Dynamic Expectation Formation in the Foreign Exchange Market

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Abstract

This paper investigates the time-varying nature of expectation formation rules for institutional investors in the foreign exchange market. Using a unique dataset of survey expectations for four exchange rates, we first distinguish three different general rules. We find a momentum rule, a fundamental rule, and a rule that takes advantage of interest differentials between countries. Apart from heterogeneity in expectation formation rules, we show that the rules are time-varying conditional on a number of different factors, such as the sign of the most recent return, the forecast horizon, the distance to the PPP rate, and the extent to which the rule produces forecast errors vis-à-vis the market exchange rate. Although we find dynamics in expectation formation for all four exchange rates, the results for the currencies against the Japanese yen deviate from the others.

Keywords:
[foreign exchange expectations, investor sentiment, market anomalies, survey data]

JEL classification codes: G12, G15

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1. Introduction

During the past decades, financial market anomalies have pushed the efficient market hypothesis (EMH) and the assumption of rational agents to the background and have positioned behavioral finance in the spotlight. Anomalies such as excessive trade (Milgrom and Stokey, 1982), the momentum effect (Jegadeesh, 1990) and long-term reversal (DeBondt and Thaler, 1985) seem to persist despite the conclusions of the EMH that deviations from the efficient state of the market should quickly vanish because of trading by rational agents in the market. Many of the occurring anomalies have been evaluated within the framework of rational agents. Fama and French (1996) have built a three-factor model to explain anomalies such as size and value effects. Sarno (2005) gives an overview of different attempts to solve exchange rate puzzles: time-varying risk premia, sophisticated econometric methods, different price indices, equation dynamics and non-linearity in the relations. However, all these suggestions do not appear to fully explain why these market inefficiencies are so persistent. The survival of such anomalies is supportive of the behavioral finance paradigm, which states that individuals are not (fully) rational and suffer from severe psychological biases, resulting in limits to arbitrage at the market level (see Barberis and Thaler, 2003).

Criticizing the assumption of rationality has a long history. The assumption of rationality was seen as a necessary simplification of reality to build models and work with them; the question that remains is how expectations are actually formed if they are not formed rationally. Within the realm of behavioral finance, different approaches can be distinguished to find a satisfying answer to this question. One approach comes from the field of *psychology* and is established by Daniel Kahneman and Amos Tversky. This branch of research mainly focuses on behavioral (decision-making) biases. The other approach that evolved within the field of economics is focused on the *bounded rationality* (introduced by Simon, 1957) of individuals. This has resulted in studies focusing on alternative ways of expectation formation. This branch of behavioral finance assumes that agents are boundedly rational and that they use certain rules of thumb, heuristics, to form expectations about future asset prices. Various attempts have been made to determine what these rules of thumb are and how they are being used, ranging from theoretical models to lab experiments and survey analyses.

The main theoretical contributions come from Frankel and Froot (1987b), De Long et al. (1990) and Lux (1998). Frankel and Froot (1987b) develop a model with three types of actors: chartists (‘trend followers’), fundamentalists (‘model followers’) and portfolio managers. The portfolio manager is the only actor who buys and sells assets, and he receives input from the two other types. Therefore, he makes trades that can be seen as a weighted average between the chartist and the fundamentalist expectations. Lux' (1998) model is similar in the sense that he makes the same distinction between chartist and fundamentalist strategies. De Long et al. (1990) also developed a model with different types of actors, but this model makes a distinction between noise traders and rational traders. In this model, the noise traders create a risky investment environment and are able to obtain excess returns without having access to inside information. Because of the presence of this group in the market, prices can deviate significantly from their fundamental value for longer periods of time. Barberis et al. (1998) use a different approach and build a model of investor sentiment that accounts for under- and over-reaction by modeling two psychological biases (conservatism and representativeness) in a switching model. All of these authors explain various market anomalies and stylized facts with their models of investor behavior.

To verify the presence of different types of agents and to further investigate how actors in financial markets behave, various methods of empirical research have been undertaken. Schmalensee (1976) was one of the first to use experimental methods to reveal expectation formation processes for time series, in particular with respect to technical rules. Smith et al. (1988) are able to replicate bubbles and crashes within laboratory experiment expectations. De Bondt (1993) and Bloomfield and Hales (2002) use classroom experiments and find evidence of trend-following behavior, where Bloomfield and Hales (2002) also find support for the assumption in Barberis et al. (1998) that investors perceive past trend reversals as an indicator for the probability of future reversals even though they are aware of the random walk character. A laboratory experiment is used by Hommes et al. (2005) to evaluate how subjects form expectations when all they know is dividend yield, interest rates and past realized prices. The authors find that participants make use of very similar linear rules, such as autoregressive or adaptive strategies, in forming expectations.

As (laboratory) experiments are, in general, not fully able to replicate the real world situation, and the generalizability has, therefore, been questioned, attempts have been made to directly measure investor expectations and expectation formation rules. To this end, both quantitative and qualitative surveys have been conducted. Taylor and Allen (1992) show, based on a questionnaire survey, that 90% of the foreign exchange dealers based in London use some form of technical analysis in forming expectations about future exchange rates, particularly for short-term horizons. The foreign exchange dealers further expressed that they see fundamental and technical analyses as complementary strategies for making forecasts and that technical analysis can serve as a self-fulfilling mechanism. Various quantitative surveys have been evaluated as well (among others, Ito, 1990; Cavaglia et al., 1993; MacDonald and Marsh, 1996; Branch, 2004; Menkhoff et al., 2009). They all find heterogeneity in expectations, and most of them attribute this to extrapolative, regressive and adaptive expectations (for an overview, see Jongen et al., 2008). Many of those studies focus on the foreign exchange market, as this market is extremely volatile and persistently disconnected from its fundamentals. However, all these studies assume static and non-time-varying expectation formation.

Branch (2004), however, investigates inflation expectations and finds that agents switch between different exogenously determined forecasting techniques (VAR, naïve and adaptive) based on the mean squared prediction errors of the strategies. This study adds to the literature by introducing dynamics in expectation formation strategies for financial markets. In addition, the forecasting rules are estimated endogenously.

In this paper, we combine insights from behavioral finance with actual investor expectations from survey data to verify whether expectations are indeed formed by using a number of forecasting strategies. We will distinguish momentum trading (i.e., chartists, or extrapolation), purchasing power parity (PPP) trading (i.e., fundamentalists, regressive, or reversion) and trading conditional on the interest differential (either UIP-based or carry-based, depending on the sign of the relation). First, these strategies are each separately tested on the panel of survey expectations to see whether we can find significant evidence for the use of these strategies. Then, the strategies are combined in one model to determine whether they still persist when regressed in combination with other strategies. Dynamics are introduced by allowing agents to put time-varying weights on the different strategies to determine if they switch between strategies and over time. Different triggers to change strategies will be studied.

We will advance the study of different types of agents in two ways. First, we introduce dynamics in the strategies by distinguishing between time-varying bandwagon versus contrarian expectations in the momentum strategies and by distinguishing between carry trade versus UIP expectations. Although, in general, it is acknowledged that the existence of such opposing beliefs could be hidden on an aggregated level because they even out, the distinction has, to the best of our knowledge, never been made when working with empirical data. Secondly, we will increase the dynamic nature of the model by allowing the agents to switch between different strategies based on forecasting accuracy with respect to the market exchange rate. These two additions, combined with the unique survey dataset, allow us to evaluate different currencies as well as different forecast horizons. Furthermore, the dataset has never been used for this purpose, thus making this paper a valuable extension to the existing literature on behavioral finance, expectation formation, exchange rate dynamics and survey data.

We find evidence for the existence of all three strategies both when tested separately and when tested in the combined model, indicating that agents use these different strategies to form expectations about future returns. Moreover, we find dynamics in expectation formation in three different ways. First, agents hold opposing beliefs within different strategies and change these beliefs over time. Secondly, expectation formation is dynamic in the sense that the expectation formation rules change for different forecasting horizons. Carry trade and momentum trade are the main applied strategies for short-term forecasting, whereas PPP trade and UIP are predominantly used for long-term forecasting. Finally, the results show that agents attach time-varying weights to the different strategies based on the past performance of the strategies.

The remainder of this study is organized as follows. In Section 2, we describe the dataset, Section 3 contains the methodology used, and Section 4 contains the results. In Section 5, we give some concluding remarks and suggestions for further research.

2. Data

To get a better understanding of the expectation formation process of agents, we use a unique dataset of investor expectations. The dataset that is central to this work is a survey dataset from FX Week[2], which contains forecasts at the weekly frequency from a large number of wholesale investors for several exchange rates and forecast horizons. The names of the respondents are revealed and include JPMorgan, Barclays Capital, Citigroup, RBS and Societe General. To the best of our knowledge, this dataset has not yet been used for this purpose.

A typical problem that may arise with survey forecasts is that respondents do not reveal their true expectations, perhaps because of private information that they do not want to reveal. However, because the names of the respondents of this survey have been made public, it is not likely that this problem will arise. After all, there is also a reputational aspect to revealing your forecast, and, therefore, we believe that the investors have an incentive to reveal their true

[2] FX Week is an industry newsletter for foreign exchange and money market professionals working within commercial banks, investment banks, central banks, brokerages, institutional investors, multinational corporations and vendor companies serving the banks and financial institutions.

expectations[3]. The Bank of International Settlement Triennial Survey (2010) states that the vast majority of foreign exchange activity occurs between large financial institutions such as the ones in our sample. Hence, our sample of institutions can be regarded as representative of the total foreign exchange market.

[insert Table 1 here]

As we can see in Table 1, the data were sampled at a weekly frequency for the one-, three- and twelve-month forecast horizon. A total number of 61 investors from large renowned banks and investment companies participated in the survey. From January 2003 to February 2008, forecasts were made for the spot rate of the U.S. dollar against the Japanese yen (USDJPY), the pound sterling (GBPUSD) and the euro (EURUSD), and for the euro against the Japanese yen (EURJPY). The data analysis will mainly be conducted in a panel structure. The panel is unbalanced as there are some one- or two-week gaps, and, over time, some panelists left or entered the survey.

Spot exchange rates and interbank lending rates were gathered from Datastream[4], as were the PPP exchange rates for the fundamental forecasting rules.

Table 2 shows the descriptive statistics for the expected returns and corresponding realized returns. From the negative period mean expectations of the one-, three- and twelve-month future EURJPY, GBPUSD and USDJPY exchange rates, we can see that investors expected an overall depreciation of the yen against the euro and the dollar as well as a depreciation of the dollar against the pound. The standard deviations of the forecasts are very high compared to the means, suggesting that the mean expectations are very volatile over time. Standard deviations increase as the forecast horizon becomes longer. Another interesting feature is that the high-low statistic, which shows the difference between the maximum and the minimum observations, increases with the forecast horizon.

It is interesting to compare these statistics to the descriptive statistics of the realized returns, where there is a positive mean for the first three currencies and a negative mean for the USDJPY. This means that for both the EURJPY and the GBPUSD exchange rates, investors were not able to predict the correct sign of the mean returns over time. Similar to the standard

[3] In this respect, the terms expectations and forecasts will be used interchangeably in this paper, as we assume that the investors' forecasts are unbiased representations of their expectations.
[4] Spot exchange rates: WM Reuters. Interbank rates: British Bankers' Association. PPP rates: OECD.

deviation of the forecasts, the standard deviation of the realized returns is high, which shows the high volatility of the foreign exchange markets. The high kurtosis shows that the distribution of the expectations is fat-tailed, which is in line with realized returns.

[insert Table 2 here]

As this is the first time this dataset is used for this purpose, it is appropriate to first conduct some rationality tests on this dataset, as done by, among others, Dominguez (1986), MacDonald and Marsh (1996) and Cavaglia et al. (1993). Testing for rationality of expectations involves testing for the unbiasedness of the predictions and testing for the information efficiency of the predictions.

[insert Table 3 here]

The results of the tests show that rationality can be rejected based on the bias and the information inefficiency of the forecasts. In the test for bias in Panel A, where rationality demands α to be zero and β to be unity, we find severe deviations from the unbiasedness hypothesis. The intercepts α are all significantly larger than zero, suggesting biased expectations. The β estimates are far from unity, sometimes even turning negative. From the orthogonality tests in Panels B, C, and D, we note that neither information from the lagged forecast errors nor from the interest rate differentials and the forward premium are used efficiently by the forecasters. Therefore, we can confirm the results of earlier work: investors do not behave rationally.

The data descriptions confirm earlier findings of non-rational expectations. The following section will describe the methodology used to evaluate which forecasting strategies, if not rational ones, are used.

3. Methodology

To investigate investors' forecasting strategies, we assume that the investors have equal access to information, but they interpret it by attaching different weights to different sources of information when forming expectations. A result of the overconfidence bias (Fischhoff et al., 1977) is that agents try to detect patterns in the exchange rate movements to predict future exchange rates while the foreign exchange market actually shows a random walk. Bloomfield and Hales (2002) indicate this in their two experiments with MBA participants. These participants used past price changes as an indicator for future reversals even though they were told that the sequences they were dealing with were random walks.

In contrast to traditional finance theory, several studies in the behavioral finance domain assume that agents use different models to process information into expectations. As noted by Hong and Stein (1999), a necessary condition for alternatives to the rational expectations setup is that there is empirical evidence supporting the alternative to bound the imagination of the researcher. The models that are widely used in the foreign exchange literature are momentum trading and PPP trading. Next to these two models, an additional model is tested that is based on the interest differential between the countries. A study from Pojarliev and Levich (2008) reveals that these trading strategies explain a substantial portion of the variability in foreign exchange funds. The choice for these models is further supported by the ETF prospects of Deutsche Bank and Barclays Capital. Deutsche Bank shows in its prospectus that the bank uses a combination of a carry, momentum and valuation strategy, in which the valuation strategy is based on the OECD's purchasing power parity rate. Barclays capital uses a combination of carry and value strategy (also based on OECD PPP rates). Allen and Taylor (1992) indicate that PPP is the fundamental model traders use.

3.1 Momentum traders

The first type of investor that we distinguish is the momentum trader, also referred to as technical analyst or positive feedback trader. According to Allen and Taylor (1990, 1992), approximately 90% of investors in the foreign exchange market use some form of technical analysis to predict future changes of exchange rates. Andreassen and Kraus (1990) indicate that investors are likely to sell if prices decline and to buy if prices increase, which is an indication of momentum trading. De Bondt (1993) confirms these findings with survey results that suggest people are optimistic in bull markets and pessimistic in bear markets.

Trading on the momentum effect is a deviation from rationality that can partly be assigned to representativeness bias. Representativeness (Tversky and Kahneman, 1974) can occur when people have to determine the probability that a series of returns generates some price or return. Rather than looking at the base rates and the overall distribution of returns, they look for similarities and think that the past returns are representative of the forecasting period.

The most basic form of momentum trading is a simple AR(1) rule:

$$s^e_{t+k} - s_t = \alpha + \beta(s_t - s_{t-k}) + \varepsilon_t \qquad (1)$$

where *k* denotes the forecast horizon. In case β>0, investors using this strategy expect price trends to continue. The traders are then said to be destabilizing as they drive the exchange rate in one direction. This is also referred to as bandwagon expectations. If β<0, traders show contrary behavior, which means that they expect past price movements to revert. This is also known as contrarian strategy.

Several studies (Frankel and Froot, 1987a,c, 1990; Cavaglia et al., 1993; Ito, 1990) show that bandwagon effects especially occur in the short run (depending on the study, up to 1 to 3 months) but disappear or turn into contrarian effects for longer horizons. This is in line with the findings of Cutler et al. (1991) of short-term positive auto-correlation and long-term negative auto-correlation of returns. Because the expectation formation process is the same for bandwagon and contrarian strategies, except for the change in sign of the explanatory coefficient, it is difficult to distinguish these effects. It is possible that some investors show extrapolative behavior and others act in a stabilizing way. When these effects even out on the macro level, making the momentum coefficient insignificant, it might not have an effect on the price; however, we cannot observe the true heterogeneity of the agents. In times of crisis or other financial turmoil, the bandwagon type may begin to dominate, causing severe destabilizations of the market. For these situations, it is useful to make a distinction between bandwagon and contrarian expectations. To the best of our knowledge, this distinction has not been made before in estimating these kinds of models. To determine whether the sign we find in Equation (1) represents a single type of investor or is a composition of a contrarian and bandwagon models, we estimate the following equation:

$$s^e_{t+k} - s_t = \alpha + \beta_1(s_t - s_{t-k})^b + \beta_2(s_t - s_{t-k})^c + \varepsilon_t \qquad (2)$$

where $\beta_1(s_t - s_{t-k})^b$ incorporates a dummy accounting for positive extrapolation (bandwagon/momentum effects), which takes the value of 1 if the past price movement and the individual expectation are of the same sign and 0 otherwise, and $\beta_2(s_t - s_{t-k})^c$ incorporates a dummy accounting for contrarian behavior, which takes the value of 1 if the past price movement and the individual expectation are of opposing signs and 0 otherwise. This introduces a form of dynamics in the expectation formation as we allow the investors to switch between bandwagon and contrarian behavior.

3.2 PPP traders

PPP traders use the purchasing power parity value of the exchange rate as an anchor in forming their expectations. They expect the exchange rate to revert back to this value. This means that they expect prices of overvalued assets to decrease and prices of undervalued assets to increase until the price of the asset reflects its PPP value. In the behavioral finance literature, this behavior is often referred to as ‘regressive’ or ‘mean reverting,’ as it assumes reversion to some kind of mean. Note that trading based on the fundamental value of the exchange rate (in this case, the PPP rate) would be rational if there were no other types of investors in the market. However, as past studies have found that there are different types of actors, it would be irrational to fully adhere to this strategy without acknowledging the deviations from market efficiency.

Obtaining the PPP value of an exchange rate is not straightforward. Economic literature is unclear about the true PPP value. Several versions of the model have been suggested in which the discussion is usually about the use of different price indices (Xu, 2003). As this is an empirical survey study, we are not concerned about whether we are using the correct PPP estimate or whether the PPP rate is the actual fundamental value; rather, we care only if investors assume this to be true and therefore use it in their expectation formation process. Although this does not particularly make it more straightforward, we can make some assumptions.

Investors in the foreign exchange market need information to form expectations and to make investment decisions. This information is costly, especially with respect to information that is not directly observable, such as the PPP value of the exchange rate. Before gathering this information, investors are likely to make some sort of cost-benefit analysis: when do the costs of obtaining this value exceed the benefits? Based on this behavior, we selected the OECD PPP value of exchange rates as an approximation of the true PPP value, as it does not require complicated analyses, models and calculations, and it is available against low costs. Furthermore, as indicated above, it is used by Deutsche Bank and Barclays as a benchmark for their value ETFs.

Figure 1 displays the OECD PPP rates and the nominal exchange rates used in this study. Figure 1 shows that the exchange rate is heavily mispriced the majority of the time. The USDJPY seems to be consistently lower than the PPP rate, whereas the GBPUSD and the EURUSD show the opposite trend beginning at the end of 2003. This indicates that the U.S. dollar was underpriced against the EU€, the JP¥ and the GB£ for over four years. Interestingly, the yen rates appear to move in the opposite direction from the fundamental rate. Whereas the PPP rate is decreasing for both exchange rates, the spot rates are generally increasing. We do not see this effect for the other two currencies. Both the perverse movements and the constant mispricing may have effects on PPP trading strategies.

[insert Figure 1 here]

PPP traders base their expectations on the deviation between the price and the PPP rate of an asset. They perceive such a situation as a mispricing, that is, an undervaluation or overvaluation of the currency.

$$s^e_{t+k} - s_t = \alpha + \gamma(\bar{s}_t - s_t) + \varepsilon_t \qquad (3)$$

where $\bar{s}$ is the PPP rate. The equation shows that the price movement expected by these traders is caused by the deviation of the price from the PPP value. For a positive γ, they are stabilizing, that is, they expect the exchange rate to revert to its PPP-based value, whereas a negative value of γ implies destabilizing behavior.

The second type of PPP trading behavior we test incorporates a non-linear response to the deviation from the PPP value (Taylor et al., 2001). The idea behind this is that a mean reverting expectation is more likely and probably stronger if the exchange rate is far from its PPP value. In such a situation, investors believe that chances are high the exchange rate will revert to this value. On the other hand, if the exchange rate is close to its PPP value, the risk of trend extrapolation is too big and the transaction costs are too high to benefit from fundamental analysis. This effect is captured by taking the deviation to the power of three:

$$s^e_{t+k} - s_t = \alpha + \gamma(\bar{s}_t - s_t)^3 + \varepsilon_t \qquad (4)$$

3.3 Interest differential traders

Many violations of the UIP relationship have been recorded, resulting in a branch of literature that focuses on the 'interest parity puzzle' (see Sarno (2005) for an overview). It is quite plausible that the UIP puzzle exists because of the presence of non-rational expectations. Then, when these deviations appear to be persistent, they get picked up by investors who try to use the deviation to make a profitable trade. This may result in carry trade, of which many cases have been observed in the past decades. Carry trade occurs under the exact opposite assumptions from uncovered interest parity in the sense that carry traders exploit the interest differential by borrowing in the low-interest country and lending in the high-interest country.

$$s^e_{t+k} - s_t = \alpha + \vartheta(i_t - i^*_t) + \varepsilon_t \qquad (5)$$

The sign of ϑ indicates whether investors apply carry trade or uncovered interest parity. A positive value of ϑ reveals trading based on uncovered interest parity, whereas a negative value reveals that there are carry traders in the market.

As was the case for momentum traders, we have the problem of two different strategies that both use the same information but do so in an exact opposite manner. In this case, it would be interesting to determine if there is actually only one type of trader that uses the interest differential or if there are both carry traders and UIP traders. We attempt to reveal this in a similar way to what we did for momentum traders, by estimating the equation:

$$s^e_{t+k} - s_t = \alpha + \vartheta_1(i_t - i^*_t)^{uip} + \vartheta_2(i_t - i^*_t)^{ct} + \varepsilon_t \qquad (6)$$

where $\vartheta_1(i_t - i^*_t)^{uip}$ (($\vartheta_2(i_t - i^*_t)^{ct}$) should reveal uncovered interest parity (carry trade) and is the interest differential multiplied by a dummy with the value of one (zero) if the individual's forecast and the interest differential are of the same sign and a value of zero (one) otherwise.

3.4 Heterogeneity: combined model

If we find the individual models to be significant, it becomes interesting to merge them into one model to exclude the possibility of omitted variable bias by testing whether the coefficients are still significant. For the combined model, we begin with the basic Equations (1), (3) and (5) for the momentum, PPP and interest differential trade models, respectively.

$$s^e_{t+k} - s_t = \alpha + \beta(s_t - s_{t-k}) + \gamma(\bar{s}_t - s_t) + \vartheta(i_t - i^*_t) + \varepsilon_t \quad (7)$$

As for the separate strategy models, this model is tested on the whole panel of investors over the entire survey sample. A valuable feature of testing this combined model on the different time horizons is that it enables us to see whether the strategies change in significance and dominance for increasing forecasting horizons. The momentum effect is usually only seen on short horizons, so we would expect β to decrease in significance and magnitude for three- and twelve-month horizons. Additionally, exchange rates generally need a long time to revert to their PPP value. Rogoff (1996) indicates that the half-life of most exchange rates is three to five years. We can therefore expect that this strategy only becomes significant for the longer horizons. The extent of the effect of horizon on the interest differential parameter is not straightforward. Nevertheless, we can characterize uncovered interest parity as a more fundamental strategy (i.e., more appropriate for longer horizons) and carry trade as a speculative strategy (for short horizons). With this characterization, we expect to see a negative parameter for the one-month horizon, which turns into a positive parameter for the twelve-month horizon.

The sophisticated model includes adjustments to the different strategies. This means it allows for dynamics within the group of momentum traders and interest differential traders. The choice for the linear PPP model is motivated by ease of interpretation of the coefficient and the added complexity of the non-linear model[5].

$$s^e_{t+k} - s_t = \alpha + \beta_1(s_t - s_{t-k})^b + \beta_2(s_t - s_{t-k})^c + \gamma(\bar{s}_t - s_t) + \vartheta_1(i_t - i^*_t)^{uip} + \vartheta_2(i_t - i^*_t)^{ct} + \varepsilon_t$$
(8)

3.5 Time-varying rules

In the previous sections, we have assumed that agents put constant weights on the forecasting rules that they use. However, both theory and empirical evidence (Barberis and Shleifer, 2003; Prat and Uctum, 2007; Bloomfield and Hales, 2002; Branch, 2004) suggest that agents change

[5] We also estimated the sophisticated model with the nonlinear response to the fundamental deviations, and this generated similar results.

the weights assigned to a certain strategy. This is often referred to as 'switching' between rules. In this section, we will investigate whether the survey data confirms the assumption of evolving weights to forecasting rules. In doing so, we will follow the approach used in the Heterogeneous Agent literature and introduced by Brock and Hommes (1997, 1998) by using a switching rule that is based on the forecasting accuracy of a certain strategy. To do this, we use mean expectations of agents. De Jong et al. (2010) applied a heterogeneous agent model to the foreign exchange rate. Estimation results for the EMS period reveal significant heterogeneity and switching between rules.

To capture agents' switching between forecasting rules, we update Equation (7) with a weighting function:

$$s_{t+k}^{e} - s_t = \alpha + W_t^c \beta(s_t - s_{t-k}) + W_t^f \gamma(\bar{s}_t - s_t) + W_t^i \vartheta(i_t - i_t^*) + \varepsilon_t \qquad (9)$$

where W_t^c, W_t^f and W_t^i are the weights assigned to the momentum, PPP and interest differential rules, respectively. How much weight agents put on a certain strategy depends on the forecasting accuracy of this strategy. The weights are, therefore, computed as:

$$W_t^s = \frac{\exp(\rho \pi_t^s)}{\sum_{s=f,c,i} \exp(\rho \pi_t^s)} , \qquad (10)$$

which is based on the model of Brock and Hommes (1997, 1998). The weight assigned to strategy s is a function of the performance of strategy s on time t (π_t^s) divided by the sum of all performances. The performance of a strategy is given by the previous period's forecast error for that strategy. Brock and Hommes (1997, 1998) do not use the forecast error but instead use the profitability of a certain strategy. Although such an approach is appropriate in an investment setting, it is not appropriate in our case, as respondents are interested in giving a good forecast with a low forecast error:

$$\pi_t^c = \left(\left(\beta(s_{t-k} - s_{t-2k})\right) - (s_t - s_{t-k})\right)^2$$

$$\pi_t^f = \left(\left(\gamma(\overline{s_{t-k}} - s_{t-k})\right) - (s_t - s_{t-k})\right)^2$$
$$\pi_t^i = \left(\left(\vartheta(i_{t-k} - i_{t-k}^*)\right) - (s_t - s_{t-k})\right)^2 \qquad (11)$$

The rationale behind these equations is that investors compare the real past change of the exchange rate with the change that was predicted by each of the models. The model with the smallest forecast error, that is, the model that had the best prediction in the previous period, should receive the highest weight in the coming period. Therefore, we expect the switching parameter ρ to be negative. If this parameter is positive, agents switch to the rule that performed worst in the previous period.

The switching parameter is often referred to in the literature as the intensity of choice, and it captures the delay in agent response to changes in performance. It is negatively related to the status quo bias described by Samuelson and Zeckhauser (1988), implying that people do not immediately change their behavior if they observe that this is desirable unless the reasons are appealing enough to do so. A high (absolute) ρ implies that the status quo bias is low, whereas the opposite occurs for a low (absolute) ρ.

In Section 4, we will present and evaluate the results from regressing the above equations. All regressions in Sections 4.1 to 4.4 are estimated using ordinary least squares on panel data with fixed effects[6], which captures some level of individual heterogeneity by allowing for individual specific intercepts. We account for the autocorrelation in the residuals, induced by the overlapping observations problem[7], with a White correction to the standard errors. In Section 4.5, mean expectations are used in combination with a maximum likelihood estimation, in which a Newey-West adjustment is used to account for autocorrelation in residuals. Accounting for serial correlation is necessary because of the overlapping character of the forecasts.

[6] A likelihood ratio test showed that the null hypothesis of redundant fixed effects was rejected. A Hausman test revealed the redundancy of random effects. Therefore, a model with fixed effects was appropriate.

[7] As the forecasts are weekly, and the horizons are one month or longer, the next forecast is made before the first forecast has expired. This would almost certainly lead to autocorrelation in the empirical model residuals (see MacDonald, 2000).

4. Results

4.1 Momentum traders

Section 4 describes the results from estimating the momentum models on the investor expectations. In this section, all equations are estimated on the full panel. Table 4 presents the results from estimating the basic momentum trading model from Equation (1).

[insert Table 4 here]

Regarding the basic setup, on the left side of the Table, the negative coefficients for all currencies[8] and all forecast horizons indicate that technical traders on the foreign exchange market are contrarian rather than extrapolative, especially for the Japanese yen against the euro and the U.S. dollar, where it is clear that momentum traders are mainly active on short horizons as the magnitude and significance of the coefficient decreases for an increasing forecast horizon. This is in line with results of earlier studies, which suggest that the momentum anomaly mainly occurs on short horizons. The opposite effect is noticeable for the EURUSD, where the strategy becomes significant for the twelve-month horizon only. Interestingly, the fit differs considerably between the currencies. This indicates that apart from the significant presence for all currencies, momentum traders are more active in the EURJPY and EURUSD markets than in the GBPUSD market.

There are two possible reasons for the small and sometimes insignificant coefficients of the basic momentum equation. Either investors that trade in these markets do not use (this form of) technical analysis in forming forecasts, or the group of contrarians and the group of positive extrapolators are of similar size, causing the effects to even out.

By testing Equation (2), we can see which of these explanations is most plausible. The results are displayed on the right hand side of Table 4. It is worth noting that there are, indeed, two types of trend extrapolators active in this market with opposing beliefs about how to extrapolate trends. In general, the contrarian effect dominates, which is why we see negative coefficients for the basic model. An interesting result is observed for the currencies listed against the Japanese yen. Both the EURJPY and the USDJPY reveal opposite momentum effects. Rather than short-term positive feedback trading and long-term negative feedback trading, the traders on these markets expect the exact opposite to happen. Over the short term, there is a dominance of

[8] Except for the one-month GBPUSD, but this coefficient is not significant.

contrarian expectations, whereas over the long term, the bandwagon effect dominates. This unconventional way of expectation formation is not observed for the other two exchange rates. Furthermore, we can see that the effect of momentum traders in the market for GBPUSD is limited, as the coefficients are small. However, when split into a bandwagon and a contrarian effect, they turn significant. As the coefficients of these strategies are very similar in absolute terms, it is plausible that their effects even out on an aggregated level, which explains the insignificant coefficients in Equation (1). The same argument applies to the one-month EURUSD expectations.

4.2 PPP traders

As we can see in Table 6, where the results from estimating Equation (3) are displayed, PPP traders appear to be mainly active in the EURUSD and the GBPUSD markets. This means that, again, the traders show deviating behavior with respect to the Japanese yen FOREX market, as the PPP strategy is not used much for these currencies. The EURUSD reveals the expected results over different horizons, namely, a growing magnitude of the coefficients for longer forecast horizons. All significant results show the correct sign, thus indicating that PPP traders are stabilizing by expecting the exchange rate to revert to its PPP value.

[insert Table 5 here]

If we allow for non-linearity in the PPP rule, on the right side of the table, the results become significant for three of the four exchange rates. These results provide some evidence for the assumption that PPP traders become increasingly active in the market when the exchange rate moves further away from its fundamental value. Within this model, we can clearly see that PPP strategies are mainly used for longer horizons, as the fit of the model increases from one to twelve months. Again, we cannot find significant coefficients for the USDJPY.

The non-linear model performs worse than the basic model in half of the cases, which makes the additional value of this model questionable.

4.3 Interest differential traders

The results of regressing Equation (5) can be found on the left side of Table 6. The evolution of the coefficients over the forecast horizons suggests that the interest differential is indeed used for carry trade for shorter horizons and that it follows the theory of uncovered interest parity for horizons of twelve months. However, none of the currencies have both significant short- and long-term effects at the same time. From the fit of the model, it seems that the information from the interest differential is mainly used for long forecast horizons and that we can find some evidence for UIP.

[insert Table 6 here]

Again, as we have seen for the momentum rule, the insignificant results might imply that the interest differential is not popular to use in forming expectations or that there are both carry traders and UIP traders in the market who cancel out each other's effects. Support for both strategies can be found on the right side of Table 6, which represents the results from estimating Equation (6). For all exchange rates and forecast horizons, the effects are significant at a 1% level. Therefore, it can be stated that both strategies are being used in the foreign exchange market, but their effect is only marginal, as they even out on an aggregated level. The fit of the model increases over time, indicating that the information from the interest differential is used particularly for longer horizons[9].

4.4 Heterogeneity: combined model

By estimating Equation (7) on the full panel, we attempt to discover whether institutional investors use the simple rules of thumb suggested by field research and the heterogeneous agents' literature: extrapolative (momentum) and regressive (PPP). For a better empirical application of the model to the foreign exchange market, we also add the interest differential as an explanatory variable. Combining all the strategies in one model reduces the risk of omitted variable bias. Results are displayed in Table 7.

[insert Table 7 here]

The momentum and PPP strategies are significant at a 1% level for all exchange rates and nearly all horizons. The PPP rule is significant for all horizons. The sign of this strategy is as expected for three out of four currencies, thereby stabilizing the exchange rate for those

[9] Note that a carry trade strategy is more difficult to detect, as this strategy is already profitable if the expected change in exchange rate is zero. With a zero change in exchange rate, a profit can still be made solely on the interest rate.

currencies. The PPP rule shows destabilizing behavior for the USDJPY exchange rate. The momentum strategy shows stabilizing behavior for the Japanese yen against the euro and the U.S. dollar. In other words, the deviating behavior of traders for the Japanese FOREX market still occurs when regressing the combined model. We can find momentum effects for the U.S. dollar against the euro and the pound sterling. A strong pattern is observable for the significance of the chartist rule over forecast horizons. The results clearly indicate that extrapolation becomes weaker and less significant for longer forecast horizons. For the twelve-month horizon, three out of four exchange rates no longer reveal extrapolative expectations. For these horizons, investors believe in UIP for two currencies. The EURJPY is dominated by carry trade, as this coefficient is negative and significant for all horizons.

Numbers can be interpreted as follows: the coefficient of 0.2534 for the EURUSD one-month horizon momentum strategy means that speculators expect 25% of the past period price movement to continue in the coming month. The EURJPY twelve month PPP coefficient of 0.2458 indicates that investors believe that, after twelve months, the deviation from the PPP value is reduced by 25%.

[insert Table 8 here]

When regressing the strategies separately on the expectations, we find that there are two main improvements in the models. Distinguishing between bandwagon and contrarian expectations in the momentum model and distinguishing between carry and UIP traders in the interest model increased the fit of those models. Therefore, it seems appropriate to include these improvements in the combined model as well. Table 8 presents the results of regressing Equation (8).

We find the results to be comparable to the regressions of the separate strategies and the regression of the combined model. In general, bandwagon and contrarian effects seem to decrease for longer forecasting horizons. The signs for bandwagon effects are as expected, but for contrarian effects, we find significant positive coefficients for the EURUSD one-month and the GBPUSD one- and three-month expectations. This can be caused by the fact that these exchange rates only showed positive log returns for the sample period, which could have had an influence on the sentiment of investors. The PPP model shows the expected sign for three out of four currencies. For these currencies, the PPP expectations are stabilizing. Only the EURJPY shows a negative sign, which can be explained by the constant undervaluation of this exchange rate. If a currency is constantly undervalued, investors might adapt their expectations and lose their faith in mean reversion of the exchange rate. For carry and UIP trade, we find the expected signs for all significant coefficients.

4.5 Time-varying rules

Until now, we have assumed that agents assign non-time-varying weights to their forecasting strategy. In this section, we will change this by estimating Equations (9) - (11) on the mean expectations using quasi-maximum likelihood. To test the added value of the switching rule, we estimate the model with static weights (Equation (7) with mean expectations) before we estimate the dynamic model. The added value is then tested by applying a likelihood ratio test and comparing these results with Chi-squared probabilities.

The results of these estimations can be found in Table 9. First, we observe that the results for the non-switching regression with mean expectations do not differ much from the panel regression results discussed in Section 4.4. This indicates that the mean expectation is a good representation of the combined individual expectations, and it is appropriate to use the mean in estimating the weighed function.

[insert Table 9 here]

The results of estimating the weighed function are found in Table 10. By comparing the estimated coefficients from the static weighing and the dynamic weighing models, we can see that the coefficients are of the same sign under the different models and are of similar magnitude after accounting for the weighting function[10]. Therefore, the salient aspects here are the intensity of choice parameter ρ (‘switching’) and the weights assigned to the strategies.

[insert Table 10 here]

[10] As the static model was estimated as $s^e_{t+k} - s_t = \alpha + \beta(s_t - s_{t-k}) + \gamma(\bar{s}_t - s_t) + \vartheta(i_t - i^*_t) + \varepsilon_t$ instead of as $s^e_{t+k} - s_t = \alpha + W^c_t\beta(s_t - s_{t-k}) + W^f_t\gamma(\bar{s}_t - s_t) + W^i_t\vartheta(i_t - i^*_t) + \varepsilon_t$ with W^c_t = W^f_t = W^i_t, accounting for the weighting function means multiplying all static coefficients by 3.

The intensity of choice parameter is significant and negative for three out of four exchange rates. This means that investors in these markets switch to the rule that generated the lowest forecast error in the previous period. The positive switching parameter of the EURJPY rate suggests that investors in this market switch to the rule that generated the largest forecast error in the previous period.

A likelihood ratio test tells us if allowing for switching in the model adds any value to the model with static weights. This is useful, as the intensity of choice parameter is sometimes insignificant because of the non-linear character of the switching (Terasvirta, 1994). The results of this test can be found in the final column of Table 16. The outcome of this test can be compared to a Chi-squared distribution to determine whether the log likelihood of the elaborate model is significantly higher than that of the nested model. This is the case for most exchange rates. For the twelve-month horizon, the likelihood ratio test shows us that the dynamic weighting model performs significantly better for all exchange rates, indicating that changing strategy becomes more important as the horizon increases.

We can see the evolution of weights for the twelve-month forecasts in Figure 2. The graphs show variations in the weights for most of the currencies. Although the PPP rule has lost popularity for the EURJPY rate in the last few years, it has increasingly been used for the EURUSD and the GBPUSD. Although the absolute changes in weights appear relatively small, note that the relative changes are substantial. Furthermore, the analyses are done in a panel setup and, therefore, represent the average. As such, small deviations have a large impact on the market itself.

[insert Figure 2 here]

The descriptive statistics of the weights are displayed in Table 11. We can see that in the majority of the cases the weight assigned to the momentum forecasting rule declines as the forecast horizon increases. The opposite occurs for the PPP forecasting rule. This is completely in line with theory, as it is assumed that momentum effects especially occur at short horizons, and forecasting based on PPP is more applicable for longer horizons (as it takes a long time before the exchange rate reverts to the value suggested by the purchasing power parity). We can also see that the standard deviation of the weights increases with forecasting horizon.

[insert Table 11 here]

Finally, it would be interesting to see between which strategies most switching takes place. We can evaluate this by looking at the correlations between the weights of the different strategies. The results are shown in Table 12. For all currencies and horizons, we find a negative correlation between momentum traders and PPP traders; thus, the switching more often occurs between these strategies. Switching between the other strategies is not that straightforward. In the short term, switching also appears to occur between momentum traders and interest traders. However, in the long term, agents particularly switch between PPP traders and interest traders.

[insert Table 12 here]

5. Conclusion

In this paper, we used survey expectations for four exchange rates to evaluate the way in which investors form their expectations. To do this, we tested three different strategies on the disaggregated expectations: momentum trading, PPP trading and interest trading strategies. The momentum strategy was divided into bandwagon and contrarian expectations, and the interest trading strategy was divided into UIP and carry trade expectations. These extensions to the basic models have shown to be a valuable improvement to the models. After testing the strategies separately and in a combined model, both using panel data, mean expectations were evaluated to determine whether agents switch between strategies over time.

We obtained significant results for all strategies when tested separately and when tested in a combined model. This implies that investors use momentum effects, PPP rates and interest rates in forming their expectations. Momentum trading especially occurs for short horizons, whereas PPP trading is more common for longer horizons. The interest differential is used on all horizons but primarily for long-horizon forecasting. Interestingly, there are also differences in expectations within different strategies. Some people expect past trends to continue and therefore positively extrapolate past returns into future forecasts (bandwagon). Other investors expect past trends to revert. There are investors who use the interest differential as a tool for carry trade, that is, they expect an appreciation of the currency of the high-interest-rate country; there are also investors who believe in UIP and therefore expect a depreciation of the currency of the high-interest-rate country. Furthermore, a long history of positive returns seems to influence investors when forming their expectations, making them more vulnerable to bandwagon expectations. A long history of undervaluation of an exchange rate can cause a loss of faith in reversion to the fundamental value.

Not only do investors use different strategies to form their expectations, they also change the weights they assign to these strategies based on the past forecasting accuracy of the strategies. The weight assigned to the momentum strategy decreases for longer horizons, and investors put more weight on PPP rates in this case. Investors switch more for longer forecasting horizons. Switching mainly occurs between momentum traders and PPP traders.

Our results further indicate that investors have deviating ways of forming expectations for the exchange rates that involve the Japanese yen. For the momentum and the PPP rules, we found surprising results that contradict earlier works as well as our empirical findings for the other exchange rates. This might suggest that Japan can be seen as a separate case. One of the reasons for this can be that Japan is still not as developed as the other countries and therefore has different market characteristics. Additionally, the Japanese government actively intervenes in the foreign exchange market, which makes conventional rules less useful. Further research could explore this phenomenon.

The results we presented in this paper are, on the one hand, a strong confirmation of theoretical statements and empirical findings from the behavioral finance literature. On the other hand, they are also an extension to the literature, as we have shown that there is also important heterogeneity within the strategies. Future research could investigate this heterogeneity and its implications for exchange rates. It would also be interesting to see whether these findings apply to other asset classes. Furthermore, applying the model to different time periods and/or focusing on different crises could provide better insight into the effect of heterogeneity and switching on crises and vice versa.

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Tables and Figures

Table 1 Dataset

Survey data set description	
Surveying institution	FX Weekly
Exchange rates	$/€, $/£, ¥/€, ¥/$
Frequency	weekly, unbalanced
Forecast horizons	1, 3 and 12 months
no. Participants	61
Background respondents	Financial institutions
Sample period	Jan 03 – Feb 08
All currencies/horizons	
Min. # resp.	9
Max. # resp.	41
Median # resp.	37
Min. # periods	3
Max. # periods	217
Median # periods	142
Average response rate	51.16%

Table 2 Descriptive statistics

	eurjpy 1m		eurjpy 3m		eurjpy 12m		eurusd 1m		eurusd 3m		eurusd 12m	
	exp	real	exp	real	exp	real	exp	real	exp	real	exp	real
Mean	-0.0044	0.0044	-0.0094	0.0108	-0.0330	0.0156	0.0015	0.0069	0.0074	0.0163	0.0176	0.0450
Median	-0.0067	0.0085	-0.0136	0.0177	-0.0418	0.0290	0.0008	0.0068	0.0057	0.0174	0.0219	0.0612
Maximum	0.0431	0.0626	0.0420	0.0924	0.0697	0.1445	0.0330	0.0746	0.0499	0.1031	0.0864	0.1919
Minimum	-0.0358	-0.0823	-0.0504	-0.0839	-0.0792	-0.3249	-0.0409	-0.0558	-0.0395	-0.0889	-0.0498	-0.1528
High-Low	0.0789	0.1449	0.0924	0.1762	0.1489	0.4694	0.0739	0.1304	0.0894	0.1919	0.1362	0.3447
Std. Dev.	0.0119	0.0250	0.0167	0.0335	0.0341	0.0963	0.0122	0.0269	0.0162	0.0413	0.0308	0.0824
Skewness	0.9146	-0.7012	0.7592	-0.5821	1.0613	-2.0235	0.0334	0.1386	0.2131	-0.2387	-0.2007	-0.7310
Kurtosis	4.7088	3.9569	3.1865	3.0642	3.3274	7.1220	3.0602	2.6470	2.2951	2.8096	2.3113	2.7136
Jarque-Bera	56.3947	25.9392	21.0636	12.2346	41.5170	300.3187	0.0727	1.8126	6.1066	2.3776	5.7192	19.9765
Probability	0.0000	0.0000	0.0000	0.0022	0.0000	0.0000	0.9643	0.4040	0.0472	0.3046	0.0573	0.0000

	gbpusd 1m		gbpusd 3m		gbpusd 12m		usdjpy 1m		usdjpy 3m		usdjpy 12m	
	exp	real	exp	real	exp	real	exp	real	exp	real	exp	real
Mean	-0.0006	0.0040	0.0004	0.0093	-0.0048	0.0112	-0.0056	-0.0024	-0.0170	-0.0056	-0.0519	-0.0294
Median	-0.0008	0.0057	0.0000	0.0110	-0.0053	0.0357	-0.0064	-0.0016	-0.0176	-0.0016	-0.0576	-0.0244
Maximum	0.0265	0.0666	0.0434	0.1107	0.0537	0.1675	0.0380	0.0675	0.0369	0.1007	0.0403	0.1648
Minimum	-0.0319	-0.0532	-0.0350	-0.0918	-0.0560	-0.3383	-0.0478	-0.0864	-0.0724	-0.1224	-0.1215	-0.2289
High-Low	0.0584	0.1199	0.0784	0.2025	0.1096	0.5058	0.0858	0.1539	0.1093	0.2231	0.1617	0.3937
Std. Dev.	0.0108	0.0251	0.0144	0.0377	0.0233	0.1112	0.0139	0.0269	0.0201	0.0402	0.0362	0.0841
Skewness	-0.1844	0.0250	0.1268	0.0742	0.0753	-1.4663	0.2128	-0.4137	0.1559	-0.2558	0.4912	0.0343
Kurtosis	2.9423	2.6028	2.9280	3.0969	2.3657	5.0012	3.3434	3.1258	2.7718	2.7777	2.5052	2.1885
Jarque-Bera	1.2536	1.4420	0.6255	0.2826	3.8256	113.44	2.6915	6.3032	1.3436	2.8008	10.8891	5.9697
Probability	0.5343	0.4863	0.7314	0.8682	0.1477	0.0000	0.2603	0.0428	0.5108	0.2465	0.0043	0.0505

Notes: The table above shows the descriptive statistics of log expected (exp) and log realized (real) returns for the 1, 3, and 12 months horizons for the EURJPY, EURUSD, GBPUSD and USDJPY.

Table 3 – Rationality tests

$E_{t-k}[\Delta s_t] = \alpha + \beta \Delta s_t + \varepsilon_t$

Panel A: Unbiasedness

	EURJPY			EURUSD			GBPUSD			USDJPY		
	1m	3m	12m	1m	3m	12m	1m	3m	12m	1m	3m	12m
α	-0.0053	-0.0125	-0.0424	0.0019	0.0077	0.0102	-0.0008	-0.0010	-0.0077	-0.0061	-0.0190	-0.0614
	(-89.982)	(-50.737)	(-137.99)	(26.851)	(27.223)	(13.136)	(-20.753)	(-10.618)	(-49.337)	(-385.38)	(-375.53)	(-79.797)
β	0.1071	0.0708	-0.0222	-0.0209	-0.0440	0.0797	0.0519	0.0888	0.1163	0.0850	-0.0514	-0.1676
	(8.1245)	(3.4154)	(-0.9746)	(-1.6980)	(-2.2175)	(3.7959)	(3.8842)	(5.2675)	(6.3512)	(7.1538)	(-2.4047)	(-5.1550)

$E_{t-k}[s_t] - s_t = \alpha + \beta X_{t-k} + \varepsilon_t$

Panel B: Orthogonality - lagged forecast errors

	EURJPY			EURUSD			GBPUSD			USDJPY		
	1m	3m	12m	1m	3m	12m	1m	3m	12m	1m	3m	12m
α	-0.0096	-0.0223	-0.1042	-0.0043	-0.0087	-0.0414	-0.0039	-0.0067	-0.0207	-0.0039	-0.0083	-0.0064
	(-51.774)	(-20.176)	(-12.438)	(-63.960)	(-37.0920)	(-112.01)	(-50.416)	(-24.813)	(-8.4697)	(-25.353)	(-12.956)	(-1.0404)
β	-0.0165	0.0426	-0.4779	0.1382	0.0456	-0.2013	0.0540	0.0332	-0.7262	0.0773	0.3056	0.1412
	(-0.8208)	(0.9674)	(-5.5756)	(6.6275)	(0.8892)	(-4.6365)	(2.5357)	(0.9506)	(-10.249)	(2.8361)	(9.8920)	(2.1219)

Panel C: Orthogonality - forward premium

	EURJPY			EURUSD			GBPUSD			USDJPY		
	1m	3m	12m	1m	3m	12m	1m	3m	12m	1m	3m	12m
α	-0.0208	-0.0357	-0.2594	-0.005	-0.011	-0.0094	-0.0067	-0.013	-0.0386	-0.0028	-0.0107	0.0218
	(-7.4041)	(-4.139)	(-9.686)	(-10.369)	(-12.329)	(-2.8111)	(-8.9704)	(-8.8338)	(-7.781)	(-1.6369)	(-2.3204)	(1.5752)
β	-4.989	-1.7929	-7.4548	1.4924	1.6776	-1.7962	-3.0409	-2.4292	-3.5674	0.712	0.6601	1.5739
	(-4.1258)	(-1.4088)	(-7.5903)	(2.1563)	(3.9724)	(-4.2996)	(-4.2432)	(-4.8608)	(-7.7468)	(1.2822)	(1.2598)	(4.0093)

Panel D: Orthogonality - interest differential

	EURJPY			EURUSD			GBPUSD			USDJPY		
	1m	3m	12m	1m	3m	12m	1m	3m	12m	1m	3m	12m
α	-0.0152	-0.0345	-0.2523	-0.0052	-0.0111	-0.0085	-0.0071	-0.0138	-0.0442	-0.0021	-0.0097	0.0199
	(-5.4075)	(-4.2427)	(-9.8656)	(-10.635)	(-12.879)	(-2.6037)	(-8.8711)	(-8.8627)	(-8.3398)	(-1.1880)	(-2.1584)	(1.5110)
β	-0.2305	-0.4130	-7.2012	0.1481	0.477	-1.8880	-0.2772	-0.6325	-3.6913	0.0834	0.1970	1.5143
	(-2.1379)	(-1.3474)	(-7.6709)	(2.4606)	(4.5108)	(-4.7624)	(-4.4480)	(-5.1150)	(-8.3077)	(1.6538)	(1.5181)	(4.0725)

Notes: Table presents the rationality tests of the survey expectations. Numbers in parentheses represent t-values.

Table 4 Results momentum

Momentum		Basic			Dynamic			
		c	momentum	adj R^2	c	bandwagon	contrarian	adj R^2
EURJPY	1m	-0.0039***	-0.3888***	0.2418	-0.0029***	0.4247***	-0.6541***	0.5205
		(-85.887)	(-19.4223)		(-67.478)	(21.846)	(-40.324)	
	3m	-0.0096***	-0.1885***	0.1170	-0.0062***	0.5935***	-0.6879***	0.4521
		(-27.178)	(-5.8352)		(-29.459)	(20.196)	(-28.719)	
	12m	-0.0375***	-0.0958	0.2280	-0.0333***	0.6738***	-0.3810***	0.5083
		(-10.755)	(-1.4920)		(-13.951)	(9.8658)	(-8.1092)	
EURUSD	1m	0.0048*	-0.0061	0.0928	0.0019	0.0254***	-0.0296***	0.5420
		(1.8671)	(-1.1647)		(1.2445)	(7.1316)	(-10.356)	
	3m	0.0169***	-0.0205*	0.1782	0.0091***	0.0315***	-0.0571***	0.5880
		(2.9086)	(-1.6888)		(2.9319)	(4.5281)	(-9.2028)	
	12m	0.0636***	-0.1173***	0.3972	0.0370***	0.0206	-0.1503***	0.6969
		(4.6049)	(-3.6495)		(4.1000)	(0.9095)	(-7.6269)	
GBPUSD	1m	-0.0060	0.0043	0.0614	-0.0045	0.0143***	-0.0081***	0.5718
		(-0.8998)	(0.8028)		(-1.1588)	(4.4133)	(-2.6969)	
	3m	0.0018	-0.0020	0.0610	-0.0024	0.0127***	-0.0098***	0.5716
		(0.2911)	(-0.3931)		(-0.6325)	(3.9192)	(-3.3177)	
	12m	0.0055	-0.0052	0.0616	-0.0006	0.0117***	-0.0116***	0.5719
		(0.7788)	(-0.8697)		(-0.1328)	(2.8719)	(-3.0745)	
USDJPY	1m	-0.0074***	-0.4353***	0.3539	-0.0054***	0.2930***	-0.6571***	0.5716
		(-142.76)	(-22.174)		(-92.666)	(13.456)	(-34.660)	
	3m	-0.0196***	-0.3329***	0.2661	-0.0138***	0.2892***	-0.6948***	0.4706
		(-314.40)	(-11.541)		(-40.879)	(6.8926)	(-23.982)	
	12m	-0.0592***	-0.2637***	0.3633	-0.0441***	0.2955***	-0.6605***	0.5128
		(-193.88)	(-5.8458)		(-35.304)	(4.6647)	(-19.474)	

Notes: The table above presents coefficient estimates and t-statistics (in parenthesis) from estimating Equation (1). Significance is listed as ***, **, * for significance on 1%, 5% or 10% level respectively.

Table 5 Results PPP

PPP		Basic			Non-linear		
		c	PPP	adj R²	c	PPP^3	adj R²
EURJPY	1m	-0.0048***	0.0003	0.0402	-0.0055***	0.3622**	0.0441
		(-14.740)	(0.0568)		(-17.016)	(2.2980)	
	3m	-0.0117***	0.0015	0.0873	-0.0135***	0.8775**	0.0967
		(-12.499)	(0.0921)		(-14.848)	(1.9936)	
	12m	-0.0474***	0.0843*	0.2463	-0.0502***	3.6655***	0.2747
		(-18.703)	(1.8589)		(-19.770)	(2.9735)	
EURUSD	1m	0.0057***	0.0397***	0.1038	0.0033***	0.7569***	0.1024
		(5.0844)	(3.4827)		(8.2771)	(3.8040)	
	3m	0.0142***	0.0730***	0.1894	0.0102***	1.5321***	0.1908
		(5.9347)	(2.9858)		(10.184)	(3.0937)	
	12m	0.0487***	0.3617***	0.4582	0.0276***	7.1707***	0.4545
		(8.3863)	(6.1109)		(12.909)	(6.7418)	
GBPUSD	1m	0.0029*	0.0203**	0.0649	0.0005	0.1551	0.0631
		(1.7354)	(2.1245)		(0.6986)	(1.6153)	
	3m	0.0093***	0.056169***	0.1377	0.003138*	0.492773**	0.1346
		(2.7185)	(2.8600)		(1.8410)	(2.1240)	
	12m	0.0375***	0.266283***	0.4264	0.010754***	2.654400***	0.4239
		(5.2212)	(6.4393)		(3.5318)	(6.4034)	
USDJPY	1m	-0.0059***	-0.0021	0.0901	-0.0070***	0.1153	0.0913
		(-5.1966)	(-0.2811)		(-12.891)	(1.4430)	
	3m	-0.0154***	-0.0229	0.1539	-0.0186***	-0.0470	0.1515
		(-5.6248)	(-1.2872)		(-14.726)	(-0.2541)	
	12m	-0.0524***	-0.0323	0.3017	-0.0571***	-0.0435	0.3003
		(-7.9246)	(-0.7528)		(-18.489)	(-0.0962)	

Notes: The table above presents coefficient estimates and t-statistics (in parenthesis) from estimating Equation (4). Significance is listed as ***, **, * for significance on 1%, 5% or 10% level respectively.

Table 6 Results Interest differential

Interest Differential		Basic			UIP & Carry			
		c	UIP/Carry	adj R²	c	Carry	UIP	adj R²
EURJPY	1m	-0.0102**	-0.2080**	0.0434	-0.0072***	-0.8032***	0.3512***	0.5617
		(-3.7829)	(-2.0125)		(-5.6279)	(-16.333)	(6.6180)	
	3m	-0.0219***	-0.3847	0.0920	-0.0125***	-1.1943***	0.5988***	0.5812
		(-2.8132)	(-1.3130)		(-3.7028)	(-8.6116)	(4.6834)	
	12m	-0.0112	1.1528	0.2336	-0.0157	-1.5264***	1.6536***	0.5741
		(-0.4998)	(1.3964)		(-1.2427)	(-3.3530)	(3.4869)	
EURUSD	1m	0.0018***	-0.0019	0.0914	0.0008**	-0.8815***	0.9122***	0.4592
		(5.0955)	(-0.0434)		(2.5213)	(-17.705)	(15.748)	
	3m	0.0062***	0.1038	0.1737	0.0033***	-1.5418***	1.3869***	0.5150
		(9.4814)	(1.2840)		(5.7370)	(-17.716)	(16.414)	
	12m	0.0003	1.2227***	0.3852	0.0029**	-2.7433***	2.8396***	0.6315
		(1.3801)	(4.3455)		(2.2195)	(-9.2416)	(16.532)	
GBPUSD	1m	-0.0014*	-0.0562	0.0620	-0.0017***	-0.7328***	0.6020***	0.4310
		(-1.8457)	(-0.9702)		(-3.0942)	(-18.802)	(9.9389)	
	3m	-0.0003	0.0131	0.1250	-0.0010	-1.0661***	1.0732***	0.4931
		(-0.2150)	(0.1110)		(-0.8987)	(-15.540)	(8.0704)	
	12m	-0.0034	0.4512*	0.3372	-0.0022	-1.3434***	1.9356***	0.5623
		(-1.0739)	(1.7226)		(-0.9180)	(-7.0672)	(7.4367)	
USDJPY	1m	0.0064***	-0.0039	0.0901	-0.0055***	-0.5098***	0.3489***	0.5343
		(-4.0887)	(-0.0852)		(-5.3215)	(-14.541)	(10.491)	
	3m	-0.0165***	0.0691	0.1521	-0.0147***	-0.8666***	0.5105***	0.5443
		(-4.3478)	(0.6307)		(-6.4663)	(-10.701)	(7.4530)	
	12m	-0.0145	1.2119***	0.3421	-0.0301***	-1.4859***	1.2319***	0.5932
		(-1.3108)	(3.8914)		(-3.8769)	(-5.7840)	(5.5814)	

Notes: The table above presents coefficient estimates and t-statistics (in parenthesis) from estimating Equation (6). Significance is listed as ***, **, * for significance on 1%, 5% or 10% level respectively.

Table 7 Results heterogeneity – basic model

		Heterogeneity - basic				
		c	momentum	PPP	uip/carry	adj R^2
EURJPY	1m	-0.0229***	-0.3792***	0.0271***	-0.6667***	0.2470
		(-4.8818)	(-19.5760)	(2.8610)	(-4.0962)	
	3m	-0.0888***	-0.1598***	0.1322***	-2.6933***	0.1472
		(-7.7750)	(-5.2730)	(5.7858)	(-6.8163)	
	12m	-0.1510***	-0.027	0.2458***	-3.5286***	0.2587
		(-5.8486)	(-0.4129)	(3.5912)	(-4.5714)	
EURUSD	1m	-0.0634***	0.2534***	0.5767***	-0.1721***	0.2135
		(-12.6704)	(15.0399)	(15.9378)	(-3.5523)	
	3m	0.0183**	0.1154***	0.2986***	-0.0563	0.2086
		(-2.4730)	(5.0013)	(6.6323)	(-0.6539)	
	12m	0.0379***	0.006	0.3391***	0.7167***	0.4728
		(3.0587)	(0.1766)	(4.6246)	(2.64230	
GBPUSD	1m	-0.2618***	0.2792***	0.5025***	-0.0892	0.2000
		(-13.5874)	(13.5712)	(13.6436)	(-1.5873)	
	3m	-0.0729***	0.0870***	0.2018***	0.0228	0.1475
		(-2.8698)	(3.2592)	(4.2384)	(0.1985)	
	12m	0.0065	0.0486	0.3321***	0.2226	0.4351
		(-0.1738)	(1.2888)	(5.3225)	(0.9751)	
USDJPY	1m	0.0092**	-0.4506***	-0.0515***	0.2550***	0.3639
		(2.2127)	(-22.9354)	(-4.3519)	(3.3461)	
	3m	0.0088	-0.3440***	-0.0958***	0.3957***	0.2835
		(1.0641)	(-12.1936)	(-3.8086)	(2.6790)	
	12m	0.0149	-0.2914***	-0.2540***	0.9923**	0.4151
		(0.7153)	(-5.4703)	(-5.1410)	(2.1231)	

Notes: The table above presents coefficient estimates and t-statistics (in parenthesis) from estimating Equation (7). The full panel is used for this estimation. Significance is listed as ***, **, * for significance on 1%, 5% or 10% level, respectively.

Table 8 Results heterogeneity – sophisticated model

		Heterogeneity - sophisticated						
		c	bandwagon	contrarian	PPP	carry	uip	adj R^2
EURJPY	1m	-0.011248***	0.059165**	-0.314531***	0.009731*	-0.744831***	0.044705	0.6118
		(-3.7337)	(2.5517)	(-18.9996)	(1.6713)	(-6.8049)	(0.4362)	
	3m	-0.033582***	0.073236**	-0.150306***	0.041707***	-1.785006***	-0.243517	0.5901
		(-4.3854)	(2.4584)	(-6.2456)	(2.901013)	(-6.7831)	(-0.9158)	
	12m	-0.090849***	0.181198**	-0.093770**	0.126403***	-3.585304***	-1.062686	0.5879
		(-4.7620)	(2.0657)	(-2.3346)	(3.4805)	(-6.1394)	(-1.5889)	
EURUSD	1m	-0.032275***	0.147338***	0.106511***	0.286166***	-0.287894***	0.170908***	0.5798
		(-10.6719)	(14.4661)	(10.6858)	(13.1347)	(-5.9297)	(2.9341)	
	3m	-0.007908*	0.084359***	0.017651	0.134920***	-0.542308***	0.379191***	0.6065
		(-1.9035)	(6.2810)	(1.2517)	(4.5900)	(-5.6505)	(3.7391)	
	12m	0.024904***	0.063069***	-0.053052***	0.189292***	-1.210606***	0.803977***	0.7175
		(3.2203)	(3.1785)	(-2.7447)	(4.5174)	(-4.0741)	(3.0124)	
GBPUSD	1m	-0.123471***	0.139596***	0.122328***	0.234073***	-0.204987***	0.114613***	0.6082
		(-10.4683)	(11.1418)	(9.7418)	(10.5688)	(-5.7674)	(1.8262)	
	3m	-0.041041***	0.058667***	0.031980**	0.092021***	-0.348834***	0.346565**	0.6182
		(-2.9242)	(3.8992)	(2.1464)	(3.5153)	(-5.6484)	(2.4734)	
	12m	-0.031858	0.070410***	0.024435	0.161648***	-0.361567**	0.427551*	0.6988
		(-1.2575)	(2.7481)	(0.9356)	(3.9987)	(-2.2364)	(1.8702)	
USDJPY	1m	0.003647	0.045613**	-0.428353***	-0.025013***	-0.124861**	0.354082***	0.6392
		(1.31924	(1.9747)	(-23.5978)	(-3.3863)	(-2.5096)	(6.2542)	
	3m	-0.002287	-0.028608	-0.324410***	-0.042148***	-0.493981***	0.551444***	0.5913
		(-0.4339)	(-0.8535)	(-17.0731)	(-2.8307)	(-4.7546)	(5.5714)	
	12m	0.006061	0.053343	-0.327808***	-0.168536***	-0.761501**	1.266500***	0.6383
		(0.4347)	(1.1025)	(-7.2755)	(-6.3084)	(-2.2499)	(3.6908)	

Notes: The table above presents coefficient estimates and t-statistics (in parenthesis) from estimating Equation (8). The full panel is used for this estimation. Significance is listed as ***, **, * for significance on 1%, 5% or 10% level, respectively.

Table 9 Results heterogeneity with mean expectations – basic model without switching

Mean results - no switching

		c	momentum	PPP	uip/carry
EURJPY	1m	-0.0256***	-0.3332***	0.0318***	-0.7646***
		(-3.9418)	(-9.2369)	(2.7332)	(-3.4182)
	3m	-0.0860***	-0.0719	0.1285***	-2.5788***
		(-5.7352)	(-1.2477)	(4.8651)	(-5.0326)
	12m	-0.1710***	0.1833**	0.3268***	-3.7496***
		(-5.0168)	(2.2180)	(6.4275)	(-3.0414)
EURUSD	1m	-0.0627***	0.2377***	0.5177***	-0.0826
		(-9.0919)	(9.5600)	(9.4451)	(-0.9517)
	3m	-0.0136	0.0933**	0.2435***	-0.0090
		(-1.2511)	(2.4572)	(3.0706)	(-0.0590)
	12m	0.0357***	0.0291	0.3951***	0.5108
		(3.2042)	(0.6782)	(4.1126)	(1.5909)
GBPUSD	1m	-0.2542***	0.2714***	0.4910***	-0.1039
		(-10.0584)	(9.9669)	(9.4703)	(-1.5328)
	3m	-0.0659*	0.0805**	0.1977***	0.0046
		(-1.7902)	(2.0777)	(2.8006)	(0.0314)
	12m	-0.0486**	0.0906***	0.3954***	0.0591
		(-1.9294)	(3.5538)	(9.8241)	(0.4137)
USDJPY	1m	0.0069	-0.4301***	-0.0461***	0.2078**
		(1.5268)	(-16.0578)	(-3.6103)	(2.5833)
	3m	0.0161	-0.3106***	-0.1202***	0.4874**
		(1.4569)	(-7.1814)	(-3.9132)	(2.4475)
	12m	0.0408***	-0.2694***	-0.3218***	1.3997***
		(2.7094)	(-4.8339)	(-6.4816)	(4.3507)

Notes: The table above presents coefficient estimates and t-statistics (in parenthesis) from estimating equation (7) on mean expectations. Significance is listed as ***, **, * for significance on 1%, 5% or 10% level, respectively.

Table 10 Results heterogeneity with mean expectations – basic model with switching

		Mean results - switching							
		c	momentum	PPP	uip/carry	switching	LL	LL no sw	2dLL
EURJPY	1m	-0.0201***	-1.1608***	0.0884***	-1.3364***	6.3019*	731.2547	728.0357	6.4380**
		(-4.2442)	(-10.1966)	(2.6520)	(-3.2415)	(1.8692)			
	3m	-0.0760***	-0.2386	0.4046***	-5.7345*	1.2508	607.5139	607.0778	0.8722
		(-3.9124)	(-1.1192)	(4.5498)	(-1.9489)	(0.4828)			
	12m	-0.1451***	0.4439	1.0108***	-6.1753**	2.5444	510.3837	499.6836	21.4002***
		(-4.2262)	(1.2726)	(4.3761)	(-2.0460)	(1.3468)			
EURUSD	1m	-0.0879***	1.0328***	1.5973***	-0.7977***	-0.2722***	700.8171	686.2083	29.2176***
		(-9.7613)	(9.8636)	(10.4521)	(-3.2592)	(-4.2833)			
	3m	-0.0257**	0.4631***	0.6198***	-0.4491	-1.2549*	600.1678	596.0562	8.2232***
		(-2.0062)	(2.6261)	(2.8945)	(-0.8329)	(-1.7187)			
	12m	0.0368***	1.0295***	0.5292***	1.3132***	-7.5988***	580.8605	535.6001	90.5208***
		(3.3314)	(3.0370)	(15.0141)	(2.7627)	(-2.6183)			
GBPUSD	1m	-0.2443***	0.7689***	1.5294***	-0.3130	0.0426	729.1925	728.9175	0.5500
		(-8.8737)	(7.7992)	(8.5008)	(-1.5156)	(0.6509)			
	3m	-0.056241	0.2020*	0.6782**	0.0322	0.4702	625.5051	625.3014	0.4074
		(-1.5381)	(1.7639)	(2.0125)	(0.0686)	(0.4720)			
	12m	0.2360**	1.4459**	0.7576***	0.1033	-0.5147***	670.5257	658.5809	23.8896***
		(-2.1179)	(1.9802)	(9.4678)	(0.3621)	(-2.9535)			
USDJPY	1m	0.0069	-1.3013***	-0.1377***	0.6199**	-0.2067	728.7084	728.6995	0.0178
		(1.5243)	(-13.7173)	(-3.5822)	(2.5371)	(-0.1033)			
	3m	0.0186*	-1.2377***	-0.3327***	1.4587***	-2.9907*	595.2054	592.8619	4.6870**
		(1.6590)	(-4.9414)	(-4.0419)	(2.7942)	(-1.8272)			
	12m	0.0518***	-1.1045***	-0.8520***	4.3001***	-1.9966***	502.9188	496.6018	12.6340***
		(3.3695)	(-4.5585)	(-6.6614)	(5.8584)	(-3.1193)			

Notes: The table above presents coefficient estimates and t-statistics (in parenthesis) from estimating equation (9) on mean expectations. Significance is listed as ***, **, * for significance on 1%, 5% or 10% level, respectively.

Table 11 Descriptive statistics weights

		Dynamic weighing											
		mean			maximum			minimum			st. dev		
		Mom	PPP	UIP/Carry	Mom	PPP	UIP/Carry	Mom	PPP	UIP/Carry	Mom	PPP	UIP/Carry
EURJPY	1m	0.300	0.321	0.379	0.436	0.371	0.459	0.224	0.235	0.308	0.038	0.026	0.028
	3m	0.307	0.322	0.371	0.312	0.346	0.406	0.294	0.289	0.348	0.003	0.018	0.017
	12m	0.276	0.331	0.393	0.323	0.457	0.498	0.225	0.192	0.315	0.023	0.078	0.058
EURUSD	1m	0.302	0.355	0.343	0.333	0.380	0.345	0.277	0.328	0.339	0.012	0.011	0.001
	3m	0.274	0.374	0.352	0.337	0.423	0.359	0.224	0.321	0.341	0.023	0.021	0.004
	12m	0.063	0.561	0.376	0.496	0.716	0.463	0.001	0.202	0.283	0.112	0.122	0.043
GBPUSD	1m	0.343	0.327	0.330	0.346	0.330	0.330	0.340	0.324	0.330	0.002	0.002	0.000
	3m	0.364	0.310	0.325	0.375	0.326	0.327	0.352	0.298	0.323	0.006	0.007	0.001
	12m	0.172	0.426	0.402	0.217	0.453	0.409	0.142	0.389	0.393	0.019	0.016	0.004
USDJPY	1m	0.332	0.334	0.330	0.337	0.337	0.330	0.328	0.332	0.330	0.002	0.001	0.000
	3m	0.297	0.357	0.346	0.382	0.431	0.398	0.227	0.292	0.293	0.030	0.033	0.024
	12m	0.267	0.370	0.363	0.348	0.470	0.416	0.208	0.276	0.311	0.030	0.056	0.032

Notes: The table presents the descriptive statistics of the weights as estimated in the model given by Eq. 9-11.

Table 12 Correlations between strategies

		Intra-currency correlations		
		mom-PPP	mom-int	int-PPP
EURJPY	1m	-0.670	-0.720	-0.032
	3m	-0.394	0.215	-0.982
	12m	-0.909	0.828	-0.986
EURUSD	1m	-0.996	-0.696	0.625
	3m	-0.988	-0.599	0.471
	12m	-0.935	0.041	-0.393
GBPUSD	1m	-0.998	0.101	-0.164
	3m	-0.997	0.874	-0.908
	12m	-0.988	-0.777	0.671
USDJPY	1m	-0.788	-0.430	0.464
	3m	-0.696	-0.287	-0.489
	12m	-0.894	0.621	-0.907

Notes: The table presents the correlations between the weights as estimated in the model given by Eq. 9-11.

Figure 1 – Nominal and PPP rates (natural logarithms)

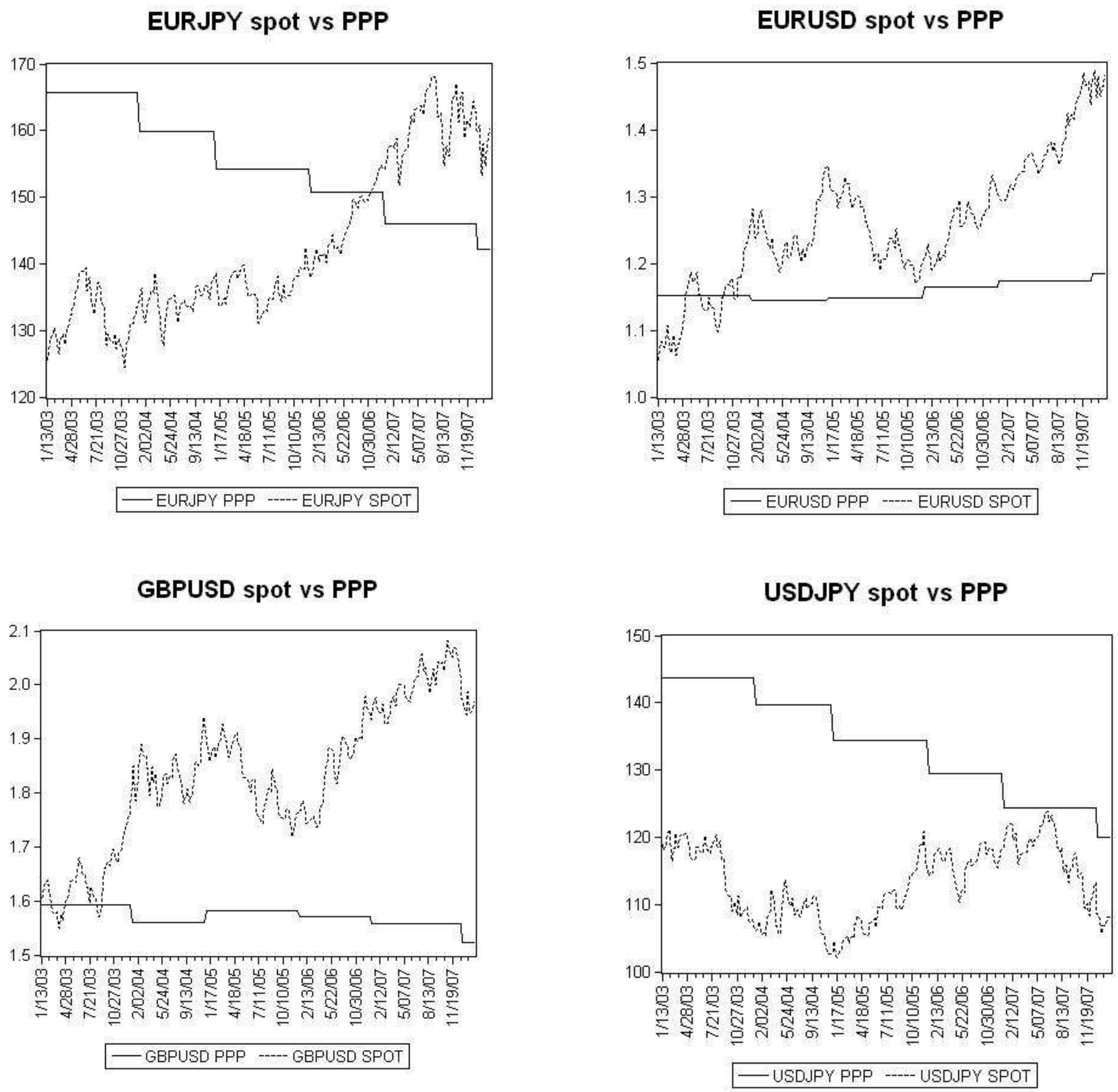

Figure 2 Time-varying weights 12m