Predicting exchange rates *via* a futures market.

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Abstract

Predicting future spot exchange rates has always been useful for companies trading internationally. Now finding future exchange rates is essential for countries that are to join common currency zones (Eurosystem) and need to set reference rates for the ERM II. This paper presents a model that attempts to determine exchange rates and, unlike others, is based on an analysis of the futures market. The model is based on the assumption that the futures market is dominated by two categories of traders: arbitrageurs and fundamental traders. The divergence of the futures rate from its theoretical value is gauged and then considered to be an indication of the direction and strength of the two forces in the market. The arbitrageurs' influence is filtered out and thus the model outputs the rate based on the fundamental traders' expectations.

Keywords: exchange rate determination, ERM II, futures market

1 Introduction

Since the 1970's, (the end of Bretton Woods era) predicting exchange rates has become one of the most difficult tasks in finance. The problem can be attributed to a number of factors. Consequently, there are numerous theories which struggle to solve the exchange rates determination puzzle, as some (Lyons 2001) call the disconnection between fundamental signals and exchange rates.

The issue is especially acute for the CEEC-10 countries that are to join Eurosystem and incept euro. Before that they need to meet the convergence criteria, set a reference rate against euro and enter the ERM II (European Exchange Rate Mechanism II) − a fixed peg exchange rate regime. For the period of two years the rate may fluctuate only within $\pm 2.25\%$ band (an asymmetric band is also being considered). Otherwise, the country will leave the ERM II and go through the procedure again.

How to find the appropriate equilibrium rate that would make the transition into the common currency zone smooth is of interest to economists in both policy-making and academic circles in Poland and other CEEC countries. According to the ECB (ECB 2002) "it is important to set a central parity that corresponds to the best possible assessment of current economic fundamentals, knowing that this will not prejudge the ultimate conversion rate". On the other hand, rejecting market spot rates and market-based forecasts just on the ground that they do not converge with some fundamentals seems too arbitrary a solution. Thus, anticipating future spot rates (attempted in this paper), although tantamount to solving only a part of the problem, appears to be a good

starting point for setting the central exchange rate. In fact we will never know where the equilibrium rate is until it is market tested.

The authors of this paper have attempted to determine the future exchange rate using a new approach. Namely, the research was conducted in the futures market. The main assumption of this paper is that there are two informed and influential groups of traders in the market: arbitrageurs (group A) whose behavior is somewhat automatic in that it is driven by interest rate parity, and fundamental traders (group F) – all the traders who refer to a wider range of information than just interest rate differential, including commercial traders who use the futures market for hedging. What follows is that the market futures rate is located between two values: the futures theoretical value (set by A group) and the expectations-based value (expected by fundamental traders). Whenever the market futures value diverges by too much from the theoretical one, arbitrageurs step in and drive it back close to the appropriate level. Then, the degree and direction of the activity of both kinds of traders is measured, and both are factored into an exchange rate determination model.

Gradually, the assumption concerning only two groups of traders is relaxed. Uninformed traders (e.g. the model by Glosten and Milgrom that shows the relationship between bid-ask spread and the activity of the uninformed traders could be used) are also incorporated into the model.

The model was tested using historical data from two different sources: the futures market on the Warsaw Stock Exchange and the Chicago Mercantile Exchange. The

main use of this model is to provide insight into how expectations concerning future spot rates are created. But, in anticipation of the empirical results, we also find that the model is a good predictor of future spot rates.

In our view the central parity rate should be based on the market-based forecast (such as the one provided in this paper). Implementing a pure fundamental equilibrium exchange rate (the rate that fosters the sustainable growth of the main economic factors), respectable as it sounds, is risky and hardly realistic, since its values are nowhere near the market rates. The central parity should be (in the spirit of behavioural theories) consistent with the rate representing a dynamic market equilibrium.

2   Related Research

How to determine the appropriate level of the fundamental rate has been a subject of many research papers – most of them unsuccessful. In 1982, Meese and Rogoff (Meese 1983) published a key paper showing that random walk predicts exchange rates movements better than macroeconomic models. The paper highlighted the poor performance of all models that had prevailed before 1982, including Dornbusch's overshooting model and the monetary models of Frankel and Mussa. Most of the monetary models had three components: money market equilibrium, interest rate parity and purchasing power parity. Later, in 2002 Cheung, Chinn and Pascual considered a wider range of models (including the portfolio models of Kouri and Branson (Branson 1985)) and proved again that none of them consistently outperformed the random walk in predictive power. Since then, it has become evident that fundamentals, except in the

long run, play very little role in explaining exchange rates movements (Food and Rose 1999, De Grauwe 2000).

Only recently have some new theories appeared. Researchers from the microstructure approach (Bacchetta 2003, Evans and Lyons 2001, Brunnermeier 2001, Lyons 2002) presented evidence that investor heterogeneity may be a critical driving force behind exchange rate fluctuations.

Another direction the general theory goes is the rejection of investors' rationality (Goodhart 1989, Gotthelf 2002). It is acknowledged that currency trading is dominated by technical analysis and liquidity traders. Hence, models based on the theory of chaos may be helpful in explaining some of the changes in exchange rates (De Grauwe 1993).

This paper's main idea is inspired by the microstructure approach. The authors believe that it is possible to identify pertinent groups of investors active in the futures market, gauge their contribution towards determining exchange rates, filter out the influence of irrelevant traders, and build a model that would generate an accurate informed traders' expectation-based prediction. The problem is that information about the market's microstructure, e.g. number of commercial and non-commercial traders, is often unavailable.

There is little literature that studies the futures market in order to find the fundamental exchange rate. So far, most of the researchers have tested whether forward rates are unbiased predictors of future spot rates and have drawn conclusions about currency market efficiency (Frankel 1981, Froot 1990). The studies have yielded conflicting

results, but most of them reject the efficient market hypothesis. Therefore, it is worth the effort to use resources to attempt to forecast exchange rates. Another approach can be found in Clarida and Taylor (Clarida 2001) who tried to prove the relevance of the forward rate term structure.

3 Fundamental Forward Rate Model

The review of the literature on the subject shows that fundamentals play little role in explaining exchange rate movements, except in the long run. The unpredictability of the changes in exchange rates in the short and medium run cannot be simply attributed to investors' irrationality. Rather, we should model the investors' behavior differently than it was done in classical monetary models. The futures market is ideal for observing various investors' expectations with regard to future exchange rates. Hence, the model that was built is based on an analysis of this market. The word "fundamental" in its name refers more to the kind of traders whose behaviour is analyzed than to macroeconomic factors.

First, it is essential to see how the prices are formed. Theoretical futures exchange rate is calculated as follows: (Hull 1998): $F(T,t) = S_t e^{(r_h - r_f)(T-t)}$. When the market futures rate diverges from the theoretical value, it would instantaneously lead to arbitrage-motivated trading and drive the futures rate to the value implied by interest rate parity. When doing realistic calculations, additional factors such as bid-ask spread, liquidity,

and political risk should be taken into consideration – however, this does not change the essence of the reasoning above.

Currency futures contracts are basically a hedging instrument, but they are not necessarily helpful in forecasting changes in future exchange rates (the underlying of the futures contract). The hypothesis that futures rates are the best unbiased predictors of future spot rates has not been confirmed (Frankel 1981, Froot 1990). The small forecasting power has little to do with the risk of investing in different currencies either. This is why some researchers (Clarida 2001) do not refer to the gap between forward premium and a difference between spot rates as a risk premium. Clarida and Taylor (Clarida 2001) remain "agnostics" when asked about the reasons for the divergence.

3.1 Structure of the Futures Traders

It is obvious that traders' behavior determines prices (Flood 1991). However, market participants appear to be using different models when predicting future rates. It was assumed that the futures market attracts two categories of price-relevant traders.

1. Arbitrageurs who try to profit from differences in spot and futures prices (without taking risk). Activity of the A group can be characterized by automatism, based strictly on interest rate parity. They simply start trading when the gap between the price of a futures contract and its theoretical value is large enough to make the arbitrage profitable.

2.   Traders who follow fundamental information. The F group includes all the other informed traders, including hedgers and speculators, but excluding those included in the A group.

In the situation when the futures value diverges from its theoretical value, it reflects on the one hand the expectations of the market participants with regard to future spot rates, while on the other hand the arbitrageurs' activity, which takes advantage of the divergence between current futures value and the value implied by interest rate parity. The F traders place orders that mirror fundamental premises; for instance they take positions meant to hedge currency risk exposure of their business activity. The A traders place orders motivated by interest rate parity-implied equilibrium rates. The purpose of the model developed in this paper is to find the fundamental exchange rate. In order to do so, it is necessary to trace the behavior of the F traders and sift out the irrelevant signals given by the A traders.

Let us follow an example of an order flow in the futures market. Initially, the futures rate equals its theoretical value. Suppose F traders are in the possession of information that the value of futures is too high compared to the future spot rate – as they perceive it (suppose PLN/EUR is the underlying). Consequently, they take short positions and the value of the futures falls. The gap between the futures and its theoretical value grows. At some stage of the process arbitrageurs intervene and take arbitrage motivated long positions in the futures. Simultaneously, they borrow EUR, convert it into PLN and deposit. As a result, spot PLN/EUR exchange rate falls. So does the futures value, as it

is contingent on the PLN/EUR spot rate. The gap between the futures and its theoretical value closes.

In some markets, unsolicited reports that incorporate information about their microstructure (Lyons 2002, O'Hara 1995) have appeared for some time, providing researchers as well as traders themselves with valuable data. Commitment of Traders Reports (Rockefeller 2002), published weekly since 1962 by Commodity Futures Trading Commission (www.cftc.gov/cftc/cftccotreports.htm), are an example. The traders are classified either as "commercials" or "non-commercials". All of a trader's reported futures positions in a commodity are classified as commercial if the trader uses futures contracts in that particular commodity for hedging. A trading entity generally gets classified as a "commercial" by filing a statement with the Commission that it is commercially engaged in business activities hedged by the use of the futures or options markets. Traders of both categories represent from 70 to 90% of the market. The others are called "nonreportable positions" and these are the traders who are only occasionally involved in trading.

Unfortunately, so far such reports have been published by commodity exchanges only (Chicago Board of Trade, MidAmerica Commodity Exchange, Kansas City Board of Trade, Minneapolis Grain Exchange, Chicago Mercantile Exchange, and New York Board of Trade). They are weekly reports that provide aggregate information. Still, it is an important tool that may be useful for predicting price changes. It also partly justifies the relevance of the division of traders used for this paper.

3.2 Fundamental Forward Rate Model

It may be useful at this point to summarize what has been learned. The main assumption of this paper is that the market forward rate is located between two values: the theoretical value (represented by the A traders) and the fundamental value (represented by the F traders). The main problem is how to measure the degree and direction of the activity of both kinds of traders. We hypothesized that how the forward rate diverges from its theoretical value may be an indication of the degree and direction (see the arrows below) of the activity of both kinds of traders.

There are two possible situations.

(1) $\quad F^{fund}(t,T) < F(t,T) < F^{teor}(t,T)$
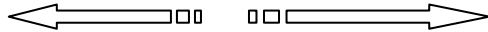
(2) $\quad F^{fund}(t,T) > F(t,T) > F^{teor}(t,T)$

The situation expressed by (1) means F traders expect that $S_T < F^{teor}(t,T)$. Simultaneously, the opposite force (2) suggests that $S_T > F^{teor}(t,T)$. In other words, the value of the forward rate that is lower than the theoretical one implies that the future spot rate will also be lower, and vice versa.

The formula (3) below is a natural consequence of this reasoning.

(3) $\quad F^{fund}(t,T) = F^{teor}(t,T) + a \times (F(t,T) - F^{teor}(t,T)) \times p$

where: a, p – (temporarily unknown) correctional values.

We hypothesized that the model (3) enabled us to determine the direction in which the future spot rates would change. The relationships (4) and (5) must be verified in order to prove that.

(4) $F(t,T) < F^{teor}(t,T) \Rightarrow S_T < F^{teor}(t,T)$

(5) $F(t,T) > F^{teor}(t,T) \Rightarrow S_T > F^{teor}(t,T)$.

If (4) and (5) were confirmed empirically, the model of exchange rate determination based on the relationship could be proposed.

The model was tested using historical data from two different sources. The first sample that was chosen included all PLN/EUR futures rates with one-month maturities traded on the Warsaw Stock Exchange between the years 1999 – 2003. The theoretical rates were calculated with WIBOR and EURO LIBOR 1M values. It appears that (4) and (5) have been proven accurate in 70% of the cases (see Table 1). In addition to this, correlation between $F(t,T) - F^{teor}(t,T)$ and $S_T - F^{teor}(t,T)$ was found to be significant (30%). This may indicate that not only the direction but also the extent to which the two forces affect the futures rate could be extracted from the data.

The Polish futures market is not extremely liquid. Hence, there was a need to test the hypothesis elsewhere. Another round of research was conducted with Euro FX futures contracts traded on the Chicago Mercantile Exchange. This is where the first currency futures contracts were introduced in 1972. Similarly, (4) and (5) hypothesis were tested, the main question being whether the futures rate and the future spot rate diverge from

the theoretical futures value in the same direction. This time positive results, meaning that (4) or (5) do work, stipulate 64% of the cases.

The results of the tests were promising and the main hypothesis has been confirmed. However, it is easy to notice that $F(t,T) - F^{teor}(t,T)$ values do not change proportionally to $S_T - F^{teor}(t,T)$ values. The relationship between the two is clearly non-linear. Besides, the linear model could generate negative values of the forward rates. This observation paves the way for a new version of the model (3) as shown in (6).

(6) $\qquad F^{fund}(t,T) = F^{teor}(t,T) + a \times \mathrm{sgn}(F(t,T) - F^{teor}(t,T)) \times \left| F(t,T) - F^{teor}(t,T) \right|^{q}$

3.3 Calibration of the Model

Parameters *a, q* were calibrated by maximizing the correlation between $F(t,T) - F^{teor}(t,T)$ and $F(t,T) - S_T$. Simultaneously, the $F^{fund}(t,T) - S_T$ difference is minimized. The parameters take the following values: $a = 0{,}11$, $q = 200$. Figure 1 illustrates the quality of the "prediction" shown as the difference in errors: $F(t,T) - S_T$ and $F^{fund}(t,T) - S_T$. Please note that it is not yet a realistic estimate of futures spot rates. The parameters were estimated *ex post* on historical data. The only purpose this procedure served is to initially calibrate the model.
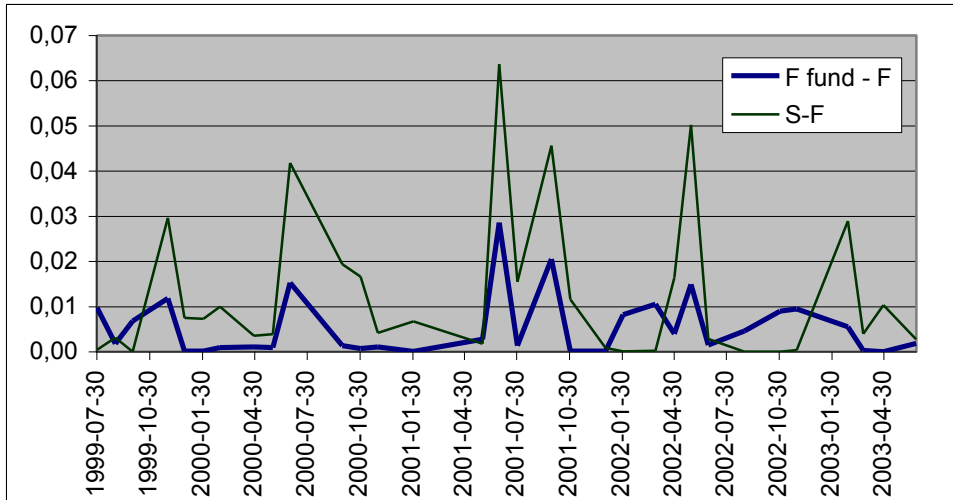
Figure 1: Prediction errors generated by FFR model (initially calibrated) and futures rate

Another figure (Figure 2), in which $S_T - F^{teor}(t,T)$, $F(t,T) - F^{teor}(t,T)$ and $F^{fund}(t,T) - F^{teor}(t,T)$ series are compared, also speaks volumes about the quality of the model. Please note that the correlation between $S_T - F^{teor}(t,T)$ and $F^{fund}(t,T) - F^{teor}(t,T)$ is now 65%, compared with the previous 30% correlation between $S_T - F^{teor}(t,T)$ and $F(t,T) - F^{teor}(t,T)$.
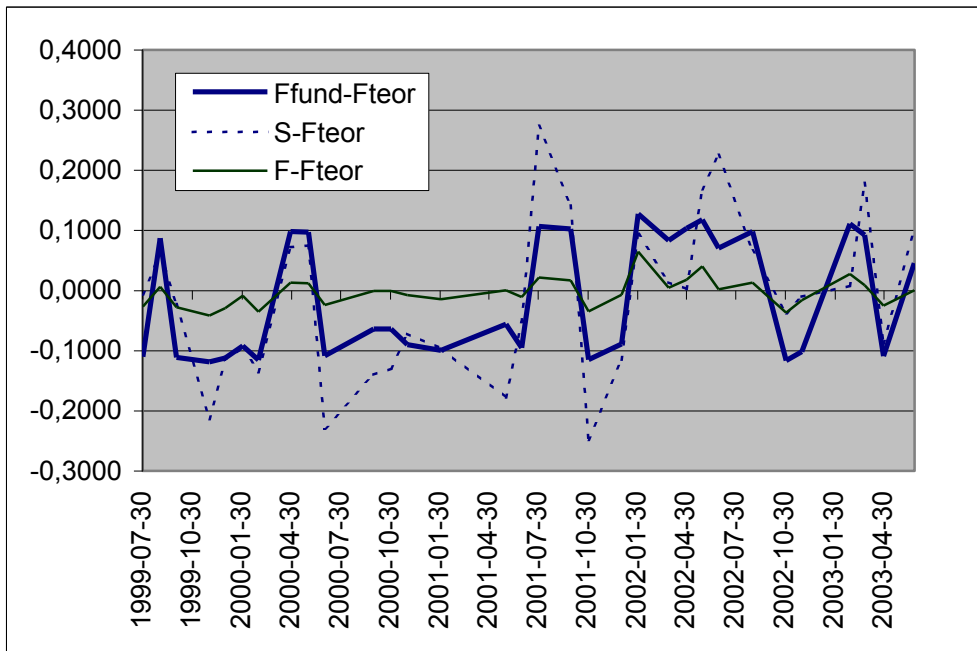
Figure 2: Quality of the model – comparison of $S_T - F^{teor}(t,T)$, $F(t,T) - F^{teor}(t,T)$ and $F^{fund}(t,T) - F^{teor}(t,T)$ series.

4 Predictive Power of the Model – Statistical Tests

The model can be used to predict the values of fundamental forward rates and indirectly the future spot rates as well. Yet, it has to be emphasized that the calculations are based on information available at time *t*. It is natural that new information arriving in the period *(T-t)* may gradually change the prediction.

The model was calibrated on three-year data sequences, starting July 1999. The parameters determined after each calibration complement the model which is then ready to generate one forecast. Then the model was calibrated again on another set of data. It is a typical one step prediction (with a one month horizon). For example, prediction for

25 January 2002 spot rate is given by (6). The parameters have been calibrated on historical data. $F^{fund}(t,T) = 3,5456 + 0,12 \times (|3,61 - 3,5456|)^{(1/200)} = 3,66$ The value of the theoretical forward rate (on 31 December 2001) is 3.5456 since 1M Wibor and Euro Libor were 0.1208 and 0.0333 respectively and the spot rate on this day was 3.52. The actual spot rate (on 25 January 2002) was 3.64 (compare it to the prediction of 3.66).

As seen in Figure 3, the values generated by the model (F^{fund}) are good predictions of future spot rates.
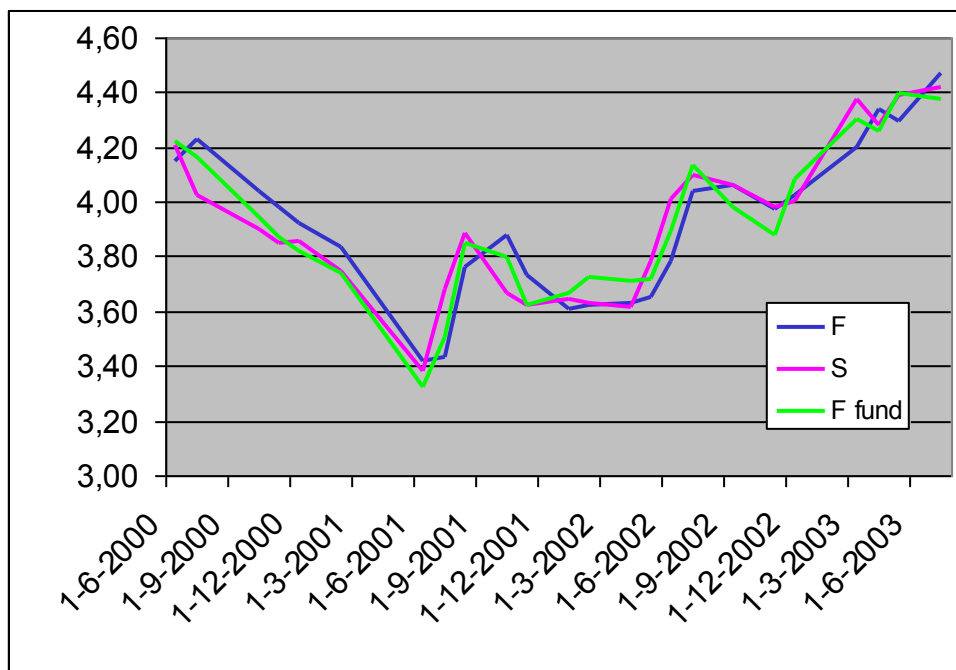

Figure 3:   Prediction of the future spot PLN/EUR rate generated by FFR model

The predictive power and quality of the model were verified *via* a series of statistical tests. Predictions generated by the model were compared with relevant spot rates $(F^{fund}(t,T) - S_T)$. Two benchmarks were used for comparison: futures rates $(F(t,T) - S_T)$ and the prediction generated by neural network (NeuroSolutions software by Neuro Dimensions was used for the tests). The prediction was generated by Multilayer Perceptron (MLP) model.) $(F^{nn}(t,T) - S_T)$.

First, mean absolute errors were compared. The measure is defined as (Makradakis 1998):

$$MAE = \frac{\sum_{i=1}^{n} | F_i^{fund}(t,T) - S_{T,i} |}{n}$$

MAE consistently appeared to be the lowest for predictions generated by the model when compared to the benchmarks. Non-parametric Wilcoxon test was used to determine whether the differences in forecasting errors were significant. For example, the two series ($F^{fund}(t,T) - S_T$ and $F(t,T) - S_T$) were compared, and the following hypothesis was verified:

H_0: $(F(t,T) - S_T) \le (F^{fund}(t,T) - S_T)$

H_1: $(F(t,T) - S_T) > (F^{fund}(t,T) - S_T)$.

According to the Wilcoxon test, the zero hypothesis was rejected at a 99% confidence level.

Additionally, the $\pm 2{,}25\%$ band allowed by ERM II is another benchmark – 71% of the values generated by the model fell into this band. In general, the values generated by the model were significantly better than all the other benchmark values.

The tests above refer to the model (6). The authors arrived at the version of the model assuming that there are two relevant groups of investors. Gradually, the assumption concerning only two groups of traders was relaxed. Uninformed traders were also incorporated into the model. Their activity is often considered "noise", and their trades cancelled each other out. Still, their presence increases the risk and volatility of exchange rates.

Finally, the Fundamental Forward Rate model has two components. The predicted values of the exchange rate lie between the $F_+^{fund}(t,T)$ and $F_-^{fund}(t,T)$ (see the two equations below).

$$F_+^{fund}(t,T) = F^{teor}(t,T) + a \times \mathrm{sgn}(F(t,T) - F^{teor}(t,T)) \times \left| F(t,T) - F^{teor}(t,T) \right|^{q} \times (1+\eta),$$

$$F_-^{fund}(t,T) = F^{teor}(t,T) + a \times \mathrm{sgn}(F(t,T) - F^{teor}(t,T)) \times \left| F(t,T) - F^{teor}(t,T) \right|^{q} \times (1-\eta),$$

where η represents the number of uninformed traders. The prediction generated by the model is rarely one number, more often it is a range of values lying within a certain band. The width of the band depends on the informed traders' activity. A major difficulty, however, lies in how to recognize informed traders. The information can be derived from either publicly available Commitment of Traders Reports or an analysis of the bid-ask spread (the model by Glosten and Milgrom that shows the relationship between bid-ask spread and the activity of the uninformed traders could be used).

5 Conclusions

The Fundamental Forward Rate model that has been presented in this paper is based on an analysis of the futures market. However, as it has been proven many times, the futures exchange rate itself is not a good predictor of future spot rates. A micro-structural analysis of the market leads to the conclusion that participants of the market are heterogeneous; there are two predominant forces and two groups of informed traders that create the greatest impact on the prices of futures contracts: arbitrageurs and fundamental traders. The former act automatically driven by interest rate parity, but the activity of the latter group can be an indication of how future spot rates will change. By measuring how far the futures rate diverges from its theoretical value, the tension between the two forces can be shown. The model, based on the assumptions provided and empirical research, enables the prediction of future spot rates more precisely than the benchmarks that have been used for comparison so far.

This paper, however, should be considered only a small step in a promising line of research. First, it is an adaptive model which relies on historical data. In order to obtain more realistic rates some other method of calibrating data must be found. Besides, a lot of the information indispensable to feed the model (data on categories of traders) is still publicly unavailable. And yet, the model provides a valuable insight into how expectations with regard to future spot rates are formed in the futures market.

The research may also be of some use to countries (e.g. CEEC-10) that face joining the

Euro zone and setting a central rate against the Euro.

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