshold value, all coefficients are allowed to differ between the two regimes.

Results are shown in Table 7, denoting a threshold value of 0.1597. Accordingly, regime 1 applies, if the exchange rate is close to the PPP rate, i.e. in a band of approximately 16 percent and hence, regime 2 holds, if the exchange rate is respectively outside this band. As expected, error-correction of sentiment increases significantly from 0.06 to 0.25, when turning from regime 1 into regime 2. Looking at sentiment's short-term relations, sentiment correlates negatively to bond rates when being in regime 1, but shows no such relation in regime 2. Moreover, influence from the regressive term on sentiment takes place in regime 2.

Overall, we find, that sentiment's mean-reversion depends on the dimension of exchange rate misalignment from long-run PPP. Around a threshold-band of about 16 percent, sentiment does not show economically important mean-reversion. However, outside this band, strong mean-reversion materializes.

## 5. Conclusions

This paper is the first analyzing exchange rate expectations from the angle of recent research on sentiment in financial markets. The fresh analysis of exchange rate expectations—measured as sentiment, i.e. upwards minus downwards expectations—by long-horizon regressions brings an unexpected result: sentiment contains value in forecasting exchange rates at time horizons of more than two years. Furthermore, we confirm earlier studies, which state that professionals' expectations do not contain value at shorter-term horizons. This indicates that our finding is not due to a particular data set, but rather driven by the different approach.

In order to understand sentiment, we analyze it in a VEC model and find a statistically significant long-term relation to exchange rate fundamentals. Identified fundamentals closely mirror the concept of PPP, since the dollar is expected to appreciate when European inflation is high compared to the US, the dollar value is low and European bond rates are higher than US rates—the latter indicating expected inflation. Short-term dynamics appear less stable, but we do find some short-term extrapolative element in sentiment in contrast to its longer-term mean-reversion behavior—this is reassuringly the same finding as introduced by Frankel and Froot (1987). However, linear VEC analysis does not capture potential non-linear effects, which could be related to regime dependent exchange rate behavior as revealed in recent studies. We thus run a threshold VEC model, which indeed identifies regime dependent mean-reversion behavior of sentiment, where the first regime holds when exchange rates are close to PPP. Here, weak mean-reversion characterizes sentiment and a positive short-term relation to higher bond rates arises. Nonetheless, in the second regime sentiment shows strong mean-reversion, whereas no relation to bond rates materializes. Overall, these three findings closely reflect established facts of recent exchange rate research, i.e. long-term validity of fundamentals, anchorage of the exchange rate on PPP and stronger mean-reversion the higher the distance of actual exchange rates from long-term PPP. In this sense, we assess sentiment—i.e. a consensus belief of market professionals—as being rational. This does not contradict earlier findings as sentiment has no value at shorter-term time horizons and even shows some form of extrapolative behavior—which is exactly what was found in the literature.

A possible misinterpretation could arise, when relating our findings to sentiment research on other financial markets: most studies state that sentiment reflects short-term exuberance of irrational market forces, which separate prices from fundamental equilibrium and contradict sentiment's value in longer time horizons. A plausible explanation of these findings states sentiment as representing noise trading, possibly by less informed investors, such as individual investors. In fact, splitting market participants into informed institutional and uninformed individual forces often reveals the latter as being the driving force in pushing prices away from fundamentals.[20] Since our analyses concern the foreign exchange market, i.e. a wholesale market among professionals, upcoming findings confirm that professionals do not form "false" expectations in all respects.

Therefore, our results are consistent with the view that professionals are a driving force in pulling exchange rates back towards equilibrium levels in the longer term. Even though these findings may be comforting for economists they leave two obvious issues open for further research: first, it would be interesting to extend research on sentiment in foreign exchange markets unto other currencies, periods or surveys as well, and, second, exchange rates' short-term disconnect from fundamentals is not solved at all.

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[20] The finding, that institutional investors often behave more sophisticated, has been shown in different studies, for example by Locke and Mann (2005), Schmeling (2006) or Shapira and Venezia (2001).

**Appendix A**

To throw light on the forecasting property of sentiment in line with earlier literature, we perform respective calculations. Since most of the standard analysis is based upon point forecasts, we have to transform the qualitative data underlying the sentiment in an appropriate way (see Carlson and Parkin, 1975). Doing so, we obtain point forecasts, which enable us to run adequate accuracy tests.

Table A1 presents results in congruency with the surveyed six months forecast horizon. Furthermore and for comparative purposes, comparable calculations are run for forecasts upon the forward rate as well as the random walk. Obviously aggregated expectations perform worse than competing forecast series in all tests except for the hit rate–the latter displays the share of correct trend forecasts. The mean error, mean absolute error and the root mean square error of the expectations are in all cases bigger than accordant numbers from the forward rate and the random walk. Direct comparisons between expectations as well as forward rates with the random walk reveal that the latter performs the best. However, consulting the hit rate shows undoubtedly better performance of expectations. Trend forecasts upon expectations reveal a hit rate of more than 55 percent, whereas forward rates prove correctness in only approximately 34 percent of the cases.[21]

**Table A1 Tests of accuracy based on six months time horizon**

| | **ME** | **MAE** | **RMSE** | **Theil's U** | **hit rate** |
|---|---|---|---|---|---|
| Sentiment | -0.0242 | 0.0923 | 0.1112 | 1.3624 | 0.5564 |
| forward rate | 0.0061 | 0.0758 | 0.0938 | 1.1500 | 0.3383*** |
| random walk | 0.0043 | 0.0664 | 0.0816 | - | - |

**Notes:** To derive aggregate point expectations we use the quantification method of Carlson and Parkin (1975), which requires three specific assumptions. We assume that the subjective probability distributions, concerning the forecast realizations, are normally distributed. However, the use of the normal distribution for the corresponding means of the individual probability distributions can be justified upon the Central Limit Theorem. Moreover, we set a symmetric scaling factor of three percent according to a specific questionnaire, which displays the threshold from which the forecasters perceive noticeable changes in the exchange rate. Nevertheless results upon other thresholds around three percent did not differ qualitatively. Random walk forecasts are calculated on current exchange rates, respectively no change forecast. Asterisks refer to the level of significance: *: ten per cent, **: five per cent, ***: one per cent. ME shows the mean error based on US-dollar/euro forecasts and realized exchange rates. MAE shows corresponding mean absolute error. RMSE shows corresponding root mean square error. Differences between forecast series were examined upon Theil's U, which shows the relation between the specific RMSE and the RMSE of the random walk. The hit rate shows the share of right direction forecasts. Trend predictability is tested upon $\chi^2$-tests.

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[21] The random walk forecasts no change; hence, the benchmark is set at 50 percent.

**Appendix B**

Using a grid search algorithm, short-term and long-term coefficients as well as the threshold are jointly estimated via LM-tests. Required confidence intervals for the grid search concerning the cointegration parameters ($\beta$) are evenly spaced around extracted estimates from the corresponding linear VEC estimation. The grid search examines all possible combinations of the parameter vector, $\beta$, and the threshold, $\gamma$, which meet the minimum size for a regime (fraction of the population, predefined by the trimming parameter). We set the trimming parameter rather conservative at 0.20 due to our relatively small sample size of 165 observations. Choosing grid sizes for the cointegration coefficients of 100 and of 300 for the threshold variable, we run 1,000 bootstraps. Furthermore, we choose the Eicker-White covariance matrix to correct for potential heteroskedasticity in the residuals. Since the parameterization of the threshold model is yet unknown, we have to rely on the linear model in our null hypothesis. Nevertheless, the asymptotic distribution of the appropriate LM-test, in order to check the validity of the threshold model, figures out to be intractable again. To run inference analysis anyhow, Hansen and Seo (2002) suggest two alternative LM-tests via bootstrap techniques, which in contrast provide usable asymptotical distributions. The fixed regressor bootstrap, upon which we will base our threshold test, fixes in contrast to conventional bootstrap techniques, next to estimated coefficients and corresponding residuals under the null hypothesis, the model variable series as well as the estimated error-corrections. Modifying the residuals by adding i.i.d.-innovations of a standard normal distribution, one regress them on the model variables–once for the whole sample and another time for the split samples upon the threshold. Using jointly latter coefficient matrixes and modified residuals from the former unseparated regression, makes possible to calculate Eicker-White covariance matrix estimators. This in turn enables to calculate a LM-like statistic. Repeating these steps numerous times delivers a simulated distribution of the test statistic and finally appropriate critical values. The other procedure is closer to standard bootstrapping. Here residuals are presumed being i.i.d., but without taking control of potential violations of heteroskedasticity, which has been revealed in fact in Section 3. Hansen and Seo claim that the fixed regressor bootstrap is robust to heteroskedasticity, therefore we judge this test statistic as being appropriate for our data set.

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**TABLE 1** Univariate tests for stationarity

| unit-root tests: | | ADF | PP | KPS |
|---|---|---|---|---|
| | sentiment | -1.2507 | -1.1346 | 0.1050 |
| | [prob. value] | [0.1936] | [0.2328] | - |
| | Δsentiment | -22.5876 | -31.8946 | 0.0793 |
| | [prob. value] | [0.0000] | [0.0000] | - |
| | inflation | -2.2787 | -2.9167 | 0.1298 * |
| | [prob. value] | [0.1802] | [0.0456] | - |
| | Δinflation | -18.61725 | -26.1050 | 0.0340 |
| | [prob. value] | [0.0000] | [0.0000] | - |
| | euro/US-dollar | -1.1176 | -1.2667 | 0.1837 ** |
| | [prob. value] | [0.2390] | [0.1885] | |
| | Δeuro/US-dollar | -16.1012 | -19.7460 | 0.0525 |
| | [prob. value] | [0.0000] | [0.0000] | - |
| | bonds | -2.1957 | -2.6228 | 0.1289 * |
| | [prob. value] | [0.0275] | [0.0904] | - |
| | Δbonds | -21.54176 | -26.37097 | 0.0444 |
| | [prob. value] | [0.0000] | [0.0000] | - |

**Notes:** The exact specification of the univariate unit-root test depends on the significance of intercept and trend variable – if significant, then the additional regressor is included. We chose a maximum number of integrated lagged differences of twelve. Appropriate lag-length selection in the Augmented Dickey-Fuller tests (ADF) is determined by the modified Akaike-procedure. In order to calculate bandwidths in the Philips-Perron tests (PP) as well as in the Kwiatkowski-Phillips-Schmidt-Shin tests (KPS), we use Andrew's procedure, whereas Bartlett's kernel is chosen for spectral estimations. Δ symbolizes the first difference of the following variable. All tests are based upon 165 observations, containing observations from December 1991 to August 2005. Asterisks refer to the level of significance: *: ten per cent, **: five per cent, ***: one per cent.

**TABLE 2** Outcomes of long-horizon return regressions

| | 1mon. | 6mon. | 12mon. | 24mon. | 30mon. | 32mon. | 36mon. |
|---|---|---|---|---|---|---|---|
| $\beta$ | 0.0021 | 0.0002 | 0.0014 | 0.0054 | 0.0074 | 0.0081 | 0.0086 |
| $\beta^{(adj.)}$ | 0.0011 | 0.0003 | 0.0007 | 0.0050 | 0.0071* | 0.0078** | 0.0084** |
| [prob.$^{(adj.)}$] | [0.3512] | [0.2258] | [0.2063] | [0.1460] | [0.0742] | [0.0474] | [0.0147] |

**Notes:** All regressions are estimated with Newey-West standard errors in which the lag-lengths depend on the number of return periods minus one. The vector of control variables, $z_t$, contains differences in domestic vs. foreign growth rates, equity returns, money growths and relative trade balance as well as corresponding short-term rates, term structures and inflation rate differences. The sample contains 165 monthly observations from December 1991 to August 2005.

The simulation procedure takes place as follows: first, long-horizon regressions of the exchange rate returns on the control variables are run using Newey-West standard deviations. Second, we estimate a VAR-model including the one-month return and the control set, whereas the beta coefficient of sentiment in the exchange rate return equation is set to zero. Arising residuals are stored. Third, using the latter, we accomplish 10,000 bootstraps in order to generate recursively new time series, with which, fourth, we run Newey-West estimations in an analogous manner as in the first step. Fifth, simulated t-values are calculated by pulling up the sentiment beta coefficients, which we correct by subtracting the mean beta estimation of the bootstraps and accordingly, by dividing over the corresponding mean standard deviation estimation. Sixth, that way we are able to set up simulated distributions, which in turn enable us to calculate adequate probabilities of the sentiment betas, which need to be adjusted beforehand. $\beta$ shows the original estimates of the coefficients of sentiment. $\beta^{(adj.)}$ shows the adjusted estimates of the coefficients of sentiment from the simulation results. Prob. $^{(adj.)}$ shows the probability for the null hypothesis that the corresponding parameter is zero. Asterisks refer to the level of significance: *: ten per cent, **: five per cent, ***: one per cent.

**TABLE 3** Misspecification tests of the VEC model

| | | | | | |
|---|---|---|---|---|---|
| **tests for autocorrelation** | | | | | |
| | LM-test (1): | $X^2$ (16) | = 21.31 | [prob. value] | [0.167] |
| | LM-test (2): | $X^2$ (16) | = 20.33 | [prob. value] | [0.206] |
| | LM-test (3): | $X^2$ (16) | = 6.15 | [prob. value] | [0.986] |
| | LM-test (4): | $X^2$ (16) | = 15.25 | [prob. value] | [0.506] |
| | LM-test (5): | $X^2$ (16) | = 14.08 | [prob. value] | [0.592] |
| **test for normality** | | | | | |
| | LM-test: | $X^2$ (8) | = 53.56*** | [prob. value] | [0.000] |
| **tests for ARCH** | | | | | |
| | LM-test (1): | $X^2$ (100) | = 110.69 | [prob. value] | [0.218] |
| | LM-test (2): | $X^2$ (200) | = 189.37 | [prob. value] | [0.694] |
| | LM-test (3): | $X^2$ (300) | = 341.12* | [prob. value] | [0.051] |
| | LM-test (4): | $X^2$ (400) | = 427.92 | [prob. value] | [0.161] |
| | LM-test (5): | $X^2$ (500) | = 563.13** | [prob. value] | [0.026] |

**Notes:** The test of normality distribution of the residuals is strongly rejected, indicating that residuals are not normal distributed. Additionally the tests of ARCH-effects reveal some heteroskedasticity in the data. Univariate tests reveal that normality is rejected due to skewness in sentiment and relative inflation and excess kurtosis in the latter one. However, the asymptotic results upon the Gaussian-likelihood seem to be robust to some types of deviations from Gaussian distribution of the residuals–heteroskedasticity and non-normality (see Johansen, 1995, 2006). Asterisks refer to the level of significance: *: ten per cent, **: five per cent, ***: one per cent.

**TABLE 4** Cointegration rank determination of the VEC model

**Trace tests**

| | rank three | rank two | rank one | rank zero |
|---|---|---|---|---|
| eigenvalue | 0.0193 | 0.0415 | 0.0963 | 0.2225 |
| LR-test | 3.15 | 10.03 | 26.44 | 67.20*** |
| [prob. value] | [0.562] | [0.643] | [0.322] | [0.002] |
| LR-test # | 2.51 | 9.20 | 24.44 | 64.75*** |
| [prob. value] # | [0.679] | [0.720] | [0.440] | [0.004] |

**Notes:** The LR-tests and p-values marked with a hash are the Bartlett-corrected LR tests and p-values because of small sample-size effects on the power of the rank determination. Asterisks refer to the level of significance: *: ten per cent, **: five per cent, ***: one per cent.

**TABLE 5** Multivariate stationarity tests of the VEC model

**unit-root tests**

| | sentiment | inflation | euro/US-$ | bonds |
|---|---|---|---|---|
| LR-test - rank 1 | 35.52*** | 24.81*** | 33.25*** | 20.46*** |
| [prob. value] | [0.000] | [0.000] | [0.000] | [0.000] |
| LR-test - rank 2 | 11.40*** | 3.54 | 10.16*** | 13.28*** |
| [prob. value] | [0.003] | [0.170] | [0.006] | [0.001] |
| LR-test - rank 3 | 2.79* | 1.73 | 0.68 | 3.75* |
| [prob. value] | [0.095] | [0.189] | [0.411] | [0.052] |

**Notes:** Included constants are restricted being in the cointegration space. The numbers in brackets are the respective prob. values of these tests. The multivariate LR-tests show under the assumption of rank of one, that no variable has a unit-root. Higher rank orders show indeed unit-roots. However, the Trace tests in Table 4 result a rank of one, which imply in connection with these test statistics, that we can treat in this approach each variable as nonstationary. Asterisks refer to the level of significance: *: ten per cent, **: five per cent, ***: one per cent.

**TABLE 6** The VEC model: Unrestricted estimation and tests of model-fit

**cointegration equation**

| | **sentiment** $^{(-1)}$ = | inflation $^{(-1)}$ | dollar-rate $^{(-1)}$ | bonds $^{(-1)}$ | constant |
|---|---|---|---|---|---|
| $\beta'$ | **1.00** = | 0.17 | - 2.51 | 0.61 | - 0.17 |

**error-correction equations**

| | **Δsentiment** | **Δinflation** | **Δdollar-rate** | **Δbonds** |
|---|---|---|---|---|
| α | - 0.08*** | 0.07 | 0.00 | 0.11*** |
| [t-value] | [- 5.03] | [1.18] | [0.31] | [2.91] |
| Δsentiment $^{(-1)}$ | - 0.20*** | - 0.02 | 0.04 | 0.03 |
| [t-value] | [- 2.63] | [- 0.08] | [1.62] | [0.15] |
| Δinflation $^{(-1)}$ | 0.03* | - 0.00 | 0.00 | - 0.06 |
| [t-value] | [1.71] | [- 0.03] | [0.45] | [- 1.25] |
| Δdollar-rate $^{(-1)}$ | 0.62** | 2.49** | 0.06 | - 1.17* |
| [t-value] | [2.34] | [2.36] | [0.65] | [- 1.75] |
| Δbonds $^{(-1)}$ | - 0.08** | 0.10 | - 0.03*** | 0.04 |
| [t-value] | [- 2.44] | [0.77] | [- 2.66] | [0.51] |
| $R^2$ | 0.17 | 0.06 | 0.08 | 0.06 |
| adj. $R^2$ | 0.15 | 0.03 | 0.06 | 0.04 |
| Akaike IC | -2.15 | 0.62 | -4.31 | -0.28 |
| Log likelihood of the system: | 1461.20 | | | |

**Notes:** This table shows the coefficients of the VEC model. The sample contains 165 monthly observations from December 1991 to August 2005. The endogenous variables are sentiment, relative year-to-year inflation, euro/US-dollar rate and the relative bond rate. Other variables were tested, amongst others production, trade balance and short-term interest rates, but could not improve the estimation and are therefore abandoned. We do not report LM-test statistics for binding cointegration restrictions, since no coefficients are restricted. Based upon calculated t-values, corresponding cointegration parameters are highly significant. Nevertheless, since latter test-statistics are not valid, they just provide rough indications about the levels of significance, why we do not present them. Asterisks refer to the level of significance: *: ten per cent, **: five per cent, ***: one per cent.

**TABLE 7** The threshold VEC model: Estimation and tests of model-fit

**cointegration equation**

| | | sentiment $^{(-1)}$ = | PPP term $^{(-1)}$ | bonds $^{(-1)}$ | constant |
|---|---|---|---|---|---|
| | $\beta'$ | **1.00** = | -1.66 | 0.41 | 0.02 |
| $\gamma = 0.1597$ | | | | | |

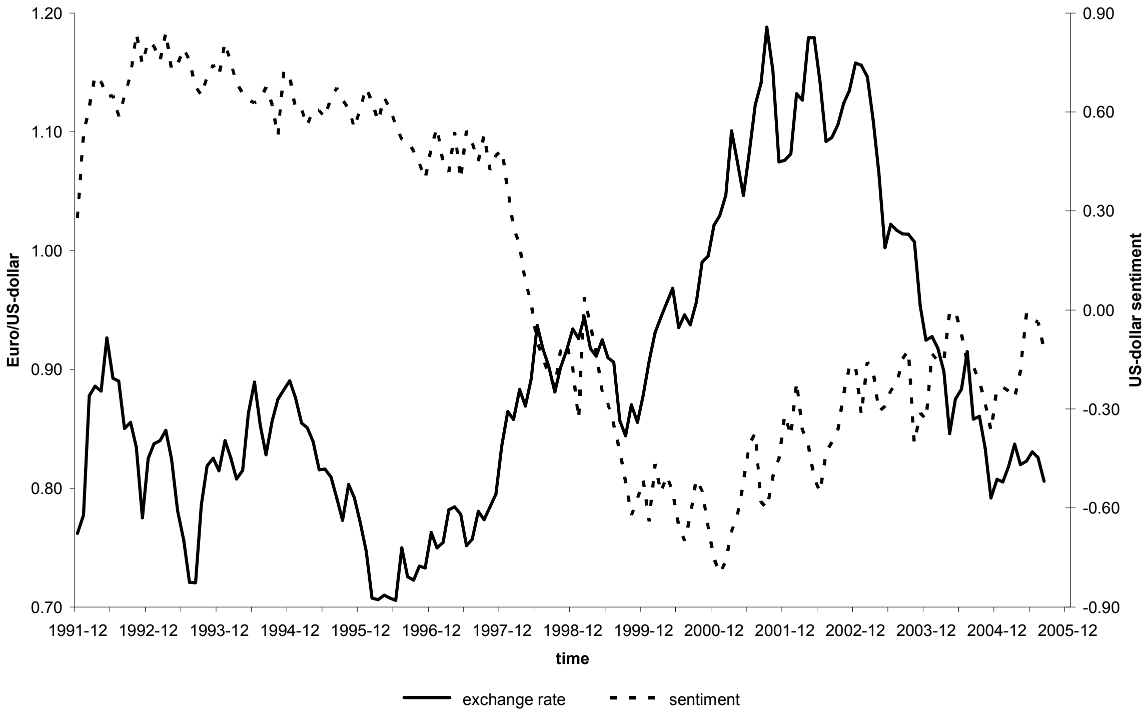
**error correction equations**

| | | α | Δsentiment $^{(-1)}$ | ΔPPP term $^{(-1)}$ | Δbonds $^{(-1)}$ |
|---|---|---|---|---|---|
| REGIME 1 | **Δsentiment** | - 0.06*** | - 0.16 | - 0.27 | - 0.09** |
| | [t-value] | [- 3.13] | [- 1.61] | [- 0.57] | [- 2.42] |
| | **ΔPPP term** | 0.00 | 0.06*** | 0.25*** | - 0.02** |
| | [t-value] | [0.86] | [2.86] | [2.63] | [- 2.02] |
| | **Δbonds** | 0.05 | 0.30* | - 1.79* | - 0.07 |
| | [t-value] | [0.99] | [1.69] | [- 1.93] | [- 0.95] |
| REGIME 2 | **Δsentiment** | - 0.25*** | - 0.13 | 1.40** | - 0.06 |
| | [t-value] | [- 4.97] | [- 1.13] | [2.54] | [- 1.41] |
| | **ΔPPP term** | 0.01 | 0.06 | 0.14 | - 0.03** |
| | [t-value] | [0.72] | [0.70] | [1.01] | [- 2.08] |
| | **Δbonds** | 0.49*** | - 0.52*** | - 1.60 | 0.03 |
| | [t-value] | [3.66] | [- 2.13] | [- 1.17] | [0.23] |

| | |
|---|---|
| Fixed regressor p-value for threshold effect | 0.09 |
| Wald p-value for equality of dynamic coefficients | 0.05 |
| Wald p-value for equality of ECM coefficients | 0.00 |

**Notes:** Here we illustrate the coefficients of the threshold VECM. Sentiment is set to one in the cointegration space. Neither are restrictions set in the cointegration space, nor in short-term dynamics. The sample contains 165 monthly observations from December 1991 to August 2005. The endogenous variables are sentiment, the (regressive) PPP term and the relative bond rate. The PPP term corresponds to the difference of the current euro/US-dollar and the accordant fundamental justified rate. The latter, however, is based upon long-term validity of the relative PPP concept. Corresponding rates are calculated upon PPI differences between the euro area and the USA. The use of CPI data does not reveal qualitatively different results. Regime 1 contains 64 percent of the observations, whereas the remaining 36 percent belong to regime 2. The estimation of the corresponding linear VEC model without threshold effect reveals qualitatively the same results as in Table 6, with an error-correction of - 0.07. Again, based upon calculated t-values, corresponding cointegration parameters are highly significant (for that purpose, see last note in Table 6). Asterisks refer to the level of significance: *: ten per cent, **: five per cent, ***: one per cent.

**FIGURE 1** Euro/US-dollar rates and realization of the US-dollar sentiment




**Notes:** This figure shows actual euro/US dollar rates and corresponding realizations of the US-dollar sentiment (left scaled). The exchange rates until December 1998 are transformed upon the official fixed exchange rate between the D-mark/euro of 1.95583. Sentiment is based upon aggregated six months euro/US-dollar forecasts – respectively the D-mark/US-dollar – from the ZEW Financial Market Survey (right scaled). We calculate our sentiment variable as follows: the relative amount of participants, which forecasts a weaker US-dollar vis-à-vis the euro, is subtracted from the amount of participants, who forecast vice versa a stronger US-dollar. However, both numbers are measured relative to the amount of all participants, who forecasted the exchange rate, though maximum value from this calculation is one and minimum value respectively minus one (for further details see note in Section 2). The sample contains 165 monthly observations from December 1991 to August 2005.