Do Dollar Forecasters Believe too Much in PPP?

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Abstract:
This paper extends earlier studies on exchange rate expectations' formation by using new data and by adding information about forecasters' reliance on fundamental analysis for the first time. We replicate the conventional result of non rational expectations. Moreover, biases in expectations are identified as professionals significantly belief too much in mean reversion, mean being represented by PPP. When respondents are grouped on their reliance to fundamental analysis, fundamentalists reveal an even stronger bias. Those, who rely the least on fundamentals – preferring technical analysis instead –, show a significantly smaller bias towards PPP hence they expect too much trend extrapolation. Biased beliefs get stronger when the US Dollar is further away from PPP. Finally, performance of point forecasts is poor for both groups but we find directional forecasting ability.

JEL-Classification: F31 (foreign exchange), G14 (information)
Keywords: Exchange rate expectations, forecasting, fundamental analysis, technical analysis, purchasing power parity

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1. Introduction

For about 20 years we know that exchange rate forecasts of professionals show some degree of "irrationality" (Dominguez, 1986, p.281). It has become a stylized fact that these forecasts do not have predictive power and that forecasters do not even use the entire information available (surveys by Takagi, 1991, MacDonald, 2000). Not much is known, however, about possible sources of this pattern. Our research contributes towards a better understanding of this seemingly "irrational" behavior by using a new database. We can analyze monthly US-Dollar/Euro and US-Dollar/Deutsche Mark forecasts for more than the past 12 years, i.e. significantly longer than before. Further on, the forecasts of professionals are examined in groups defined by their relative reliance on fundamental analysis for the first time in this literature. We determine that forecasters in general rely too much on mean reversion on exchange rates, mean represented by purchasing power parity (PPP). The revealing fact is that fundamentalists show even more biased forecasts – this is consistent to the opinion that Dollar forecasters believe too much in PPP.

Right from its beginning the thorough analysis of exchange rate expectations has been motivated by the theme of market efficiency. The Frankel and Froot (1987) "finding of systematic expectational errors" (p.150) set the ball to roll and were confirmed by numerous authors and various samples (see MacDonald, 2000). The many repetitions of the early results might have been responsible for the fact that a caveat has been readily neglected so far: Frankel and Froot (1987) reveal systematical errors but they also report that the sign of the error may depend on the sample period. This puts into question, whether there are deeper forces at work that may be responsible for the changing sign. An analysis of this issue requires longer time series than the often employed two to four years.

Another important issue already addressed by Frankel and Froot is the forecast heterogeneity. Earlier studies, such as Dominguez (1986) or Frankel and Froot (1987), are based on consensus forecasts. More recent studies however analyze individual expectation data to reveal indeed different pattern in forecasts (e.g. MacDonald and Marsh, 1996, Bénassy-Quéré, Larribeau and MacDonald, 2003). This
line of work describes and examines heterogeneity but does not allow inferences on possible sources of heterogeneity. For the latter purpose one would need additional, exogenous information. An exception to it is seen on the examination of a relatively short Japanese sample which allows classification of six groups, such as exporters etc. This data indicates that expectations can be affected by private information (Wakita, 1989) but also influenced by wishful thinking (Ito, 1990). It is again Frankel and Froot (1987) who suggest another cut in the data that might be warranted: they speculate that there may be forecasters "who think long-term" consequently form regressive expectations and others "who think short-term" form rather static expectations. We know that professionals picture expectations differently, though we need a rationale for this behavior – such as the one suggested by Frankel and Froot – provided that we want to reach beyond description and build an economic understanding instead.

We read the suggestion of long-term motivated regressive exchange rate expectations as a hint towards the possible importance of PPP. PPP is a core part in many exchange rate models, it is an intuitively plausible benchmark for thinking about exchange rates and – most important – it has received credit as an empirically valid concept as surveyed by Rogoff (1996). To pinpoint it further: as there is no single exchange rate theory that holds empirically (Frankel and Rose, 1995, Sarno and Taylor, 2002), which economic concept forecasters ought to use if not PPP?

An examination of this issue would therefore profit from data that fulfills two conditions: the time series should be long and there should be information indicating that the economic concept of PPP drives expectations. The long period is needed in order to cover exchange rate movements to and from PPP. Additional information towards motivation of forecasters is useful to derive directly the importance of PPP. To the best of our knowledge, there is no data set in the literature that would fulfill these two conditions except for the data used here.

We show that professionals from Germany, covering more than the past 12 years, behave very conventionally: our first result shows that according to standard surveys their expectations are not purely rational and they seem to apply different kinds of expectation formation. As this is unison with the literature, we declare it as indication that other results derived from our data can be generalized too. Second, biases in expectations are identified in the consensus forecasts as professionals significantly belief too much in mean reversion, mean being represented by PPP. Third,
according to their reliance on fundamental analysis and when the sample is divided into three groups, the forecasters who rely most strongly on fundamentals analysis – "fundamentalists" – reveal an even stronger bias. The group who relies the least on fundamentals – prefer technical analysis instead: "technicians" – shows a much smaller bias. So, stronger belief in fundamentals and thus PPP is revealed as a source of bad forecasting performance. Fourth, however, the technicians' "advantage" in this respect is compensated by another bias not unexpected for technicians, showing too much expectation of trend extrapolation. Fifth, we illustrate, that forecasting biases of fundamentalists and technicians become stronger when the US Dollar is further away from PPP. Finally, point forecasts' performance of both groups is of similar poor quality. Interestingly, all groups distinguished show some directional forecasting ability.

The remainder is structured as follows. Section 2 describes data, whereas results are presented in Section 3. Section 4 concludes.

2. Data

Our expectation data is based upon the ZEW Financial Market Survey. The Centre for European Economic Research (ZEW) of Mannheim (Germany) collects every month numerous economic and financial forecasts with a horizon of six months. The ZEW survey is a qualitative questionnaire, which has been driven since December 1991 and soon became a stable panel with more than 300 participants of various cities in Germany, whereas around 75 per cent of the participants work in the banking sector (as analysts, fund managers etc.) and 25 per cent work either in the insurance or in the industrial sector. In comparison to other surveys the amount of participants is relative large and its composition according to their profession is similar to others (Consensus forecasts, London, contain 75 per cent participants from financial institutions). The forecasts collected are standardized by fax and will be processed on the last Friday of each month.

Our dataset contains the individual exchange rate forecasts of the US-Dollar/Euro (respectively the US-Dollar/Deutsche Mark) from December 1991 to April 2004 and sums up to a total of 149 surveys. To our knowledge no other study uses a

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1 The ZEW publishes out of the ZEW Financial Market Survey regularly amongst others the ZEW Indicator of Economic Sentiment, which is a leading indicator for the German economy and of similar prominence like the ifo Index.
panel of monthly exchange rate expectations with a dataset as long as ours.\textsuperscript{2} Additionally we use daily US-Dollar/Euro and US-Dollar/Deutsche Mark rates from the Deutsche Bundesbank, six month Libor rates from EcoWin and price index data from the International Financial Statistics (IFS) of the International Monetary Fund (IMF).

We are aware about criticism regarding the use of survey data for modeling expectations in general and for financial forecasts in particular. Nevertheless, incentives for participants that do not reveal their true beliefs are very limited as the ZEW publishes only the aggregated forecasts (consensus forecasts) only. Moreover manipulating the data with extreme forecasts is practically impossible, due to around 300 participants and the qualitative responses given. Additionally the incentive to participate at the survey in order to get an extensive summary of the consensus data with additional background information from the ZEW directly seems to be quite strong as this data is well covered by the financial media.

To get a first impression of the exchange rate forecasts, some descriptive statistics are presented in Table 1. For comparison we include the corresponding six month forward rates and realized exchange rates also. With respect to the level statistics one can recognize that consensus forecasts as well as forward rates behave similar to realized exchange rates though forward rates resemble exchange rates even better. If one looks at the change statistics consensus forecasts behave still similar to realized exchange rates, contrary forward rates differ especially on their variability measures. Finally the consensus shows on average a slightly stronger US-Dollar towards the Euro whereas the US-Dollar actually weakens on average.

Furthermore we asked the ZEW participants in a specific survey which information they actually base their exchange rate forecasts upon (see ZEW Financial Market Report, 2004).\textsuperscript{3} This enables us to categorize the participants according to their use of analytical instruments. We base our classification on the use of fundamental analysis and organize the survey participants in fundamentalists, technicians and intermediates. We could not find any significant difference between people who use primarily technical analysis or flow analysis due to the fact, that flow analysis is used to a much smaller degree than other instruments of analysis (the average flow analy-

\textsuperscript{2} Recently Audretch and Stadtmann (2005) use the Wall Street Journal survey which covers a longer time period (1989 – 2003), but at the cost of semi yearly data only, which generates just 30 data points.

\textsuperscript{3} Participants were asked to distribute 100 points amongst the categories fundamental, technical and flow analysis according to the way how they do their exchange rate analysis.
sis sums up to 10 per cent, whereas technical analysis adds up to 30 per cent and fundamental analysis to 60 per cent).\(^4\)

The respective outcome of this questionnaire is summarized in Table 2. One can see that the group of fundamentalists is nearly as big as the group of technicians. In addition to that the other statistical means suggest that their size behaves very similar to the whole panel.\(^5\) The average numbers of fundamentalists and technicians representing more than 35 seem big enough for accurate analysis.

3. Results

In the following regression analysis we use OLS estimators corrected for Newey-West standard-errors with five lags as a result of the overlapping problem attributed to monthly forecasts with six month forecast horizons, which imparts a fifth order moving average error process (see, for example Hansen and Hodrick, 1980). In addition and by reason of the qualitative nature of the expectation data we use the quantification technique from Carlson and Parkin (1975) to generate point forecasts.\(^6\) Due to non-stationarity characteristics of the time series, we use change forecasts rather than point forecasts.

3.1. Rationality of expectations

In order to check characteristics on our survey participants with well established results in the literature, we perform conventional tests of forecast rationality. Since Dominguez (1986) and for this purpose it is common to check the degree of unbiasedness as well as efficiency.

Test of unbiasedness:  \begin{equation}
    \Delta s_{t+6} = \alpha + \beta \cdot \Delta s'_{t+6}
\end{equation}

Test of efficiency:  \begin{equation}
    \Delta s'_{t+6} - \Delta s_{t+6} = \alpha + \beta \cdot FD_{t+6}
\end{equation}

\(^4\) This could be connected to the panel composition, i.e. analysts are more represented than traders. We know that traders rely significantly more than others on flow analysis (see Gehrig and Menkhoff, 2004).

\(^5\) The group of intermediates appears different to the others, but this is unimportant since we are interested in comparing the other two groups at first.

\(^6\) Taylor (1989), among others, also uses this method to quantify categorical responses.
The unbiasedness test is modeled in equation (1) and to satisfy the postulate of rationality the estimated value of $\beta$ has to be one, whereas $\alpha$ needs to be zero. In addition equation (2) shows the test of efficiency and rationality requires that $\beta$ as well as $\alpha$ are both zero.

Table 3 presents results on the test of unbiasedness which refuse the hypothesis of rational expectations, because $\beta$ is significantly below unity. Furthermore the test of orthogonality shows evidence of irrationality too, since $\beta$ is significantly above null, which implies that even data easily available such as the forward premium is not completely processed in exchange rate forecasts. All in all the assumption of rationality on consensus forecasts has to be rejected, being well in-line with the literature (see, MacDonald, 2000, p. 77-80).

### 3.2. Bias of expectations

However, our primary interest lies on the sources for the irrationality of FX-forecasts. To reveal the kind of forecast pattern we estimate a hybrid model. Since the work by Frankel and Froot (1987) a lot of analyses have been carried out to estimate the expectation formation for exchange rates, i.e. extrapolative, adaptive, regressive expectations and some sort of mixed models on former (see i.e. Takagi, 1991, p. 170-177). In summary it figures out that depending on the forecast horizon short-term forecasts exhibit evidence of destabilizing behavior whereas long-term forecasts show stabilizing evidence.

Here we use a mixed model to regress the exchange rate forecasts on an extrapolative and a regressive term, since the former term covers well technical orientated forecaster behavior whereas a regressive term should display the way how fundamentalists form their expectations. Furthermore, this procedure fits well into the relevant literature for comparative purposes (i.e. Bénassy-Quéré et al., 2003, Audretsch and Stadtmann, 2005).

\[
\Delta s^e_{t+1} = \alpha + \gamma \cdot (s_t - s_{t-1}) + \nu \cdot (s_t - \tilde{s}_t)
\]

(expectations formation)

\[
\Delta s^e_{t+1} - \Delta s_{t+1} = \alpha + \gamma \cdot (s_t - s_{t-1}) + \nu \cdot (s_t - \tilde{s}_t)
\]

(systematic bias)
Equation (3) shows the expectation mechanism, where the first term represents the extrapolative concept with the previous one month change of the exchange rate. The second term displays the regressive formation on which a fundamental equilibrium is required. We have chosen the well known relative PPP model and calculated corresponding rates upon PPI differences. In addition to that we would like to find out, whether the consensus relies too much on these expectations concepts on average. Doing so, we calculate expectation errors and follow in equation (4) the approach of Frankel and Froot (1987, 147-150) by regressing them on the expectations mechanisms.7

The results in Table 4 show that the consensus is based upon a mixture of extrapolative and regressive expectation, so both mechanisms seem to matter. More interestingly the results for equation (4) show that forecasters rely too much on regressive expectations on average, whereas the same doesn’t hold in respect to the extrapolation of current trends. We can summarize that the participants of the ZEW panel rely too heavily on the concept of PPP when forming US-Dollar/Euro forecasts.

3.3. Expectations of fundamentalists and technicians

In this section we run the same regressions for the separated groups as in section 3.2. We would like to know, if there are any differences in the way that groups form exchange rate expectations (indicator i separates the different groups).

Expectations formation: \[
\Delta s'_{t+6} = \alpha + \gamma' \cdot (s_i - s_{t-1}) + \upsilon' \cdot (\tilde{s}_i - s_i)
\] (5)

Systematic bias:

\[
\Delta s'_{t+6} - \Delta s_{t+6} = \alpha + \gamma' \cdot (s_i - s_{t-1}) + \upsilon' \cdot (\tilde{s}_i - s_i)
\] (6)

Table 5 shows that the \(\gamma\) coefficient of equation (5) differs between the different groups. Technicians seem to rely most heavily on the extrapolative term and fundamentalists least, whereas intermediates take a position in between. On the other hand forming regressive expectations seems to be most important for fundamentalists, followed by intermediates and least important for technicians. Not surprisingly when we compare the biased coefficients in equation (6) fundamentalists rely significantly too much on the regressive term but not on the extrapolative term. Contrary,

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7 As related dates of forecast fulfilments can be easily derived, to get subsequent realized forecast errors for the consensus, we actually have to calculate average dates of forecast fulfilments.
technicians orientate on a smaller degree too much on the regressive term, but additionally, they seem to follow too much on trend extrapolation (here the statistical significance is less obvious). Again intermediates find themselves between the other two groups with biased forecasts towards the regressive term.\textsuperscript{8}

3.4. A threshold analysis of expectations

Following our last results we use a switching regression model with two regimes in order to get deeper insights into the different structures of US-Dollar/Euro forecast biases. We determine the absolute value of the regressive term as the transition variable and choose threshold levels via a grid search method (see, Franses and Dijk, 2000). We follow this approach to see, whether the group specific forecast biases differ during periods, where the US-Dollar/Euro shows large deviations from PPP and periods, where exchange rates are in line with the fundamental concept.

Expectations formation:
\[
\Delta s_{t+6}^i = f_{1,i}(\bullet) \cdot I[c_i^r] + f_{2,i}(\bullet) \cdot (1 - I[c_i^r])
\]

Systematic bias:
\[
\Delta s_{t+6}^i - \Delta s_{t+6} = f_{1,i}(\bullet) \cdot I[c_i^r] + f_{2,i}(\bullet) \cdot (1 - I[c_i^r])
\]

with \( f_r(\bullet) = \alpha_s + \beta_i \cdot (s_t - s_{i-1}) + \gamma_i \cdot (\bar{s}_i - s_i) \) and \( r = 1,2 \)

with \( c_i^r = |\bar{s}_i - s_i| \) and \( I(c_i^r) \)
\[
= \begin{cases} 
1 & \text{if } |\bar{s}_i - s_i| \geq \kappa^i \\
0 & \text{if } |\bar{s}_i - s_i| < \kappa^i 
\end{cases}
\]

Table 6 represents the corresponding results. Summarizing and focusing on the estimation results of equation (7), the group of fundamentalists forms regressive expectations in both regimes, whereas the extent in regime one is greater (periods of major exchange rate deviations from PPP). Additionally they rely on trend extrapolation, but only in regime 2 (periods of minor exchange rate deviations from PPP). Contrary, technicians show a mix of regressive and extrapolative formation in both regimes. Further and looking at the parameter estimations of equation (8), all groups

\textsuperscript{8} To test whether expectation coefficients are statistically different between the groups, t-tests are performed. Indeed between fundamentalists and the other groups all coefficients are significantly different, whereas between technicians and intermediates the same applies for the regressive coefficient in equation (5) only.
show a regressive bias in regime 1 but not in regime 2. Finally we reveal also an extrapolative bias in the expectation formation of technicians but only for regime 1, while fundamentalists still do not show any adherence on an extrapolative bias.

3.5. Performance of expectations

Our last analyses examine the forecast ability of the separated groups. Additionally we deal with related forward rates and random walk forecasts for comparison. The results are shown in Table 7 and include four accuracy tests applied to point forecasts and a hit rate applied to underlying trend forecasts.

To cut a story short, one can not detect significant differences in the performance between fundamentalists, intermediates and technicians. If we concentrate on measurements for point forecasts such as MAE and RMSE, the random walk beats all groups of forecaster as well as the forward rate, even though the later one performs also better than the forecaster groups. On the other hand if we consider the hit rate, which is calculated upon underlying trend forecasts, all groups perform much better than the forward rate and significantly better than the random walk.

We do not want to interpret this result too much but it definitely shows that participants of the ZEW survey may have forecasting ability despite all kinds of biases revealed (see also Wakita, 1989). Nevertheless, if they would be able to avoid systematic distortions there is the chance to forecast even better.

4. Conclusions

Our study on exchange rate expectations intends to bring fresh evidence into an established field. Thus, we first reproduce the stylized fact of non-rational expectation formation and conclude that our participants do not differ in this respect from those of earlier survey studies. We also notice – largely in line with the literature – that forecasts are biased, in particular that the sign of the bias does change over time. Our objective is, however, not just to perform the conventional tests for another survey at another time. We rather aim for adding a completely different and most interesting kind of information to the field in order to understand biased forecasts better: our sur-

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9 The different behavior of the bias depending on the currently valid regime approves, that in conventional regressions the bias depends on the sample period (see, Frankel and Froot, 1987, p. 150).

10 Note that the origin of the individual forecasts is of qualitative nature.
vey is the first to combine a large data set of forecasts with information on the forecasters' preferred analytical instrument, i.e. their reliance on fundamental analysis.

We reveal that the preference of fundamental analysis is useful information to understand the way how exchange rate expectations are formed. Moreover, we detect that the preference of fundamental analysis helps to understand specific biases: fundamentalists believe too much in mean reversion of the US-Dollar/Euro, than other participants. So, this misguided belief is consistent with poor forecasting performance. However, any claim of superior performance due to reliance on technical analysis is premature. Although the technicians' expectations are less distorted by too much reliance on PPP, they also show a misguided belief: they extrapolate short-term trend as one would assume, however, they extrapolate too much. Consequently, this additional expectation distortion hinders them to form appropriate forecasts.

Overall, we argue that our data provide new evidence on possible sources of systematic forecasting biases. In addition to Ito's (1990) discovery of wishful thinking we reveal too much belief in mean reversion which can be interpreted usefully as too much belief in PPP. One ought to speculate whether Ito's and our detections may be connected to behavioral distortion in decision making: in this sense, our participants possibly overestimate the precision of their knowledge of exchange rate changes by relying too much on their interpretation of PPP. A competing explanation for fully rational forecasters, who show proper understanding of fundamentals, however, consistent with the data – as we are covering professionals with somewhat long-term orientation – would be, if markets act in consistency to them. Possibly, foreign exchange markets are dominated by short-term considerations which are less consistent with the directions that fundamentals advise.
References


**Figure 1** US-Dollar/Euro realizations, PPP exchange rates and consensus forecasts

Note:
This figure shows actual realizations of the US-Dollar/Euro, calculated exchange rates upon the PPP concept (both series left scaled) and consensus change predictions (right scaled). The consensus data were generated with the quantification method introduced by Carlson/Parkin, 1975 (for further details see note in Table 1). To calculate the fundamental exchange rates we used the PPP concept (further explanations are given in chapter regressive expectations). The exchange rate series US-Dollar/Euro contains also the US-Dollar/Deutsche Mark exchange rates, where the later were transformed on the official exchange rate between the Deutsche Mark/Euro of 1.95583. Whereas the US-Dollar/Euro as well as the PPP exchange rates are presented in their levels (corresponding left axis), the consensus data are shown in their changes (corresponding right axis). It can be seen, that the swap of the consensus forecasts from an appreciation of the US-Dollar/Euro to a depreciation occurred around the same time, when the US-Dollar/Euro crossed the line of the PPP exchange rates. Furthermore the amplitudes show a little similar pattern, at least in their peaks.
### Table 1. Statistics of consensus forecasts, forward rates and exchange rates

<table>
<thead>
<tr>
<th>Consensus forecasts</th>
<th>Forward rates</th>
<th>Exchange rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_{t+6}$</td>
<td>$S_{t+6}$</td>
<td>$S_{t+6}$</td>
</tr>
<tr>
<td>$\Delta S_{t+6}$</td>
<td>$\Delta S_{t+6}$</td>
<td>$\Delta S_{t+6}$</td>
</tr>
<tr>
<td>Mean</td>
<td>1.1169</td>
<td>1.1297</td>
</tr>
<tr>
<td></td>
<td>-0.0141</td>
<td>0.0006</td>
</tr>
<tr>
<td>Variance</td>
<td>0.0120</td>
<td>0.0224</td>
</tr>
<tr>
<td>SD</td>
<td>0.1094</td>
<td>0.1497</td>
</tr>
<tr>
<td>Min.</td>
<td>0.8808</td>
<td>0.8464</td>
</tr>
<tr>
<td>Max.</td>
<td>1.3282</td>
<td>1.4358</td>
</tr>
<tr>
<td></td>
<td>0.1312</td>
<td>0.0292</td>
</tr>
</tbody>
</table>

Source: Centre for European Economic Research of Mannheim, Deutsche Bundesbank and EcoWin.

$S^e$ is defined as the (consensus) forecast of the US-Dollar/Euro, whereas $\Delta S^e$ represents the percentage change forecast of the US-Dollar/Euro.

$S^f$ is defined as the implicit forecast of the US-Dollar/Euro based upon the 6 month LIBOR rate difference and $\Delta S^f$ represents the corresponding change forecast in percentage.

$S$ is defined as the US-Dollar/Euro and $\Delta S_{t+6}$ represents the percentage change of the US-Dollar/Euro from $t$ to $t+6$.

Note:

Using the method of Carlson and Parkin (1975) to derive aggregate point expectations requires two assumptions. First, each individual forecast is based upon a subjective probability distribution concerning the outcome of this forecast. However, applying the logistic distribution did not yield the results in any qualitatively different way. Second, the corresponding means of the individual probability distributions follow-up a normal distribution, which can be justified with the Central Limit Theorem. Furthermore we have to set a scaling factor, which displays the threshold, of which the forecasters perceive noticeable changes in the exchange rate. We choose a symmetric scaling factor of three percent. In a special survey the participants of the ZEW Financial Market Survey were asked to reveal their individual thresholds in correspondence to their different forecasts. The average median for the US-Dollar/Deutsche Mark was a symmetric threshold of roughly three percent. Nevertheless, choosing other thresholds around three percent, didn’t show any qualitatively different results. Other methods like choosing the threshold that the mean expected change is equal to the mean actual change or that squared prediction errors are minimized seem inappropriate to us by reason of overwhelming evidence towards irrational and inaccurate exchange rate expectations. Finally, in order to rescue some data points, in cases where the probability of a category is zero, we used neighboring estimated volatilities to compute the forecast (Carlson/Parkin, 1975, p. 130-131).

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11 Taylor (1989) uses also the normal distribution and sets his scaling factor on 2.5 per cent.
### TABLE 2. Separated groups of the panelists

<table>
<thead>
<tr>
<th>Group criteria: Fundamental analysis ≡ X</th>
<th>Fundamentalists</th>
<th>Intermediates</th>
<th>Technicians</th>
</tr>
</thead>
<tbody>
<tr>
<td>X ≥ 80</td>
<td>35.05</td>
<td>80.44</td>
<td>38.75</td>
</tr>
<tr>
<td>80 &lt; X &gt; 40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X ≤ 40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>35.05</td>
<td>80.44</td>
<td>38.75</td>
</tr>
<tr>
<td>Variance</td>
<td>104.54</td>
<td>564.51</td>
<td>112.16</td>
</tr>
<tr>
<td>SD</td>
<td>10.22</td>
<td>23.76</td>
<td>10.59</td>
</tr>
<tr>
<td>Min.</td>
<td>12</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Max.</td>
<td>57</td>
<td>122</td>
<td>58</td>
</tr>
</tbody>
</table>

Note: All measurements are based upon a quantity of people. The statistics are calculated on the ZEW surveys from 12.1991 to 04.2004. Accordingly the number 35.05 that corresponds to the combination "Mean" and "Fundamentalists" represents the average number of people amongst all surveys, who use fundamental analysis to a degree of 80 or more per cent. Furthermore the combination "Max." and "Technicians" shows 58 and implies the maximum number of technicians in one survey. Concerning the participants in the survey, whom we categorized as technicians, their mean of technical analysis adds up to 52 per cent (considering the mean of the whole survey is 30 per cent) whereas they use 17 per cent on flow analysis on average (the corresponding overall mean is 10 per cent). In fact we are dealing with 237 individuals as not all participants of the ZEW survey responded to our questionnaire.

### TABLE 3. Testing rational expectations: Unbiasedness and efficiency tests

**Test of unbiasedness:**

\[ \Delta s_{t+6} = \alpha + \beta \cdot \Delta s_{t+6}^e \]  \hspace{1cm} (1)

**Test of efficiency:**

\[ \Delta s_{t+6} - \Delta s_{t+6} = \alpha + \beta \cdot FD_{t+6} \]  \hspace{1cm} (2)

<table>
<thead>
<tr>
<th>$\beta$</th>
<th>$t: \beta = 0$</th>
<th>$\alpha$</th>
<th>$t: \alpha = 0$</th>
<th>DF</th>
<th>adj. $R^2$</th>
<th>F (prob.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta s_{t+6}$</td>
<td>0.00</td>
<td>0.02</td>
<td>0.00</td>
<td>-0.07</td>
<td>147</td>
<td>-0.01</td>
</tr>
<tr>
<td>$\Delta s_{t+6}^e$</td>
<td>1.79</td>
<td>3.73</td>
<td>0.02</td>
<td>1.35</td>
<td>147</td>
<td>0.23</td>
</tr>
</tbody>
</table>

$\Delta s$ is defined as the change of the Euro/US-Dollar (Deutsche Mark/-) in per cent.

$\Delta s^e$ is defined as the expected change of the Euro/US-Dollar (Deutsche Mark/-) in per cent.

FD is defined as the forward discount of the Euro/US-Dollar (Deutsche Mark/US-Dollar) in per cent calculated upon the difference of 6 month Libor rates.
TABLE 4. Hybrid model for consensus expectations

<table>
<thead>
<tr>
<th>Equation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\Delta s_{t+6}^\gamma = \alpha + \gamma \cdot (s_t - s_{t-1}) + \nu \cdot (\bar{s}_t - s_t))</td>
<td>Expectations formation</td>
</tr>
<tr>
<td>(\Delta s_{t+6}^\gamma - \Delta s_{t+6}^\alpha = \alpha + \gamma \cdot (s_t - s_{t-1}) + \nu \cdot (\bar{s}_t - s_t))</td>
<td>Systematic bias</td>
</tr>
</tbody>
</table>

All valuables are calculated in logarithmic form so that following differences represent corresponding changes.

\(\Delta s_{t+6}\) is defined as the difference between the current Euro/US-Dollar rate and their prior six month rate.

\(\Delta s^s\) is defined as the difference between the expected Euro/US-Dollar consensus rate and their subsequent actual realization.

Note:
The extrapolative term represents the previous one month change of the Euro/US-Dollar rate. Longer periods i.e. 3 months or 6 months changes show less significant results therefore we use the one month changes. The equilibrium rate of the foreign exchange rate is based upon the relative PPP concept. Corresponding rates are calculated upon PPI differences between the Euro area and the USA. The use of CPI data could not reveal qualitatively different results.

<table>
<thead>
<tr>
<th>(\gamma)</th>
<th>(t: \gamma = 0)</th>
<th>(\nu)</th>
<th>(t: \nu = 0)</th>
<th>(\alpha)</th>
<th>(t: \alpha = 0)</th>
<th>adj. R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\Delta s_{t+6}^\gamma)</td>
<td>0.38</td>
<td>3.81</td>
<td>0.35</td>
<td>10.25</td>
<td>0.00</td>
<td>0.72</td>
</tr>
<tr>
<td>(\Delta s_{t+6}^\gamma - \Delta s_{t+6}^\alpha)</td>
<td>0.34</td>
<td>1.26</td>
<td>0.26</td>
<td>2.96</td>
<td>0.01</td>
<td>0.56</td>
</tr>
</tbody>
</table>

TABLE 5. Hybrid model for group expectations

<table>
<thead>
<tr>
<th>Equation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\Delta s_{t+6}^{\gamma'} = \alpha' + \gamma' \cdot (s_t - s_{t-1}) + \nu' \cdot (\bar{s}_t - s_t))</td>
<td>Expectations formation</td>
</tr>
<tr>
<td>(\Delta s_{t+6}^{\gamma'} - \Delta s_{t+6}^{\alpha'} = \alpha' + \gamma' \cdot (s_t - s_{t-1}) + \nu' \cdot (\bar{s}_t - s_t))</td>
<td>Systematic bias</td>
</tr>
</tbody>
</table>

Note:
The extrapolative term as well as the regressive one is calculated in the same way showed in section 3.2.
### TABLE 6. Hybrid model for group expectations with thresholds

**Expectations formation:**

\[ \Delta s_{i+6}^{r_i} = f_{1,i}(\bullet) \cdot I[c_i] + f_{2,i}(\bullet) \cdot (1 - I[c_i]) \]  

**Systematic bias:**

\[ \Delta s_{i+6}^{r_i} - \Delta s_{i+6} = f_{3,i}(\bullet) \cdot I[c_i] + f_{4,i}(\bullet) \cdot (1 - I[c_i]) \]  

with \( f_i(\bullet) = \alpha_i^r + \gamma_i' \cdot (s_i - s_{i-1}) + \nu_i' \cdot (\bar{s}_i - s_i) \) and \( r = 1,2 \)

\[ c_i^r = |\bar{s}_r - s_r| \]

\( I(c_i^r) \) shows in which regime exchange rates are currently located. Concerning the grid search method, we restrict the search for the threshold in a range of 2.5 – 25.0 per cent (with intervals of 2.5 per cent in between). Additionally we require that the number of observations in each of the regimes contains 30 per cent at minimum. Finally, the threshold is selected, if the overall residual sum of squares is minimized. Alternatively, setting wider threshold ranges results in slightly different thresholds between the separated groups; however, the outcomes do not show any qualitatively changes.

<p>| | | | | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( r )</td>
<td>( \gamma_i^r )</td>
<td>( t: \gamma_i = 0 )</td>
<td>( \nu_i^r )</td>
<td>( t: \nu_i = 0 )</td>
<td>( \alpha_i^r )</td>
<td>( t: \alpha_i = 0 )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \Delta s_{i+6}^{r_i} )</td>
<td>1</td>
<td>0.06</td>
<td>0.16</td>
<td>0.46</td>
<td>5.95</td>
<td>0.00</td>
<td>-0.15</td>
<td>0.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.29</td>
<td>2.22</td>
<td>0.37</td>
<td>2.45</td>
<td>-0.01</td>
<td>-1.12</td>
<td>0.32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fundamentalists</td>
<td>1</td>
<td>0.30</td>
<td>0.73</td>
<td>0.39</td>
<td>3.42</td>
<td>0.00</td>
<td>-0.16</td>
<td>0.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-0.15</td>
<td>-0.48</td>
<td>0.20</td>
<td>0.47</td>
<td>0.00</td>
<td>0.21</td>
<td>-0.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( s_{i+6}^{r_i} - s_{i+6} )</td>
<td>1</td>
<td>0.70</td>
<td>1.75</td>
<td>0.40</td>
<td>5.01</td>
<td>0.03</td>
<td>1.91</td>
<td>0.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.51</td>
<td>2.48</td>
<td>0.47</td>
<td>2.29</td>
<td>-0.01</td>
<td>-0.72</td>
<td>0.31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intermediates</td>
<td>1</td>
<td>0.92</td>
<td>2.03</td>
<td>0.33</td>
<td>3.24</td>
<td>0.03</td>
<td>1.20</td>
<td>0.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.06</td>
<td>0.16</td>
<td>0.24</td>
<td>0.53</td>
<td>0.00</td>
<td>0.19</td>
<td>-0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \Delta s_{i+6}^{r_i} )</td>
<td>1</td>
<td>0.67</td>
<td>2.48</td>
<td>0.38</td>
<td>6.41</td>
<td>0.03</td>
<td>2.58</td>
<td>0.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.60</td>
<td>3.62</td>
<td>0.41</td>
<td>2.71</td>
<td>0.00</td>
<td>-0.01</td>
<td>0.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technicians</td>
<td>1</td>
<td>0.87</td>
<td>2.25</td>
<td>0.31</td>
<td>3.12</td>
<td>0.03</td>
<td>1.34</td>
<td>0.19</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.17</td>
<td>0.52</td>
<td>0.23</td>
<td>0.55</td>
<td>0.01</td>
<td>0.64</td>
<td>-0.01</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
Regime one represents the periods, when the Euro/US-Dollar deviates ten percent or more from his fundamentally fair value based upon the relative PPP theory. Regime two therefore represents the periods, when the realized exchange rates deviate less than ten percent from PPP exchange rates. The indicator function \( I(c_i) \) shows in which regime exchange rates are currently located. Concerning the grid search method, we restrict the search for the threshold in a range of 2.5 – 25.0 per cent (with intervals of 2.5 per cent in between). Additionally we require that the number of observations in each of the regimes contains 30 per cent at minimum. Finally, the threshold is selected, if the overall residual sum of squares is minimized. Alternatively, setting wider threshold ranges results in slightly different thresholds between the separated groups; however, the outcomes do not show any qualitatively changes.
<table>
<thead>
<tr>
<th></th>
<th>ME</th>
<th>MAE</th>
<th>RMSE</th>
<th>Theil’s U (Prob.)</th>
<th>Hit rate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fundamentalists</strong></td>
<td>-0.0157</td>
<td>0.0964</td>
<td>0.1226</td>
<td>1.5367 (0.0060)</td>
<td>0.6154 (0.0060)</td>
</tr>
<tr>
<td><strong>Intermediates</strong></td>
<td>-0.0319</td>
<td>0.0974</td>
<td>0.1246</td>
<td>1.5613 (0.0223)</td>
<td>0.5946 (0.0223)</td>
</tr>
<tr>
<td><strong>Technicians</strong></td>
<td>-0.0392</td>
<td>0.0956</td>
<td>0.1247</td>
<td>1.5681 (0.0247)</td>
<td>0.5959 (0.0247)</td>
</tr>
<tr>
<td><strong>Forward rate</strong></td>
<td>-0.0006</td>
<td>0.0746</td>
<td>0.0912</td>
<td>1.1455 (0.0010)</td>
<td>0.3289 (0.0010)</td>
</tr>
<tr>
<td><strong>Random Walk</strong></td>
<td>-0.0010</td>
<td>0.0656</td>
<td>0.0796</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**Table 7.** Tests of accuracy and quality of performance

- **ME** represents the mean error based on Euro/US-Dollar forecasts and realized exchange rates.
- **MAE** represents the corresponding absolute mean error.
- **RMSE** represents the corresponding root mean square error.
- **Theil’s U** represents the relation between the group-specific RMSE and the RMSE of the random walk. Prob. shows the p-value for statistical significance.
- **Hit rate** represents the share of correct direction forecasts. In brackets you find the p-values of the chi-square test statistic in correspondence to the hypothesis of no directional forecast ability (Diebold and Lopez, 1996, p. 256-258).

**Note:**
Random walk forecasts are calculated on current exchange rates, respectively no change forecast.