## MAREK RACZKO

# The Term Structure of Forward Premiums. Can They Be Used for Understanding of Transition Economy Exchange Rate?

### Abstract

*The problem of forecasting exchange rate is apparent in economic literature since Meese and Rogoff (1983). Clarida and Taylor (1997) show that it is possible to beat the random walk forecast by the usage of VECM that uses term structure of forward premiums. This paper tries to use this type of model for forecasting of Zloty / Sterling exchange rate. It finds that the original model does not fit the exchange rate of transition economy due to the fact of non stationary deviations form Risk Neutral Efficient Market Hypothesis. The paper presents the addition of long term interest rate differential as a remedy for non-stationary deviation problem. The conclusion from the model is that the model of the term structure of forward premiums cannot totally outperform random walk in an out-of-sample forecast of Zloty / Sterling exchange rate.*

### Introduction

The aim of this project is to build a vector error correction model which accommodates the rejection of the efficient market hypothesis but still permits forward premiums to carry information relevant to future spot rate changes. According to this hypothesis the forward (or futures) price of an asset should equal the expected value of that asset's spot price in the future. However there is now plenty of evidence in the literature supporting the rejection of this simple form of the efficient market hypothesis.

Meese and Rogoff (1983) have shown that the random walk model performs at least as good as univariate time series model, an unconstrained vector autoregression or structural models, in forecasting exchange rates in an out-of-sample fit. Models based on fundamentals are still unable to describe exchange rate volatility so they cannot be used for forecasting. Nonetheless, Clarida and Taylor (1997) have discovered that it is possible to beat the random walk in an out of sample forecast, buy using information contained in forward premiums. This paper aims at analyzing term structure of spot and forward exchange rates. The key difference is that an analogical model is used for forecasting based on a short span of data from a transition economy – Polish economy.

## Theoretical Framework

It is common knowledge in the field of finance that the nominal spot exchange rates among the currencies of the major industrialized countries are well described by random walk process.

A unit root process is a generalization of the random walk process.The key difference is that a unit root process may have higher autoregressive properties than a pure random walk which is autoregressive of order one. However, both these processes do not have a constant mean and finite variance but their first differences are covariance stationary.

Beveridge and Nelson (1981) and Stock and Watson (1988) have proven that any unit root process can be decomposed into the sum of a pure random walk model and a stationary process. Clarida and Taylor (1997) have used this result in their paper and I also follow the same approach. In fact, the methodology used in my paper is essentially derived from their analysis of spot and forward exchange rates.

We can write spot exchange rate as:

$$s_t = m_t + q_t$$

where $s_t$ is the logarithm of the spot exchange rate at time t, $m_t$ is the random walk process with drift $\theta$ and $q_t$ is the stationary process with zero mean.

Next we allow for general departures from the risk neutral efficient market hypothesis:

$$\gamma_t^{(k)} \text{ § } f_t^{(k)} - E(s_{t+k} \mid \Omega_t)$$

where $\gamma_t^{(k)}$ is the deviation from RNEMH at time t, $f_t^{(k)}$ is the logarithm of the k-period forward rate at time t, $E(s_{t+k} \mid \Omega)$ is expectation of $s_{t+k}$ based on the information set $\Omega_t$ at time t. These departures exist either due to the presence of risk premia or owing to the failure of rational expectations or both.

From equation (1.1) and (1.2) we create a formula describing k period forward exchange rate at time t:

$$f_t^{(k)} = \gamma_t^{(k)} + k\theta + E_t(q_{t+k} \mid \Omega_t) + m_t$$

The final step is to subtract from . This gives us a formulation for the forward premium rate at time t:

$$f_t^{(k)} - s_t = \gamma_t^{(k)} + k\theta + E_t(q_{t+k} - q_t \mid \Omega_t)$$

The above equation indicates that as long as $\gamma_t$ is stationary there exists a cointegrating relationship between the forward and the spot rates. It is caused by elimination of nonstationary component $m_t$ in equation .

Let us consider a vector:

$$\mathbf{y} = [s_t, f_t^{(1)}, f_t^{(2)}, ..., f_t^{(j)}]$$

It follows from the discussion above that the spot and forward rates contained in vector $\mathbf{y}$ must be cointegrated with j unique cointegrating vectors.

Now let us consider the case where $\gamma_t^{(k)}$ possesses a unit root. Firstly we should be able to reject the hypothesis that each of the k forward premiums $f_t^{(k)} - s_t$ is stationary. Secondly, among the j+1 variables in the system there will be two common stochastic trends unless the trends from $\gamma_t^{(k)}$ and from $m_t$ are proportional to one another. This also implies that there will be j-1 cointegrating vectors.

## Data description

Data consisted of 210 observations on weakly spot and 4-, 9-, 13-, 26-, and 39- week forward Polish Zloty to Sterling Exchange rates. The sample runs from 15th February 2002 to 17th February 2006. The data is sourced form Data Stream and Data Stream obtained the data from Reuters service. For estimation purposes the first 180 observations were used hence 30 observations were left to generate an out of sample forecast. The data was converted into a logarithmic form.

The full names of each variable along with their short hands are given in Table 1. The graphs indicate that the spot and forward rates move together, this implies that probably they exhibit a common stochastic trend therefore probably

**Table 1. Variables description**

| Variable shorthand | Variable name |
|---|---|
| LPOLZLOT | Polish zloty to UK £ - exchange rate |
| LUKPLN1F | 4 weeks forward of exchange rate of polish zloty to UK £ |
| LUKPLN2F | 9 weeks forward of exchange rate of polish zloty to UK £ |
| LUKPLN3F | 13 weeks forward of exchange rate of polish zloty to UK £ |
| LUKPLN6F | 26 weeks forward of exchange rate of polish zloty to UK £ |
| LUKPLN9F | 39 weeks forward of exchange rate of polish zloty to UK £ |

Preliminary unit-root testing was conducted using ADF tests. Lag length was automatically selected based on Schwartz Information Criteria. Summary of the test results are presented in Table 2. Results showed that the spot and all forward rates are I(1). This is consistent with expectations towards the data formulated in theoretical section.

**Table 2. Unit root testing**

| Tested series | $H_0$:X~I(1) | | $H_0$:X~I(2) | | Conclusion |
|---|---|---|---|---|---|
| | ADF test statatisitic | 5% critical value | ADF test statatisitic | 5% critical value | |
| LPOLZLOT | -1.333340 | -3.431471 | -13.98979 | -3.431471 | I(1) |
| LUKPLN1F | -1.336539 | -3.431471 | -14.00204 | -3.431471 | I(1) |
| LUKPLN2F | -1.335053 | -3.431471 | -14.01335 | -3.431471 | I(1) |
| LUKPLN3F | -1.330139 | -3.431471 | -13.99844 | -3.431471 | I(1) |
| LUKPLN6F | -1.326594 | -3.431471 | -13.93347 | -3.431471 | I(1) |
| LUKPLN9F | -1.316225 | -3.431471 | -13.85703 | -3.431471 | I(1) |

Theory assumes that deviations from RNEMH follows stationary process. This assumption cannot be tested directly, but I can test whether forward premiums are stationary. Equation  shows that if deviations from RNEMH are stationary than forward premiums have to be stationary too. It seems obvious that I can use standard ADF test to test for stationarity of the forward premium. This is due to the fact that the cointegrating vector is calibrated with vector [1,-1] rather than estimated. However Zivot (1999) criticizes such an approach as a one that put too much binding restrictions.  That is why I present both critical values in Table 3.

**Table 3. Unit root testing**

| Tested series | $H_0$:X~I(1) | | | Conclusion |
|---|---|---|---|---|
| | ADF test statistic | 5% critical value | 5% critical value – Mac Kinon | |
| LUKPLN1F- LPOLZLOT | -1.487472 | -3.431576 | -3.43299 | Non-stationary |
| LUKPLN2F- LPOLZLOT | -2.065088 | -3.431471 | -3.43299 | Non-stationary |
| LUKPLN3F- LPOLZLOT | -2.308924 | -3.431471 | -3.43299 | Non-stationary |
| LUKPLN6F- LPOLZLOT | -2.159053 | -3.431471 | -3.43299 | Non-stationary |
| LUKPLN9F- LPOLZLOT | -2.134326 | -3.431471 | -3.43299 | Non-stationary |

Test shows that all forward premiums are generated by non-stationary processes. This is in contradiction with the findings of Clarida and Taylor (1997), but consistent with findings of Evans and Lewis (1995). The consequence of non stationarity of forward premiums will be a finding of j-1 of cointegrating vectors (such result is shown in Table 4 and Table 5).

**Table 4. Number of cointegrating vectors in the system due to Trace test**

| Hypothesized No. of CE(s) | Eigenvalue | Trace Statistic | 5% Critical Value | 1% Critical Value |
|---|---|---|---|---|
| At most 3 * | 0.137213 | 35.18107 | 29.68 | 35.65 |
| At most 4 | 0.046349 | 9.353363 | 15.41 | 20.04 |

**Table 5. Number of cointegrating vectors in the system due to Max-Eigen test**

| Hypothesized No. of CE(s) | Eigenvalue | Max-Eigen Statistic | 5% Critical Value | 1% Critical Value |
|---|---|---|---|---|
| At most 3 ** | 0.137213 | 25.82771 | 20.97 | 25.52 |
| At most 4 | 0.046349 | 8.305149 | 14.07 | 18.63 |

Non stationarity of forward premiums indicates that deviations form RNEMH are also non stationary. I can explain this nonstationarity by following reasons:

- the deviations are very persistent and short span of data causes the test to indicate nonstationarity;

- there are many structural breaks in a data set – for example due to political reasons;
- risk premiums for Poland may be driven by non stationary process.

Personally I believe that risk premiums might be driven by nonstationary process as we are inspecting a transition economy. To support my believes I created a proxy that could present a country risk of polish economy. As a measurement of such a risk I took a difference between Poland's and England's 3 month inter bank interest rate. This may also be interpreted in terms of Covered Interest Parity which states that forward premiums should be equal to interest rates differential. As shown in Table 6 difference in interest rate is a variable generated by a unit root process. Moreover Graphical analysis allows us to suspect that it is cointegrated with forward premiums. The hypothesis about cointegration will be verified in the next section.

**Table 6. Unit root testing**

| Variable shorthand | Variable description | $H_0$:X~I(1) | | $H_0$:X~I(2) | | Conclusion |
|---|---|---|---|---|---|---|
| | | ADF test statistic | 5% critical value | ADF test statistic | 5% critical value | |
| Riskp | | -2.700733 | -3.431471 | -14.67748 | -3.431576 | I(1) |

Generally data used in an empirical verification of a established theory yields results which are consistent with that theory. One advantage of my data is the fact that it is taken from one database hence it is coherent. Unfortunately the span of my data is very short and exchange rates and related variables usually have some persistent futures.

## Econometric theory – Johansen procedure and Vector Error Correction Model

Theory presented in section II and empirical material presented in section III suggest that the econometric analysis will be based on the Vector Error Correction Model (VECM).

Consider $\mathbf{y_t}$ to be a vector of n variables. Then p-th order Vector Autoregresive (VAR) can be written:

$$\mathbf{y}_t = \mathbf{A}_1\mathbf{y}_{t-1} + \mathbf{A}_2\mathbf{y}_{t-2} + ... + \mathbf{A}_p\mathbf{y}_{t-p} + \varepsilon_t$$

System can be re-written in a first difference form:

$$\Delta \mathbf{y}_t = \Pi \mathbf{y}_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta \mathbf{y}_{t-i}$$

$$\text{where: } \Pi = \sum_{i=1}^{p} \mathbf{A}_i - \mathbf{I} \text{ and } \Gamma_i = -\sum_{j=i+1}^{p} \mathbf{A}_j$$

System is known as VECM. The rank of $\Pi$ indicates the number of distinctive cointegrating vectors. There are to border solution: first, when rank( $\Pi$ )=0 then there are no cointegrating vectors hence model becomes VAR in first differences; second, when rank( $\Pi$ )=n then there are as many cointegrating relationships as variables so each variable is stationary, hence it is possible to reduce the model to usual level VAR. In the intermediate cases there are from 1 to n-1 cointegrating vectors.

In order to determine the rank of $\Pi$ we use a common fact that the rank has to be equal to the number of characteristic roots that are different from 0. As we just have an estimates of $\Pi$ matrix, we have to test whether characteristic roots are statistically significant. In order to do that we use two tests.

Trace test tests null hypothesis that the number of cointegrating vectors is less or equal to r against a general alternative using following statistic:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i)$$

where: $\hat{\lambda}_i$ - the estimated values of characteristic roots, T – the number of usable observations.

Maximum eigenvalue test tests the null that the number of cointegrating vectors is r against the alternative r+1 cointegrating vectors, using following statistic:

$$\lambda_{\max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1})$$

Because of the construction of the alternative hypothesis maximum eigenvalue test is perceived as a little bit more powerful.

Finding of the number of cointegration relationships between 1 and n-1 enables us to factor $\Pi$ matrix into the product of two $n \times r$ matrices $\alpha$ and $\beta$ such that:

$$\Pi = \alpha \beta '$$

where $\beta '$ is the matrix of the systems r cointegrating vectors and $\alpha$ is the matrix of r adjustment coefficients.

Tests for finding the number of cointegrating vector are not very strong, they are not resistant to structural breaks. It is also unknown how the test will react to nonlinearities in the data, which are common among financial variables. It may seem that they will underestimate the number of cointegrating vector. On a contrary Monte Carlo experiments prove that tests tends to over estimate the number of cointegrating relations (see Reimers 1992).

## Core Econometric Model

First part of econometric investigation focuses on the construction of a vector error correction model (VECM). Let me denote vector of system's variables:

$$\mathbf{y} = [LPOLZLOT_t, LUKPLN1F_t, LUKPLN2F_t, LUKPLN3F_t, \\ LUKPLN6F_t, LUKPLN9F_t, RISKP_t]'$$

This vector corresponds to vector , but it has one more variable which is $RISKP_t$. As mentioned before this variable was added, because forward premiums were non stationary. I estimated the model based on system without $RISKP_t$, but as predicted by the theory the number of distinct cointegrating vectors found by Johansen procedure was 4. This confirms the finding that forward premiums are not stationary.

The first step in construction of VECM was to choose the correct number of lags in the basic Vector Autoregresion (VAR) and then to apply Johansen procedure to find the number of cointegrating vectors (Paterson (2000)). Akaike, Schwarz and Hannan-Quinn information criteria indicated that inclusion of one lag is necessary. Nonetheless I decided to include 4 lags as suggested by likelihood ratio testing. In my opinion 4 lags have economic interpretation, because of two reasons:

- There may be a group of economic agents who make they decisions based on monthly data.
- Polish ministry of finance issues once a month 5 and 10 year to maturity bonds which are mainly bought buy foreign investors. As polish market is not very deep it may cause some distortions.

The Lagrangean Multipliers test for autocorrelation did not rejected the null hypothesis about lack of autocorrelation. The results for lag length criteria and for LM test are available in Table 7 and Table 8, respectively.

**Table 7. VAR lag order selection criteria**

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | 5985.500 | NA | 1.52E-39 | -69.51744 | -69.38934 | -69.46547 |
| 1 | 6899.439 | 1742.861 | 6.52E-44* | -79.57487* | -78.55010* | -79.15910* |
| 2 | 6932.258 | 59.91364 | 7.89E-44 | -79.38672 | -77.46528 | -78.60714 |
| 3 | 6960.112 | 48.58259 | 1.02E-43 | -79.14084 | -76.32273 | -77.99746 |
| 4 | 7004.578 | 73.93853* | 1.08E-43 | -79.08812 | -75.37334 | -77.58094 |
| 5 | 7043.627 | 61.75072 | 1.24E-43 | -78.97240 | -74.36096 | -77.10142 |

**Table 8. VAR residual serial correlation**

| Lags | LM-statistic | Probability |
|---|---|---|
| 4 | 63.21775 | 0.0834 |

The next step is the Johansen procedure. I allowed for a constant in the cointegrating vectors, because there might be a need of a scaling factor as there is also RISKPt variable. Moreover I also allowed for a deterministic trend in the data just to allow more general version of the model. Results of maximum eigenvalue test and trace test are shown in . At 5% critical values both tests shows that there exists 5 distinct cointegrating vectors what is consistent with theoretical assumption.

**Table 9. Johansen procedure test for number of cointegraing vectors**

| Trace test | | | | Max - eigenvalue test | | | |
|---|---|---|---|---|---|---|---|
| Hypothesized No. of CE(s) | Eigenvalue | Trace Statistic | 5 Percent Critical Value | Hypothesized No. of CE(s) | Eigenvalue | Max-Eigen Statistic | 5 Percent Critical Value |
| At most 3 ** | 0.170868 | 65.52683 | 47.21 | At most 3 ** | 0.170868 | 32.79085 | 27.07 |
| At most 4 * | 0.123658 | 32.73598 | 29.68 | At most 4 * | 0.123658 | 23.09974 | 20.97 |
| At most 5 | 0.048121 | 9.636240 | 15.41 | At most 5 | 0.048121 | 8.630566 | 14.07 |

Theory also predicts that the basis for the space of cointegration relationships is defined by risk premiums. In this model it cannot be true because RNEMH deviations were not stationary, I still may verify whether each cointegrating relationship comprises of one forward premium and interest difference (RISKPt). In order to do that I put normalizing restrictions on cointegrating equations so that one forward rate is in each equation. In the next step I put additional restrictions to set the coefficients standing next to spot rate equal to 1. Assuming that there are 5 cointegrating relationships in the system, likelihood ratio test indicates that we cannot reject the hypothesis that restrictions are not binding. The results of the test and cointegrating relationships are presented in Table 10. The coefficient standing next to RISKP variable in cointegrating vector are consistent with Covered Interest Parity and with our prediction that they may indicate the country risk. This is also confirmed by a rise in that parameter in subsequent cointegrating vector due to the fact that forward with longer horizon has higher risk premiums.

**Table 10. Restriction testing and estimates of cointegrating vectors**

| Hypothesized No. of CE(s) | Restricted Log-likehood | LR Statistics | Degrees of Freedom | Probability |
|---|---|---|---|---|
| 5 | 7148.793 | 4.671130 | 5 | 0.457318 |
| 6 | 7155.444 | NA | NA | NA |

NA indicates restriction not binding.

**Table 11. All 5 cointegrating equations with restrictions**

| | Restricted cointegrating coefficients (std.err. in parentheses) | | | | | | |
|---|---|---|---|---|---|---|---|
| Number of cointegrating equations | LPOLZ LOT | LUKPL N1F | LUKPL N2F | LUKPL N3F | LUKPL N6F | LUKPL N9F | RISKP |
| CE1 | 1.0000 | -1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0008 |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (1.5E-05) |
| CE2 | 1.0000 | 0.0000 | -1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.001705 |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (1.5E-05) |
| CE3 | 1.0000 | 0.0000 | 0.0000 | -1.0000 | 0.0000 | 0.0000 | 0.0025 |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (1.1E-05) |
| CE4 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | -1.0000 | 0.0000 | 0.004771 |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (8.4E-05) |
| CE5 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -1.0000 | 0.006762 |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0002) |

Findings of Johansen procedure indicates that model should be well represented by VECM. Full information maximum likelihood estimates of VECM are shown in Appendix 4.

Before I comment on the results of VECM estimation I would like to write about two additional tests. First showed that the model is homoskedastic. Second indicated that residuals are not normally distributed (see Table 12). This result is not strange, in models based on financial data it is a common feature that due to outliers in sample residuals are not normally distributed. Nonetheless this fact should be kept in mind when interpreting statistics that are based on assumption of normally distributed errors, for example t statistics.

**Table 12. Heteroskedasticity and Normality Tests**

| White Heteroskedastisity Test | | Multivariate Normality Test | |
|---|---|---|---|
| Chi-sq | 1797.666 | Jarque-Bera | 31.64003 |
| Probability | 0.7952 | Probability | 0.0045 |

The key estimation of VECM are parameters standing next to cointegrating vectors (see Table 13). They should indicate weather there is a correction mechanism. Findings of my model contradicts correction mechanism as there is just one negative coefficient. This is also in contradiction to Clarida and Taylor (1997) were they do find an error correction mechanism in all cointegrating vector. It might be caused by the fact that in my model cointegrating vectors indicate more deviations from CIP not deviations from forward premiums.

**Table 13. Estimates of the adjustment coefficients**

| Correction Error | D(LPOLZLOT | D(LUKPLN1F | D(LUKPLN2F | D(LUKPLN3F | D(LUKPLN6F | D(LUKPLN9F) | D(RISKP) |
|---|---|---|---|---|---|---|---|
| CointEq1 | 15.75610 | 16.84244 | 16.11369 | 16.11259 | 17.29392 | 17.44639 | 137.7402 |
| | (21.9874) | (22.0013) | (22.0360) | (22.0545) | (22.2090) | (22.3860) | (185.148) |
| | [ 0.71660] | [ 0.76552] | [ 0.73124] | [ 0.73058] | [ 0.77869] | [ 0.77934] | [0.74395] |
| CointEq2 | -10.37038 | -10.52077 | -9.762287 | -10.59596 | -11.24379 | -11.39387 | 28.35946 |
| | (15.6636) | (15.6735) | (15.6982) | (15.7114) | (15.8215) | (15.9476) | (131.897) |
| | [-0.66207] | [-0.67125] | [-0.62187] | [-0.67441] | [-0.71067] | [-0.71446] | [0.21501] |

**Table 13. Estimates of the adjustment coefficients - continuation**

| Error Correction | D(LPOLZLOTI) | D(LUKPLN1F) | D(LUKPLN2F) | D(LUKPLN3F) | D(LUKPLN6F) | D(LUKPLN9F) | D(RISKP) |
|---|---|---|---|---|---|---|---|
| CointEq3 | 13.11837 | 12.81374 | 12.71486 | 13.68605 | 13.05691 | 13.19509 | -249.8018 |
| | (21.3736) | (21.3870) | (21.4208) | (21.4388) | (21.5890) | (21.7610) | (179.979) |
| | [ 0.61377] | [ 0.59914] | [ 0.59357] | [ 0.63838] | [ 0.60480] | [ 0.60636] | [-1.38795] |
| CointEq4 | 4.008786 | 4.106352 | 4.236356 | 4.147117 | 5.250656 | 5.393795 | 75.70438 |
| | (11.4518) | (11.4590) | (11.4771) | (11.4868) | (11.5672) | (11.6594) | (96.4314) |
| | [ 0.35006] | [ 0.35835] | [ 0.36911] | [ 0.36103] | [ 0.45393] | [ 0.46261] | [ 0.78506] |
| CointEq5 | 0.852649 | 0.863244 | 0.794513 | 0.760137 | 0.364682 | 0.304321 | -34.91302 |
| | (3.88332) | (3.88576) | (3.89190) | (3.89517) | (3.92245) | (3.95371) | (32.6999) |
| | [ 0.21957] | [ 0.22216] | [ 0.20415] | [ 0.19515] | [ 0.09297] | [ 0.07697] | [-1.06768] |

One of the most interesting hypothesis is whether spot exchange rate is not weakly exogenous with respect to lagged information contained in the coinegrating vectors. I test this hypothesis by putting additional "zero" restrictions on adjustment coefficient in equation determining spot rate. Additional restrictions are still not binding, that means that in this model "corrected" forward premiums do not bring any additional information to spot rate (see Table 14).

**Table 14. Restriction testing**

| Restrictions identify all cointegrating vectors | |
|---|---|
| LR test for binding restrictions (rank = 5): | |
| Chi-square(10) | 17.65603 |
| Probability | 0.061051 |

## Forecast

Although the tests showed that the equation for spot exchange rate is not dependent on founded long run relationships. I will still do basic forecast just to check how big the forecast error is. The forecast is based on dynamic deterministic simulation and is compared to a naïve forecast. Comparison of two basic indicators is presented in Table 15.

**Table 15. Forecast errors**

| | | 4-week horizon | 13-week horizon | 26-week horizon | 31-week horizon |
|---|---|---|---|---|---|
| MAE | VECM | 0,0205 | 0,0287 | 0,0325 | 0,0370 |
| | naive random walk | 0,0200 | 0,0321 | 0,0398 | 0,0459 |
| RMSE | VECM | 0,0215 | 0,0318 | 0,0367 | 0,0416 |
| | naive random walk | 0,0206 | 0,0357 | 0,0451 | 0,0519 |

As we can see only in 4 week horizon naïve forecast does better. In a longer horizon VECM does better although as shown by the graph it is still not good.

## Possible improvements

Below are presented hints how can the model be developed in future. Firstly there is a question of why the forward premiums are not stationary. His topic should be inspected from several points, for instance whether the underlying process of forward premiums is nonlinear, or try to include many structurl breaks. Another conceptis to compare this process to other generated in economies of countries from the region.

Secondly, if the forward premiums is really driven by a non stationary process, so maybe other proxies then intrest rate differentials should be tried out.

Thirdly, more modern analysis of the topic is done by Clarida, Sarno, Taylor and Valente (2002). They use a Markov Switching mechanism to allow for regime change. This kind of analysis is very successful in their paper, so it may also bring many insights to this one. However this method requires large sample sets, so it cannot be applied to our example.

Another point would be to put additional restrictions on VECM so that some of statistically irrelevant variables would be eliminated from the model. In this sense one should also try to use a different procedure for lag and number of cointegrating vector selection. Paterson suggest a method when the choice of lags and number of cointegrating vectors can be chosen simultaneously.

The last group of improvements should be done in the forecasting section. Actually this section should be done form the basis. In this project it was not done in depth because of problems with underlying model. A good forecasting part would include statistical evaluation of differences in few forecasts based for example on VAR, VECM, pure random walk and some technical analysis methods. It would also be good to make a density forecast by implementing the concept of bootstrapping.

## Conclusions

The main aim of the paper was to replicate the forward term structure forecasting model in the environment of transition economy. The simple replication failed in the early stage of assumptions about the key variables. Nonetheless there was a proxy variable introduced and the model was actually based not on deviations from risk neutral effective market hypothesis but from covered interest parity. The cointegration analysis was coherent with assumptions. Unfortunately VECM presented estimates of adjustment coefficients that had signs opposite to expected. Moreover it was proved that deviation from long run equilibria have no impact on key variable – spot rate. Because of all of those problems it is surprising that model is giving slightly better forecasts than Meese and Rogoff random walk benchmark. In fact forecast comparisons should not be taken into consideration as the underlying model was wrong and as there was no statistical evaluation of the forecast.

## Bibliography

Stephen Beveridge and Charles R. Nelson, "A New Approach to Decomposition of Economic Time Series Into Permanent and Transitory Components with Particular Attention to Measurement of the "Business Cycle"", Journal of Monetary Economics, Volume 7, Issue 2, pp. 151-174, 1981.

Richard H. Clarida and Mark P. Taylor, "The Term Structure of Foreward Exchange Premiums and the Forecastability of Spot Exchange Rates: Correcting the Errors", The Review of Economics and Statistics, Vol. LXXIX, August 1997/3.

Richard H. Clarida, Lucio Sarno, Mark P. Taylor and Giorgio Valente, "The Out-of-Sample of Term Structure Models as Exchange Rate Predictors: A step Beyond" Journal of International Economics, 60(1), pp. 61-83, 2003.

Walter Enders, "Applied Econometric Time Series" Hoboken, NJ:Wiley, 2004.

Martin D. Evans and Karen K. Lewis, "Do Long-Term Swings in the Dollar Affect estimates of Premia?" Review of Financial Studies, 8, pp. 709-724, 1995.

Richard Meese and Kenneth Rogoff, "Empirical Exchange Rate Models of the Seventies: Do They Fit Out of Sample?", Journal of International Economics 14, pp. 3-24, 1983.

Kerry Patterson, "An Introduction to Applied Econometrics, a time series approach", MacMillan Press Ltd, 2000.

Lucio Sarno, Mark P. Taylor, "The economics of exchange rates", Cambridge University Press, 2005.

James Stock and Mark Watson, "Testing for Common Trends", Journal of the American Statistical Association 83, 1988.

Marno Verbeek," A Guide to Modern Econometrics", John Wiley & Sons, Ltd, 2004.

Eric Zivot, "The power of single equation test for cointegration when the cointegrating vector is prespecified", Economic Theory, 1999.