Investor sentiment in the US-dollar:

longer-term, nonlinear orientation on PPP

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Abstract:

How is it possible that exchange rates move in the long run towards fundamentals, while professionals form consistently irrational exchange rate expectations? We look at this puzzle from a different perspective by analyzing investor sentiment in the US-dollar market. First, long-horizon regressions show that investor sentiment is connected with exchange rate returns at longer horizons, i.e. more than two years. Second, sentiment is cointegrated with fundamentals, whereas third, this relation becomes stronger, the larger exchange rate's misalignment from long-run PPP. In sum, investor sentiment's behavior in the US-dollar market closely matches with established facts of empirical exchange rate research.

JEL classification: F31, G14

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

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0. Introduction

Foreign exchange markets, such as the US-dollar/Euro market, seem to be characterized by a separation along the time horizon (see Frankel and Rose, 1995, p.1718). At shorter horizons, i.e. up to one or two years, there reigns the "exchange rate disconnect puzzle" (see Obstfeld and Rogoff, 2000). At longer horizons, however, exchange rates appear linked with economic fundamentals (see e.g. Sarno and Taylor, 2002). Unfortunately, this longer-term tendency of exchange rates towards equilibrium values—revealed in empirical exchange rate research—has never been reconciled with actual professionals' expectations. On the contrary, evidence shows that professionals' exchange rate expectations are consistently irrational.[1] This leaves us with a puzzle: why are exchange rates in the long run in line with fundamentals, whereas professional forecasts underlie considerable "expectational errors" (Frankel and Froot, 1987, p.150)? Our paper contributes to this question from a different perspective, first by analyzing the effective time horizon, to what investor sentiment is connected with subsequent exchange rate returns, and further, by distinguishing between sentiment's short- and long-run determinants. In sum, we find investor sentiment in exchange rates to be longer-term oriented than the predefined forecast horizon states, to be aligned with exchange rate fundamentals and to depend nonlinear on the actual exchange rate deviation from long-run purchasing power parity (PPP).

Researchers have always been unsatisfied with the consistent finding of "poor" exchange rate expectations of professionals. We argue that this result underlies a joint hypothesis problem, i.e. next to irrational expectations, drawing on an inappropriate time horizon could be on hand as well.[2]

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[1] In fact, MacDonald (2000) surveys the related literature and states that professionals' exchange rate expectations violate throughout the criteria of unbiasedness and orthogonality. Thus, it seems "hard to avoid the conclusion that [this finding] implies some form of irrationality among market participants" (p.94).

[2] There may be other reasons as well, such as Peso problems or learning processes (see e.g. MacDonald, 2000).

According to the empirical exchange rate literature, we propose three hypotheses concerning investor sentiment, which we test in this study (see e.g. Sarno, 2005): first, sentiment derived from qualitative 6-month exchange rate expectations is longer-term oriented than the predefined forecast horizon states, which second, is attributed to its alignment with economic fundamentals. Third, higher deviations of current exchange rates from PPP cause stronger dependence of investor sentiment on fundamentals.

One robust finding in the empirical literature states that exchange rate models fail to outperform naïve (random walk) forecasts over shorter-term horizons (see Cheung, Chinn and Garcia Pascual, 2005). However, there exists a lot of evidence, which shows that exchange rates are linked to fundamentals in the long run (see early contributions e.g., MacDonald and Taylor, 1994, Mark, 1995).[3] Recent contributions confirming the latter finding include Abhyankar, Sarno and Valente (2005), who reveal the economic value of out-of-sample exchange rate forecasts using a monetary model as well as Rapach and Wohar (2002) or Sarno, Valente and Wohar (2004), who show cointegration between monetary fundamentals and exchange rates using long spans of data. Taken together, it appears to us, that professional forecasters cannot seriously expect to predict exchange rates in shorter-term horizons successfully, but are possibly aware about the long-term relation between exchange rates and fundamentals, which motivates our first hypothesis: because exchange rate expectations are aligned with fundamentals, they may well be biased towards longer-term horizons.[4]

Concerning the actual fundamentals, which probably influence investor sentiment, we refer particularly to the prominence of long-run PPP as a main building block of the monetary model. Its economic motivation is well understood and calculating equilibrium values is simple. Furthermore, the debate on the validity of PPP has experienced a complete reversal in the literature during the 1990s, since its absolute rejection has been later replaced by gradual acceptance (see Taylor and Taylor,

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[3] The fact that some contributions show the long run linkage between exchange rates and fundamentals as early as in the 1990s, supports our argument, since professional forecasters could have known about this finding at the time the ZEW survey began.

[4] There is indeed early evidence of regressive expectations, e.g. in Frankel and Froot (1987). However, even 12-month expectations prove to be poor, when compared to related exchange rates.

2004). In the beginning, PPP was seen as a very long-run phenomenon at best. However, calculated half-lives for deviations of exchange rates from PPP have remarkably decreased in empirical analyses, due to the application of more sophisticated methods. Estimated half-lives have decreased from five to six years (see Rogoff, 1996) to approximately one to two years only (see Coakley and Fuertes, 2000, Imbs et al., 2005).[5] Thus, the concept of PPP has probably gained importance for investor sentiment.

With respect to our third hypothesis, empirical exchange rate research shows the existence of nonlinear adjustment processes towards fundamental concepts. Particularly it is found that the speed of exchange rates' mean reversion depends on the deviation of the current exchange rate from its equilibrium level. If exchange rates are close to fundamental equilibrium values, adjustments turn out being slow, if existent at all. However, if exchange rates deviate from fundamentals substantially adjustments towards related equilibriums are significantly stronger. Various studies confirm this finding, e.g. Taylor, Peel and Sarno (2001) or Kilian and Taylor (2003), both use an ESTAR model, different from Canjels, Prakash-Canjels and Taylor (2004) who run a TAR model, and Sarno and Valente (2006) who apply a Markov switching model. It follows that investor sentiment's relation to exchange rate fundamentals may be nonlinear, i.e. depending positively on the distance of the current exchange rate from its fundamental equilibrium.[6]

In the following sections we test whether these three hypotheses—i.e. longer-term orientation, alignment with fundamentals and nonlinear dependence on the PPP deviation—are reflected in investor sentiment in the US-dollar/Euro. Our analysis is based on professionals' 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, has established as a standard source for financial market analyses and is featured inter alia by Bloomberg and Reuters.

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[5] Flôres et al. (1999) show that half-lives are about two years for various European countries, but considerable longer for Japan and Canada. Coakley et al. (2005) show further evidence in favor of relative PPP.

[6] Coakley and Fuertes (2006) reveal analogous stock dynamics concerning their related adjustment speeds.

We pursue the first hypothesis by applying long-horizon regressions, which allow us to investigate investor sentiment's orientation over various time horizons. In doing so, we follow Brown and Cliff's (2005) simulation technique, which is used to analyze investor sentiment's impact on US stock markets. Furthermore, since we are dealing with qualitative expectations, we condense the latter into a conventional sentiment indicator by calculating the relative share of upwards minus downwards expectations (i.e. known as "bull-bear spread"). It turns out that investor sentiment is not connected with subsequent exchange rate returns over shorter horizons, but becomes relevant to a significant degree in time horizons of more than two years.[7]

This finding encourages us to analyze investor sentiment's determinants. We examine a range of potential determinants, derived from common exchange rate models, e.g., interest rates, moneys and growth rates (see Sarno and Taylor, 2002). Since investor sentiment shows very persistent behavior, we apply Johansen's vector error-correction approach (see Johansen, 1995), which in addition enables us to separate sentiment's short-term and long-term elements. In fact, we reveal one cointegration relation to which sentiment error-corrects and which in turn confirms hypothesis two, i.e. investor sentiment is aligned with fundamentals.

Finally, in order to test for nonlinear effects underlying investor sentiment, we apply a threshold vector error-correction model, attributed to Hansen and Seo (2002). There are two reasons for following the threshold approach. First, threshold models, such as Canjels, Prakash-Canjels and Taylor (2004), have been applied successfully in the empirical exchange rate literature and, second, it seems economically plausible that sentiment changes somewhat abruptly, depending on accordant changes in professionals' mindsets. Studies arguing along this line include Shiller (1990), referring to financial markets in general, and Bacchetta and van Wincoop (2004) referring to the foreign exchange market. In so far, the "coordination channel", regarding the usefulness of official exchange rate intervention (see Sarno and Taylor, 2001, Reitz and Taylor, 2006) provides a plausible economic explanation. In this connection, central bank interventions act as a coordinating device to bring about the combined

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

engagement of fundamentally oriented, stabilizing speculators at the same time. Accordingly, this linkage motivates to follow a threshold approach in order to test hypothesis three, i.e. the nonlinear dependence on the PPP deviation.[8]

Reassuringly, we reveal nonlinearity concerning investor sentiment's error-correction. Thus, once we consider the existence of different regimes, depending on the exchange rate's deviation from long-run PPP, mean reversion is weak inside a specific range around the PPP value. However, if actual exchange rates are outside this range, mean reversion becomes significantly stronger.

A misunderstanding could possibly arise by relating our findings to sentiment research on stock markets: most such studies find that investor sentiment reflects short-term exuberance, caused by irrational market forces, which disconnects stock prices from related fundamentals.[9] One plausible explanation of these findings states that investor sentiment comprises noise trader risk, which is introduced by less informed investors, such as private investors. In fact, separating market participants into informed institutionals (professionals) and uninformed individuals (private investors) reveals the latter being the driving force of stock price misalignments.[10] However, we cannot reveal such a phenomenon in our long-horizon regressions, possibly because there are hardly any individual investors in the foreign exchange market.

Nevertheless, also exchange rates may well be influenced at shorter-horizons by sentiment even though this does not show up in our long-horizon regressions. One way of considering this alternative, which is consistent with findings in stock market research, is thinking of sentiment as the sum of two unobserved components: a longer-term (stabilizing) component, described as a non-stationary process, and a shorter-term (destabilizing) component, constituting the stationary process.[11] A plausible reason

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[8] We are aware that threshold as well as smooth transition models are approximations of the true but unknown nonlinear process. Both approaches have been successfully applied in many earlier studies.

[9] See e.g. Baker and Wurgler (2006), Brown and Cliff (2004, 2005), Coakley and Fuertes (2006), and Fung and Lam (2004).

[10] The finding, that institutional investors often behave more sophisticated than individuals, has been shown in several studies (see e.g. Locke and Mann, 2005, Schmeling, 2006).

[11] We thank the referee for this argument.

why we only find the longer-term component in investor sentiment may be due to the survey's composition, which consists mainly of analysts, strategists and portfolio managers. These groups tend to hold longer-term views on exchange rates, whereas short-term oriented foreign exchange traders amount only a minor fraction in the dataset (see e.g. Gehrig and Menkhoff, 2006).

In sum, we conclude that investor sentiment in exchange rates reflects three characteristic features: longer-term orientation, alignment with fundamentals and nonlinear dependence on exchange rate's deviation from PPP. We emphasize that we do not argue investor sentiment causing exchange rate dynamics in longer-term horizons. In lieu thereof, it reflects anticipation of apparent longer-term mean reversion in exchange rates towards PPP–acknowledged in several studies e.g., Kilian and Taylor (2003), Coakley et al. (2005), and, Sarno and Valente (2006). However, we emphasize that our findings contribute to put the apparent puzzle of contemporaneous exchange rate's long-run move towards fundamentals and professionals' seemingly irrational beliefs in perspective: given that investor sentiment in exchange rates is strongly aligned with fundamentals, it proves biased towards longer-term horizons.

The paper is structured as follows: Section 1 presents a description of the data used for the empirical analyses. Section 2 examines investor sentiment's orientation on future exchange rate returns. In Section 3, sentiment's determinants are revealed, whereas we allow in Section 4 for nonlinearity in the corresponding relations. Section 5 summarizes the main findings.

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 expectations, which are based on 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 work 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 markets. The ZEW survey asks participants to reveal their qualitative expectations, i.e. "up", "down" or "no change". This sort of data fits absolutely to generate a bull-bear spread, which is a common measure in the financial community (see Brown and Cliff, 2004):

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

Investor sentiment is analyzed for the major foreign exchange market, i.e. the US-dollar/Euro market, which links the two largest economic areas in the world (we convert the D-mark/US-dollar into Euro/US-dollar until December 1998 respectively). In order to ensure continuity we take the reciprocal value of the Euro’s conventional notation, i.e. from January 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 with respect to "down". Both numbers are measured in relation to all participants; thus, sentiment yields zero when the numbers of upwards and downwards expectations are equal.[12]

We cover the period from December 1991, i.e. the survey’s introduction, to August 2005, which sums up to 165 observations. In addition to the sentiment series, further data is necessary for the analysis. Thus, we use Euro/- and D-mark/US-dollar end of month rates from the Deutsche Bundesbank in order to generate the required exchange rate series. Both time series, i.e. sentiment and exchange rate, are shown in Figure 1 over the investigation period. Moreover, we consider various fundamental variables, which are used in standard exchange rate models. Taking the monetary model as the reference model, these variables are the following: differences of changes in money and income as well as of interest rates between the Euro zone (Germany until December 1998 respectively) and the US. In detail, we use a broader definition of money, i.e. M3, and a narrower one, M2. In order to proxy income growth on a monthly basis, we rely on industrial production; additionally quarterly GDP is interpolated to generate a monthly frequency. With respect to interest rates, we use six months Libor

[12] Unless all participants expect either "up" or "down", investor sentiment outcomes range below one and above minus one. However, in this study investor sentiment never hits one of these borders.

rates. Furthermore, in order to consider Frankel's real interest differential model (1979) we incorporate 10-year government bond yields. Finally, and somewhat pragmatic, we control for the following variables in addition to this reference model. First, inflation is often seen to be a better proxy to capture price trends than money aggregates. Second, the trade balance is often assessed as a further exchange rate determinant (see e.g. Obstfeld and Rogoff, 1995) and, third, capital flows reach out money market instruments why we consider stock index returns too (see Hau and Rey, 2006).[13] Before we run the analyses, the time series properties of the underlying data have to be examined. Hence, we consult standard unit-root tests (Augmented Dickey-Fuller, Philips-Perron as well as KPSS). Overall, these tests provide somewhat mixed results, depending on the particular procedure as well as the exact investigation period (see Table 1). Hence, the level series of the considered variables show at least very persistent behavior.[14]

2. Investor sentiment's horizon

By investigating professional's expectations formation, respective studies have taken formal forecast horizons literally—the related horizon of our data spans six months. However, we allow for various time horizons and find that investor sentiment in exchange rates is connected to longer-term returns. Nevertheless, the validity of aggregated exchange rate expectations based upon their predefined time horizons have been consistently irrational (see MacDonald, 2000). The same result applies to our data, as shown in Appendix A.[15] Initiating our somewhat different approach; we draw on long-horizon regressions in order to test investor sentiment's orientation on future exchange rates by considering a bulk of different time horizons—ranging from one month to 60 months. In doing so,

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[13] 6-month Libor rates and stock indices are taken from EcoWin. M2, M3, industrial productions, GDP, CPI inflation and trade balances stem from IMF's International Financial Statistics. German government bond yields are taken from the Deutsche Bundesbank and equivalent US yields from the Federal Reserve.

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

[15] Here we analyze the accuracy of expectations: the test results are very much alike as that in other studies, which are based on different surveys (see Menkhoff et al., 2006, analyzing a somewhat shorter sample).

we follow Brown and Cliff's bootstrap technique (2005) with which they investigate investor sentiment in the US stock market.

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

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 investor sentiment, S_t. The variables in the control vector are all those exchange rate determinants, which we already discussed in Section 1. Thus, we follow the question, to which exact time horizon investor sentiment is related. The methodological difficulty of this approach is twofold. First, we deal with overlapping observations. Calculating average returns of sequential periods, one generates a moving average process in the error term, ε_t^k, of order k-1. Using Newey-West standard errors would be a way out, but due to our relatively small sample size, this correction has small power and so turns out being inappropriate (see Hodrick, 1992). Second, the persistent behavior of some of the regressors as well as the regressand has to be considered. The regressors appear as stochastic processes, possibly influenced by innovations, which are correlated with the disturbance term, ε_t^k. Accordingly, corresponding estimations would be biased, even though the regressors are predetermined, and hence, spurious regressions are the outcome (see Stambaugh, 1999). Therefore, significance levels of estimates of long-horizon regressions could increase even though an actual relation does not exist, because the overlapping of sample fractions alters the stochastic orders of the variables, which in turn generates persistence (see Valkanov, 2003).[16] Following Brown and Cliff (2005), we deal with this issue by applying a bootstrap simulation technique. 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.

Results presented in Table 2 reveal an interesting pattern. In the short run, investor sentiment does not correlate with future exchange rate returns at time horizons up to twelve months. However, by increasing the time horizon, corresponding beta coefficients rise and probability values decline, indicating that longer horizons matter. From month 32 upwards, investor sentiment's corrected coefficients turn out being statistically significant at the five percent level.

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[16] Ferson et al. (2003) show that even if the regressand is not highly persistent, spurious regressions could result.

Thus, we receive our first finding: investor sentiment does not correlate in the short run with subsequent exchange rates but in longer horizons, which supports hypothesis one that investor sentiment is longer-term connected with exchange rates than the predefined forecast horizon states.[17]

3. Determinants of investor sentiment

Since we showed that investor sentiment is connected to longer-term exchange rates, one may wonder to which sources this finding is attributed. Therefore, we search in this section for investor sentiment's economic determinants. In fact, we find that sentiment depends on several exchange rate fundamentals, i.e. the difference in inflation and in bond yields as well as the current exchange rate. Altogether, investor sentiment seems to align with long term PPP, which backs up hypothesis two that professionals are influenced by the insights from long-run exchange rate modeling. Due to the strong persistence of our data, we use a vector error-correction model (VEC model) in order to explain investor sentiment. Treating investor sentiment as integrated of order one, we can separate between its shorter-term and longer-term elements. Bearing in mind that investor sentiment is longer-term aligned we expect to reveal a long-term relation between fundamentals and investor sentiment. If investor sentiment also consists of destabilizing elements, we expect them being captured in sentiment's stationary component and thus showing up in the short-term relation.

In the following, the VEC model is formulated in differences, in which we restrict the constants into the cointegration space:[18]

$$\Delta x_t = \mathbf{\Pi} \cdot x_{t-1} + \mathbf{\Gamma}_1 \cdot \Delta x_{t-1} + \varepsilon_t \tag{3}$$

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

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

[17] We do not judge sentiment being of value in forecasting longer-term exchange rate returns. Although our dataset covers almost 14 years, it constitutes one entire up- and down-cycle of the Euro/US-dollar (see Figure 1).

[18] For robustness, we consider other specifications without restrictions on the constants. Respective results do not change qualitatively the outcome. By testing for seasonal effects, no meaningful changes in the results show up.

Vector X_t contains the essential variables forming the system, in which we have considered all variables mentioned in Section 1, inter alia interest rates, growth etc. Our objective is to find a dataset, which delivers best model-fit and specification properties in order to explain sentiment. By checking the model specification, we run residual tests and present respective 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 test results are robust to 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-run 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 related LR-tests. Results in Table 5 show clearly that the revealed long-run relation does not constitute one of the variables being a unit-root.[19]

Table 6 presents the estimation results of the VEC model.[20] Regarding the long-run relation, it turns out that all variables of X_t are significant. Putting investor sentiment on the left, both the inflation and the bond yield difference affect sentiment positively. We associate the influence from bond yields on sentiment with longer-term inflation expectations. Moreover, the exchange rate correlates negatively with investor sentiment, which points to anticipated mean reversion in the Euro/US-dollar. Turning to the short-run dynamics, next to investor sentiment only the bond yield difference significantly error-corrects to the cointegration relation. Nevertheless, the magnitudes of the corresponding alpha-coefficients seem rather small, which consequently puts the economic significance into question. Furthermore, regarding the short-run coefficients arising from lagged differences of investor sentiment, we notify that investor sentiment does not influence any other variable in the short run. Looking at the significant determinants of investor sentiment's short-run equation, investor sentiment is affected negatively by the bond yield difference and positively by the Euro/US-dollar. Whereas we attribute the short-term impact from the nominal exchange rate to

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[19] By selecting the lag-length of the VEC model via LR-tests, the lag of one proves being sufficient.

[20] Other attempts, using different variable sets, turn out being less fruitful than our final set up. However, related results will be provided upon request.

common extrapolative behavior in financial markets, the negative short-run affect arising from the bond term is in line with the importance of real interest rates in foreign exchange markets (see Frankel, 1979).

Summarized, investor sentiment shows some destabilizing elements in the short run, caused by exchange rate momentum and changes in bond yields. In contrast, its nonstationary component is driven by stabilizing elements, which are associated with anticipated mean reversion in the exchange rate and expected future inflation. Regarding sentiment's error-correction parameter value, the long-run relation is lacking economic significance, which may indicate that some further sort of nonlinearity underlying investor sentiment has not been taken into account yet.

4. Threshold effects in investor sentiment

Following the idea of different speeds of investor sentiment's reaction on exchange rate misalignments, we analyze whether sentiment error-corrects differently by using a regime-switching model. Hereunto, we set up a threshold vector error-correction model (threshold VEC model), in which investor sentiment depends on exchange rate deviations from long term PPP.

Picking up our third hypothesis, i.e. investor sentiment's alignment with fundamentals depends on the exchange rate's deviation from PPP; we refer to Kilian and Taylor (2003). They assume that in a market with heterogeneous beliefs, consensus' anticipation of exchange rate mean reversion grows, the larger the misalignment from PPP (see also Taylor and Taylor, 2004, p.148). Relying on our previous results, we assume one cointegration relation, to which investor sentiment error-corrects.[21] Next to sentiment and the bond term, the long-run relation contains the inflation difference and the actual exchange rate (see Table 6). However, we incorporate the latter two variables into a regressive term, which comprises the difference between the actual exchange rate and the corresponding PPP value.[22] Our procedure is motivated by Frankel's (1979) real interest differential model, in which next to the regressive term, the bond yield difference determines exchange rate expectations. By

[21] In fact, the linear VEC analyses in Section 4 do not indicate another existing long-run relation (see Table 4).

[22] Indeed, we estimated also the accordant linear VEC model and obtained very similar results to that in Table 6.

considering the latter variable, Frankel extends Dornbusch's sticky-price monetary exchange rate model by longer-term inflation expectations (proxied by bond yields).[23] In spirit of Kilian and Taylor (2003), investor sentiment should error-correct stronger to the cointegration relation, the higher the current exchange rate deviates from PPP. Hence, we draw on Hansen and Seo's model (2002), which combines cointegration and regime-switching and incorporates an exogenous threshold variable (see Appendix B).[24] Since recent studies in nonlinear exchange rate modeling show symmetric behavior of exchange rates, irrespective of being above or below their fair values (see e.g. Taylor, Peel and Sarno, 2001, Kilian and Taylor, 2003), we use symmetric thresholds as well by measuring the threshold variable in absolute values. Hence, we handle a two–regime model; in regime 1, the exchange rate is close to its PPP value, whereas in regime 2, exchange rate deviations from PPP are comparatively huge. Our model shows up as follows:

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

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

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

Vector X_t comprises sentiment, the regressive term and the bond yield difference. Since we follow the idea that investor sentiment is subject to nonlinear (symmetric) error-correction, depending on exchange rate's misalignment from PPP, we regard the regressive term measured in absolute values as being the threshold variable, z. Hence, the current value of the latter identifies in connection with the endogenously generated threshold, γ, the effective regime, whereas all short-term coefficients are considered to vary between the two regimes.

[23] MacDonald and Marsh (1997) consider balance of payment equilibriums, 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 and the interest rate differential.

[24] Seo (2003) tests the expectations hypothesis of the term structure and shows significant nonlinear mean reversion in the term structure. He puts this down to threshold effects existing in the error-correction process.

Results are shown in Table 7, denoting a threshold value of 0.1597. Accordingly, regime 1 applies, if the exchange rate's misalignment is small, i.e. in a range of up to approximately 16 percent around the PPP value, whereas regime 2 holds, if the exchange rate is respectively outside this range. Overall, 64% of the observations take place in regime 1 and so the remaining 36% belong to regime 2. As expected, error-correction of investor sentiment to the cointegration relation increases significantly from 0.06 to 0.25, when switching over from regime 1 to regime 2. Looking at investor sentiment's short-run relation, the bond term influences sentiment negatively in regime 1, whereas no such relation shows up in regime 2. Moreover, influence from the regressive term on investor sentiment only takes place in regime 2.

Although we do not claim to take the estimated 16% threshold value too literally, we provide some intuitive interpretation regarding its usefulness. Looking at Figure 2 that shows the PPP-rate for the full post-Bretton Woods period it seems interesting to note that the frequency of regime 2 turns out almost equal to the corresponding frequency in our dataset. The last occurrence of regime 2 happened between February 2000 and October 2002, i.e. a period of considerable US-dollar strength and Euro weakness, respectively. A look at investor sentiment given in Figure 1 shows that, indeed, sentiment turned strongly negative during this episode, indicating a fundamental undervaluation of the Euro from the viewpoint of survey participants. Obviously, investor sentiment runs ahead of the later Euro appreciation, whereas in the second half of 2000 actual interventions almost precisely mark the point when the Euro weakness stopped.[25]

Overall, we find that sentiment's error-correction depends on the degree of the exchange rate misalignment from long-run PPP. In a 16 percent-range around the corresponding PPP value, investor sentiment does not show economically significant error-correction. However, outside this range, error-correction becomes definitely significant.

[25] Fratzscher (2006) reveals around the years 1999 and 2000 heavy oral interventions by the European Central Bank with the purpose of supporting the Euro; however, these coincide with higher sentiment in the Euro strength.

5. Conclusions

This paper analyzes investor sentiment in the Euro/US dollar–based on professionals' qualitative expectations. In sum, investor sentiment is longer-term connected with exchange rates than the predefined forecast horizon states. Adapted from our analysis, we attribute this to investor sentiment's alignment with fundamentals, which in turn depends positively on exchange rate's deviation from long-run PPP.

By applying long-horizon regressions, we investigate investor sentiment's alignment over various time horizons, independent from its predefined forecast horizon. In fact, it turns out that sentiment is connected with future exchange rate returns over horizons of more than two years. In order to distinguish between investor sentiment's short- and long-run determinants, we set up a VEC model and reveal one statistically significant cointegration relation to which sentiment error-corrects. The long-run relation comprises variables, which closely mirror the concept of long-run PPP. By contrast, as the short-term relation of investor sentiment shows some extrapolative behavior, exchange rate sentiment seems to be influenced by destabilizing forces as well. However, since recent empirical studies reveal some sort of regime-switching behavior in exchange rates, we run a threshold VEC model in order to capture such nonlinearity. In fact, we identify that investor sentiment error-corrects regime-dependent: error-correction shows up being weak, when current exchange rates are close to long-run PPP, i.e. inside a range of about 16 percent around the corresponding PPP value, but strong, when exchange rates' misalignments are high, i.e. outside this specific range.

Overall, these three findings regarding investor sentiment closely match with well-established facts of empirical exchange rate modeling, i.e. longer-term validity of fundamentals, exchange rate's mean reversion towards long term PPP and stronger mean reversion the greater the distance of actual exchange rates from PPP values.

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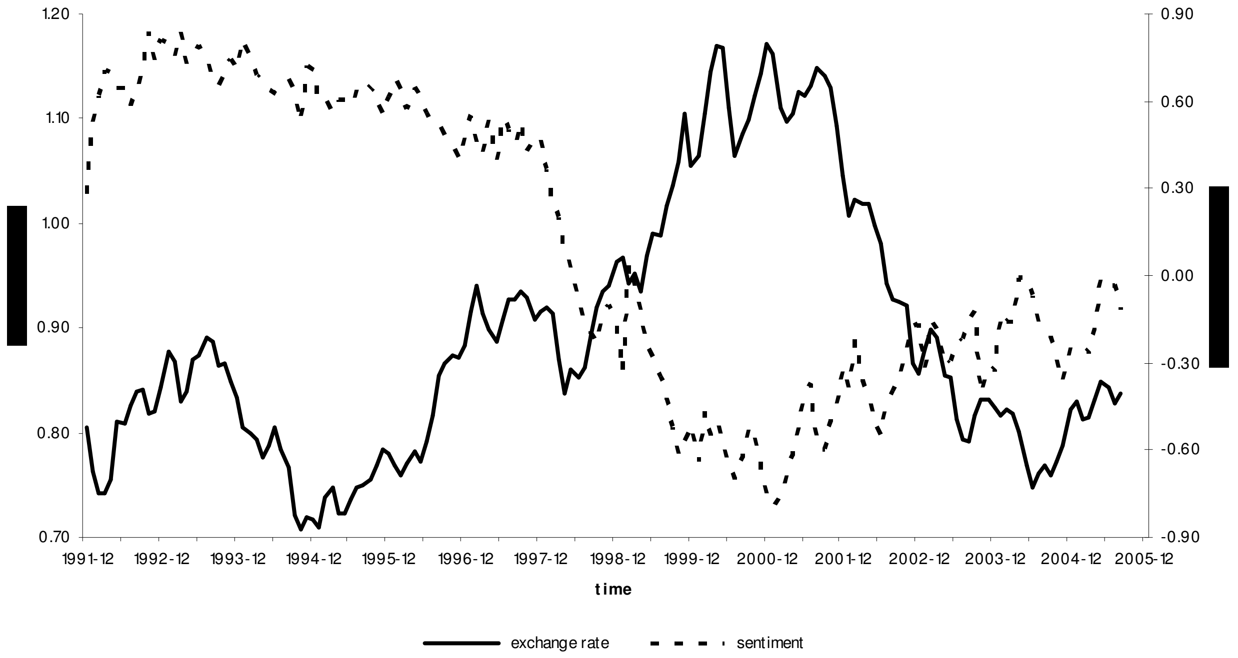
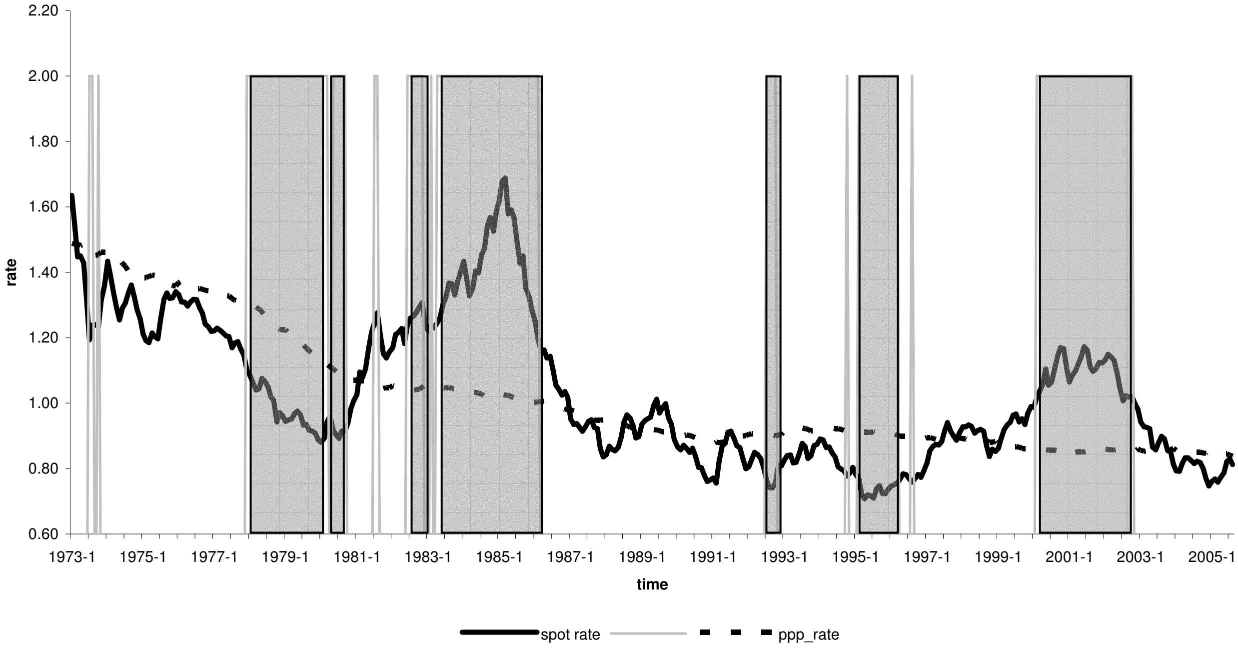
FIGURE 1 Euro/US-dollar rates (shifted 6 months forward) and Investor sentiment



Notes: This figure shows US-dollar investor sentiment (right scaled) and the 6-month-subsequent Euro/US dollar (left scaled). The sample contains 165 monthly observations from December 1991 to August 2005. Corresponding exchange rates until December 1998 are transformed based upon the official fixed exchange rate of 1.95583 between the D-mark and the Euro. Investor sentiment is calculated upon qualitative 6-month Euro/US-dollar forecasts–D-mark/US-dollar until December 1998 respectively–from the ZEW Financial Market Survey. We calculate investor sentiment as follows: the share of participants, which forecasts a stronger US-dollar vis-à-vis the Euro, is subtracted from the share of participants, who forecast vice versa a weaker US-dollar. Since, both numbers are measured in relation to the total amount of participants, who forecasted the exchange rate, maximum and minimum value show up at one and minus one. However, investor sentiment never hits one of these borders.

FIGURE 2 Euro/US-dollar rates and PPP rates



Notes: This figure shows the spot rate of the Euro/US-dollar and the related PPP-rate. The sample contains 392 monthly observations from January 1973 to August 2005. Corresponding exchange rates until December 1998 are transformed based upon the official fixed exchange rate of 1.95583 between the D-mark and the Euro. The related PPP rate is based upon long-run validity of the relative PPP concept. Respective rates are calculated upon PPI-differences between the Euro area and the USA. Highlighted grey areas symbolize the periods, when the difference between the spot rate and the PPP rate results in 15.97 percent or more. Regime 1 includes 66 percent of the observations, whereas the remaining 34 percent belong to regime 2.

TABLE 1 Unit-root tests

	ADF	PP	KPS
sentiment	-1.25	-1.13	0.11
[prob. value]	[0.1936]	[0.2328]	-
Δsentiment	-22.59	-31.89	0.08
[prob. value]	[0.0000]	[0.0000]	-
inflation	-2.28	-2.92	0.13 *
[prob. value]	[0.1802]	[0.0456]	-
Δinflation	-18.62	-26.11	0.03
[prob. value]	[0.0000]	[0.0000]	-
dollar-rate	-1.12	-1.27	0.18 **
[prob. value]	[0.2390]	[0.1885]	
Δdollar-rate	-16.10	-19.75	0.05
[prob. value]	[0.0000]	[0.0000]	-
bonds	-2.20	-2.62	0.13 *
[prob. value]	[0.0275]	[0.0904]	-
Δbonds	-21.54	-26.37	0.04
[prob. value]	[0.0000]	[0.0000]	-

Notes: The chosen unit-root test specifications depend on intercepts' and trend variables' significances–i.e. if significant, then the additional regressor is included. We chose the integration of maximum twelve lagged differences. Appropriate lag-length selections in the Augmented Dickey-Fuller tests (ADF) are determined by the modified Akaike-procedure. In order to calculate the bandwidths for the Philips-Perron tests (PP) as well as for the Kwiatkowski-Phillips-Schmidt-Shin tests (KPS), we use Andrew's procedure, whereas Bartlett's kernel is chosen for the spectral estimations. Δ symbolizes the first difference of the respective variable. All tests are based upon 165 observations, containing observations from December 1991 to August 2005. The variables are investor sentiment (sentiment), relative-rate of year-to-year inflation (inflation), Euro/US-dollar rate (dollar-rate) and the bond yield difference (bonds). Asterisks refer to the significance level: *: ten percent, **: five percent, ***: one percent.

TABLE 2 Long-horizon regression tests

	1mon.	6mon.	12mon.	24mon.	36mon.	48mon.	60mon.
β	0.0021	0.0002	0.0014	0.0054	0.0086	0.0089	0.0082
$\beta^{(adj.)}$	0.0020	0.0023	0.0026	0.0069*	0.0097***	0.0088***	0.0073***
[prob.$^{(adj.)}$]	[0.3833]	[0.2109]	[0.1906]	[0.0822]	[0.0051]	[0.0002]	[0.0001]

Notes: All regressions are estimated using 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, stock returns, money growths and relative trade balance as well as respective interest rates, bond yields and inflation differences. The sample contains 165 monthly observations from December 1991 to August 2005.

The simulation procedure works as follows: first, long-horizon regressions of the exchange rate returns on the control variables and investor sentiment are run using Newey-West standard errors. Second, we estimate a VAR-model including the 1-month return and the control set, whereas investor sentiment's beta coefficient is set to zero in the exchange rate return equation. The arising residuals are stored. Third, using the latter, we conduct 10,000 bootstraps in order to generate recursively new time series, which in turn are used, fourth, to run Newey-West estimations in an analogous manner as in the first step. Fifth, simulated t-values are calculated by pulling up investor sentiment's beta coefficients, which we correct by subtracting thereof the mean beta estimation of the bootstraps and further, by dividing the latter term over the mean standard deviation estimation accordingly. Sixth, now we set up the simulated distributions, which in turn enable to calculate adequate probabilities of investor sentiment's betas, in which the latter have to be adjusted as well. β represents sentiment's original coefficient, whereas $\beta^{(adj.)}$ shows the respective adjusted coefficient, generated by the above-described bootstrap. Prob. $^{(adj.)}$ represents the p-value of the null, i.e. the adjusted coefficient is zero. Asterisks refer to the significance level: *: ten percent, **: five percent, ***: one percent.

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 normally distributed. Additionally, the tests of ARCH-effects reveal heteroskedasticity in the data. Univariate tests reveal that normality is rejected due to skewness of investor sentiment and of the inflation difference as well as excess kurtosis of the latter. However, asymptotic results based upon the assumption of a Gaussian likelihood function, seem to be robust to some deviations of the residuals from the Gaussian distribution–i.e. heteroskedasticity and non-normality (see Johansen, 1995, 2006). Asterisks refer to the significance level: *: ten percent, **: five percent, ***: one percent.

TABLE 4 Cointegration rank determination (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 the p-values marked with a hash are the Bartlett-corrected LR tests and the corresponding p-values, considered because of small sample-size effects on the power of the rank tests. Asterisks refer to the significance level: *: ten percent, **: five percent, ***: one percent.

TABLE 5 Multivariate unit-root tests

	sentiment	**inflation**	**dollar-rate**	**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: Here, constants are restricted to the cointegration space. The numbers in brackets are the respective p-values. Since the Trace tests in Table 4 reveal a rank of one, we have to look on respective likelihood-ratio-tests. Hence, we find that the long-term relation does not constitute a unit-root underlying one of the endogenous variables. Asterisks refer to the significance level: *: ten percent, **: five percent, ***: one percent.

TABLE 6 Unrestricted VEC model estimation and model-fit

cointegration equation

	sentiment $^{(-1)}$ =	inflation $^{(-1)}$	dollar-rate $^{(-1)}$	bonds $^{(-1)}$	constant
β'	**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 variables of the system are investor sentiment (sentiment), relative-rate of year-to-year inflation (inflation), Euro/US-dollar rate (dollar-rate) and the bond yield difference (bonds). The numbers in brackets are the respective t-values. Other variables were tested, amongst others production, trade balance and interest rates, which could not improve the estimation results 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, the cointegration parameters prove to be highly significant. Nevertheless, since latter test-statistics are not valid, they just provide rough indications, wherefore we do not present them. Asterisks refer to the significance level: *: ten percent, **: five percent, ***: one percent.

TABLE 7 Threshold VEC model estimation and model-fit

cointegration equation

		sentiment $^{(-1)}$ **=**	PPP term $^{(-1)}$	bonds $^{(-1)}$	constant
	β'	**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 VEC model. Investor sentiment is set to one in the cointegration space, whereas no further restrictions are set in the cointegration space or in the short-run relations. The sample contains 165 monthly observations from December 1991 to August 2005. The endogenous variables are investor sentiment (sentiment), the regressive term (PPP term) and the bond yield difference (bonds). The regressive term corresponds to the difference between the current Euro/US-dollar and the related PPP rate. The numbers in brackets are the respective t-values. The latter variable, however, is based upon long-run validity of the relative PPP concept. Respective rates are calculated upon PPI differences between the Euro area and the USA. Using CPI data, the results do not change qualitatively. Regime 1 includes 64 percent of the observations, whereas the remaining 36 percent belong to regime 2. The estimation of the related linear VEC model without threshold effect reveals qualitatively the same results as the ones reported in Table 6– -0.07 error-correction of investor sentiment. Again, based upon calculated t-values, the cointegration parameters are highly significant (see hereunto related notes in Table 6). Asterisks refer to the significance level: *: ten percent, **: five percent, ***: one percent.

Appendix A

To replicate common of earlier studies, we perform several accuracy tests. Since most of the standard analyses are calculated upon point forecasts, we quantify our qualitative expectations data by using Carlson and Parkin's technique (1975). In doing so, we obtain point forecasts (consensus), which enables us to run standard accuracy tests.

Table A1 presents derived results, which are based upon the predefined six months forecast horizon. Furthermore, for comparable purposes, we run the same calculations upon the forward rate as well as the random walk without drift. Obviously, the derived consensus performs throughout worse than the competing forecast series, except upon the hit rate, which is defined as the share of correct trend forecasts. Consensus' mean error, the mean absolute error as well as the root mean square error are all larger than accordant errors of the forward rate and the random walk. Taken together and blinding out the hit rate, the forward rate performs in all tests the best. Again, drawing on the hit rate, the consensus performs undoubtedly better than the other forecasts, by generating a hit rate of more than 55 percent, whereas the forward rate forecast proves correctness in only approximately 34 percent of the observations.[26]

Table A1 Tests of accuracy based on six months time horizon

	ME	**MAE**	**RMSE**	**Theil's U**	**hit rate**
Consensus	-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: In order to generate aggregate point expectations, we use Carlson and Parkin's quantification method (1975). This requires three assumptions. We assume that the subjective probability distributions, concerning the individual forecast realizations, are normally distributed. However, using the normal distribution for related means of the individual probability distributions is justified upon the Central Limit Theorem. Moreover, we set a symmetric scaling factor of three percent according to a related ZEW questionnaire, in which the survey participants revealed their perceived threshold wherefrom noticeable the exchange rate changes are perceived. Nevertheless, results did not change qualitatively by pulling up other thresholds around three percent. Random walk forecasts are calculated upon current exchange rates, implying no change forecasts. Asterisks refer to the significance level: *: ten percent, **: five percent, ***: one percent. ME represents the mean error based on US-dollar/Euro forecasts and realized exchange rates. MAE shows the accordant mean absolute error whereas RMSE represents the root mean square error–significance levels of the error differences are calculated upon Theil's U. The hit rate shows the share of inherent accurate direction forecasts–significance levels are based upon χ^2-tests.

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[26] Since a random walk without drift forecasts no change, the appropriate benchmark is set at 50 percent.

Appendix B

By using a grid search algorithm in connection with accordant LM-tests, we estimate jointly short-run and long-run coefficients as well as the threshold. Required confidence intervals for the grid search of the cointegration parameters (β) are evenly spaced around related parameter estimations derived from the accordant linear VEC estimation. Hence, the grid search examines all possible combinations of the parameter vector, β, and the threshold, γ, which meet the minimum regime size, i.e. the trimming parameter defines the required minimum fraction of the population in each regime. Due to our relatively small sample of 165 observations, we set the trimming parameter rather conservative at 0.20. By choosing the grid size for the cointegration coefficients and the threshold variable of 100 and 300, we run 1,000 bootstraps at a time. Furthermore, we use the Eicker-White covariance matrix in order to correct for arising heteroskedasticity in the residuals. Since the parameterization of the threshold model is a priori unknown, we base the null hypothesis upon the accordant linear model. Nevertheless, the asymptotic distributions of the arising LM-tests, which check the validity of the threshold model, figure out being intractable. In order to run inference analysis anyhow, Hansen and Seo (2002) suggest two alternative LM-tests via bootstrap techniques, which in contrast deliver appropriate asymptotic distributions. The "fixed regressor bootstrap", upon which we base our threshold tests, fixes in contrast to conventional bootstrap techniques, next to the estimated coefficients and the resulting residuals under the null, the original variable series as well as the estimated error-correction term. Modifying these residuals by adding i.i.d.-innovations of a standard normal distribution, then one regresses them on the variables–once for the whole sample and another time for the split samples determined by the threshold variable. By using jointly the latter generated coefficient matrixes and the modified residuals from the former complete regression, makes it possible to calculate the Eicker-White covariance matrix estimators. This in turn enables to calculate a LM-like statistic. By repeating these steps numerous times, simulated distributions of the test statistics with appropriate critical values are delivered. The alternative procedure is closer to standard bootstrapping, in which residuals are presumed being i.i.d., but without taking control of heteroskedasticity. Since Section 3 reveals heteroskedasticity in our data, we stick to the fixed regressor bootstrap, which proves, accordant to Hansen and Seo (2002), to be robust to heteroskedasticity.