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Behavioral and Permanent Zloty/Euro Equilibrium Rate

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Abstract

Poland is expected to enter the Exchange Rate Mechanism II (ERM II). The European Central Bank recommends that the ERM II central rate should reflect the best possible assessment of the equilibrium exchange rate. Since the equilibrium rate is changing in time, it is important to identify the pushing and pulling forces of the exchange rate. This knowledge will let the authorities to defend only the exchange rate that is in equilibrium and to assess outcomes of their actions.

We use the VEC approach of Johansen to estimate the behavioral equilibrium exchange rate and to identify the pushing forces of the Polish zloty/euro rate. We apply the Gonzalo-Granger decomposition to calculate the permanent equilibrium exchange rate and to identify the pulling forces of the zloty exchange rate. We demonstrate that this approach may be useful for Polish authorities while entering the ERM II as well as within that mechanism.

Keywords: equilibrium exchange rate, cointegration analysis, Gonzalo- Granger decomposition, ERM II

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1 Introduction

Poland is obliged to adopt the euro after the fulfilment of the nominal convergence criteria (European Union 2002), and, inter alia, the exchange rate criterion, which requires to maintain exchange rate stability for at least 2 years while participating in the Exchange Rate Mechanism II (ERM II). Since in current floating exchange rate regime does not exist any reference rate, at some point it will be necessary to set the central parity against the euro. The European Central Bank (ECB) recommends that the central rate should be an equilibrium rate (European Central Bank 2003). Thus, many researchers focus on the methods of the estimation of the equilibrium exchange rate. In this paper we argue that it is not enough to estimate credible equilibrium rate. As it is changing in time, it is also important to identify the exchange rate determinants to be able to forecast the direction of its future evolution. This knowledge will let the authorities to defend, as it is recommended, only the exchange rate that is in equilibrium (see e.g. Williamson 1994) and to assess what outcomes their actions may have. Thus, our main focus is to identify the pushing and pulling forces of the equilibrium exchange rate.

In this paper we apply the behavioral equilibrium exchange rate (BEER) model to calculate the current equilibrium exchange rate and the permanent equilibrium exchange rate model (PEER) to estimate the medium-run equilibrium exchange rate. In essence the BEER approach involves reduced form modelling of the equilibrium exchange rate using cointegration analysis, while the PEER is the outcome of the Gonzalo-Granger decomposition. The BEER/PEER approach will enable us to answer the question about the pushing and pulling forces of the real exchange rate.

The outline of the remainder of the paper is as follows. In the next section we shortly discuss the BEER/PEER approach to estimating the equilibrium exchange rate. Section 3 describes the econometric methodology used to estimate the equilibrium exchange rates, both BEER and PEER. Our estimates of these 2 equilibrium measures for the real Polish zloty/euro rate (hereafter PLN/EUR) and identification of its determinants are presented in Section 4. The final section provides some concluding remarks.

2 BEER/PEER approach

In this section we outline the methodology of the BEER and PEER approaches to estimating the equilibrium exchange rate. It should be mentioned at the very beginning that the BEER/PEER approach is one of the possible ways to estimate the real equilibrium rate. Other methods constitute variants of the internal-external balance approach and assume that the real equilibrium exchange rate is the rate satisfying both internal and external balance. As this approach is broadly discussed in the literature, it is not the subject of this paper (for details, see for example MacDonald 2000, also Bęza-Bojanowska and MacDonald 2009).

The BEER approach of Clark and MacDonald (1998) assumes that the real factors are a key explanation for the slow mean reversion to PPP observed in the data (so-called PPP puzzle, Rogoff 1996), which is subject to rigorous statistical testing. The starting point of the model is the uncovered interest parity (UIP) adjusted to include a risk premium, rearranged as an expression for the real exchange rate:

$$q_t = E(q_{t+k}) - (r_t - r_t^*) + \lambda_t, \tag{1}$$

where: q_t is a real exchange rate, r_t and r_t^* denotes respectively a domestic and foreign real interest rate, λ_t denotes a risk premium, E is the expectations operator and $E(q_{t+k}) = \overline{q}_t$ is interpreted as the *long-run* or systematic component of the real exchange rate (t+k defines the maturity horizon of the bonds). Since in this paper we express the real exchange rate as the home currency price of a unit of foreign currency, we adjust all equations to this definition. By assuming rational expectations we can rearrange (1) as:

$$q_t = \overline{q}_t - (r_t - r_t^*) + \lambda_t, \tag{2}$$

where $\overline{q}_t$ is a function of net foreign assets (*nfa*), the Balassa-Samuelson effect (*bs*), and the terms of trade (*tot*):

$$\overline{q}_t = f(nfa_t, tot_t, bs_t). \tag{3}$$

In practice, the estimation of the BEER model proceeds in the following steps (Clark and MacDonald 1998, see also Bęza-Bojanowska and MacDonald 2009):

1. estimating current equilibrium exchange rate ($\overline{q}_t$),

2. calculating current misalignment (cm_t) - the deviation of the actual exchange rate from the current equilibrium exchange rate:

$$cm_t = \varepsilon_t = q_t - \overline{q}_t, \tag{4}$$

3. estimating medium-run equilibrium exchange rate ($\overline{\overline{q}}_t$),

4. calculating total misalignment (tm_t) - the difference between the actual exchange rate and the medium-run equilibrium exchange rate:

$$tm_t = q_t - \overline{\overline{q}}_t. \tag{5}$$

The current misalignment is generated as the difference between the actual real exchange rate and the BEER (see e.g. Clark and MacDonald 1998). As the data fundamentals may deviate from their equilibrium values, the total misalignment may substantially differ from the current misalignment. Clark and MacDonald (1998, 2004) proposed two ways to calculate medium-run equilibrium rate:

1. by calibrating the fundamentals on the sustainable level (e.g. using the Hodrick-Prescott filter):
$$\bar{\bar{q}}_t = B^T \overline{x}_t, \tag{6}$$
where B denotes a vector of the coefficients and $\overline{x}_t$ is a vector of fundamentals in the equilibrium,

2. by applying the permanent-transitory decomposition (Gonzalo and Granger 1995):
$$x_t = P_t + T_t, \tag{7}$$
$$\bar{\bar{q}}_t = P_t,$$
where: P and T denote respectively a permanent and transitory element of vector x_t comprising the fundamentals.

As our main goal is to assess the pushing and pulling forces of the real PLN/EUR rate, in this paper we focus on the second approach. For examples of applications of the first method see e.g. Bęza-Bojanowska (2008) or Bęza-Bojanowska and MacDonald (2009). In the later paper, the sensitivity analysis of both abovedescribed approaches is also presented.

3 Econometric methodology

The identification of the long-run relationship between an exchange rate and economic fundamentals is performed by applying the full information maximum likelihood estimation procedure proposed by Johansen (1995) to estimate the cointegrated vector error-correction model (VECM):

$$\triangle x_t = AB^T x_t + \sum_{s=1}^{S-1} \Gamma_s \triangle x_{t-s} + \Phi d_t + \varepsilon_t, \tag{8}$$

where the notation is as follows: x_t is a vector of variables, B is a matrix of orthogonal linearly independent cointegrating vectors between the variables in x_t, A is an adjustment matrix to the equilibrium trajectories (loading coefficients), Γ is a matrix of the short-run coefficients, d_t is a vector of deterministic variables, Φ is a matrix of parameters of deterministic components, ε_t is a vector of white noise residuals.
In order to secure the proper power of the test, the estimation and testing strategy follows that proposed by Greenslade, Hall and Henry (2002). After estimating the unrestricted VAR model:

$$x_t = \sum_{k=1}^{K} \triangle x_{t-k} \Pi_k + d_t \Phi + \varepsilon_t, \tag{9}$$

the cointegration rank together with the weak exogeneity restrictions are tested. As the existence of the weakly exogenous variables may affect the cointegrating rank, the cointegration test is performed once again. The cointegrating rank is determined by applying the trace test with Bartlett correction (to secure a cor- 5 rect test size; Johansen 2002) as well as the analysis of the largest characteristic roots of the companion matrix (Juselius 2006). The number of characteristic roots close to one indicates the number of common trends in the system. Thus, by extracting it from the number of endogenous variables, the number of potential cointegrating vectors may be obtained. In the final stage the identification of the long-run structure (Gonzalo and Granger 1995) as well as the recursive test for the coefficients stability (e.g. Hansen and Johansen 1999) are performed.
As Johansen (1995) has demonstrated, the above VEC model has a vector moving average representation of the following form:

$$x_t = C\sum_{i=1}^{t}\varepsilon_i + C\sum_{i=1}^{t}d_t\Phi + Y_t, \tag{10}$$

where:

$C = B_\perp(A_\perp^T \Gamma B_\perp)^{-1}A_\perp^T = \tilde{B}_\perp A_\perp^T$ is a long-run impact matrix,

$A_\perp$ and $B_\perp$ denote orthogonal complements to A and B, respectively,

$\tilde{B}_\perp$ is a matrix of loadings to p-r common stochastic trends $A_\perp^T \sum_{i=1}^{t}\varepsilon_i$,

$Y_t = C^*(L)(\varepsilon_t + d_t\Phi)$ is a stationary process,

$C^*(L)$ is a non-singular matrix polynomial given by the parameters of VAR model.

Gonzalo and Granger (1995) have demonstrated that if the vector x_t has an ECM representation, the elements of this vector can be explained in terms of a smaller number n-r of $I(1)$ variables, called common factors, f_t, plus some $I(0)$ components, the transitory elements, $\tilde{x}_t$:

$$x_t = A_1 f_t + \tilde{x}_t, \tag{11}$$

where:

$A_1 = \beta_\perp(\alpha_\perp^T\beta_\perp)^{-1}$ is a loading matrix such as $\alpha^T A_1 = 0$,

$f_t = A_2 x_t$,

$A_2 = \alpha(\beta^T\alpha)^{-1}$.

The identification of the common factors facilitates obtaining the following permanent-transitory decomposition of x_t:

$$x_t = P_t + T_t, \tag{12}$$

where:

$$P_t = A_1 \alpha_\perp^T \beta_\perp x_t, \tag{13}$$

$$T_t = A_2 \beta^T x_t. \tag{14}$$

In this paper we intend using the VECM approach of Johansen to obtain BEER estimates and we will use the Gonzalo-Granger decomposition to calculate the PEER.

4 Real PLN/EUR equilibrium rate

4.1 Time span and model specification

During the transition process the exchange rate system in Poland evolved from a fixed exchange rate regime, to a more flexible system (crawling band) with the increasing role of the market in the determination of the exchange rate, to the free floating that we currently observe (for more details see e.g. Bęza- Bojanowska and MacDonald 2009). These institutional changes substantially limit the time span of our analysis of the PLN/EUR equilibrium rate. Since the last large intervention on the Polish foreign exchange market took place in February 1998 and the exchange rate thereafter has been flexible, the period after March 1998 can be recognized as a homogeneously flexible exchange rate regime. For those reasons our monthly data spans the period from March 1998 to December 2007.

In estimating the equilibrium exchange rate we assume that the real PLN/EUR rate is determined by a standard set of conditioning variables described in Section 2 (for analysis of other BEER specifications for the Polish zloty see e.g. Bęza-Bojanowska 2008), thus the vector x_t consists of 6 variables:

$$x_t = [q_t, NFA_t, bs_t, tot_t, R_t, \lambda_t], \tag{15}$$

where small letters refer to logarithms.

The real exchange rate of the zloty against the euro (q_t) is defined as a monthly average of the nominal PLN/EUR rate deflated by the index of prices in manufacturing (PPIm) at home and in the euro area. The PPIm represents here a proxy of the prices in tradable sector. An increase in q_t indicates the real 7 depreciation of the zloty.

Data sources: National Bank of Poland (NBP) and Eurostat.

The net foreign assets (NFA_t) in relation to industrial production are calculated based on the methodology proposed by Lane and Milesi-Ferretti (2004):

$$NFA_t = NFA_0 + \triangle NFA_t, \tag{16}$$

$$\triangle NFA_t \cong CA_t + \triangle KA_t, \tag{17}$$

where: NFA_0 is an initial value of the net foreign assets, CA denotes current account balance, $\triangle KA$ is a change in capital account balance.

Data sources: own calculation based on NBP and Polish Central Statistical Office (CSO) data.
The Balassa-Samuelson effect (bs_t) is approximated directly as a ratio between seasonally adjusted productivity in manufacturing in Poland and in the euro area.
Data sources: own calculation based on Eurostat data.
The terms of trade (tot_t) is defined as a relative ratio between export and import prices in Poland and Germany.
Data sources: CSO and German Federal Statistical Office (Statistisches Bundesamt Deutschland).
The real interest rate disparity (R_t) is defined as a difference between monthly average of 10-year government bond yields for Poland and the euro area, deflated by PPIm.
Data sources: Eurostat.
In order to check the sensitivity of the equilibrium exchange rate estimates to the choice of the risk premium proxy (λ_t), it is approximated by the budget deficit (DEF_t) and the budget debt ($DEBT_t$) in relation to industrial production (for other risk premium proxies applied to the analysis of the zloty equilibrium rate see e.g. Kelm and Bęza-Bojanowska 2005).
Data sources: Polish Ministry of Finance and CSO.

4.2 Behavioral PLN/EUR equilibrium rate - pushing forces

At the outset the integration order of all potential exchange rate determinants, as well as exchange rate itself, was checked using standard ADF and KPSS 8 tests. As all variables are integrated of order one (see Table 1), the VECM methodology was used to estimate the behavioral PLN/EUR equilibrium rate.
In the first stage of the econometric analysis, we estimated two VAR models: VAR01 and VAR02, with the budget deficit and budget debt as risk premium proxies, respectively. We jointly specified the deterministic component of the VAR models and the lag length. Taking into account sample size, the maximum lag length in both VARs was set at 4. The analysis of information criteria as well as the Likelihood ratio test leads to 2 lags in each model variant. Simultaneously, the analysis of the residuals from the unrestricted VAR models (with constant) indicates the existence of some outliers. As the presence of outliers may affect the skewness and the kurtosis of the empirical distribution, in order to get normally distributed residuals, 7 permanent intervention dummies and one transitory shock dummy were included in both specification variants. Additionally, in VAR01 two dummies (representing shocks specific to budget deficit) were incorporated.
The analysis of a number of residual diagnostic tests confirms that the estimated VARs are well specified (see Tables 2-3). The LM test indicates the lack of significant residual autocorrelation, while the test for multivariate normality (Doornik and Hansen 1994) indicates that residuals are normally distributed. Furthermore, as the VAR estimates are sensitive to deviations from normality due to skewness, we also reported this measure for each variable (see Table 3). We found that normality is

rejected in none of the equations. The univariate statistics indicate, however, a moderate ARCH effect in both models: in VAR01 it results from tot equation, while in VAR02 from DEBT equation. Nevertheless, as Rahbek, Hansen and Dennis (2002) have shown, the cointegration rank tests are robust against moderate ARCH effects (see also Juselius 2006).

Following the proposition of Greenslade, Hall and Henry (2002) described in Section 3, in the next stage the cointegration rank test and the identification of weakly exogenous variables were performed. The trace test strongly indicates the existence of one cointegrating vector in each system. The analysis of the number of characteristic roots confirms the former finding. The exogeneity tests (individual as well as joint tests) indicate that three variables (tot, bs, $DEF/DEBT$) are weakly exogenous in each model (compare last column of Table 5). Finally, the existence of one cointegrating relation in the restricted model was again supported (see Table 4). To secure space we do not report all partial results in this paper (for details see Bęza-Bojanowska and MacDonald 2009).

As the system is to represent the real PLN/EUR equilibrium rate trajectories, we next performed the identification of the long-run structure of the VEC models, by imposing one normalizing restriction. In both variants of the model there are significant adjustments to the identified long-run relationship, implying that the cointegrating relations represent the PLN/EUR equilibrium rate trajectories. All variables have correct signs and are statistically significant at the standard significance level (see Table 5) and the forward recursive test of parameter constancy accepts coefficient stability over time (see Figures 1-2).

The net foreign assets, the real interest rate disparity, the terms of trade, the BS effect and the risk premium proved to have a significant influence on the real PLN/EUR equilibrium rate in the long-run.

An increase in net foreign debt leads to the zloty appreciation. Steady growth in foreign assets and liabilities of agents is a result of the integration process of the Polish financial market with international market (National Bank of Poland 2007). Since budget debt takes over a part of NFA impact on the exchange rate through the interest payment channel, the magnitude of the NFA coefficient is lower in this model than in the model variant with a budget deficit variable.

An increase in the real interest rate disparity, implying higher profitability of zloty denominated assets, also creates an appreciation pressure. As the coefficient value depends, inter alia, on the price stickiness and the output gap sensitivity on the price level (MacDonald and Nagayasu 2000), it is lower than in the models based on CPI (about 0.5 compared to close to 1 in CPI-based models).

An increase in the BS effect proxy is again associated with the real apprecia- 10 tion of the zloty. Higher relative productivity implies improvement in domestic goods quality and its supply, resulting in changes in consumers' preferences (a rise in the share of domestic goods accompanied by decrease in the share of imported goods).

An increase in the terms of trade also results in the zloty appreciation, affecting the exchange rate via the channel of an amelioration of the trade balance. Simultaneously, growing exports revenues may induce higher consumption of nontradables and may intensify a pressure on domestic currency appreciation through the BS effect (Egert and Lommatzsch 2004).

An increase in the risk premium generates a depreciation of the domestic currency. It is natural that higher budget deficit and debt undermines confidence in the national currency. Simultaneously, as noted above, an increase in government indebtedness affects domestic currency through the interest payments channel (Maeso-Fernandez, Osbat, Schnatz 2001).

The finding that the real interest rate differential and the risk premium affect the equilibrium exchange rate is very important, as the other convergence criteria (apart from the exchange rate criterion) are connected with these variables, i. e. the price stability criterion, the long-run interest rate criterion and the fiscal discipline criterion, respectively (see EU 2002).

The first two criteria require in general the convergence of the inflation as well as the long-run interest rates to the level in the three EU countries with the most stable prices (with some toleration band, for details see EU 2002). It means that the real interest rate disparity should decline and thus it will negatively affect the zloty equilibrium rate in the ERM II (real depreciation). At the same time the fiscal policy will focus on the fulfilment of the third from the abovementioned criteria. As the decrease in the risk premium (lower budget deficit and/or debt) creates the appreciation pressure on the real zloty/euro rate, this should mitigate the effect of the real interest disparity term.

The set of the fundamentals that push the zloty equilibrium rate encompass also net foreign assets, terms of trade and the BS effect. As the Poland's entry to the ERM II will signify the strong signal for the market of the approaching euro area accession, this will attract the capital inflows (increase in the NFA debt), implying the zloty appreciation. Additionally, assuming that the strategy for the integration with the euro area will be consistent with the position of the Polish authorities (see Bęza-Bojanowska, Błażej, Janecki, Kolski, Szeląg, Wójcik 2005), it can be expected that the ERM II membership will foster the real convergence. Thus, the relative productivity as well as the competitiveness of the Polish economy should increase, creating additional appreciation pressure on the equilibrium rate.

Finally, assuming rationality of economic agents (that does not seem to be strong assumption taking into account the level of the adjustment parameter) the equilibrium exchange rate appreciation will be accompanied by the actual PLN/EUR rate appreciation and thus Poland may follow the Slovak experience within ERM II.

4.3 Permanent PLN/EUR equilibrium rate - pulling forces

Having estimated the VEC models, we can calculate the permanent PLN/EUR equilibrium rate by making use of the moving average representation of the VECM, described in Section 3. The alpha and beta orthogonal components of each model as well as the long-run impact matrices are reported in Tables 6- 11. For simplicity we separately analyze the MA representation of each VECM specification and focus only on the exchange rate, as our aim is to identify the pulling forces of the PLN/EUR rate.

Table 6, presenting the estimates of the alpha orthogonal complements, gives us an information on which variables drive the common stochastic trends. The values in columns indicate the contribution of each variable to the trend. As three variables proved to be weakly exogenous, they represent 3 common trends, CT(2)-CT(4), driven respectively by term of trade, BS effect and budget deficit. As a result we have to identify only two common trends. Reading across second and third column, the cell with the largest absolute value indicates the variable that makes the largest contribution to the trend, so in VECM01 the first and fifth common trends (CT(1) and CT(5)) correspond to unanticipated shocks to real interest disparity and net foreign assets.

Table 7, showing the estimates of the beta complements, indicates variables that are mostly affected by the common trends. The numbers in columns indicate how each common trend in distributed amongst the variables. Reading across rows, we obtain the information which trend has the largest effect on a particular variable. The analysis of beta orthogonal components of VECM01 indicates that the real PLN/EUR rate is significantly pulled by the real interest disparity, the BS effect and the shocks to budget deficit.

Finally, the long-run impact matrix, Table 8, gives an indication if a shock to a particular variable has a permanent effect on the other variables in the system. Analysis of this table reinforce the message from Tables 6-7 that shocks to real interest disparity, BS effect and budget deficit have a significant cumulative impact on the real PLN/EUR rate.

In VECM02 unanticipated shocks to weakly exogenous variables: terms of trade, BS effect and budget debt are represented by the first, second and third common trends (CT(1)-CT(3)), respectively, while CT(4) and CT(5) are driven by net foreign assets and real interest rate disparity (see Table 9). Similarly to VECM01, the exchange rate is pulled by the unanticipated shocks to real interest disparity term and BS effect (see Table 10) and all above-mentioned shocks have a significant long-run impact on the real PLN/EUR rate (see Table 11).

As the ERM II is the system with limited exchange rate fluctuations band, the membership in this mechanism will require high stabilization of the PLN/EUR rate. Beside the direct interventions in the foreign exchange market, monetary policy (interest rates) and fiscal policy (deficit and debt) will become the only available instruments to influence exchange rate developments. Thus, the most important findings of the above described analysis concern the effects of the actions of the monetary and fiscal authorities.

Regardless of the variant of the model an unanticipated positive shock to the interest rate disparity leads the real zloty appreciation. It implies that the Monetary Policy

Council will be able to affect the zloty developments by the changes in NBP interest rates. However, within the ERM II, this channel may be limited by the convergence play resulted from the expectations on the future adjustment of the policy rates to the ECB level. Thus, the fiscal policy channel that, in light of our results, seems to significantly affect the zloty developments, may become more important. We found that the unanticipated decrease in a risk premium approximated by the budget deficit leads to the real zloty appreciation (compare also Bęza-Bojanowska 2008 for the results of estimation of the impulse response function that led to similar findings).
It is also worth mentioning that the Balassa-Samuelson effect is one of the most important determinants of the real zloty exchange rate. It seems reasonable to expect that during the real convergence process this effect will be still significant and positive. It implies that within the ERM II the zloty may be under persistent appreciation pressure resulted form this effect.

4.4 Misalignment analysis

In the final stage of our analysis we calculate the real PLN/EUR equilibrium rate. We are especially interested in the difference between current and mediumrun equilibrium rates represented here by the behavioral and permanent equilibrium exchange rate, respectively. We found the relatively close relationship between the BEER and PEER series which indicates that the BEER (especially BEER02) has only a small transitory component (see Figure 3). Simultaneously, the statistical analysis of the transitory factor of the real PLN/EUR rate proved that it has required properties, i.e. it is generated by the stationary process. Thus, it has no long-run impact on the equilibrium exchange rate.
Analysis of Figure 4 indicates that there were periods of large misalignment. For example, in 2004, when the largest discrepancy between estimated PEER and real PLN/EUR rate was observed, transitory factor (an effect of the political tensions in Poland) drove the actual rate far above the value suggested by the permanent component identified by the model. However, since the EU accession the real PLN/EUR rate development was broadly in line with the current and medium-run equilibrium rate (for detail analysis of the misalignment see Bęza-Bojanowska and MacDonald 2009). Moreover, both the zloty appreciation in the first half of 2008 and its strong depreciation in the second half of the year may be perceived as equilibrium phenomena as the PLN/EUR rate seems to be mainly affected by risk premium and net foreign assets development.
The BEERs, especially BEER01, tend to be strongly affected by transitory factors, while, since the EU accession, very tight link between the estimated PEERs and the actual exchange rate is observed. It means that in this period the total misalignment was not significant. The last finding has practical implications for the ERM II entry strategy, as the ERM II central rates of the New Member States (e.g. Slovakia) were set at the level close to the market rate. If such a strategy is also applied to the Polish zloty, assuming that abovedescribed tendency (rational expectations of the

foreign exchange rate market participants) is persistent, it should not have a negative impact on the economy.
It is also worth mentioning that the later measure of the equilibrium exchange rate, the PEER, is robust to the choice of the risk premium proxy, while there are significant differences between BEER01, with the budget deficit, and BEER02, with the budget debt, developments. Thus, it seems that the PEER approach is to be recommended for taking into account while setting the central parity of the zloty in the ERM II.

5 Conclusions

Poland is obliged to enter the euro area after the fulfilment of nominal convergence criteria, which includes participation in the ERM II. This requires, abandoning the floating regime and setting the central parity against the euro. The ECB recommends that the central rate should reflect the best possible assessment of the equilibrium exchange rate, based on a broad of economic indicators while taking into account the market rate. As the equilibrium exchange rate tend to change over time, this study focuses not only on the methods to estimating the equilibrium rate, but also on the determinants of the real PLN/EUR equilibrium rate.
Applying Johansen's procedure, two models of the behavioral PLN/EUR equilibrium rate were estimated. Those models differ in the scope of proxies for risk premium. The results indicate that net foreign assets, real interest disparity, terms of trade, BS effect and risk premium represent pushing forces of the real PLN/EUR equilibrium rate. As the exchange rate determinants values may deviate from their equilibrium, the medium-run equilibrium exchange rate was also computed by applying the Gonzalo-Granger decomposition for permanent and transitory components. This analysis leads to the conclusion that the real PLN/EUR rate is permanently affected by the unanticipated shocks to the real interest rate disparity, the Balassa-Samuelson effect and the budget deficit. It implies that beside the direct interventions in the foreign exchange market, monetary policy (interest rates) and fiscal policy (deficit and debt) may constitute the effective instruments to influence exchange rate developments within the ERM II.
The analysis carried out in this paper shows that the results are statistically robust and significant. In particular, the choice of risk premium proxy does not affect in statistically significant way the estimate of the real PLN/EUR equilibrium rate - especially the PEERs - as well as the pushing and pulling forces of the real PLN/EUR rate. Thus, it can be concluded that the BEER/PEER approach is an appropriate tool for calculating the PLN/EUR equilibrium rate. Moreover, as the BEERs tend to be significantly affected by transitory factors, the PEER model may be an appropriate tool for calculating the PLN/EUR equilibrium rate, which is to be taken into account while setting the central parity in the ERM II.

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Appendix - Tables and Figures

Table 1: Unit root test

	ADF	*exogenous regressors*	*lag length*	*KPSS*	*exogenous regressors*	*bandwidth*
q	-2.1891	c	1	0.1077*	c,t	9
NFA	-1.8490	c,t	2	0.3012	c,t	9
R	-1.9603	c	1	0.0875*	c,t	9
tot	-0.9538	c	0	0.0794*	c,t	9
bs	-1.2937	c	1	0.2606*	c,t	9
DEF	-1.1493	c	1	0.2753*	c	9
$DEBT$	-1.2614	c	0	0.1403*	c	9

*) rejection of H_0, significance level at 10%.
ADF: lag length selected using a Schwarz Information Criterion
KPSS: Bartlett kernel estimation method, bandwidth selected using the Newey-West method.

Table 2: Residual analysis - multivariate diagnostics

	VAR01	**VAR02**
Information Criteria		
SC	-57.869	-56.213
HQ	-59.815	-57.990
Trace Correlation	0.485	0.472
Test for Autocorrelation		
LM(1)-ChiSqr(36)	33.370 [0.594]	30.138 [0.743]
LM(2)-ChiSqr(36)	41.753 [0.235]	39.921 [0.300]
Test for Normality		
ChiSqr(12)	6.614 [0.882]	12.726 [0.389]
Test for ARCH		
LM(1)-ChiSqr(441)	428.819 [0.652]	429.700 [0.641]
LM(2)-ChiSqr(882)	897.573 [0.350]	927.343 [0.141]

p values in square brackets

Table 3: Residual analysis - univariate diagnostics

		q	*NFA*	*R*	*tot*	*bs*	*DEF*
VAR01	*Skewness*	0.267	-0.230	-0.157	-0.009	-0.171	0.255
	Kurtosis	2.764	3.145	3.069	3.194	3.326	3.246
	Normality	1.818[0.403]	1.405 [0.495]	0.803 [0.669]	0.954 [0.621]	1.842 [0.398]	1.865 [0.394]
	ARCH	0.867 [0.648]	1.779 [0.411]	0.852 [0.653]	**6.316 [0.043]**	**6.052 [0.049]**	1.575 [0.455]
VAR02	*Skewness*	0.250	-0.186	-0.196	0.040	-0.243	-
	Kurtosis	2.516	2.628	3.094	3.174	3.461	-
	Normality	2.860 [0.239]	1.247 [0.536]	1.069 [0.586]	0.879 [0.645]	2.759 [0.252]	-
	ARCH	1.988 [0.370]	1.085 [0.581]	0.282 [0.869]	4.373 [0.112]	2.418 [0.298]	-

p values in square brackets

Table 4: Cointegration test

Hypothesis	*Eigenv.*	*Trace*	*TraceBC*	*Trace**	*Modulus: 3 largest roots*		
					r=2	*r=1*	*r=0*
VECM01							
r=0	0.427	93.148	85.316*	52.172	1.000	1.000	1.000
r=1	0.161	28.502	24.001	32.287	0.962	1.000	1.000
r=2	0.068	8.196	5.942	15.425	0.721	0.891	1.000
VECM02							
r=0	0.366	91.539	83.758*	52.600	1.003	1.000	1.000
r=1	0.225	38.760	31.518	32.202	1.000	1.000	1.000
r=2	0.076	9.157	.NA	15.439	0.551	0.914	1.000

TraceBC – trace test statistic with Bartlett correction
Trace* - 90% quantiles from the asymptotic tables generated in CATS

Table 5: Behavioural PLN/EUR equilibrium rate model

Variant		*q*	*NFA*	*R*	*tot*	*bs*	*DEF*	*DEBT*	*c*	*LR p-value*
VECM01	*LT*	1.000	0.690	0,560	0,467	0,442	-1,763	-	-5,986	0.819
			(4.101)	(2.094)	(1.664)	(10.831)	(-4.227)	(-4.355)		
	ECT	-0.085	-0.046	-0.022	0.000	0.000	0.000	-		
		(-2.294)	(-7.533)	(-1.734)						
VECM02	*LT*	1.000	0.322	0.545	0.471	0.321	-	-0.696	-4.811	0.522
			(3.217)	(2.056)	(1.973)	(10.359)	(-4.664)	(-4.170)		
	ECT	-0.167	-0.047	-0.035	0.000	0.000	-	0.000		
		(-3.484)	(-5.136)	(-2.077)						

The table is divided into 2 parts, corresponding to different BEER model specifications. The upper and lower panel of each part reports respectively the loading (LT) and the adjustment (ECT) coefficients of the normalized vector, with t-Student statistics in brackets. The last column reports the joint significance level of weak exogeneity restrictions.

Table 6: Common Trends - VECM01

$\alpha_{\perp}(T)$	q	NFA	R	tot	bs	DEF
CT(1)	-0.313	-0.190	**0.930**	0.000	0.000	0.000
CT(2)	0.000	0.000	0.000	**1.000**	0.000	0.000
CT(3)	0.000	0.000	0.000	0.000	**1.000**	0.0000
CT(4)	0.000	0.000	0.000	0.000	0.000	**1.000**
CT(5)	0.518	**-0.855**	0.000	0.000	0.000	0.000

Figure 1: Recursive test for stability of loading coefficients

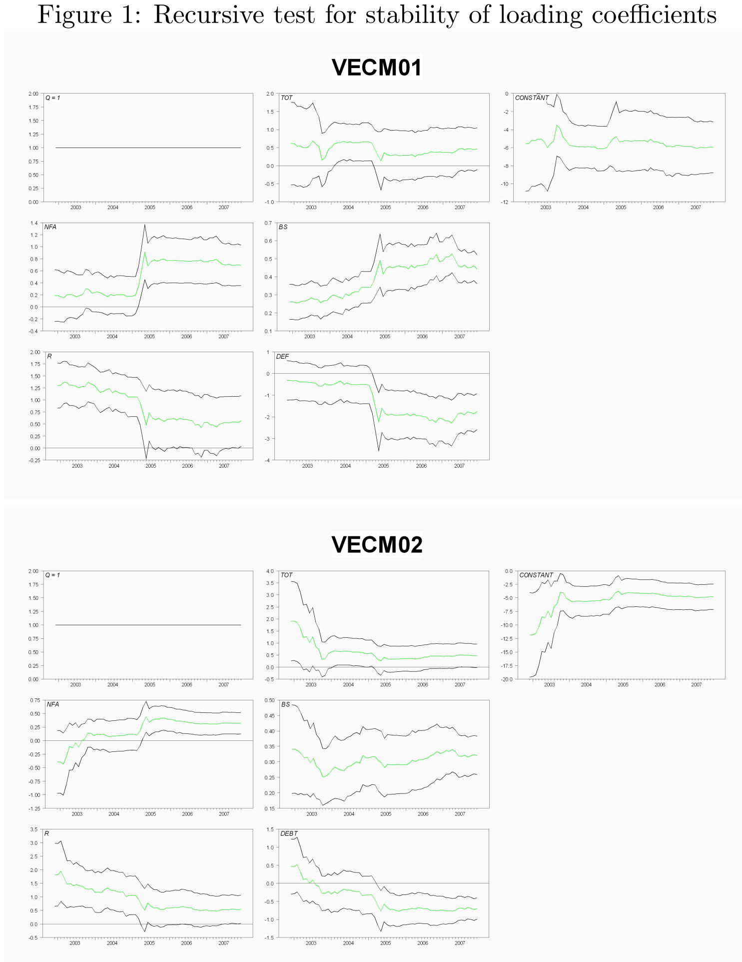

Figure 2: Recursive test for stability of adjustment coefficients

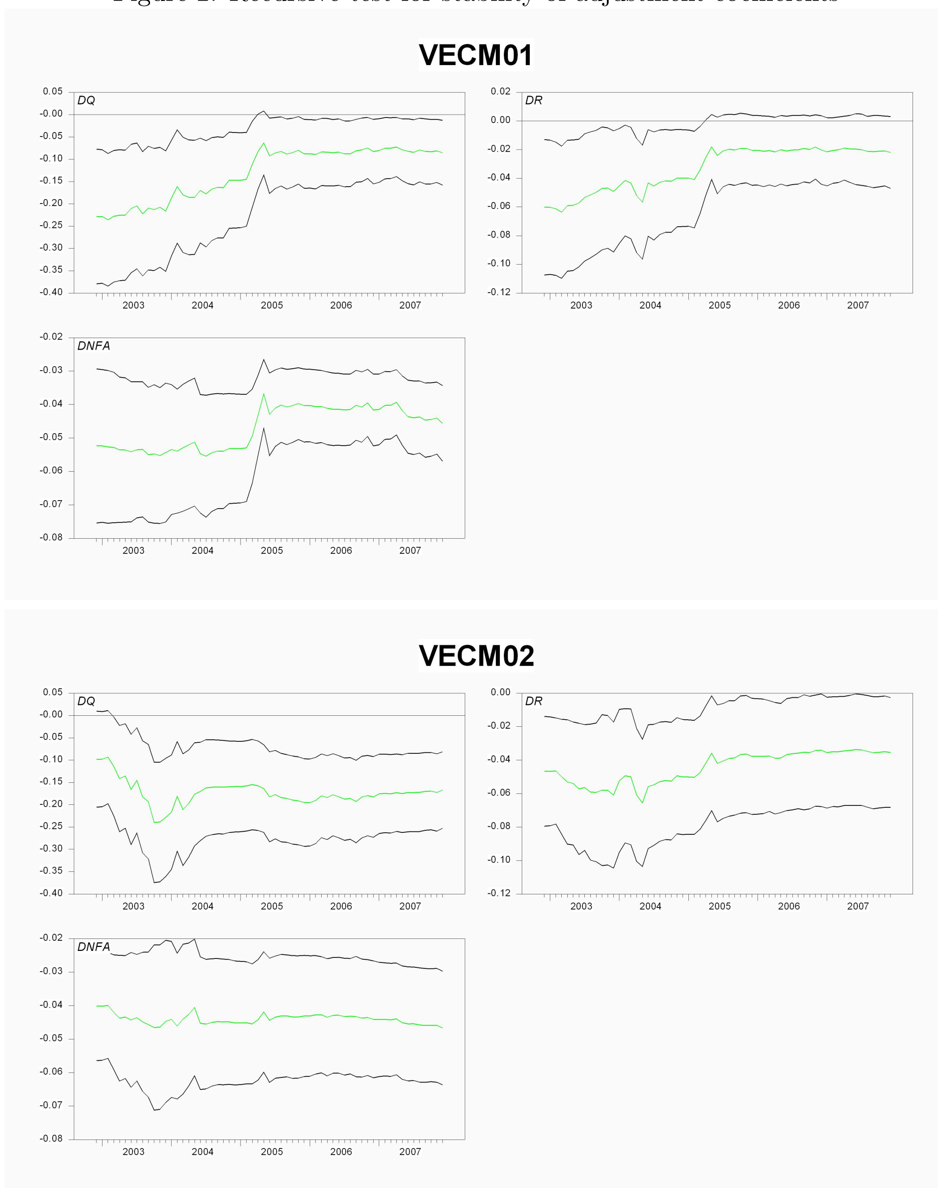

Table 7: Loadings to Common Trends - VECM01

$\beta_{\perp}(\sim)$	CT(1)	CT(2)	CT(3)	CT(4)	CT(5)
q	**-1.736** (-3.184)	-1.109 (-0.221)	**-0.265** (-3.184)	**1.667** (2.284)	0.417 (0.533)
NFA	-0.897 (-1.154)	8.674 (1.215)	-0.083 (-0.698)	0.798 (0.767)	1.872 (1.680)
R	1.402 (3.085)	4.951 (1.186)	0.010 (0.151)	0.437 (0.718)	-0.814 (-1.250)
tot	-0.092 (-0.161)	8.620 (1.643)	0.111 (1.275)	0.213 (0.278)	-0.080 (-0.097)
bs	0.062 (0.135)	-2.283 (-0.538)	0.693 (9.832)	0.443 (0.716)	0.305 (0.460)
DEF	-0.162 (-0.832)	1.032 (0.577)	-0.039 (-1.326)	1.545 (5.928)	0.319 (1.142)

Table 8: Long-Run Impact Matrix - VECM01

C	q	NFA	R	tot	bs	DEF
q	0.547 (1.765)	0.417 (0.533)	**-1.736** (-3.184)	-1.109 (-0.221)	**0.265** (-3.184)	**1.667** (2.284)
NFA	-0.722 (-1.633)	1.872 (1.680)	-0.897 (-1.154)	8.674 (1.215)	-0.083 (-0.698)	0.798 (0.767)
R	-0.152 (-0.589)	-0.814 (-0.250)	1.402 (3.085)	4.951 (1.186)	0.010 (0.151)	0.437 (0.718)
tot	0.091 (0.279)	-0.080 (-0.097)	-0.092 (-0.161)	8.620 (1.643)	0.111 (1.275)	0.213 (0.278)
bs	-0.214 (-0.813)	0.305 (0.460)	0.062 (0.135)	-2.283 (-0.538)	0.693 (9.832)	0.443 (0.716)
DEF	-0.119 (-1.071)	0.319 (1.142)	-0.162 (-0.832)	1.032 (0.577)	-0.039 (-1.326)	1.545 (5.928)

Table 9: Common Trends - VECM02

$\alpha_{\perp}(T)$	q	NFA	R	tot	bs	$DEBT$
CT(1)	0.000	0.000	0.000	**1.000**	0.000	0.000
CT(2)	0.000	0.000	0.000	0.000	**1.000**	0.000
CT(3)	0.000	0.000	0.000	0.000	0.000	**1.000**
CT(4)	0.490	**-0.872**	0.000	0.000	0.000	0.000
CT(5)	-0.376	-0.211	**0.902**	0.000	0.000	0.000

Table 10: Loadings to Common Trends - VECM02

$\beta_{\perp}(\sim)$	CT(1)	CT(2)	CT(3)	CT(4)	CT(5)
q	-1.630 (-0.330)	**-0.233** (-3.362)	0.073 (0.337)	1.005 (1.290)	**-1.890** (-3.3-556)
NFA	8.472 (1.167)	-0.027 (-0.259)	-0.334 (-1.053)	2.026 (1.767)	-0.936 (-1.197)
R	5.981 (1.236)	0.021 (0.296)	0.055 (0.260)	-0.925 (-1.211)	1.304 (2.504)
tot	9.243 (1.573)	0.124 (1.460)	0.066 (0.256)	-0.126 (-0.136)	0.002 (0.003)
bs	-2.878 (-0.642)	0.679 (10.449)	0.109 (0.558)	0.572 (0.807)	-0.089 (-0.184)
$DEBT$	2.961 (0.689)	-0.084 (-1.358)	0.785 (4.179)	1.753 (2.586)	-0.948 (-2.049)

Table 11: Long-Run Impact Matrix - VECM02

C	q	NFA	R	tot	bs	$DEBT$
q	0.470 (1.772)	1.005 (1.290)	**-1.890** (-3.556)	-1.630 (-0.330)	**-0.233** (-3.262)	0.073 (0.337)
NFA	-0.627 (-1.607)	2.026 (1.767)	-0.936 (-1.197)	8.472 (1.167)	-0.027 (-0.259)	-0.334 (-1.053)
R	-0.194 (-0.748)	-0.925 (-1.211)	1.304 (2.504)	5.981 (1.236)	0.021 (0.296)	0.055 (0.260)
tot	0.070 (0.221)	-1.126 (-0.136)	0.002 (0.003)	9.243 (1.573)	0.124 (1.460)	0.066 (0.256)
bs	-0.273 (-1.132)	0.572 (0.807)	-0.089 (-0.184)	-2.878 (-0.642)	0.679 (10.449)	0.109 (0.558)
$DEBT$	-0.467 (-2.025)	1.753 (2.586)	-0.948 (-2.049)	2.961 (0.689)	-0.084 (-1.358)	0.785 (4.179)

Figure 3: BEER and PEER fro real PLN/EUR rate

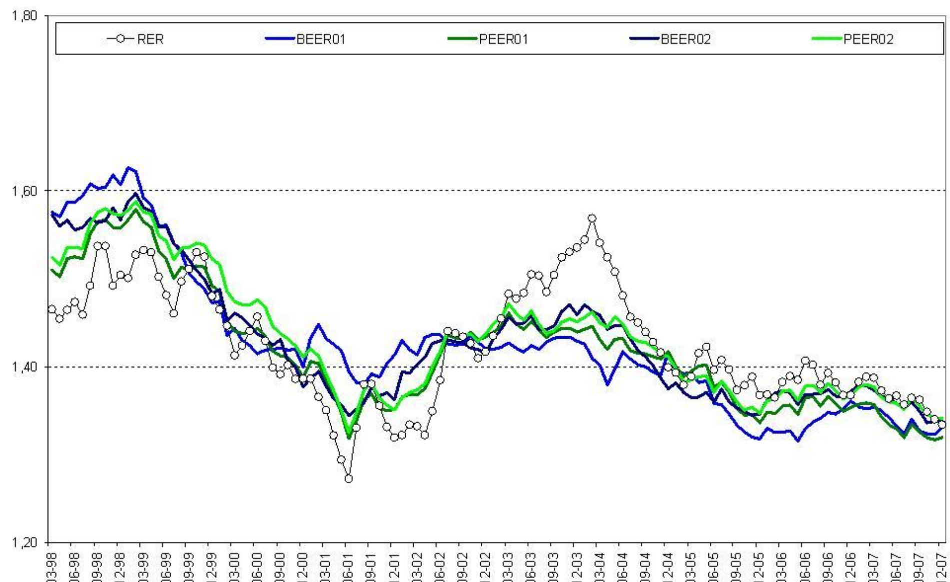

Figure 4: Transitory component of the real PLN/EUR rate