The Behavioural Zloty/Euro Equilibrium Exchange Rate

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Abstract

Poland is obligated to adopt the euro after the fulfilment, inter alia, of the exchange rate criterion which requires entering 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. In this paper we use the BEER and PEER approach to estimate real Polish zloty/euro equilibrium rate. Although the main goal of our analysis is to compute measures of current and total misalignment, we also check the sensitivity of the equilibrium exchange rate estimates to our choice of the risk premium proxy as well as to our approach for computing the total misalignment. We demonstrate that the BEER/PEER estimates of the PLN/EUR rate are statistically robust and that this approach may be useful for setting the central parity rate at which the zloty enters ERM II.

JEL Code: F31, F32.

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

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1. Introduction

Since becoming a member of the European Union, Poland has been participating in the 3rd stage of the Economic and Monetary Union with the status of a country with derogation (European Union, 2003). That means Poland is obligated to adopt the euro after the fulfilment of the Maastricht criteria (European Union, 2002), and, inter alia, the exchange rate criterion. Thus, at some point it will be necessary to abandon the current floating exchange rate regime and enter the Exchange Rate Mechanism II (ERM II), which requires setting the central parity against the euro. However, this raises the question of what that central rate should be. In this paper we argue the rate should be an equilibrium rate and our main focus here is on calculating current and medium-run Polish zloty/euro (hereafter PLN/EUR) equilibrium rates and the implied misalignment of the actual PLN/EUR rate from its equilibrium.

Two measures of equilibrium are used in this paper to estimate the equilibrium PLN/EUR, namely the behavioural equilibrium exchange rate (BEER) model, which is applied 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/PEER approach involves reduced form modelling of the equilibrium exchange rate using cointegration analysis.

The outline of the remainder of the paper is as follows. In the next section we discuss the various ways of estimating an equilibrium exchange rate and in Section 3 we go on to present the econometric methodology used to estimate our preferred measures of the equilibrium exchange rate, namely the BEER and PEER. Our estimates of these equilibrium measures for the Polish zloty/euro rate are presented in Section 4 and in Section 5 we give some concluding remarks.

2. Measuring the Equilibrium Exchange Rate

In this section we outline the methodology of the BEER and PEER approaches to estimating the equilibrium exchange rate and contrast them with variants of the internal-external balance approach.

The BEER approach of Clark and MacDonald (1998) is not based on any specific exchange rate model and in that sense may be regarded as a very general approach to modelling equilibrium exchange rates. However, it takes as its starting point, though the proposition that real factors are a key explanation for the slow mean reversion to PPP observed in the data (so-called PPP puzzle, see Rogoff, 1996). In contrast to some of the FEER based approaches, discussed below, it's specific modus operandi is to produce measures of exchange rate misalignment which are free of any normative elements and one in which the exchange rate relationship is subject to rigorous statistical testing.

We follow Clark and MacDonald (1998) and define Z_{1t} as a set of fundamentals which are expected to have persistent effects on the long-run real exchange rate and Z_{2t} as a set of fundamentals which have persistent effects in the medium-run, that is over the business cycle. Given this, the actual real exchange rate may be thought of as being determined in the following way:

$$q_t = \beta_1^{T'} Z_{1t} + \beta_2^T Z_{2t} + \tau^T T_t + \varepsilon_t , \tag{2.1}$$

where T_t is a set of transitory, or short-run, variables and ε_t is a random error. Following Clark and MacDonald (1998), it is useful to distinguish between the actual value of the real exchange rate and the current equilibrium exchange rate, $\overline{q}_t$. The latter value is defined for a position where the transitory and random terms are zero:

$$\overline{q}_t = \beta_1^T Z_{1t} + \beta_1^T Z_{2t} . \tag{2.2}$$

The related current misalignment, *cm*, is then given as:

$$cm_t = q_t - \overline{q}_t = q_t - \beta_1^T Z_{1t} - \beta_1^T Z_{2t} = \tau^T T_t + \varepsilon_t , \tag{2.3}$$

and so *cm* is simply the sum of the transitory and random errors. As the current values of the economic fundamentals can deviate from the sustainable, or desirable, levels, Clark and MacDonald (1998) also define the total misalignment, *tm*, as the difference between the actual rate and the rate given by the sustainable or long-run values of the economic fundamentals, denoted as:

$$tm_t = q_t - \beta_1^T \overline{Z}_{1t} - \beta_2^T \overline{Z}_{2t} . \tag{2.4}$$

By adding and subtracting $\overline{q}_t$ from the right hand side of (2.4) the total misalignment can be decomposed into two components:

$$tm_t = (q_t - \overline{q}_t) + [\beta_1^T (Z_{1t} - \overline{Z}_{1t}) + \beta_2^T (Z_{2t} - \overline{Z}_{2t})], \tag{2.5}$$

and since $q_t - \overline{q}_t = \tau^T T_t + \varepsilon_t$, the total misalignment in equation (2.5) can be rewritten as:

$$tm_t = \tau^T T_t + \varepsilon_t + [\beta_1^T (Z_{1t} - \overline{Z}_{1t}) + \beta_2^T (Z_{2t} - \overline{Z}_{2t})]. \tag{2.6}$$

Expression (2.6) indicates that the total misalignment at any point in time can be decomposed into the effect of the transitory factors, the random disturbances, and the extent to which the economic fundamentals are away from their sustainable values.

To illustrate their approach, Clark and MacDonald (1998) take the risk adjusted real interest parity relationship, which has been used by a number of researchers to model equilibrium exchange rates (see, for example, Faruqee, 1995 and MacDonald, 1998):

$$\Delta q_{t+k}^{e} = -(r_t - r_t^{*}) + \lambda_t . \qquad (2.7)$$

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. Expression (2.7) may be rearranged as an expression for the real exchange rate as:

$$q_t = q_{t+k}^{e} - (r_t - r_t^{*}) + \lambda_t , \qquad (2.8)$$

and if q_{t+k}^{e} is interpreted as the 'long-run' or systematic component of the real exchange rate, $\hat{\bar{q}}_t$ and rearranging (2.8) with rational expectations imposed, we get:

$$q_t = \hat{\bar{q}}_t - (r_t - r_t^{*}) + \lambda_t . \qquad (2.9)$$

By assuming that $\hat{\bar{q}}_t$ is, in turn, a function of net foreign assets, *nfa*, the Balassa-Samuelson effect, *bs*, and the terms of trade, *tot*, an expression for the real exchange rate may be written as:

$$q_t = f[r_t - r_t^{*}, nfa_t, tot_t, bs_t, \lambda_t] . \qquad (2.10)$$

In practice, the estimated BEER is calculated by linearily summing the cointegrating vectors and 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 be away from their equilibrium values, the total misalignment may substantially differ from the current misalignment. Clark and MacDonald (1998, 2004) proposed two measures of total misalignment. In first exercise they suggest to set the NFA position (of the US) at a 'sustainable level' or to use a simple Hodrick-Prescott filter to remove the business cycle related component from the data. As an alternative to using a Hodrick-Prescott filter Clark and MacDonald (2004) propose calculating a total misalignment using the Granger-Gonzalo decomposition of the VECM (Granger and Gonzalo, 1995) and this labelled the permanent equilibrium exchange rate (PEER), and is discussed in more detail in the next section.

The internal-external balance (IEB) approach is an alternative and popular way of estimating an equilibrium exchange rate in which deviations from PPP are explicitly recognised. In that sense it has some similarities to the BEER approach. However, the key difference with the BEER approach is that the IEB usually places more structure, in a normative sense, on the determination of the exchange rate. In particular, and in general terms, the equilibrium real exchange rate is defined as that rate which satisfies both internal and external balance. Internal balance is usually taken to be a level of output consistent with full employment and low inflation – say, the NAIRU - and the net savings generated at this output level have to be equal to the current balance, which need not necessarily equal zero in this approach. The general flavour of the IEB approach may be captured by the following equation (for more details see, for example, MacDonald, 2000, 2007):

$$S(W) - I(X) = CA(\hat{q}, Y) = -CAP \,, \tag{2.11}$$

where S denotes national savings, I denotes investment spending, W, X, Y are vectors of variables, depending on the model specification[1], and $\hat{q}$ is the real exchange rate consistent with internal balance and the value chosen for the external balance objective (*CAP*). All of the approaches discussed in this part use a variant of this relationship. In the fundamental equilibrium exchange rate (FEER) of Williamson (1983, 1994) the equilibrium exchange rate is an explicitly medium-run concept, in the sense that the FEER does not need to be consistent with stock-flow equilibrium (the medium-run is usually taken to be a period of about 5 years in the future). The definition of internal balance used in this approach is as given above - high employment and low inflation and external balance is characterised as the sustainable desired net flow of resources between countries when they are in internal balance. This is usually arrived at judgementally, essentially by taking a position on the net savings term in (2.11) which, in turn, will be determined by factors such as consumption smoothing and demographic changes. The use of the latter assumption, especially, has meant that the FEER is often interpreted as a normative approach and the calculated FEER is likely to be sensitive to the choice of the sustainable capital account. It also means that the misalignment implied by the FEER is a total misalignment. The NATREX model of Stein (1994, 1999) is also within the spirit of the IEB approach although, in contrast to the FEER approach, both medium-run and long-run – stock-flow consistent – measures of the equilibrium exchange rate are calculated and the equilibrium is estimated using cointegration-based methods which makes the actual measure of equilibrium similar to the BEER.

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

[1] In the FEER W usually contains budget deficit, domestic output gap, GDP differential and dependency ratio; X is a vector of domestic output gap, GDP differential and dependency ratio; Y consists of domestic and foreign output gap.
In the NATREX W in general contains rate of time preference and net foreign assets; X consists of productivity, Tobin's 'q' and capital stock; Y is a vector of Tobin's 'q', capital stock and net foreign assets.

procedure proposed by Johansen (1995) to estimate the cointegrated vector error-correction model (VECM):

$$\Delta x_t = AB^T x_{t-1} + \sum_{k=1}^{K-1} \Gamma_k \Delta x_{t-k} + \Phi D_t + \varepsilon_t , \qquad (3.1)$$

where the notation is as follows: x is a vector of p variables, B is a matrix of r orthogonal linearly independent cointegrating vectors between the variables in x, A is an adjustment matrix to the equilibrium trajectories (loading coefficients), Γ is a matrix of the short-run coefficients, D is a vector of j deterministic variables, Φ is a matrix of parameters of deterministic components, ε is a vector of white noise residuals and $p = 1,2,...,P$, $k = 1,2,...,K$, , $j = 1,2,...,J$, $t = 1,2,...,T$, $\Gamma_s = -\Pi$, $\Pi = AB^T$.

As the data set is limited, the estimation and testing strategy follows that proposed by Greenslade et al. (2002). In the first stage, the weak exogeneity restrictions were tested and imposed (the model reduction process), the cointegration rank was then tested and the small sample Bartlett correction was then applied (Johansen, 2002). In a 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) were performed.

As Johansen (1995) has demonstrated, the above VEC model has a vector moving representation of the following form:

$$x_t = C\sum_{i=1}^{t} \varepsilon_i + C\sum_{i=1}^{t} \Phi D_i + Y_t \qquad (3.2)$$

where:

$$C = \beta_\perp (\alpha_\perp^T \Gamma \beta_\perp)^{-1} \alpha_\perp^T = \tilde{\beta}_\perp \alpha_\perp^T \qquad (3.3)$$

$\alpha_\perp$, $\beta_\perp$ - orthogonal complements to α and β, respectively,

$\tilde{\beta}_\perp$ - loadings to *p-r* common stochastic trends $\sum_{i=1}^{t} \varepsilon_i$,

C - the long-run impact matrix.

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

$$x_t = A_1 f_t + \tilde{x}_t , \qquad (3.4)$$

where:

A_1 - the loading matrix such as $\alpha^T A_1 = 0$,

$f_t = B_1 x_t$,

$$A_1 = \beta_\perp (\alpha_\perp^T \beta_\perp)^{-1}, \tag{3.5}$$

$$A_2 = \alpha(\beta^T \alpha)^{-1}. \tag{3.6}$$

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

$$x_t = P_t + T_t, \tag{3.7}$$

where:

$$P_t = A_1 \alpha_\perp^T \beta_\perp x_t, \tag{3.8}$$

$$T_t = A_2 \beta^T x_t. \tag{3.9}$$

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

4. Real PLN/EUR equilibrium rate

4.1. Model specification and data description

During the transition process the exchange rate regime in Poland evolved from a fixed exchange rate regime, to a more flexible system with the increasing role of the market in the determination of the exchange rate, to the pure floating regime that we currently observe (see International Monetary Fund, 2005). The National Bank of Poland was forced to change exchange rate regimes due to increasing capital flows, which implied growing sterilization costs (for more details see Annex 1).

These institutional changes substantially limit the time span of our analysis of the PLN/EUR equilibrium rate. Since February 1998 was the last large intervention on the Polish foreign exchange market and the rate thereafter has either been flexible within a crawling band or fully flexible, we take the period after March 1998 as a homogenously flexible exchange rate regime. For those reasons our monthly data spans the period from March 1998 to December 2007.

In estimating the PLN/EUR equilibrium exchange rate we assume that the real PLN/EUR rate is determined by a standard set of conditioning variables (see, for example MacDonald (2007): net foreign assets (*NFA*), Balassa-Samuelson effect (*bs*), terms of trade (*tot*), real interest rate disparity (*R*) and risk premium (λ):

$$q_t = f(\overset{-}{NFA_t}, \overset{+/-}{tot_t}, \overset{-}{bs_t}, \overset{-}{R_t}, \overset{+}{\lambda_t}), \qquad (4.1)$$

where the small letters denote logarithms and the signs above the variables indicate the predicted relationships between the systematic determinants of the real exchange rate and the real exchange rate (see Table 1 for examples of BEER applications to the Polish zloty).

The **real exchange rate of the zloty against the euro** (*q*) 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. We use the PPI in manufacturing, rather than the overall PPI (or CPI[2]), so as to exclude administered prices for electricity, gas and water. As a result the price deflator represents a proxy of the prices in tradable sector.

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

$$NFA_t = NFA_0 + \Delta NFA_t, \qquad (4.2)$$

$$\Delta NFA_t \cong CA_t + \Delta KA_t, \qquad (4.3)$$

where: NFA_0 - initial value of the net foreign assets, CA - current account balance, ΔKA - change in capital account balance.

In this paper, we intended to employ the direct measure of the **Balassa-Samuelson effect** (i.e. the ratio between relative productivity in Poland and in the euro area) to verify the hypothesis that the real exchange rate of a catching-up economy based on tradable prices may appreciate as a result of the BS effect via the channel of the improvement in goods quality (compare Oomes, 2005). This effect is discussed in more detail in the next section. However, as the sectoral data on productivity is not available, we make use of the overall productivity differential (*bs*) between these two economies. Assuming that:

$$a^T = \alpha a, \qquad (4.4)$$

[2] We decided to not make use of CPI as a price deflator because in Poland it is strongly influenced by the administered prices, while there is lack of comparable net inflation data for Poland and the euro area for such a long period.

$$a^{NT} = \beta a\,, \tag{4.5}$$

where a^T and a^{NT} denote respectively productivity in tradable and nontradable sector and a is an overall productivity, then relative productivity grows at rate:

$$a^T - a^{NT} = (\alpha - \beta)a\,, \tag{4.6}$$

which is proportional to overall productivity growth (compare Oomes, 2005).

To check the influence of this assumption on our results, we decided to construct the second proxy of the BS effect (*bstnt*), where the tradebles productivity is approximated by the productivity in manufacturing, while the nontradable productivity growth differential between Poland and the euro area is assume to be constant and equal to 5%. The higher productivity growth in the Polish nontradables sector results from foreign direct investment inflows (see e.g. Alberola, Navia, 2007).

The **terms of trade** (*tot*) is defined as a relative ratio between export and import prices in Poland and Germany. As the corresponding data for the euro area is unavailable, it was assumed that changes in German terms of trade are representative for the euro area. This assumption should not have significant impact on the results as the relative terms of trade is to represent competitiveness of Polish economy and Germany constitutes Polish main trading partner[3].

The **real interest rate disparity** (*R*) is defined as a difference between monthly average of 10-year government bond yields for Poland and the euro area, deflated by PPIm.

In order to perform the sensitivity analysis, we also employ different proxies of the **risk premium** reflecting the fiscal stance of the economy: the **budget deficit** (*DEF*) and **budget debt** (*DEBT*) in relation to industrial production, respectively. As the monthly data on a comparable risk premium measure in the euro area is not available, this variable is not expressed in the relative terms. However, this should not result in the loss of the informativeness of the data. The risk premium for the zloty denominated investment is determined by the deviation of the deficit from the reference value (3% of GDP for the general government deficit and 60% of GDP for the debt; European Union, 2002) and the actions taken by the government in order to fulfil fiscal criterion rather than its level in the euro area.

For data sources and time series plots see Annex 2.

[3] In 2007 Germany accounted for 25,9% of Polish exports and 24,1% of imports.

Table 1: Specifications of BEER model for the Polish zloty (based on time series)

PAPER	TIME SPAN	EXCHANGE RATE	OTHER VARIABLES
Alberola and Navia, 2007	1993-2004, Q	effective, CPI-based	PROD, NFA
Bęza-Bojanowska, 2008	1998-2006, M	bilateral, PPI-based	REL(CPI/PPI), RIR, NFA, TOT, DEF, DEBT
Darvas, 2001	1993-2000, Q	bilateral, CPI-based	PROD, TOT, EXP, NFA, FDI, NFA, FDI, rGER
Egert and Lahreche-Revil, 2003	1992/1993-2001, Q	effective, CPI-based	PROD, PRIV, REL(CPI), CA, TOT, OPEN
Egert and Lommatzsch, 2004	1993-2002, Q	bilateral, based on CPI and PPI	PROD, RIR, OPEN, TOT, REG, FDEBT, DEBT
Kelm and Bęza-Bojanowska, 2005	1995-2004, M	bilateral, CPI-based	RIR, DEF, SDEBT, TB
Kemme and Teng, 2000	1990-1999, M	effective, based on CPI and PPI	EXP, CA, RW, OPEN
Lommatzsch and Tober, 2002	1994/1995-2001, Q	bilateral, PPI-based	PROD, GDP*, RIR, NFA
Rahn, 2003	1990/1993-2002, Q	bilateral and effective, CPI-based	REL(CPI/PPI), NFA
Rawdanowicz, 2002	1995-2002, Q	bilateral, CPI-based	PROD, TOT, RIR
Rubaszek, 2003	1994-2002, Q	effective, PPI-based	GDP, GDP*, NFA, RIR, DEF

CA– current account to GDP/industrial production; DEF– budget deficit to GDP/industrial production; DEBT- government debt to GDP/industrial production, EXP– government expenditure to GDP/industrial production; FDEBT– foreign debt to GDP, FDI– foreign direct investment to GDP; GDP- domestic product, GDP*– foreign product; NFA– net foreign assets to GDP/industrial production; OPEN– openness ratio (foreign trade turnover to GDP/industrial production); PROD– productivity; PRIV– private consumption to GDP; REL(CPI)– nontradable prices differential approx. by CPI; REL(CPI/PPI)– indirect BS effect proxy; REG– differential in regulated prices vis-à-vis Germany, rGER– real interest rate in Germany; RIR– real interest rate disparity; RW– real wages; SDEBT– short term budget debt to GDP, TB– trade balance to GDP, TOT– terms of trade, Q- quarterly data, M- monthly data.

Source: The authors (partly based on Egert, 2004).

4.2. Behavioural PLN/EUR equilibrium rate

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 tests. As all variables are integrated of order one (see Table 9 in Annex 3), the VECM methodology was used to estimate the PLN/EUR equilibrium rate.

In the first stage of the econometric analysis, we estimated two VAR models: VAR01, with the budget deficit included, and VAR02 with budget debt as an alternative to the budget deficit[4]. We jointly specified the deterministic component of the VAR models and the lag length. This resulted in VAR(2) model and the deterministic component consisting of the constant and dummies variables[5] (necessary to eliminate the residuals skewness). The analysis of a number of residual diagnostic tests confirms that the estimated VARs are well specified (see Table 10 in Annex 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; there is also no significant ARCH effect in residuals.

In the next stage, following the proposition of Greenslade et al. (2002), the cointegration rank test along with the identification of weak exogeneity was performed. The number of cointegrating vectors was determined by applying the trace test with a Bartlett correction, as well as the analysis of the largest characteristic roots of the companion matrix (see Table 11 in Annex 3). The trace test strongly indicates the existence of one cointegrating vector in each system. The analysis of the number of characteristic roots (Juselius, 2006) confirms the former finding.

Assuming that cointegration rank equals 1, the long-run relations were determined on the basis of the Johansen procedure. As the system is to represent the real PLN/EUR equilibrium rate trajectories, all vectors were normalised on the exchange rate. Three variables (terms of trade, BS effect and risk premium proxy) proved to be weakly exogenous in each model (see Table 12 and Chart 8 in Annex 3). The weak exogeneity of these variables is fully in line with economic reasoning. Poland, as a small open economy, is the price-importer, thus the prices (terms of trade and BS effect) are not significantly adjusting to the exchange rate equilibrium trajectory, mainly defined for domestic variables. Moreover, the composition of the cointegrating vector implies also the weak exogeneity of the risk premium. As the existence of the weakly exogenous variables may affect the cointegration rank, the cointegration test was performed once again and the existence of one cointegrating relation was again supported (see Table 2).

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[4] As the results proved to be robust to changes in the BS effects proxy, we did not report partial results with the second BS proxy (*bstnt*). The final outcome, the estimates of the equilibrium exchange rate, is reported in Chart 9-Chart 10 in Annex 3.

[5] Dummy variables reflects such effects as: last National Bank of Poland intervention on the foreign exchange market (Jul 98), currency crisis in Russia (Aug-Sep 98), financial and political tensions in Turkey (Jun 01), Polish Prime Minister's announcement of a risk of financial crisis in Poland (Jul 07), speculation attack on Hungarian forint (Jun 03), tensions on the Hungarian foreign exchange market, decrease in the Hungarian rating (Jun 05).

Table 2. Cointegration test (restricted models)

Hypothesis	*Eigenv.*	*Trace*	*Trace^{BC}*	*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

Trace^{BC} – trace test statistic with Bartlett correction

Trace* - 90% quantiles from the asymptotic tables generated in CATS

Source: The authors.

Having established the existence of a single cointegrating vector, we next performed the identification of the long-run structure of the VEC models with weak exogeneity restrictions (see Table 3), by imposing 1 normalizing restriction. In each model variant all variables are correctly signed and statistically significant. Moreover, the forward recursive test of parameter constancy accepts coefficient stability over time (see Chart 1 and Chart 2).

Table 3: Identification of the long-run structure for real PLN/EUR rate

Variant		*q*	*NFA*	*R*	*tot*	*bs*	*DEF*	*DEBT*	*c*
VECM01	*LT*	1.000	0.690	0.560	0.467	0.442	-1.763	-	-5.968
			(4.104)	(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
			(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 estimation with t-Student statistics in brackets.

Source: The authors.

In each variant of the model the identified long-run relationship is significantly adjusting to the exchange rate equation. This implies that the cointegrating relations represent the

PLN/EUR equilibrium rate trajectories with a half-life of a shock 8 and 4 months, respectively. This is a high speed of convergence to the equilibrium and is substantially faster than in PPP-based models. However, it is broadly consistent with those obtained in other studies, which apply the BEER methodology (e.g. for Poland: Alberola and Navia, 2007; for the euro area: Maeso-Fernandez et al., 2001).

The estimation results indicate that in the long-run net foreign assets, the real interest rate disparity, the terms of trade, the BS effect and the risk premium have a significant influence on the real PLN/EUR rate. An increase in net foreign debt leads to the zloty appreciation. Sustainable net foreign debt is natural for catching-up economies like Poland (see European Commission, 2002). Steady growth in foreign assets and liabilities of agents is a result of the integration process of the Polish financial market with international market as well as the conviction that Poland is an attractive country for foreign investment (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 on the currency. The coefficient value depends on the price stickiness and the output gap sensitivity on the price level as well as the aggregate demand sensitivity to the real exchange rate and the existence of capital restrictions (MacDonald and Nagayasu, 2000).

The outcome that an increase in terms of trade results in the zloty appreciation points to low price elasticities of net exports. If exports and imports have low price elasticities, such as primary or very differentiated goods, an increase in the terms of trade would imply an increase in export revenues and hence an amelioration of the trade balance, which could result in an appreciation of the nominal and thus the real exchange rate. At the same time, growing exports revenues may induce higher consumption of nontradables and may intensify a pressure on domestic currency appreciation through the BS effect.

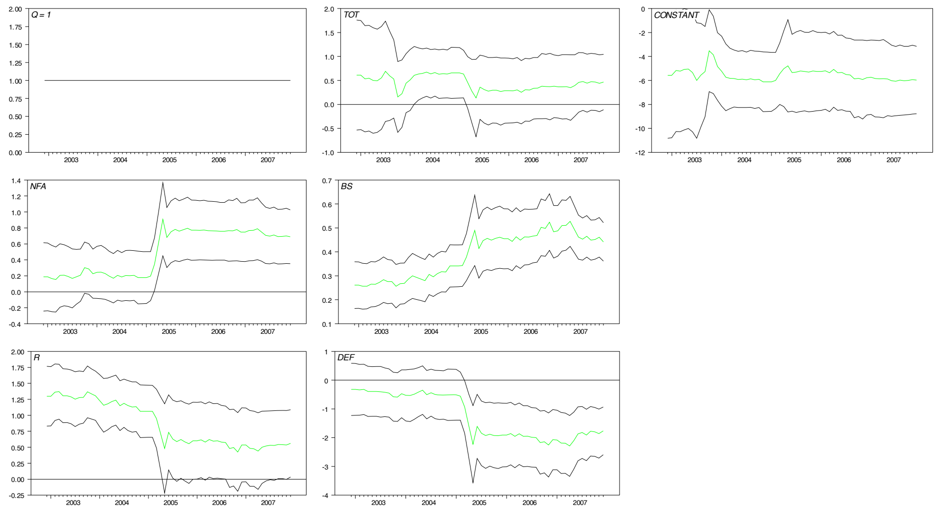
An increase in the BS effect is associated with the real appreciation of the Polish zloty. Higher relative productivity, partly driven by foreign direct investment, implies improvement in supply capacities and quality of domestic goods as well as its reputation. This results in changes in consumers' preferences: a rise in the share of domestic goods accompanied by decrease in the share of imported goods. Simultaneously, higher demand for domestic goods (also from abroad) increases demand for domestic currency and results in the zloty appreciation (for more details see e.g. Egert and Lommatzsch, 2004).

An increase in the risk premium generates a depreciation of the domestic currency. Higher government spending, leading to an increase in the budget deficit and debt, undermines confidence in a currency. Simultaneously, as noted above, an increase in government indebtedness negatively affects domestic currency through the interest payments channel (Maeso-Fernandez et al., 2001).

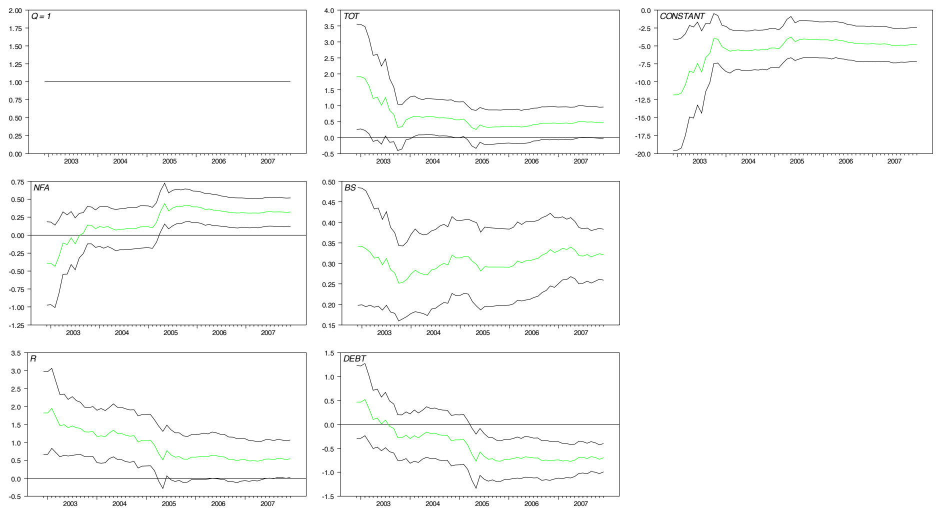
The results described above are very interesting from the point of view of Poland's future membership of ERM II. They imply that in terms of rational macroeconomic policy, as well as the good shape of the economy, PLN/EUR equilibrium rate will be subject to appreciation pressure. Assuming rationality of economic agents (that does not seem to be strong assumption taking into account the level of the adjustment parameter) the actual PLN/EUR rate should appreciate. It does imply that the exchange rate criterion may not be as problematic for Poland as it used to be expected and that Poland may follow Slovak experience within ERM II (strong and persistent appreciation pressure).

Chart 1: Recursive test for stability of loading coefficients

VECM01



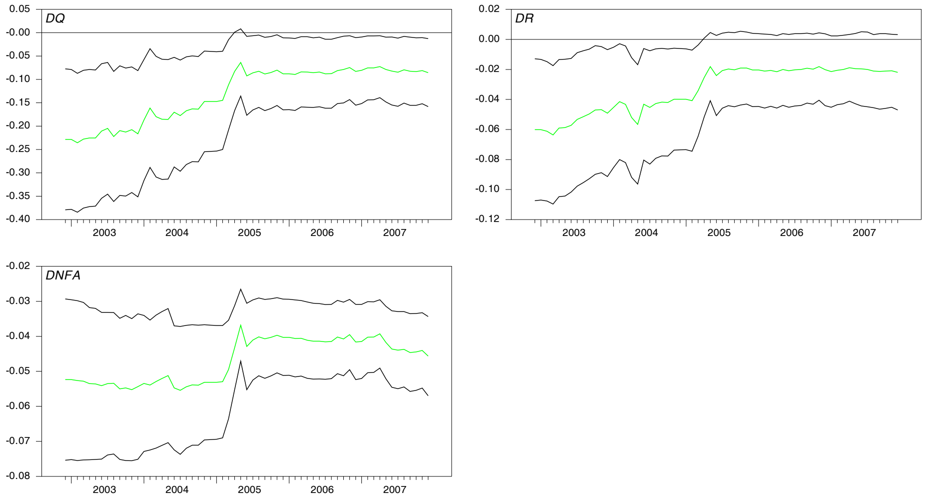
VECM02



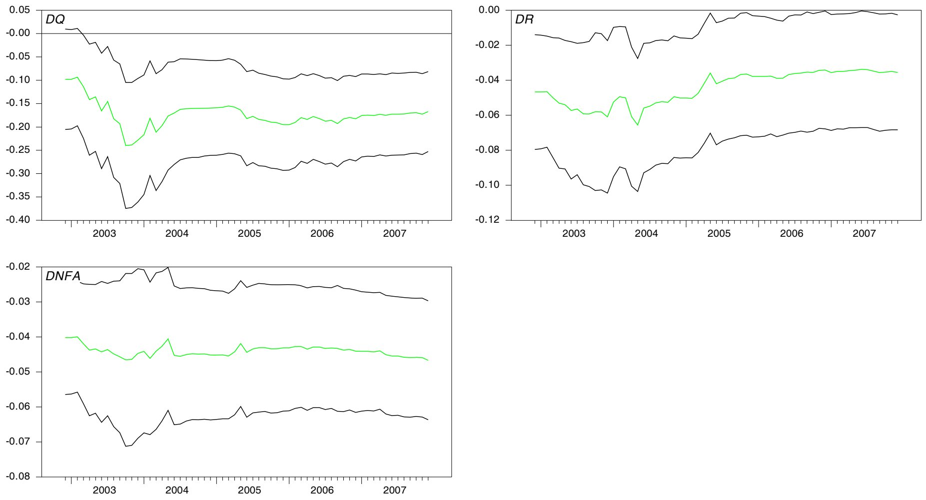
Source: The authors.

Chart 2: Recursive test for stability of adjustment coefficients

VECM01



VECM02



Source: The authors.

4.3. Permanent PLN/EUR equilibrium rate

In the next stage of our equilibrium exchange rate analysis we estimated a PEER. In constructing the PEER we made use of the moving average representation of the VEC model and this follows the derivation outlined in Section 2. The beta orthogonal components of each model and the long-run impact matrices are reported in Table 4-Table 7.

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, while CT(2)-CT(4) are driven by terms of trade, BS effect and risk premium, respectively. In VECM02 unanticipated shocks to net foreign assets and real interest disparity are represented by the forth and fifth common trends (CT(4) and CT(5)), while CT(1)-CT(3) are driven by terms of trade, BS effect and risk premium, respectively. For details see Table 13 and Table 14 in Annex 3

The analysis of Table 4 and Table 6 give us the information about the forces (represented here by common trends) that pull each variable in the system. From our point of view the most interesting is the exchange rate that in each system is significantly influenced by the shocks to the real interest disparity term and the BS effect. The VECM01 points that the PLN/EUR rate is also affected by the unanticipated shocks to budget deficit.

Further insight into the pulling variables in our system may be obtained by calculating the long-run impact matrix (Table 5 and Table 7) which gives information if the shock to a particular variable has a permanent effect on the other variables in the system. These results confirm our previous finding that shocks to real interest disparity, BS effect and budget deficit have a significant long-run impact on the real PLN/EUR rate.

It is also interesting to note that in the log-run most of the variables influence the budget debt. The last finding has a practical implication for fiscal policy within ERM II. In this period the long-run interest rates will be under the pressure of the convergence play resulted from the expectations on the adjustment of the policy rates to the ECB level. Additionally, in terms of increasing probability of the membership in the euro area, the capital inflows will be attracted (increase in the NFA debt), implying the zloty appreciation. These will facilitate financing budgetary needs and might result in expansionary fiscal policy. However, the fiscal criterion requirements will limit the moral hazard and should ensure optimal policy mix within the ERM II period: tight fiscal policy combined with looser monetary policy. Thus, it should eliminate the potential depreciation pressure on the exchange rate.

Table 4: Loadings to Common Trends - VECM01

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

Source: The authors.

Table 5. Long-Run Impact Matrix - VECM01

C	*q*	*NFA*	*R*	*tot*	*bs*	*DEF*
q	0.547	0.417	**-1.736**	-1.109	**-0.265**	**1.667**
	(1.765)	(0.533)	**(-3.184)**	(-0.221)	**(-3.184)**	**(2.284)**
NFA	-0.722	1.872	-0.897	8.674	-0.083	0.798
	(-1.633)	(1.680)	(-1.154)	(1.215)	(-0.698)	(0.767)
R	-0.152	-0.814	1.402	4.951	0.010	0.437
	(-0.589)	(-1.250)	(3.085)	(1.186)	(0.151)	(0.718)
tot	0.091	-0.080	-0.092	8.620	0.111	0.213
	(0.279)	(-0.097)	(-0.161)	(1.643)	(1.275)	(0.278)
bs	-0.214	0.305	0.062	-2.283	0.693	0.443
	(-0.813)	(0.460)	(0.135)	(-0.538)	(9.832)	(0.716)
DEF	-0.119	0.319	-0.162	1.032	-0.039	1.545
	(-1.071)	(1.142)	(-0.832)	(0.577)	(-1.326)	(5.928)

Source: The authors.

Table 6: Loadings to Common Trends - VECM02

BETA_ORT(tilde)	CT(1)	CT(2)	CT(3)	CT(4)	CT(5)
q	-1.630	**-0.233**	0.073	1.005	**-1.890**
	(-0.330)	(-3.262)	(0.337)	(1.290)	(-3.556)
NFA	8.472	-0.027	-0.334	2.026	-0.936
	(1.167)	(-0.259)	(-1.053)	(1.767)	(-1.197)
R	5.981	0.021	0.055	-0.925	1.304
	(1.236)	(0.296)	(0.260)	(-1.211)	(2.504)
tot	9.243	0.124	0.066	-0.126	0.002
	(1.573)	(1.460)	(0.256)	(-0.136)	(0.003)
bs	-2.878	0.679	0.109	0.572	-0.089
	(-0.642)	(10.449)	(0.558)	(0.807)	(-0.184)
DEBT	2.961	-0.084	0.785	1.753	-0.948
	(0.689)	(-1.358)	(4.179)	(2.586)	(-2.049)

Source: The authors.

Table 7. Long-Run Impact Matrix - VECM02

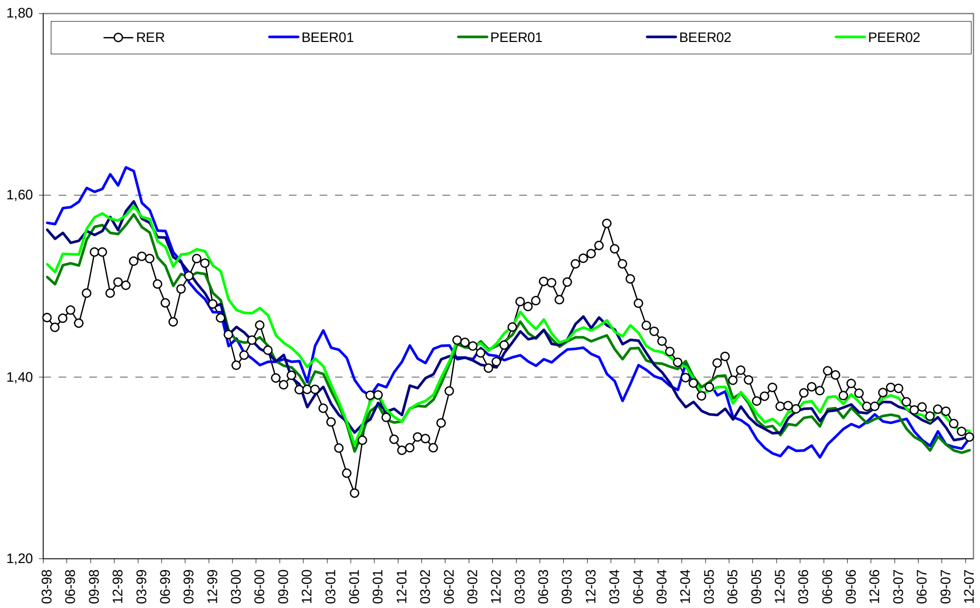
C	*q*	*NFA*	*R*	*tot*	*bs*	*DEBT*
q	0.470	1.005	**-1.890**	-1.630	**-0.233**	0.073
	(1.772)	(1.290)	(-3.556)	(-0.330)	(-3.262)	(0.337)
NFA	-0.627	2.026	-0.936	8.472	-0.027	-0.334
	(-1.607)	(1.767)	(-1.197)	(1.167)	(-0.259)	(-1.053)
R	-0.194	-0.925	1.304	5.981	0.021	0.055
	(-0.748)	(-1.211)	(2.504)	(1.236)	(0.296)	(0.260)
tot	0.070	-0.126	0.002	9.243	0.124	0.066
	(0.221)	(-0.136)	(0.003)	(1.573)	(1.460)	(0.256)
bs	-0.273	0.572	-0.089	-2.878	0.679	0.109
	(-1.132)	(0.807)	(-0.184)	(-0.642)	(10.449)	(0.558)
DEBT	-0.467	1.753	-0.948	2.961	-0.084	0.785
	(-2.025)	(2.586)	(-2.049)	(0.689)	(-1.358)	(4.179)

Source: The authors.

Finally, we calculate the PEER level and compare it with our BEER estimates (see Chart 3). The relatively close relation between the BEER and PEER series indicates that the BEER (especially BEER02) has only a small transitory component. As Clark and MacDonald (1998, 2004) proved for US the total misalignment may depend significantly on the approach to computing it. Thus, in order to check whether it is also valid for Polish zloty, we decided to compute the total misalignment also using the 'standard' way, described by the equations (2.4)-(2.6). In the first variant (labelled BEER HP in Chart 4) we set the long-run values of the economic fundamentals at the level indicated by the Hodrick-Prescott filter (with the smoothing parameter fixed at the level of 14400; Ravn and Uhlig, 2002). Additionally, we calibrate the NFA at its optimal level (39% of GDP, European Commission, 2002) and the real interest rate disparity at the level consistent with the natural interest rates in Poland and in the euro area[6], while the rest of the fundamentals are maintained at the level indicated by HP filter (BEER LT in Chart 4). However, as the assumptions on the sustainable optimal level of the above listed variables is fairly strong, we recommend to treat the BEER LT with some caution and we reported it only for the comparison.

The analysis of Chart 4 indicates that in the past there used to be significant and persistent differences between the PEER and the medium-run BEER, but since 2003 the relation between PEER and the latter type of BEER becomes closer, and, what's more, since EU accession the misalignment almost disappeared (in case of BEER01 LT since mid-2005). It may imply that the assumptions on the optimal level of fundamentals are correctly chosen only for the second half of the analysis horizon.

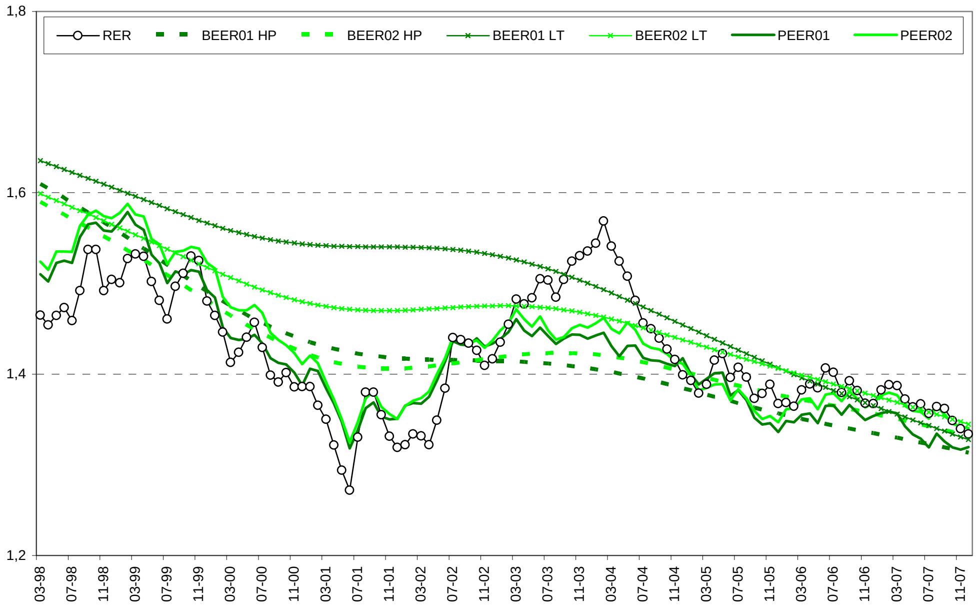
Chart 3: Current BEER and PEER for real PLN/EUR rate



Source: The authors.

[6] The assumptions on the real natural interest rate in Poland (4%) and in the euro area (2%) follow Brzoza-Brzezina (2005).

Chart 4: Medium-run BEER and PEER for real PLN/EUR rate



BEER HP - long-run values of the fundamentals set at the level indicated by HP filter
BEER LT - long-run values of the fundamentals, except of NFA and R, set at the level indicated by HP filter, NFA and R calibrated at the optimal level
Source: The authors.

4.4. Misalignment analysis

Since the main goal of the paper is to identify the equilibrium PLN/EUR rate we now in the final stage of our analysis compute the current and total real PLN/EUR rate misalignment. The current misalignment reflects the difference between the actual real PLN/EUR rate and the current behavioural equilibrium exchange rate while the total misalignment is represented by the difference between the actual exchange rate and the permanent equilibrium rate.

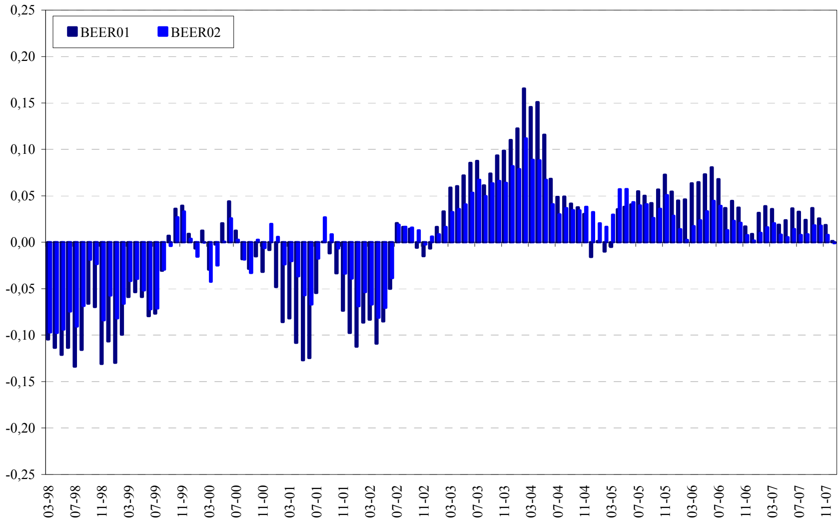
All models point to significant misalignments at the same points in time and of the same direction. The misalignment magnitude is comparable between model types (the BEERs and PEERs). In general the misalignment direction indicated by the models is in line with other researchers results, both with BEERs and FEERs estimates for the zloty (see Table 8).

The last finding has practical implications for any future decision on the level of the central parity in the ERM II. There are concerns about the applicability of the equilibrium exchange rate estimates for setting the central parity of the catching-up economies' currencies (European Commission, 2004). This seems not to be valid for Polish zloty as the misalignment proved to be invariant to the changes in the approach to estimate the equilibrium rate, especially to switches between BEERs/PEERs and FEERs (see Table 8 for details).

The resulting misalignments for both the BEER and PEER, presented in Chart 5 and Chart 6, contain several interesting findings:

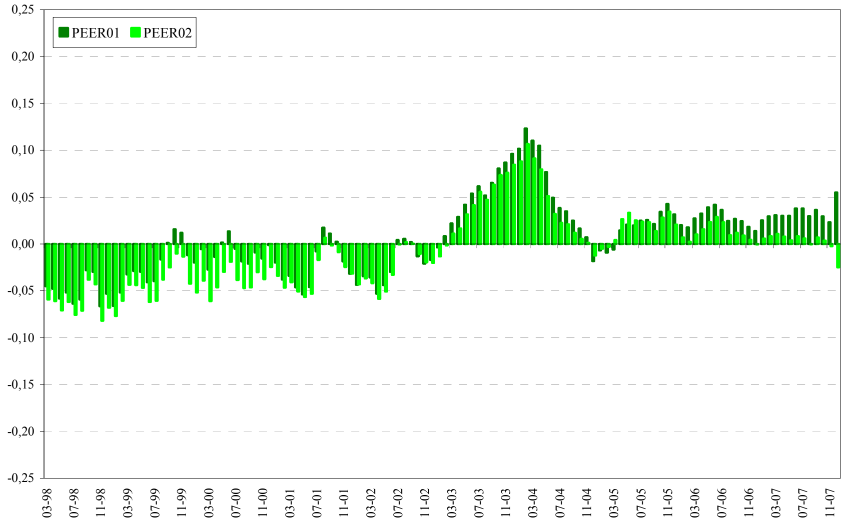
1. The strong appreciation of the real equilibrium exchange rate, accompanied by an actual exchange rate appreciation, observed in the years 1998-2001 may be interpreted as a confirmation of the hypothesis of the natural appreciation of the exchange rate of the transition country (Halpern and Wyplosz, 1997). This appreciation reflects the adjustment of the market exchange rate to its equilibrium value that is also in the majority of cases appreciating (see e.g. Kelm and Bęza-Bojanowska, 2005).
2. It seems that the timing of the introduction of a floating exchange rate regime (April 2000) was correctly chosen, as the actual exchange rate was close to the actual equilibrium exchange rate and the total misalignment was rather small. This finding may seem to be controversial, taking into account high current account deficit at that time. However, if the relation between the accumulation of the large net foreign liabilities and the production potential (especially the productivity) is strong, the relationship between the current account balance and the exchange rate is broken. Thus, in the presence of high current account deficit, the exchange rate may prove to be fairly valued (compare Alberola, Navia, 2007).
3. In the years 2001-2002, when the PLN/EUR rate reached its historically strongest level, the zloty was overvalued on average by 3-6% in terms of the current misalignment and 2-3% in terms of the total misalignment. The magnitude of the misalignment seems to be much lower that that perceived at that time by various economists.
4. All models unambiguously indicate the highest misalignment in February 2004, amounting to the zloty undervaluation of 11-16% in terms of the current real equilibrium exchange rate and of 11-12% for medium-run equilibrium exchange rate. This maximum misalignment coincides with the historically weak level of the PLN/EUR rate, reached mainly as a result of political tensions in Poland.
5. Since May 2004 to the end of 2007, the real PLN/EUR rate development was broadly in line with the current and medium-run equilibrium rate. We observe gradual appreciation of the equilibrium rate, that was a little bit stronger (especially in 2007) than that of the actual rate. The appreciation pressure seems to be mainly a result of the BS effect and significant decrease in risk premium. In this connection, the zloty appreciation in 2008 may be perceived – to some extent – as a correction of the actual rate towards its equilibrium.

Chart 5: Current misalignment



Source: The authors.

Chart 6: Total misalignment



Source: The authors.

Table 8. The real PLN/EUR rate misalignment – review of the literature

PAPER	MODEL	PERIOD	MISALIGNMENT	OUR OUTCOMES
Bęza-Bojanowska, 2008	BEER PPI-based	Feb 2004 Dec 2006	(+): 12.7-15.9% close to ER	(+): 10.7-16.6% close to ER
Coudert and Couharde, 2002	FEER CPI-based	2000 2001	(-): 7% (-): 3%	(-): 1-4% (-): 2-3%
Égert and Lommatzsch, 2004	BEER based on CPI and PPI	Q4 2002	(-): 12-15%	(-): 1%
Lommatzsch and Tober, 2002	BEER PPI-based	Q4 2001	(-): 10%	(-): 3-7%
Rahn, 2003	BEER CPI-based	Q1 2002	(-): 10-15%	(-): 6-9%
Rawdanowicz, 2002	FEER CPI-based	2002	(-): 3.7-6.9%	(-): 2-3%
Rubaszek, 2004	FEER based on GDP deflator	Q4 2003	(+): 6.4%	(+): 8-9%

(+) – undervaluation, (-) – overvaluation, ER – equilibrium rate
For FEERs totals misalignment was reported (last column)
Source: The authors (partly based on Egert, 2004).

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 range of economic indicators while taking into account the market rate (European Central Bank, 2003).

The analysis carried out in this paper focuses on calculating the current and medium-run real PLN/EUR equilibrium rate while different risk premium proxies are employed. The objective of the analysis, apart from the assessment of the current situation on the foreign exchange market, includes the sensitivity analysis of the current and medium-run equilibrium rate estimates using BEER and PEER approaches.

Applying Johansen's procedure, two models of the PLN/EUR equilibrium rate were estimated. Those models differ in the scope of proxies for the risk premium. The results indicate that net foreign assets, real interest disparity, the terms of trade, the BS effect and the risk premium determine the real PLN/EUR equilibrium rate. It means the budgetary situation may play a crucial role for the stability of the PLN/EUR rate in the ERM II.

The results of the analysis performed in this paper are encouraging. In particular, the choice of a risk premium proxy does not affect in any statistically significant way the estimates of PLN/EUR equilibrium rate (especially permanent rate) or the sources of changes in the PLN/EUR equilibrium rate. Also the way of calculating total misalignment, i.e. PEER approach or BEER model based on long-run fundamentals values, does not significantly influence the assessment of the actual situation on the foreign exchange market. Thus, the presented approach, especially PEER model, seems to be an appropriate tool for calculating the PLN/EUR equilibrium rate, which will be taken into account while setting the central parity in the ERM II.

In addition, the fundamentals seem to account for most of the PLN/EUR rate behaviour while the unexplained movements in the PLN/EUR rate are a measure of the exchange rate misalignment. All models point to significant misalignments of the same periods, of the same direction and of a comparable magnitude. The models indicate that since the EU accession, the real PLN/EUR rate development was broadly in line with the current and medium-run equilibrium rate with a decrease in the misalignment magnitude and persistence is accompanied by gradual appreciation of the equilibrium rate. The appreciation pressure seems to result mainly from the BS effect and a significant decline in the risk premium. As the ERM II entry should be accompanied by a further drop in the risk premium, we can expect zloty appreciation within that mechanism. It means that the exchange rate criterion may not be as problematic for Poland as it used to be perceived and it is probable that Poland will follow the Slovak experience within ERM II.

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Annex 1 Main institutional changes in Polish exchange rate regime in the years 1989-2000

Data	Action
01.01.1989	Introduction of the fixed exchange rate regime
17.05.1991	Zloty devaluation of 16.8% Introduction of the currency basket (45% USD, 35% DEM, 10% GBP, 5% FRF, 5% CHF)
14.10.1991	Adoption of the crawling peg system (monthly rate of crawl against the currency basket set at 1.8%)
26.02.1992	Zloty devaluation of 12.0%
27.08.1993	Zloty devaluation of 8.0% Reduction of the rate of crawl to 1.6%
13.09.1994	Reduction of the rate of crawl to 1.5%
30.11.1994	Reduction of the rate of crawl to 1.4%
16.02.1995	Reduction of the rate of crawl to 1.2%
16.05.1995	Introduction of the crawling band system with the band width of +/-7%
22.12.1995	Zloty revaluation of 6.0%
08.01.1996	Reduction of the rate of crawl to 1.0%
26.02.1998	Reduction of the rate of crawl to 0.8% Widening of the fluctuation band to +/-10%
17.07.1998	Reduction of the rate of crawl to 0.65%
10.09.1998	Reduction of the rate of crawl to 0.5%
29.10.1998	Widening of the fluctuation band to +/-12.5%
01.01.1999	Adjustment of the currency basket composition (55% EUR and 45% USD)
25.03.1999	Reduction of the rate of crawl to 0.3% Widening of the fluctuation band to +/-15%
12.04.2000	Introduction of the floating exchange rate regime

Source: The authors based on the National Bank of Poland official publications.

Annex 2 Data sources and time series plots

DATA SOURCES

Real PLN/EUR rate: nominal PLN/EUR rate [NBP[7]], index of prices in manufacturing in Poland and in the euro area [Eurostat].

Net foreign assets: Poland's international monetary position [NBP], current account balance [NBP], capital account balance [NBP], industrial production in Poland [CSO[8]].

Balassa-Samuelson effect: seasonally adjusted index of total industrial production, of production in manufacturing, of employment in total industry, of employment in manufacturing in Poland and in the euro area, respectively [Eurostat].

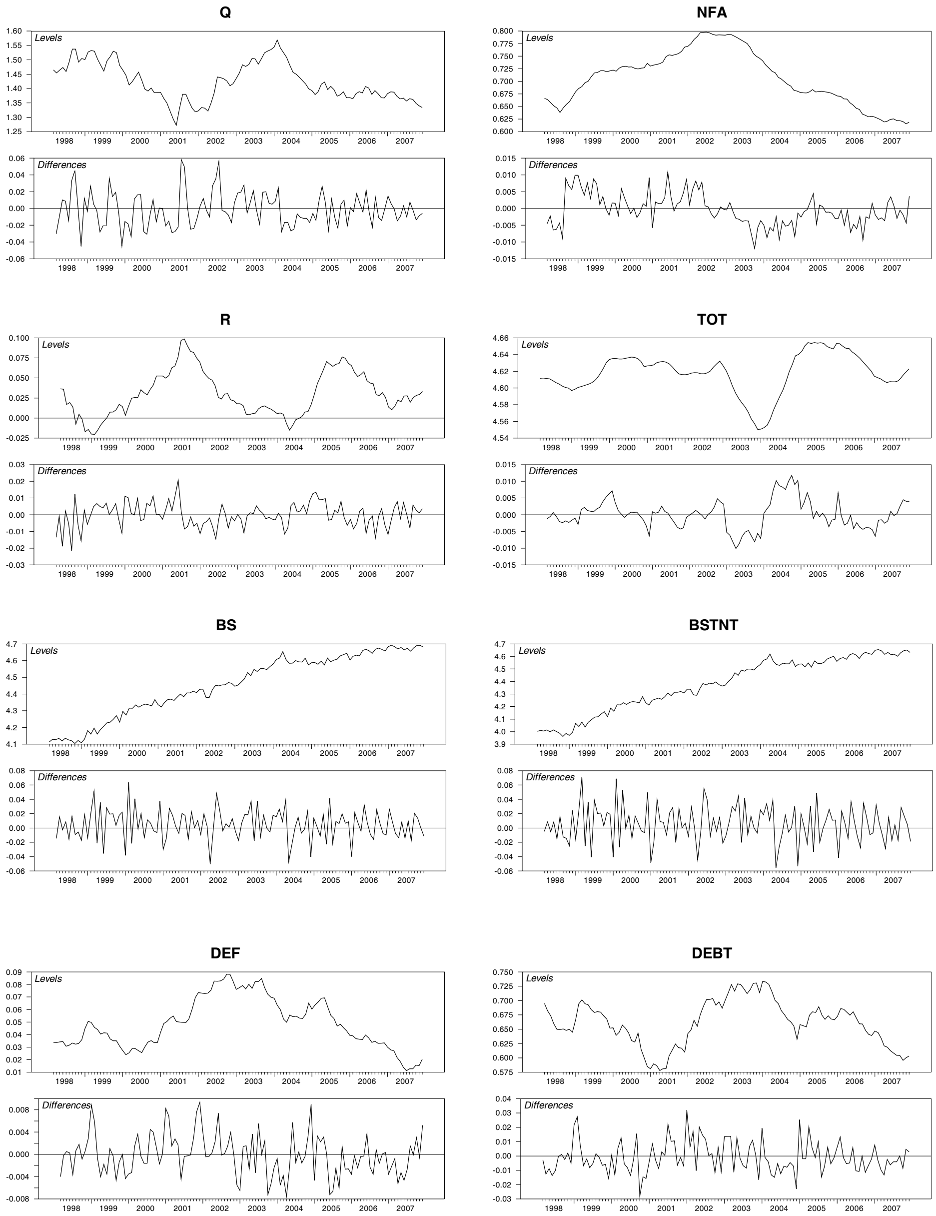
Terms of trade: export to import prices ratio in Poland [CSO] and Germany [SBD[9]].

Real interest rate disparity: 10-year government bond yields for Poland and the euro area [Eurostat], index of prices in manufacturing in Poland and in the euro area [Eurostat].

Risk premium: budget deficit [MF[10]], budget debt [MF], industrial production [CSO].

[7] National Bank of Poland; www.nbp.pl.
[8] CSO - Polish Central Statistical Office; www.stat.gov.pl.
[9] SBD - German Federal Statistical Office (Statistisches Bundesamt Deutschland); www.destatis.de.
[10] CSO - Polish Central Statistical Office; www.stat.gov.pl.

Chart 7: Levels and first differences of the real PLN/EUR rate and its determinants



Source: The authors.

Annex 3 Econometric analysis outcomes

Table 9: 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
bstnt	-1.1890	c	1	0.2541*	c, t	9
DEF	-1.1493	c	1	0.2753*	c	9
DEBT	-1.2614	c	0	0.1403*	c	9

*) rejection of H0, 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
Source: The authors.

Table 10. Multivariate diagnostics

	VAR01	VAR02
	Information Criteria	
SC	-57.546	-55.893
HQ	-59.492	-57.669
Trace Correlation	0.481	0.467
	Test for Autocorrelation	
LM(1) - ChiSqr(36)	30.801 [0.714]	28.226 [0.819]
LM(2) - ChiSqr(36)	39.393 [0.321]	40.178 [0.290]
	Test for Normality	
ChiSqr(12)	4.704 [0.967]	10.258 [0.593]
	Test for ARCH	
LM(1) - ChiSqr(441)	411.061 [0.844]	428.566 [0.655]
LM(2) - ChiSqr(882)	884.081 [0.474]	913.935 [0.221]

p values in square brackets
Source: The authors.

Table 11: Cointegration test (no weak exogeneity restrictions)

Hypothesis	*Eigenv.*	*Trace*	*Trace^{BC}*	*Trace**	*Modulus: 6 largest roots*		
					r=2	*r=1*	*r=0*
			VAR01				
r=0	0.450	148.228	113.677*	97.041	1.000	1.000	1.000
r=1	0.279	78.779	59.458	72.130	1.000	1.000	1.000
r=2	0.149	40.836	28.453	49.942	1.000	1.000	1.000
r=3	0.118	22.084	14.003	32.158	1.000	1.000	1.000
r=4	0.045	7.553	3.945	18.043	0.938	1.000	1.000
r=5	0.019	2.245	1.354	7.436	0.938	0.899	1.000
			VAR02				
r=0	0.378	143.537	110.305*	96.862	1.000	1.000	1.000
r=1	0.290	88.506	68.569	71.992	1.000	1.000	1.000
r=2	0.147	48.799	36.577	49.671	1.000	1.000	1.000
r=3	0.134	30.403	17.042	31.445	1.000	1.000	1.000
r=4	0.081	13.684	8.802	17.662	0.937	1.000	1.000
r=5	0.033	3.899	2.787	7.561	0.937	0.891	1.000

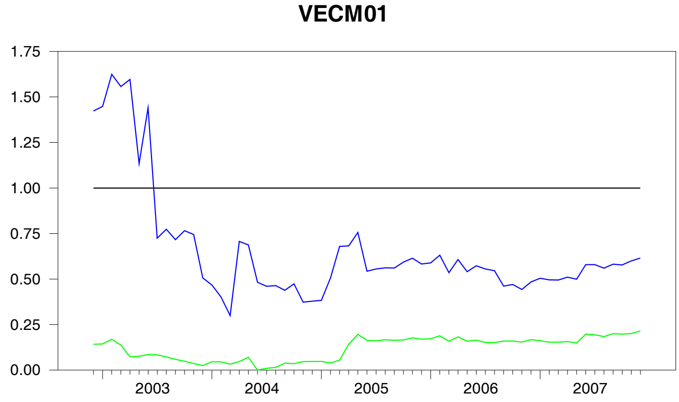
Trace^{BC} – trace test statistic with Bartlett correction
*Trace** - the 90% quantiles from the asymptotic tables generated in CATS
Source: The authors.

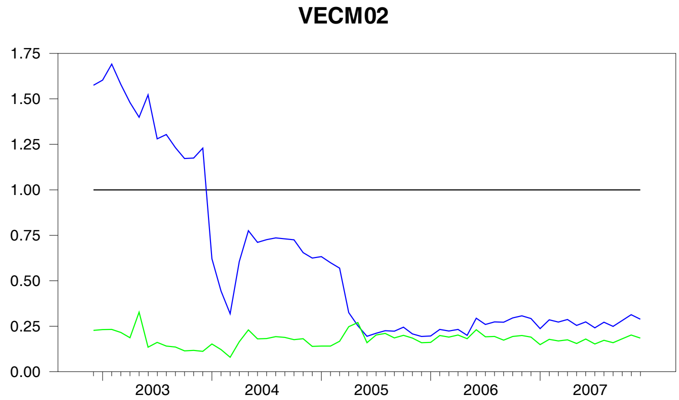
Table 12: Coefficients of VEC models and weak exogeneity test

variant		*q*	*NFA*	*R*	*tot*	*bs*	*DEF*	*DEBT*	*c*	LR *p-value*
VECM01	*LT*	1.000	0.577	0.619	0.272	0.429	-1.553	-	-4.943	
			(3.534)	(2.382)	(0.998)	(10.837)	(-3.836)		(-3.716)	
	ECT	-0.086	-0.047	-0.021	0.007	0.020	-0.012	-		
		(-2.324)	(-7.909)	(-1.643)	(1.584)	(0.453)	(-1.811)			
	LT	1.000	0.690	0.560	0.467	0.442	-1.763	-	-5.968	0.189
			(4.104)	(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	0.315	0.512	0.243	0.351	-	-0.694	-3.895	
			(2.845)	(1.746)	(0.923)	(10.261)		(-4.207)	(-3.055)	
	ECT	-0.132	-0.043	-0.031	0.009	-0.027	-	-0.000		
		(-3.074)	(-5.361)	(-2.019)	(1.809)	(-0.522)		(-0.009)		
	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 panel of each part reports the normalized vector estimation: the loading (LT) and the adjustment (ECT) coefficients with t-Student statistics in brackets. The lower panel reports the coefficients of the restricted model (with weak exogeneity restrictions) and the joint significance level of these restrictions (last column of this table).
Source: The authors.

Chart 8: Recursive LR-test of restrictions





Source: The authors.

Table 13: Common Trends - VECM01

ALPHA_ORT (T)	*q*	*NFA*	*R*	*tot*	*bs*	*DEF*
CT(1)	-0.461	0.000	1.000	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	0.000
CT(4)	0.000	0.000	0.000	0.000	0.000	1.000
CT(5)	-0.606	1.000	0.000	0.000	0.000	0.000

Source: The authors.

Table 14: Common Trends - VECM02

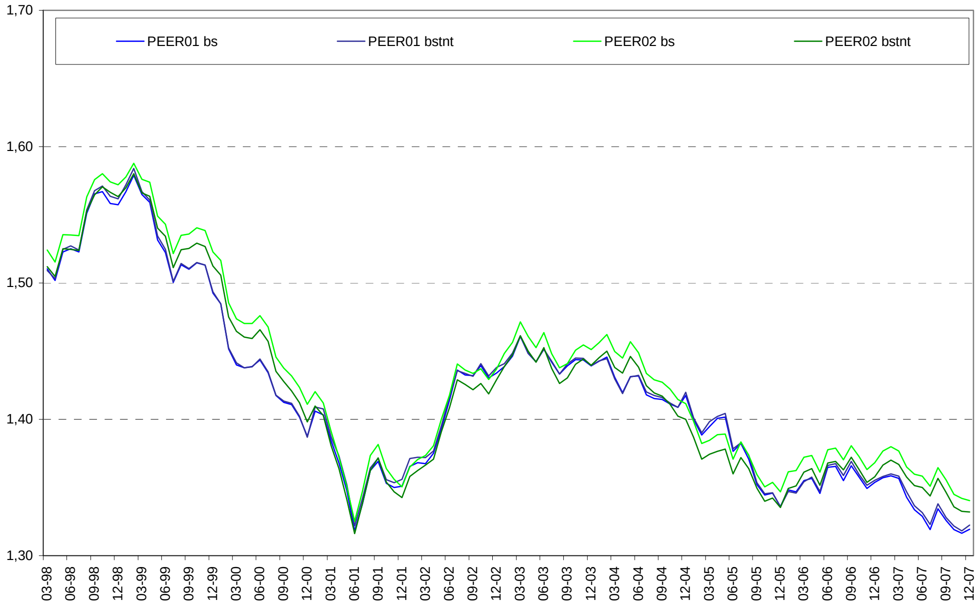
ALPHA_ORT (T)	*q*	*NFA*	*R*	*tot*	*bs*	*DEBT*
CT(1)	0.000	0.000	0.000	1.000	0.000	0.000
CT(2)	0.000	0.000	0.000	0.000	1.000	0.000
CT(3)	0.000	0.000	0.000	0.000	0.000	1.000
CT(4)	-0.562	1.000	0.000	0.000	0.000	0.000
CT(5)	-0.548	0.000	1.000	0.000	0.000	0.000

Source: The authors.

Chart 9: The comparison of BEERs estimates using different BS proxies

Source: The authors.

Chart 10: The comparison of PEERs estimates using different BS proxies



Source: The authors.

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