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The Polish Zloty / Euro Exchange Rate under Free Float: An Econometric Investigation

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Abstract

Empirical studies of exchange rates in the emerging economies are usually medium-term, because they assume foreign debt stabilization and the Balassa-Samuelson mechanism being in force. This perspective becomes doubtful when the investigation sets out to detect the major exchange rate determinants.

In the paper, a set of structural vector error correction (VEC) models is constructed for the Polish zloty / euro exchange rate in the period of free float, 1999-2009. An attempt is made to construct an eclectic VEC model comprising two approaches – a medium-term behavioral equilibrium exchange rate model (BEER) and a short-term capital enhanced equilibrium model (CHEER). The estimation results indicate that extension of the CHEER model to include risk premium approximated by short-term government debt stabilizes the relationship between the real zloty /euro exchange rate and the real interest rates. The attempts at extending the PPI-based real zloty/euro exchange rate to the standard proxy of the Balassa-Samuelson failed. However, taking account of the foreign debt heterogeneity allows identifying an alternative channel transmitting the impacts of the supply-side factors. The results point to relationships existing between the real exchange rate and terms of trade. The latter turn out to be determined by foreign direct investments and this finding confirms the thesis that FDI accumulation, total factor productivity growth and improvement of the non-price competitiveness of the tradables sector in Poland are interrelated. As a result, the thesis about a 'permanent' medium-term appreciatory trend in the zloty/euro exchange rate is becoming less and less obvious.

Keywords: exchange rate, transition economies, econometrics modeling, cointegration

JEL: C51, C32, F31, F32

The Polish Zloty / Euro Exchange Rate under Free Float: An Econometric Investigation[1]

1. Introduction

The turning point in the research on the exchange rates of the CEECs' currencies was the study by Halpern and Wyplosz [1], presenting the results of empirical investigations into the relationships between exchange rates and structural changes in the countries' economies. The interest in the influence exerted by the mechanisms described by the Balassa-Samuelson model (hereinafter BS) on inflation in the transition countries and consequently on the evolution of their real exchange rates has given rise to numerous studies that mainly undertake the empirical verification of the occurrence of the BS effect and the quantification of its scale (recently [2], [3], [4], [5], [6], [7], [8]).

A review of the literature devoted to exchange rates allows concluding that the BS effect is perceived to be major mechanism determining the real exchange rates of the currencies in the emerging economies. This perspective produces obvious implications: the conclusion about a medium-run appreciatory trend is one of the most frequently formulated with respect to the currencies of countries going through the catching-up process. However, the expectations of appreciation are not so obvious when their underlying premises are scrutinized. The restrictive and rarely verified assumptions of the BS model stir reservations, but most of the skepticism arises from the solutions accepted in empirical studies. As the latter usually build on the CPI-based real exchange rate, some doubts are caused by the fact that the real exchange rate is first „enriched" with the BS effect, only to enable the quantification and positive verification of the effect's influence on the CPI-based real exchange rate at the next step.

The role that the analyses of the real exchange rates of the emerging markets' currencies give to the Balassa-Samuelson mechanism is illustrated by the fact than even when deflators assumed to approximate the indices of the tradables sector's prices (e.g. PPI in manufacturing) are used, the supply-side factors are still perceived to be the key cause of RER appreciation ([2], [9], [10]). Bęza-Bojanowska and MacDonald [11] indicate that the PPI-based appreciation of the real PLN/euro exchange rate in the years 1998-2007 resulted from the non-tradables component being part of the tradables prices. On the other hand, the natural appreciation hypothesis assumes that the PPI-based exchange rate is likely to appreciate, because of the significantly undervalued CEECs' currencies at the beginning of the transition period ([1], [12]). Égert and Lommatsch [13] formulate the hypothesis that appreciation can have its roots in the growth of the tradables prices caused by the improving quality of domestic goods and consumers redirecting their preferences to the domestic goods. The

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basic drawback of both models is that they accentuate the importance of adjustment processes observed in the early transition period that are empirically indistinguishable, at least in the Polish case, from the effects of economic policy that used the exchange rate as its anti-inflationary anchor (for example [14]).

Finding the relevant extensions to the exchange rate models of the emerging markets' currencies is not troublesome. The theoretical framework allowing the exchange rates to be analyzed is well known, because the exchange rate modeling and equilibrium level estimation methods have been given a lot of attention and have been expanding dynamically (see [15], [16], [17], recently [18]). In the most general case, the problem of modeling exchange rates (and of estimating their equilibrium trajectories) can be considered within the macroeconomic balance approach ([19], [20]). It is assumed that the medium-run differences between domestic savings and investments are reflected on the current account. The current account disequilibrium leads to the accumulation of the net foreign assets and, once the external equilibrium conditions are met, to foreign debt stabilization at a medium-run equilibrium level. The exchange rate fluctuates following the variability of the net foreign assets.

Although the theoretical basis for analyzing the relationships between the exchange rates and the net foreign assets is at least as solid as the reasons for analyzing the BS effect, the scope of the stock-flow approach for the catching-up countries' currencies is incomparably narrower. It is also notable that the analyses of the relationships between the net foreign assets and the exchange rates of the emerging economies' currencies very frequently offer conclusions contradicting the predictions of the stock-flow approach (overview for the catching-up economies: [18]). Interpretations explaining that appreciation may accompany a foreign debt growth accentuate the importance of capital accumulation in the catching-up countries; however, they are unconvincing because they are based on the empirical investigations that ignore the heterogeneity of the net foreign assets and the relations between foreign direct investments and productivity changes (an exception is [21]).

The above discussion draws attention to the uncertainty involved in the specification of empirical models, which arises even when only two key determinants of the exchange rates of the emerging markets' currencies are considered. Complications appear when the analysis is to be extended to account for the demand-side factors (for example [22], [23]), the influence of which may coincide with the Balassa-Samuelson mechanism. Other doubts emerge when the exchange rate model takes account of changing terms of trade, the measures of economy's openness or the effects of the administered prices ([23], [13]). The ultimate effect of the absence of clear-cut variable selection criteria is eclecticism of the empirical models and fundamental differences between the specifications of the exchange rate models for the same currencies.

Application of the reduced forms of the exchange rate models poses an equally serious problem. In practice, the most common approach involves the construction of the behavioral equilibrium exchange rate models (hereinafter BEER), which are derived from the uncovered interest rate parity model. A key part of the BEER analysis aims to identify what the exchange rate expectations are – the final model's specification is determined based on statistical tests. This approach fits into the FGTS modeling strategy. It can be argued that running a sequence of statistical tests could help reduce the general model and thereby identify the most important determinants of the exchange rate variability. It is pointless to oppose this conclusion, when the model specification problems are considered conceptually. This position has to change, however, when the FGTS strategy is applied to a case where the available time series are relatively short and the selection of the explanatory variables is questionable.

Last but not least, a problem that the empirical studies of exchange rates rarely deal with is the time horizon assumed for the analyses. The BEER models implicitly assume that these analyses are medium run and that the conditions of equilibrium are defined by foreign debt stabilization at the equilibrium level (external equilibrium) and by the BS model's assumptions ensuring internal equilibrium. This perspective is acceptable when the objective of the research is estimates of the real equilibrium exchange rate, but it becomes doubtful when the investigation is expected to help compile a full list of the exchange rate determinants. It may be necessary for analyses dealing with the period of financial crisis induced by the subprime crash to consider the short-run determinants of exchange rates. The natural and simplest solution examines the exchange rate risk relationships and generalizes the research to UIP model with time-varying risk premium.

This paper aims to present the results of cointegration analyses applied to the model of the zloty/euro exchange rate during the free-float regime. In seeking answers to the questions provoked by the outlined criticism of the exchange rate models of the catching-up countries' currencies, the study used monthly time series spanning the period 1999:01-2009:09. In particular, an attempt was made to construct a model containing a full list of variables affecting the real zloty/euro exchange rate in the short and medium run. The consideration for the endogeneity of the medium-run determinants of the exchange rate resulted in the recursive structure of the relations between variables that are identified as the fundamental determinants of exchange rates in the theoretical models. Another objective was to construct a model enabling the analysis of the joint impact of the medium and short-term mechanisms on the PLN/euro exchange rate.

The structure of the paper is as follows. Section one outlines the theoretical framework of the empirical analyses and discusses the theoretical underpinning of the capital enhanced equilibrium exchange rate model (CHEER) and the behavioral equilibrium exchange rate model (BEER) and formulates the research hypotheses. Section two briefly discusses the econometric methodology applied and the data. The inconsistencies between the predictions provided by the theoretical models and the fundamentals' fluctuations are highlighted. The next three sections present in detail the estimates obtained for (i) the CHEER model, (ii) the CHEER model with risk premium and the outcomes of the joint analysis of (iii) the CHEER models (with risk premium) and the BEER models. The last section of the paper contains conclusions.

2. The theoretical framework and working hypotheses

The medium and short-run analyses of exchange rates start with the equation of uncovered interest rate parity:

$$E_t(e_{t+N}) - e_t = N \cdot (i_t - i_t^*) + \lambda_t , \qquad (1)$$

where: e - a nominal exchange rate (a unit price of a foreign currency in a domestic currency), i , i^* - domestic and foreign nominal interest rates, respectively, λ - risk premium, N - the time horizon of the exchange rate expectations. The equation (1) can be equivalently written for the real variables as:

$$E_t(q_{t+N}) - q_t = N \cdot (r_t - r_t^*) + \lambda_t , \qquad (2)$$

where: $q = e - p + p^*$ - a real exchange rate, p , p^* - domestic and foreign price indices, r , r^* - real interest rates, $r = i - E(\Delta p)$, $r^* = i^* - E(\Delta p^*)$.

If the inflationary expectations are assumed to be static, then equations (1)-(2) contain two unobservable variables, i.e. the exchange rate expectations and risk premium[2].

The problem of the exchange rate expectations is dealt with in the capital enhanced equilibrium exchange rate models ([24], [25], [26], [27], [28], [29], [30]; for the Polish zloty: [31], [32]). Juselius [26] argues that the analysis should simultaneously cover processes taking place in (i) the goods markets that are in equilibrium when the PPP holds and (ii) in the capital markets that are kept in balance by the mechanisms described by the UIP model.

The above hypotheses are verified within the framework of the vector error correction model (VEC):

$$y_t = [e_t, p_t, p_t^*, i_t, i_t^*] . \qquad (3)$$

The exchange rate expectations are defined by the following relation:

$$E_t(e_{t+1}) = \omega_1(p_t - p_t^*) + \omega_2(i_t - i_t^*) . \qquad (4)$$

[2] The investigation omitted the market measures of risk, such as Credit Default Swaps. One of the reasons for taking this approach was the unavailability of suitably long time series.

The CHEER model extensions include analyses of the term structure of the interest rates and real interest rates parity ([28],[29], [30], [27], [31]). Then the VEC model is analyzed:

$$y_t = [q_t, \Delta p_t, \Delta p_t^*, i_t^S, i_t^{*S}, i_t^L, i_t^{*L}], \tag{5}$$

where the exchange rate expectations are formulated with respect to the rates of growth of the nominal exchange rate:

$$E_t(\Delta e_{t+1}) = -\omega_1 q_t + \omega_2(\Delta p_{t+1} - \Delta p_{t+1}^*) + \omega_3(i_{t+1}^S - i_{t+1}^{*S}), \tag{6}$$

where: $E_t(\Delta e_{t+1}) = E_t(e_{t+1}) - e_t$.

Endogenization of the exchange rate expectations is a key element of the analysis of the behavioral equilibrium exchange rate models proposed by Clark and MacDonald [33]. It starts with the equation (2). The exchange rate expectations are determined by the fluctuations in the fundamental variables z, which are derived from the theoretical models:

$$y_t = [q_t, r_t - r_t^*, z_t]. \tag{7}$$

The elements of the z vector are usually identified using two theoretical models, i.e. the stock-flow approach and the Balassa-Samuelson model.

The conclusions offered by the stock-flow approach are summarized by the following equations ([19], [20]):

$$q_t = \bar{q}_t - \varphi \cdot (A_{t-1} - \bar{A}_{t-1}), \tag{8}$$

$$\bar{q}_t = -\gamma(r_t^* \bar{A}_{t-1} + \bar{z}_{t-1}^S), \tag{9}$$

where: $\varphi > 0$, $\gamma > 0$.

The equation (8) stands for an exchange rate adjustment process running along the equilibrium path. The process continues until the net foreign assets A reach a value corresponding to the internal and external equilibrium $\bar{A}$. The equation (9) describes the equilibrium exchange rate as a function of the discounted expectations formulated with respect to the shocks affecting the current account $\bar{z}^S$ and the expected changes in net foreign assets $\bar{A}$.

The variable that is usually used for approximating the supply and demand shocks in export and import is terms of trade. There are two reasons for using the terms of trade in formulating the exchange rate expectations. Firstly, their changes can be linked to the oil shocks; this approach is necessary when the exchange rates of the crude oil exporting countries are analyzed. Secondly, in analyzing the currencies of the catching-up countries the production specialization processes in the tradables sector need to be considered ([34]). In either case, improving relative terms of trade lead to appreciation.

The analysis is extended to include the BS effect by decomposing the real exchange rate into one part shaped in the tradables market (q^T) and another part that fluctuates because of relative changes in productivity in the domestic and foreign tradables sectors (h^{BS}):

$$q_t = q_t^T - h_t^{BS}, \tag{10}$$

where: $q^T = e - p^T + p^{*T}$.

Under the standard assumptions that the TFP dynamics in the tradables sectors of the catching-up countries exceeds that recorded abroad and that the TFP dynamics in the non-tradables sectors is roughly the same, the measure of the BS effect is positive ($h^{BS} > 0$) and real appreciation of the domestic currency is observed.

Joint consideration of the stock-flow approach, the approach based on the relative terms of trade and the Balassa-Samuelson model generates the following equation of the exchange rate expectations:

$$E_t(q_{t+1}) = -\delta_1 A_t - \delta_2 r_t^{TOT} - \delta_3 h_t^{BS}, \tag{11}$$

that allows extending the specification of the BEER model (7):

$$y_t = [q_t, r_t, r_t^*, A_t, r_t^{TOT}, h_t^{BS}]. \tag{12}$$

The CHEER (5) and BEER (12) models merged into one VEC model:

$$y_t = [q_t, \Delta p_t, \Delta p_t^*, i_t^S, i_t^{*S}, i_t^L, i_t^{*L}, A_t, r_t^{TOT}, h_t^{BS}]. \tag{13}$$

can be interpreted in two ways. Firstly, the CHEER and BEER models are constructed around the UIP hypothesis and the differences between them arise from differently formulated expectations. From this perspective, the model (13) can be seen as an "environment" for the empirical discrimination between the two approaches. Secondly, the BEER model can be interpreted as a reduced form of the balance of payments model, where the primary significance is given to the relationship between the real exchange rate and the fundamental variables. Then the CHEER model should also be treated as a reduced form, but one showing a higher „degree of reduction", where the fundamentals are approximated using the long-term interest rates. The interpretation should be different, though, when the point of reference is the mechanisms induced by the short-term interest rates and risk premium. In this case, the CHEER model will allow analyzing the strictly short-run relationships that the BEER models lack.

In the empirical part of the paper, the latter interpretation was accepted. This approach provides the grounds for both excluding the long-term interest rates from the analysis and formulating the hypothesis that two cointegrating relationships for exchange rate exist in the model (13):

$$q_t = -\varphi_1\{(i_t - \Delta p_t) - (i_t^* - \Delta p_t^*)\} + \varphi_2 \lambda_t, \tag{14}$$

$$q_t = -\phi_1\{(i_t - \Delta p_t) - (i_t^* - \Delta p_t^*)\} - \phi_2 a_t^{NFA} - \phi_3 r_t^{TOT}, \tag{15}$$

where: a^{NFA} - the net foreign assets (share in GDP).

3. Econometric methodology and the data

In the cointegration analysis, the standard vector error correction model was used (VEC, [35]):

$$\begin{aligned}\Delta y_t &= \Pi y_{t-1} + \sum_{s=1}^{S-1} \Gamma_s \Delta y_{t-s} + \mu + \Psi d_t + u_t \\ &= \alpha\beta' y_{t-1} + \sum_{s=1}^{S-1} \Gamma_s \Delta y_{t-s} + \mu + \Psi d_t + u_t\end{aligned}, \tag{16}$$

where: y - $M \times 1$ vector of endogenous variables, d - $J \times 1$ vector of deterministic variables, Π - $M \times M$ matrix of total multipliers, α - $M \times V$ matrix of adjustment parameters, β - $M \times V$ matrix of V orthogonal cointegrating vectors, Γ - $M \times M$ matrix of the short-term parameters, Ψ - $M \times J$ matrix of the deterministic variables' parameters, u - vector of error terms.

In the case of the long-run weak exogeneity of y^X, the VEC model is written as follows:

$$\Delta y_t^E = \alpha^E \beta' y_{t-1} + \sum_{s=1}^{S-1} \tilde{\Gamma}_s \Delta y_{t-s} + \Theta \Delta y_{t-s}^X + \mu + \Psi d_t + u_t^E, \tag{17}$$

where y^E - $(M-H) \times 1$ vector of endogenous variables, y^X - $H \times 1$ vector of weakly exogenous variables.

The cointegration space is uniquely defined by the matrix β, but the structural cointegrating vectors $\tilde{\beta}$ can be identified up to a non-singular matrix transformation

$$\alpha\beta' = \alpha\xi^{-1}\xi\beta' = \tilde{\alpha}\tilde{\beta}', \tag{18}$$

which allows verifying empirically the economic theory-congruent or working hypotheses-based hypotheses on the equilibrium conditions of the system.

The empirical analysis covered the period 1999:01-2009:09. The data were derived from various sources. The domestic data were extracted from the publications by the Polish Central Statistical Office and the National Bank of Poland. The values of the variables that are not observable at monthly frequency were estimated using interpolation procedures proposed in [36]. The information about the euro area was found in the OECD, EUROSTAT, ECB and Bundesbank databases. When the monthly data were not available, the quarterly data were interpolated.

Figure 1 presents the variables used for estimating the CHEER model (3). The fluctuations in the nominal exchange rate allow identifying appreciatory trends in the periods following the introduction of the free float and Poland's entry to the EU, a depreciatory trend connected with fiscal imbalance intensifying in the years 2001-2003 and the rapid depreciation of the zloty in the third quarter of 2008. The fluctuations in the PPI-based real exchange rate correspond to the variability of the nominal exchange rate and of real interest rate differential.

Figure 2 presents the other variables used in the investigation. The relative government short-term debt is defined in the following way:

$$U_t^{DST} = (D_t^{ST} / X_t)/(D_t^{*ST} / X_t^*), \qquad (19)$$

where: D^{ST}, D^{*ST} - short-term government debt in Poland and in euro area, X, X^* - GDP in Poland and in euro area. The BS effect is defined as relative labor productivity in tradables (LP^T, LP^{*T}) and non-tradables (LP^{NT}, LP^{*NT}) sectors:

$$H_t^{BS} = (LP_t^T / LP_t^{NT})/(LP_t^{*T} / LP_t^{*NT}). \qquad (20)$$

The relative terms of trade are defined as follows:

$$R_t^{TOT} = (P_t^E / P_t^M)/(P_t^{*E} / P_t^{*M}), \qquad (21)$$

where: P^E, P^{*E} - export deflators, P^M, P^{*M} - import deflators in Poland and euro area. Foreign debt A^{NFL} was decomposed into debt resulting from FDI inflows A^{FDI} and from other financial liabilities A^{OFL}. Figure 2 presents the logarithms of A^{NFL}, A^{FDI} and A^{OFL} shares in GDP.

Comparison of the fluctuations in the real zloty/euro exchange rate with the variability of the fundamentals leads to the following conclusions. Firstly, real exchange rate changes after the introduction of a free float, following U^{DST} oscillations. Secondly, the BS effect, the relative terms of trade, the FDI to GDP ratio and the share of the other financial liabilities in GDP steadily rise. The theoretical models predict that a growth of the first two variables should appreciate the zloty, while an increase in the ‘other debt’ should result in depreciation. Given that the PPI-based real exchange rate oscillates roughly around a steady level, it is justified to formulate the hypothesis that the appreciatory impacts of h^{BS} and/or r^{TOT} will become quantifiable only when the cointegrating vector will contain a^{OFL}. The same line of reasoning can be presented for the pair of variables a^{FDI} and a^{OFL}, but then a key role in driving TFP growth must be given to a growing FDI/GDP ratio.

Allowing for the heterogeneity of the net foreign liabilities leads to the respecification of the equation (15):

$$q_t = -\phi_1\{(i_t - \Delta p_t) - (i_t^* - \Delta p_t^*)\} + \phi_2 a_t^{OFL} \mp \phi_3 a_t^{FDI} - \phi_4 r_t^{TOT} - \phi_5 h_t^{BS}. \qquad (22)$$

4. Uncovered Interest Rate Parity

Before the CHEER model of the zloty / euro exchange rate (e) was built, the uncovered interest rate parity model was verified. Prices in the domestic and foreign tradables sectors were approximated using the producer price indices for the manufacturing industry (p^T , p^{*T}) and the three-month interest rates in the interbank markets WIBOR 3M and EURIBOR 3M (i^S , i^{*S}) were taken to represent the nominal interest rates:

$$y_t = [e_t \, , p_t^T \, , p_t^{T*} , i_t^S , i_t^{*S}]. \tag{23}$$

Because the cointegrating procedures are sensitive to outliers and autocorrelated error terms, the preliminary estimation stage of the model (23) consisted in compiling the list of necessary dummy variables and finding the optimal lag. Table 1 provides the obtained results together with the basic residuals diagnostics for the VAR model (23) with three lags.

[Table 1 *about here*]

At the same time, an attempt was made to analyze the integration order of the variables in model (23). The problem turned out to be quite significant, because notwithstanding all reservations about the limited power of the univariate integration tests the latter indicate that the nominal exchange rate and the producer prices in the euro area are integrated of order one and that domestic prices are integrated of order two, regardless of the period of analysis[3]. If accepted, the results lead to confusion, suggesting that the real exchange rate is integrated of order two. The problems with interpretation of this conclusion are obvious, especially if one takes into account that the same integration tests explicitly point to the difference-stationarity of the real exchange rate. An natural solution is to analyze the VEC model that clearly allows the I(2) variables to be present, in which case hypotheses enabling a choice between a VEC model with I(1) variables and a model allowing the joint analysis of I(1) and I(2) variables are tested. It is also possible to take a simplified approach, where the nominal variables are appropriately transformed to remove the double unit roots in line with nominal-to-real transformation or I(2)-in-I(1) analysis ([27]).

The VEC model (23) was estimated using the latter approach. At its preliminary stage, the values of the characteristic roots of the companion matrix under the assumption about different cointegration ranks were analyzed, as well as the residuals from the cointegrating vectors. The lower panel of the table 1 presents the characteristic roots of the companion matrix in the model (23). The largest unit roots different from one are located close to the unit root circle, which confirms the presence of variables I(2) ([27], pp.298, 292-293). The graphic analysis of the cointegrating vectors leads to a similar conclusion.

A review of the literature devoted to the construction of the CHEER models provides grounds for considering a specification where the existence of common double unit roots in the processes

[3] The ADF and KPSS tests and the Phillips-Perron test were applied to the following periods 1995:01-2009:09, 1999:01-2009:09, 1995:01-2008:06 and 1999:01 -2008:06.

generating both the nominal exchange rate and the prices is assumed (e.g. [26]). This leads to the respecification of the model (23), which comprises the real exchange rate and the growth rates for two of the three nominal variables. One of the three acceptable transformations can be written as follows:

$$y_t = [q_t^T, \Delta p_t^T, \Delta p_t^{T*}, i_t^S, i_t^{*S}]. \qquad (24)$$

The long-run homogeneity restrictions need testing. The procedure consists in finding the number of the cointegrating vectors and then applying a LR test to verify the restriction assuming that the parameters for the nominal exchange rate, the foreign price index and – with a reverse sign – for the domestic prices are equal in all cointegrating vectors. The empirical grounds for replacing model (23) with its transformed form (24) are sufficient. For the VAR model (23) with one cointegrating vector the p-value of the test for the long-run homogeneity is 0.377, while for the systems spanned by two or three cointegrating vectors the p-values are 0.365 and 0.286, respectively.

The results of the VAR model (24) cointegration test point to the presence of two cointegrating vectors and they meet expectations as the CHEER model is built on the PPP and UIP equations. However, serious doubts arise when the companion matrix whose largest characteristic root lies outside the unit circle (its modulus is 1.019) is analyzed, as this points to explosive tendencies of the VAR model (24). The results are less questionable when the model specification allows a trend to be present in the cointegrating space:

$$y_t = [q_t^T, \Delta p_t^T, \Delta p_t^{T*}, i_t^S, i_t^{*S}, t]. \qquad (25)$$

The *Trace* test and the *Trace* test with Bartlett correction still justify considering two cointegrating relations. Then the modulus of the explosive root is only slightly greater than one (1.008) and its smaller value may indirectly point to model (24) misspecification.

Model structuralization was performed assuming that two cointegrating vectors exist. An analysis of the adjustment matrix in the unrestricted model suggest that the first cointegrating vector should be normalized with respect to price inflation in the domestic tradables sector and the second one with respect to the real exchange rate, which is the only domestic variable gravitating in this direction.

[Table 2 *about here*]

Table 2 presents the estimates of the CHEER model (25) with structuralizing restrictions. The conclusions are the following. Firstly, it is not possible to obtain a parameter estimate linking inflation of the domestic and foreign prices that would be statistically significantly different from zero. Secondly, the parameter estimates allow concluding that the domestic inflation may adjust along a trajectory determined by the PPP model. However, the negative sign of the trend parameter estimate indicates that linking the changes in price dynamics in the tradables sector with the price pressures generated by the supply-side factors is problematic – the parameter estimate accounts for the fact that disinflation tendencies were still strong in the analyzed period. Thirdly, the parameter estimates for the second cointegrating vector point to both a relatively long, 2.5-year horizon of the exchange rate expectations and the existence of a quite stable tendency towards „autonomous" appreciation. Fourthly, the low value of the error correction term (*ECT*) estimate for the second cointegrating vector is worth noting, as it suggests that the system slowly returns to the path of equilibrium determined by the uncovered interest rate parity. Therefore, assuming that the UIP model describes the short-run adjustment processes, a doubt arises whether the system does not equilibrate too slowly and whether the second cointegrating vector really defines the trajectory along which the real exchange rate zloty/euro fluctuates. Fifthly, although the probability value of the LR test for over-identifying restrictions (0.156) is greater than the standardly assumed values, it is also too small not to stir some doubts about the correctness of the model specification.

5. Risk Premium

The estimation results of the CHEER models (23)-(24) are not satisfactory. The simplest way to correct the specification is to skip the assumption about the domestic and foreign assets being perfect substitutes, which has been implicitly made so far, and to extend the UIP equation to include risk premium.

The choice of the risk proxies is problematic and it should be finally perceived as an empirical problem. Very few recommendations concentrate on the analysis of the fiscal situation, typically accentuating the role of the total debt or the government sector's debt. In all cases, adding specific variables to extend a model presents a kind of a research hypothesis subject to testing. Particularly Clark and MacDonald [33] use the relative ratio of the domestic to foreign share of the government sector's debt in GDP to analyze the effective exchange rates of US dollar, Japanese yen and Deutsche Mark. The authors stress that their choice, being one of many possible ways, arises from the positive outcomes (i.e. meeting their expectations) produced by analyses of exchange rates for selected countries (for Italy, see [37]). The alternative approaches employ short-term measures of the foreign sector disequilibrium ([38]). Juselius [26] approximates risk premium using a balance of payments deficit in relation to GNP.

The influence of risk premium on the real zloty/euro exchange rate was analyzed using variables recommended by the aforementioned studies and variables whose effect on the zloty/euro exchange rate was confirmed in the earlier investigations into the zloty/euro exchange rate ([39],

[40]), i.e. a relation between the domestic and foreign shares of the short-term government debt in GDP (U^{DST}) and a share of the state budget's domestic deficit in GDP (U^{BD}).

Because criteria allowing *a priori* selection of variables that would be satisfactorily precise in approximating exchange rate risk fluctuations cannot be determined, the ultimate choice is of the empirical character. Yet, it is possible to try to identify relationships linking the short-term debt and the budget deficit with the internal (λ^{INT}) and external (λ^{EXT}) determinants of the exchange rate risk. Assuming that the growth of the short-term debt is mainly driven by (i) the fiscal sector disequilibrium that can be described using the budget deficit function, and (ii) the demand for assets denominated in the Polish zlotys fluctuating because of the changes in global risk, the short-term debt can be written as follows:

$$U_t^{DST} = U_{t-1}^{DST} + \rho_1(U_t^{BD}) + \rho_2(\lambda_t^{EXT}) + V_t\,, \tag{26}$$

where V stands for valuation effects. Because the first two components are determined by domestic variables, the model (26) can be equivalently written as:

$$U_t^{DST} = \tilde{\rho}_1(\lambda_t^{INT}) + \rho_2(\lambda_t^{EXT}) = \rho(\lambda_t)\,. \tag{27}$$

Taking the above perspective is tantamount to stating that an increase in debt U^{DST} caused by larger issues of T-bills indicates growing problems with funding current government expenditures or decreasing investors' trust in securities having longer maturity. A variant with an extremely expansionary fiscal policy can be considered, where excessive government expenditures are funded from increased short-term debt, or a variant involving a response of the government to suddenly falling output dynamics in a less controversial scenario. In either case, a deep budget deficit will appear, the short-term debt will grow larger and risk premium will increase, induced by internal factors. An alternative source of fluctuations in U^{DST} is the transmission of global risks. Because selling the long-term securities is a safer way of funding government spending, larger T-bill issues can be expected in cases when the demand for bonds meets a barrier under the exogenous interest rates. The barrier may be caused by higher investment risk in countries classified as the emerging markets.

The above discussion provides the grounds for considering the following specification of the CHEER model:

$$y_t = [q_t^T, \Delta p_t^T, \Delta p_t^{T*}, i_t^S, i_t^{*S}, U_t^{DST}, t]\,. \tag{28}$$

The preliminary empirical analysis of the model (28) was the same as that applied to the CHEER model (25) without risk premium[4]. The VAR model with three lags turned out to be the

[4] In all variants of the CHEER model, the dummy variables distinguished in table 1 were used.

optimal system. Because of the possibility of causal relations appearing between the real exchange rate and the interest rates, on one hand, and the relative domestic and foreign short-term debt, on the other, the cointegration test was preceded by the tests of weak exogeneity of U^{DST}. The obtained results allow for conditioning the system (28) on U^{DST} under standard levels of significance:

$$y_t^E = [q_t^T, \Delta p_t^T, \Delta p_t^{T*}, i_t^S, i_t^{*S}, t], \tag{29a}$$

$$y_t^X = [U_t^{DST}]. \tag{29b}$$

[Table 3 *about here*]

As far as the model with endogenous U^{DST} is concerned, a standard cointegration *Trace* test (table 3) shows that two equilibrium conditions exist in the VEC system (28). This result is consistent with the findings provided by the analysis of the companion matrix roots suggesting that four common stochastic trends and two cointegrating relations should be considered. Further, the *Trace* test with Bartlett corrections points to the existence of only one equilibrium condition. Exogenization of U^{DST} leads to a partial revision of the conclusions on the order of cointegration. A standard cointegration test justifies considering three cointegrating vectors, but it must be noted that the p-value of the test assuming that only two equilibrium relations exist is 0.08 and from a formal point of view this provides a basis for applying the V=2 restriction. On the other hand, allowing for the Bartlett correction leads to the conclusion about two cointegrating vectors being present in the conditional model (29).

The results of the VEC (29) system structuralization for V=2 are summarized in table 4.

[Table 4 *about here*]

The equilibrium trajectory of producer price inflation is given by the equation:

$$\Delta p_t^T = \underset{(3,2)}{0{,}0183}(e_t - p_t^T + p_t^{*T}) - \underset{(3,8)}{0{,}0001}t. \tag{30}$$

The accuracy of parameter estimates in the equation (30) is markedly higher than the precision of the estimates obtained for the model without risk premium. This result supports the hypothesis about prices in the tradables sector of a small and open economy being determined by foreign prices. The structure of the cointegrating vector (30) shows that the above adjustments were non-linear. In particular, an increase in the nominal exchange rate (depreciation) or in the prices of the foreign tradables sector accelerated the domestic prices, thus making inflation rise. When the domestic prices grew above the level determined by the PPP level, then inflation had to be brought down what means that domestic prices converge to a level determined by price arbitrage in the tradables sector.

The equation for the real exchange rate is as follows:

$$q_t^T = \underset{(5,9)}{-8,649}[(i_t^S - \Delta p_t^T) - (i_t^{*S} - \Delta p_t^{*T})] + \underset{(4,9)}{0,142} U_t^{DST}. \tag{31}$$

The depreciation of the zloty against the euro induces adjustment processes, whose intensity is considerably stronger compared with the estimates standardly produced by the PPP models (half life of 3-4 years) or the UIP models without risk premium (see table 2 and [31]), because disequilibrium as observed in one month decreases by around 15% over the next month. The q^T fluctuations run simultaneously along the long-run condition of equilibrium for the tradables sector's prices – higher price dynamics Δp^T resulting from the nominal depreciation of the zloty will lead to real depreciation (*ECT*=1,294).

The estimates of the net results of the zloty depreciation were obtained by estimating the total multiplier matrix Π (table 4, lower panel). As found, the exchange rate multipliers with respect to interest rates and the inflation of foreign prices are significantly different from zero and the direction of their long-run impacts on the real zloty/euro exchange rate is consistent with the predictions produced by the UIP model. The influence of the risk premium is also important; its higher value results in the depreciation of the zloty. However, the situation is different when the effects of a disturbed real exchange rate in the price inflation equation and of disturbed inflation in the exchange rate equation are considered. Then both multipliers are statistically indistinguishable from zero. The results are not surprising, because higher inflation simultaneously affects the level of prices and – in line with the PPP model – the nominal exchange rate, as a result of which the real exchange rate follows the equilibrium path in the long run.

6. BEER Approach

During the next stage of the investigation into the zloty/euro exchange rate the BEER model was considered, being a synthesis of (i) the stock-flow approach, (ii) the relationships between the exchange rate and the relative terms of trade, and (iii) the Balassa-Samuelson mechanism influencing the non-tradable component of the tradables sector's prices. This combination of such defined BEER system and CHEER model leads to the following VEC model:

$$y_t = [q_t^T, \Delta p_t^T \Delta p_t^{*T}, i_t^S, i_t^{*S}, a_t^{OFL}, a_t^{FDI}, r_r^{TOT}, h_t^{BS}, U_t^{DST}, t]. \tag{32}$$

Because of the large size of the model (32), the cointegration tests were preceded by a sequence of variables' exclusion tests and weak exogeneity tests. The results[5] provide grounds for conditioning the VEC model on U^{DST} and a^{FDI}, if only the number of the cointegrating vectors is not greater than 6:

[5] As in all VAR models previously considered, the optimal lag length is three months (*S*=3). Introducing additional dummies is not necessary; the list of dummies exactly corresponds to dummies distinguished in table 1.

$$y_t^E = [q_t^T, \Delta p_t^T, \Delta p_t^{*T}, i_t^S, i_t^{*S}, a_t^{OFL}, r_r^{TOT}, h_t^{BS}, t], \tag{33a}$$

$$y_t^X = [a_t^{FDI}, U_t^{DST}]. \tag{33b}$$

The results of the exclusion and weak exogeneity tests for the VEC model (33) are provided in table 5. They allow to formulate several conclusions. Then, if only one cointegrating vector is considered the real exchange rate q^T is a weakly exogenous variable. Considering that after the second cointegrating vector is added the results of the weak exogeneity test become ambiguous, it is justified to suspect that the real exchange rate may adjust along the second cointegrating relation. A similar reasoning can be applied to support the thesis that the third cointegrating vector determines the equilibrium trajectory of the exchange rate too; this would mean that the model (33) may turn out to be a system within which two cointegrating vectors having specifications similar to equations (14) and (22) can be identified . The preliminary conclusions about the possible relationships between the relative terms of trade, the measure of the BS effect and the trend are also interesting. As found, none of these variables can be removed from the cointegration space when the latter is spanned by four cointegrating vectors. However, h^{BS} and r^{TOT} can be excluded from the cointegration space, if the VEC (33) allows analyzing only three conditions of equilibrium. This finding indirectly justifies the thesis that the fourth cointegrating vector may describe the causal relationships between variables standardly approximating the supply effects.

[Table 5 *about here*]

The above discussion shows that the final specification of the euro/zloty exchange rate model depends on the decision concerning the cointegration rank. The problem is serious given the ambiguous outcomes of the test (table 5, lower panel). The *Trace* test shows that four conditions of equilibrium exist, but when the Bartlett correction is allowed for, then the conclusion is that there are only three cointegrating relations. This result is supported by the analysis of the roots of the cointegration matrix pointing to the presence of three cointegrating relations.

The results of the cointegration analysis of the system spanned by three cointegration vectors are not satisfactory, because of the impossibility of applying the earlier considered structuralizing restrictions or due to instability of parameter estimates. For this reason, the VEC (33) with four cointegrating relations was analyzed. As expected, it is possible to consider two cointegrating vectors along which the real exchange rate adjusts and one cointegrating relation to which price inflation in the domestic tradables sector adjusts. However, the analysis of the fourth cointegrating vector leads to a rather surprising conclusion: the variables that the vector is an attractor for are the nominal interest rates and price inflation in the euro area.

Structuralization of the VEC model (33) allows „reproducing" the CHEER model – the first two cointegrating vectors are identical with cointegrating relations (30) and (31) (table 6, upper panel). Parameter estimates for the cointegrating vector defining the second equilibrium condition for the real exchange rate indicate that the relationships between q^T and variables a^{OFL}, a^{FDI} and r^{TOT} are consistent with the predictions produced by the BEER models and the working hypothesis. The last cointegrating vector determines the equilibrium path for the nominal interest rates and price inflation in the euro area.

[Table 6 *about here*]

The test of over-identifying restrictions shows that the structure of the model cannot be accepted and attempts to respecify it do not lead to the construction of a system having interpretable parameters. The conclusions are different when one notes that adding a fourth cointegrating vector decomposes the VEC (33) into two blocks: one describing domestic inflation and the exchange rate and the other one indicating stationarity of the real interest rates in the euro zone. This outcome justifies imposing arbitrary weak exogeneity restrictions on the interest rates and inflation in the euro zone euro**.**

The results of the cointegration test for the model:

$$y_t^E = [q_t^T, \Delta p_t^T, i_t^S, a_t^{OFL}, r_r^{TOT}, h_t^{BS}, t], \tag{34a}$$

$$y_t^X = [a_t^{FDI}, U_t^{DST}, \Delta p_t^{*T}, i_t^{*S}] \tag{34b}$$

point to the presence of 2 to 4 cointegrating vectors. Finally, the results of the *Trace* test with Bartlett correction and the analysis of the of the companion matrix roots caused that empirical analysis was applied to the VEC model (34) with three conditions of equilibrium.

Table 6 (lower panel) shows parameter estimates for the model (34). Comparing them with the results of the VEC (33) shows that the cointegrating vector's estimates have low sensitivity to specification changes, which indirectly justifies reducing the estimation process only to relations describing domestic variables. There are two conclusions that can be derived from the analysis. Firstly, it is not possible to quantify the relationships between the real exchange rate q^T and the proxy of the Balassa-Samuelson effect. Secondly, the specification of the cointegrating relations:

$$q_t^T = \underset{(16,8)}{-16{,}6}\{i_t^S - \Delta p_t^T\} + \underset{(5,8)}{0{,}297}\, a_t^{OFL} - \underset{(4,8)}{0{,}219}\, a_t^{FDI} - \underset{(4,3)}{0{,}434}\, r_t^{TOT} + \underset{(0,6)}{0{,}126}\, h_t^{BS} + c \tag{35}$$

is eclectic, as two interrelated supply mechanisms determine the real exchange rate's appreciatory trend. Although it can be assumed that the FDI trend approximates TFP growth and leads to the appreciation of q through the BS mechanism, it must be also taken into account that TFP growth and the „saturation" of the economy with modern technologies are factors supporting specialization in the tradables sector, so they are likely to improve terms of trade. Acceptance of this perspective exposes the equation (35) to criticism for taking account of the effects of the supply-side mechanisms twice. Further, the model (35) can be accused of being over-parameterized and the VEC system (34) can be criticized for ignoring the endogeneity problem.

A solution to this problem would be the omission of the Balassa-Samuelson effect from the analysis and an attempt at decomposing the equation (35) into two cointegrating vectors, one of which would be interpreted as a relationship describing the real exchange rate as a function of foreign debt a^{OFL} and the relative terms of trade or alternatively as the FDI/GDP ratio, while the other one would explicitly quantify the relationship between r^{TOT} and a^{FDI}.

The results of the cointegration test for the system:

$$y_t^E = [q_t^T, \Delta p_t^T, i_t^S, a_t^{OFL}, r_r^{TOT}, t], \qquad (36a)$$

$$y_t^X = [a_t^{FDI}, U_t^{DST}, \Delta p_t^{*T}, i_t^{*S}] \qquad (36b)$$

are again confusing, because the Trace test with Bartlett correction and the two roots of the companion matrix located near the unit circle suggest that the variant *V*=3 should be considered, while the standard *Trace* test points to the existence of four cointegrating relations.

Assuming that three cointegrating vectors exist, two conditions of equilibrium can be identified for the exchange rate (upper panel table 7). The first of them directly corresponds to the exchange rate equation identified within the CHEER model and the differences actually come down to slightly larger estimates of the equilibrium parameters. The conclusions offered by the analysis of the second equation of the exchange rate directly correspond to the results produced by the analysis of the VEC (34), but attention is drawn to the markedly smaller and less precise parameter estimate for the FDI/GDP ratio.

[Table 7 *about here*]

Some reservations are stirred by the parameter estimates for the inflation equation, because the parameter quantifying the domestic prices' convergence to PPP is indistinguishable from zero. In the simplest case, the respecification of the second cointegrating vector consists in adding the wage costs. The extension of the VECR model (36) by incorporating additional variables is extremely troublesome, because the time series are short. It must be noted, however, that the specification of the model (36) allows considering a „reduced" cost-based pricing formula, if only an assumption is made that FDI increases productivity of labor, ultimately decreasing unit wage costs.

The parameter estimates for the model with a „reduced" cost-based pricing formula are presented in the middle and lower panels of table 7. The results provide the grounds for formulating three conclusions. Firstly, approximating the disinflation trend by means of foreign investments increases the precision of estimation of the parameter measuring the domestic prices' convergence towards the PPP path. Secondly, the parameter estimate for a^{FDI} in the third cointegrating vector becomes insignificantly different from zero. This result is somewhat surprising, because it may suggest – in the first approximation – that the direction of the TFP changes' impact on the real exchange rate is inconsistent with the predictions of the BS model. In such a case, the direct, appreciatory influence of the FDI/GDP ratio on the real exchange rate is replaced by a mechanism working in a reverse direction – an FDI inflow brings costs and prices down, depreciating the zloty in real terms. Thirdly, the parameter estimate for a^{FDI} is decreasing accompanied by only slight corrections of parameter estimates for the domestic real interest rates and foreign debt a^{OFL}, whereas the estimates for the terms of trade change considerably. This situation is definitely caused by the imposition of an additional restriction, but the fact that parameter estimates for r^{TOT} change the most can also be interpreted as an indirect premise confirming the thesis about part of the information contained in the FDI/GDP ratio being also found in the terms of trade.

Summing up, the empirical analysis of the model (36) leads to the construction of a model where the equilibrium trajectories are determined by two exchange rate equations corresponding to the specifications of the CHEER and BEER models, respectively:

$$q_t^T = \underset{(7,2)}{-12{,}8}\{(i_t^S - \Delta p_t^T) - (i_t^{*S} - \Delta p_t^{*T})\} + \underset{(4,9)}{0{,}159}\, U_t^{DST} + c\,, \tag{37}$$

$$q_t^T = \underset{(16,1)}{-13{,}09}\{i_t^S - \Delta p_t^T\} + \underset{(10,0)}{0{,}287}\, a_t^{OFL} - \underset{(10,6)}{0{,}661}\, r_t^{TOT} + c\,, \tag{38}$$

and by a domestic inflation equation closing the system:

$$\Delta p_t^T = \underset{(1,8)}{0{,}0081}\, q_t^T - \underset{(4,5)}{0{,}0063}\, a_t^{FDI} + c\,. \tag{39}$$

According to the test of over-identifying restrictions, the above structure of relationships is fully consistent with information contained in the time series. Some doubts may be stirred by (i) the first order residual autocorrelation test, where the p-value is slightly greater than 0.05 and (ii) the results of the recursive estimation pointing to the existence of a very small, yet quite distinct trend in the estimates of the cointegrating vectors.

At the last stage of the model (34) analysis, the system spanned by four cointegrating vectors was considered. The restrictions structuralizing the first three cointegrating vectors corresponded to the specifications of the equations (37)-(39).

$$q_t^T = \underset{(6,5)}{-10{,}1}\{(i_t^S - \Delta p_t^T) - (i_t^{*S} - \Delta p_t^{*T})\} + \underset{(6,5)}{0{,}184}\, U_t^{DST} + c\,, \tag{40}$$

$$q_t^T = \underset{(17,0)}{-12{,}4}\{i_t^S - \Delta p_t^T\} + \underset{(10,5)}{0{,}261}\, a_t^{OFL} - \underset{(12,3)}{0{,}694}\, r_t^{TOT} + c \tag{41}$$

$$\Delta p_t^T = \underset{(1,5)}{0,0086}\, q_t^T - \underset{(3,3)}{0,0046}\, a_t^{FDI} + c\,. \tag{42}$$

The fourth cointegrating relation was normalized with respect to the terms of trade. According to the estimates, the structuralization of four cointegrating vectors is much more troublesome than the identification of relationships in a model with three equilibrium relations, as proved by the small p-value in the test of over-identifying restrictions (table 8).

[Table 8 *about here*]

The interpretation of the parameter estimates for the additional cointegrating relation:

$$r_t^{TOT} = -\underset{(6,5)}{0,740}\, q_t + \underset{(11,1)}{0,293}\, a_t^{FDI} + c \tag{43}$$

is not completely clear. On one hand, the terms of trade and the FDI/GDP ratio are confirmed to be are interrelated, which proves an indirect, appreciatory influence of the supply-side factors. On the other hand, additional assumptions are needed to prove that the terms of trade are negatively related to the exchange rate. In particular, it is possible to consider a case when, because of specialization, export prices are more clearly affected by domestic prices than import prices are. The net results are the nominal exchange rate changes having a stronger effect on import prices and the consequent deterioration of the terms of trade.

7. Conclusions

The contribution of the exchange rate risk to the deviations of the CEECs' currencies from their long-term paths is a problem that has not become a subject of a broader empirical research yet. The econometric analysis of the relationship between the exchange rate and fluctuations in the risk premium presented in the paper covers the Polish zloty/euro exchange rate in a period of the free float. Its results substantiate the hypothesis that risk premium can be a significant variable contributing to the variability of the zloty exchange rate.

The estimation results allow formulating two general conclusions. Firstly, extension of the CHEER model to include risk premium approximated by short-term government debt stabilizes the empirical results in the UIP model and enables identification of the cointegrating relations being attractors for the real zloty/euro exchange rate. A review of the literature shows that the latter property of the cointegrating relations is rarely identified in the CHEER models, where the exchange rate is either a weakly exogenous variable or the accuracy of *ECT* estimates turns out to be rather unconvincing. Secondly, the possibility of approximating risk premium with the short-term debt improves the normative advantages of the proposed CHEER model. The thesis about the exchange rate fluctuations being related to tensions in the fiscal sector has been confirmed, which strengthens the argument that the attainment of steady fiscal stability is not only the condition for Poland becoming a member of the monetary union, but also one of the major conditions for stabilizing the zloty exchange rate against the euro in ERM2.

The skepticism about the rather automatic linking the fluctuations in the real exchange rates of the catching-up economies' currencies with the mechanisms described by the Balassa-Samuelson model formulated in the introduction was confirmed empirically. The attempts at extending the PPI-based real zloty/euro exchange rate to the standard proxy of the BS failed. However, the question about the supply-side factors' influence on the real exchange rate remains to be answered. Taking account of the foreign debt heterogeneity by decomposing the debt into the inflow of FDI and other financial debt allows identifying an alternative channel transmitting the impacts of the supply-side factors. The results point to strong relationships between fluctuations in the real exchange rate and the terms of trade. The latter turn out to be determined by FDI and this finding confirms the thesis that FDI accumulation, TFP growth and significantly improving non-price competitiveness of the tradables sector in Poland are interrelated. It should be noted, though, that the scale of the transmissions between TFP and a real exchange rate in the proposed BEER model may be overestimated for the omission of the direct specialization effects in tradables sector, not induced by FDI.

When debt unrelated to FDI inflows is distinguished, then the BEER specification is extended to include a variable „offsetting" the appreciatory influence of FDI and terms of trade. This allows identifying the cointegrating vector describing the real zloty/euro exchange rate that oscillated around a steady level in the analyzed period. This solution gives rise to important implications. Firstly, it is possible then to construct a model with properties similar to those possessed by the exchange rate models for developed countries' currencies that replicate the predictions of the stock-flow approach – the expanding amount of debt is accompanied by depreciatory pressures that partly compensate for the appreciatory effects of TFP growth. Secondly, the heterogeneous influence of FDI and other financial liabilities on the zloty/euro exchange rate leads to the question about the time horizon during which the non-price competitiveness of the tradables sector can be maintained or – viewing the problem form a different perspective – about the point in time when the payments of the FDI-related capital installments, interest and dividends exceed export surplus arising from non-price competitiveness. A simple extrapolation of the a^{OFL} and a^{FDI} trends may be misleading, because both the variables are vulnerable to disturbances generated by the subprime crisis. The mild symptoms of decelerating FDI inflow and fast increasing other financial debt may suggest, though, that the thesis about a "permanent" medium-term appreciatory trend in the zloty/exchange rate is becoming less and less obvious.

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Table 1. UIP model (23) – dummies, diagnostics and characteristic roots.

	Δe	Δp^{T}	Δp^{*T}	Δi^{S}	Δi^{*S}
Dummies	-	u:0902-u:0903 u:0907	u:0304 u:0609 u:0808	u:9910 u:0001-u:0002 u:0112	u:0801 u:0811
			Lag length determination		
	SBIC	HQ	VAR(*s*) *vs.* VAR(*s*+1) (p-values)	AR(1) (p-values)	AR(*s*) (p-values)
VAR(5)	-61.079	-63.982	-	0.094	0.188
VAR(4)	-61.621	-64.186	0.001	0.108	0.0255
VAR(3)	-62.378	-64.606*	0.375*	0.122*	0.332*
VAR(2)	-62.647*	-64.537	0.000	0.006	0.012
VAR(1)	-61.360	-62.913	0.000	0.000	0.000
			Diagnostics (*S*=3, p-values)		
	Δe	Δp^{T}	Δp^{*T}	Δi^{S}	Δi^{*S}
Normality (DH)	0.191	0.352	0.369	0.137	0.129
Joint normality (DH)	0.016				
Aurocorrelation (LM)	AR(1)=0.128	AR(2)=0.641	AR(3)=0.411	AR(4)=0.137	
ARCH effect (LM)		ARCH(1)=0.544	ARCH(2)=0.976		
			Roots of companion matrix		
Root	*V*=5	*V*=4	*V*=3	*V*=2	*V*=1
1	0.9999	1	1	1	1
2	0.9995	0.9900	1	1	1
3	0.9995	0.9900	0.9621	1	1
4	0.9335	0.9362	0.9148	0.9838	1
5	0.9335	0.9362	0.9148	0.8487	0.9717
6	0.7626	0.7561	0.9147	0.8487	0.8078

SBIC – Schwarz Bayesian Information Criterion, HQ – Hannan-Quinn criterion, DH – Doornik-Hansen normality test, AR(*s*) – autocorrelation LM test, ARCH(*s*) – ARCH effect test (for details see: Juselius [26]).

Table 2. UIP model (24) – cointegrating vectors and ECTs

	q^T	Δp^T	i^S	Δp^{*T}	i^{*S}	t
β_1	-0.0103 (1.8)	**1**	0	0	0	0.0001 (4.0)
β_2	**1**	-32.44 (9.5)	32.44 (9.5)	32.44 (9.5)	-32.44 (9.5)	0.0016 (2.7)
α_1	-2.079 (3.3)	**-0.867** (5.5)	-0.412 (3.6)	0.018 (2.7)	0.006 (2.1)	-
α_2	**-0.057** (3.3)	.	.	-0.010 (3.1)	.	-

LR = 0,156

AR(1) = 0,118 AR(2) = 0,194 Joint DH = 0.155

AR(3) = 0,100 AR(4) = 0,295 ARCH(1) = 0.129 ARCH(2) = 0.638

t-ratios are reported in parentheses. Dots stand for the parameters with *t*-ratios smaller than 2. *P*-values are reported for LR, AR, DH and ARCH tests.

Table 3. CHEER models (28)-(29) – cointegration tests and the roots of companion matrices

	CHEER model (28)				CHEER model (29)			
r	*Trace*	*Trace*(B)	*p-val*	*p-val* (B)	*Trace*	*Trace*(B)	*p-val*	*p-val* (B)
0	170.41	146.52	0.000	0.000	159.99	140.73	0.000	0.000
1	91.91	76.76	0.016	0.202*	83.54	70.87	0.004	0.057
2	51.81	43.40	0.283*	0.655	45.96	39.46	0.080	0.265*
3	20.16	16.48	0.933	0.987	16.96	14.84	0.668*	0.804
4	4.51	2.88	0.999	1.000	0.90	0.65	1.000	1.000
5	0.00	0.00	1.000	1.000	-	-	-	-
Roots	Real	Imaginary	Modulus	Argument	Real	Imaginary	Modulus	Argument
1	0.998	0.000	0.998	0.000	0.980	0.028	0.980	0.028
2	0.964	0.000	0.964	0.000	0.980	-0.028	0.980	-0.028
3	0.938	-0.045	0.939	-0.048	0.840	-0.094	0.845	-0.112
4	0.938	0.045	0.939	0.048	0.840	0.094	0.845	0.112
5	0.676	0.047	0.677	0.069	0.209	0.569	0.606	1.218
6	0.676	-0.047	0.677	-0.069	0.209	-0.569	0.606	-1.218

(B) indicates *Trace* test with Bartlett correction (for details see: Juselius [26]).

Table 4. CHEER model (29) – cointegrating vectors, ECTs and total multipliers

	q^T	Δp^T	i^S	Δp^{*T}	i^{*S}	U^{DST}	t
β_1	-0.0183 (3.2)	**1**	0	0	0	-	0.0001 (3.8)
β_2	**1**	-8.649 (5.9)	8.649 (5.9)	8.649 (5.9)	-8.649 (5.9)	-0.142 (4.9)	0
α_1	-1.294 (2.8)	**-0.742** (6.3)	0.033 (6.2)	-0.177 (2.0)	0.005 (2.3)	-	-
α_2	**-0.151** (4.8)	.	0.002 (4.8)	.	.	-	-
LR = 0.290							
	AR(1) = 0.402 AR(2) = 0.078				DH = 0.037		
	AR(3) = 0.196 AR(4) = 0.541				ARCH(1) = 0.744 ARCH(2) = 0.988		
Total multipliers							
Δq	**-0.127** (4.3)	.	-1.306 (4.8)		1.306 (4.8)	0.021 (4.8)	-0.00005 (2.8)
$\Delta^2 p$	.	**-0.685** (6.2)	.		.	.	-0.00003 (6.3)
Δi	0.001 (3.4)	0.018 (3.5)	**0.015** (4.8)		-0.015 (4.8)	-0.0003 (4.8)	0.000005 (6.2)

t-ratios are reported in parentheses. Dots stand for the parameters with *t*-ratios smaller than 2. *P*-values are reported for LR, AR, DH and ARCH tests.

Table 5. BEER model (33) – variables' exclusion, weak exogeneity and cointegration tests

r	q^T	Δp^T	i^S	Δp^{*T}	i^{*S}	a^{OFL}	a^{FDI}	r^{TOT}	h^{BS}	U^{DST}	t
1	0.127	0.029	0.612	0.012	0.046	0.272	0.028	0.935	0.308	0.005	0.040
2	0.036	0.000	0.007	0.000	0.035	0.007	0.011	0.979	0.157	0.011	0.062
3	0.013	0.000	0.013	0.000	0.019	0.003	0.005	0.887	0.274	0.023	0.088
4	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.005	0.007	0.039	0.000
5	0.000	0.000	0.000	0.000	0.002	0.001	0.000	0.000	0.002	0.068	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.009	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.003	0.000
r	q^T	Δp^T	i^S	Δp^{*T}	i^{*S}	a^{OFL}	a^{FDI}	r^{TOT}	h^{BS}	U^{DST}	t
1	0.826	0.001	0.066	0.010	0.001	0.104	-	0.373	0.261	-	-
2	0.118	0.004	0.003	0.035	0.000	0.021	-	0.613	0.003	-	-
3	0.038	0.003	0.001	0.075	0.000	0.043	-	0.785	0.009	-	-
4	0.000	0.001	0.000	0.014	0.000	0.087	-	0.005	0.000	-	-
5	0.000	0.000	0.000	0.020	0.000	0.098	-	0.010	0.000	-	-
6	0.000	0.000	0.000	0.005	0.000	0.012	-	0.010	0.000	-	-
7	0.000	0.000	0.000	0.002	0.000	0.004	-	0.005	0.000	-	-

r	*Trace*	*Trace*(B)	*p-val*	*p-val* (B)
0	321.13	264.17	0.000	0.000
1	240.73	197.83	0.000	0.002
2	172.82	137.04	0.000	0.060
3	120.30	94.07	0.006	0.277*
4	71.95	56.42	0.163*	0.704
5	39.89	27.22	0.527	0.966
6	19.64	13.18	0.703	0.966
7	7.60	6.37	0.685	0.803

P-values are reported for exclusion test and weak exogeneity test. (B) indicates Trace test with Bartlett correction (for details see: Juselius [26]).

Table 6. BEER models (33)-(34) – cointegrating vectors and ECTs

	q^T	Δp^T	i^S	Δp^{*T}	i^{*S}	a^{OFL}	a^{FDI}	r^{TOT}	h^{BS}	U^{DST}	t
β_1	-0.0195	**1**	0	0	0	0	0	0	0	0	-0.0015
	(3.9)										(2.7)
β_2	**1**	-6.724	6.724	6.724	-6.724	0	0	0	0	-0.1497	0
		(5.4)	(5.4)	(5.4)	(5.4)					(6.1)	
β_3	0	0	0	-1	**1**	0	0	0	0	0	0
β_4	**1**	-16.51	16.51	0	0	-0.2702	0.2023	0.3569	-0.1798	0	0
		(19.5)	(19.5)			(5.9)	(4.8)	(4.0)	(0.9)		
α_1	-4.769	**-1.160**	.	.	.	-6.249	-	.	-0.865	-	-
	(5.8)	(4.9)				(2.8)			(4.2)		
α_2	**-0.182**	.	0.001	.	.	-0.258	-	.	.	-	-
	(5.5)		(2.6)			(2.8)					
α_3	.	.	.	0.381	**-0.014**	.	-	.	0.365	-	-
				(3.0)	**(4.6)**				(2.5)		
α_4	**-0.243**	-0.031	-0.002	.	.	-0.299	-	-0.258	-0.066	-	-
	(5.1)	(2.3)	(3.1)			(2.3)		(2.3)	(5.4)		
LR = 0.00016											
AR(1) = 0.240 AR(2) = 0.375						DH = 0.511					
AR(3) = 0.140 AR(4) = 0.491						ARCH(1) = 0.710 ARCH(2) = 0.648					
	q^T	Δp^T	i^S	Δp^{*T}	i^{*S}	a^{OFL}	a^{FDI}	r^{TOT}	h^{BS}	U^{DST}	t
β_1	**1**	-7.286	7.286	7.286	-7.286	0	0	0	0	-0.2173	0
		(4.3)	(4.3)	(4.3)	(4.3)					(6.5)	
β_2	-0.0104	**1**	0	0	0	0	0	0	0	0	0
	(1.7)										
β_3	**1**	-16.59	16.59	0	0	-0.2974	0.2189	0.4337	-0.1264	0	0
		(16.8)	(16.8)			(5.8)	(4.8)	(4.3)	(0.6)		
α_1	**-0.130**	-0.018	.	-	-	-0.162	-	.	.	-	-
	(6.5)	(3.4)				(3.3)					
α_2	-4.333	**-0.843**	.	-	-	-6.077	-	.	-0.794	-	-
	(6.1)	**(4.5)**				(3.5)			(4.4)		
α_3	**-0.216**	-0.028	-0.002	-	-	-0.294	-	-0.299	0.055	-	-
	(5.0)	(2.5)	(3.7)			(2.8)		(2.9)	(5.0)		
LR = 0.216											
AR(1) = 0.391 AR(2) = 0.620						DH = 0.806					
AR(3) = 0.196 AR(4) = 0.153						ARCH(1) = 0.729 ARCH(2) = 0.474					

t-ratios are reported in parentheses. Dots stand for the parameters with *t*-ratios smaller than 2. *P*-values are reported for LR, AR, DH and ARCH tests.

Table 7. BEER model (36) – cointegrating vectors and ECTs (V=3)

	q^T	Δp^T	i^S	Δp^{*T}	i^{*S}	a^{OFL}	a^{FDI}	r^{TOT}	U^{DST}	t
β_1	**1**	-10.76	10.76	10.76	-10.76	0	0	0	-0.1697	0
		(5.9)	(5.9)	(5.9)	(5.9)				(5.0)	
β_2	-0.0061	**1**	0	0	0	0	0	0	0	0.0001
	(1.1)									(3.0)
β_3	**1**	-16.39	16.39	0	0	-0.3358	0.1342	0.4829	0	0
		(16.3)	(16.3)			(10.8)	(3.0)	(4.5)		
α_1	**-0.129**	.	0.0007	-	-	-0.193	-	.	-	-
	(5.3)		(2.4)			(3.3)				
α_2	-4.889	**-1.023**	.	-	-	-6.624	-	.	-	-
	(6.3)	(5.7)				(3.5)				
α_3	**-0.231**	-0.041	-0.002	-	-	-0.331	-	-0.256	-	-
	(5.6)	(4.3)	(3.5)			(3.3)		(2.6)		

LR = 0.524

AR(1) = 0.065 AR(2) = 0.466 DH = 0,866

AR(3) = 0.512 AR(4) = 0.103 ARCH(1) = 0,590 ARCH(2) = 0,636

	q^T	Δp^T	i^S	Δp^{*T}	i^{*S}	a^{OFL}	a^{FDI}	r^{TOT}	U^{DST}	t
β_1	**1**	-11.22	11.22	11.22	-11.22	0	0	0	-0.1654	0
		(6.4)	(6.4)	(6.4)	(6.4)				(5.3)	
β_2	-0.0095	**1**	0	0	0	0	0.0053	0	0	0
	(1.9)						(3.3)			
β_3	**1**	-15.07	15.07	0	0	-0.3194	0.0818	0.5412	0	0
		(14.9)	(14.9)			(10.2)	(1.6)	(5.0)		
α_1	**-0.141**	.	0.0007	-	-	-0.197	-	.	-	-
	(5.7)		(2.5)			(3.3)				
α_2	-4.400	**-0.932**	.	-	-	-6.644	-	.	-	-
	(6.0)	(5.5)				(3.8)				
α_3	**-0.221**	-0.040	-0.002	-	-	-0.310	-	-0.246	-	-
	(5.5)	(4.2)	(3.8)			(3.2)		(2.6)		

LR = 0.630

AR(1) = 0.059 AR(2) = 0.691 DH =0,840

AR(3) = 0.628 AR(4) = 0.065 ARCH(1) = 0,833 ARCH(2) = 0,597

	q^T	Δp^T	i^S	Δp^{*T}	i^{*S}	a^{OFL}	a^{FDI}	r^{TOT}	U^{DST}	t
β_1	**1**	-12.79	12.79	12.79	-12.79	0	0	0	-0.1591	0.0759
		(7.2)	(7.2)	(7.2)	(7.2)				(4.9)	(2.7)
β_2	-0.0081	**1**	0	0	0	0	0.0063	0	0	0.0058
	(1.8)						(4.5)			(2.9)
β_3	**1**	-13.09	13.09	0	0	-0.2865	0	0.6606	0	-0.6608
		(16.1)	(16.1)			(10.0)		(10.6)		(11.3)
α_1	**-0.122**	.	0.0008	-	-	-0.180	-	.	-	-
	(5.2)		(2.9)			(3.1)				
α_2	-4.098	**-0.873**	.	-	-	-5.932	-	.	-	-
	(6.0)	(5.5)				(3.6)				
α_3	**-0.232**	-0.045	-0.002	-	-	-0.291	-	-0.318	-	-
	(5.3)	(4.4)	(3.4)			(2.7)		(3.1)		

LR = 0.595

AR(1) = 0.059 AR(2) = 0.691 DH =0.840

AR(3) = 0.628 AR(4) = 0.065 ARCH(1) = 0.833 ARCH(2) = 0.597

t-ratios are reported in parentheses. Dots stand for the parameters with *t*-ratios smaller than 2. *P*-values are reported for LR, AR, DH and ARCH tests.

Table 8. BEER model (36) – cointegrating vectors and ECTs (*V*=4)

	q^T	Δp^T	i^S	Δp^{*T}	i^*	a^{OFL}	a^{FDI}	r^{TOT}	U^{DST}	t
β_1	**1**	-10.14 (6.5)	10.14 (6.5)	10.14 (6.5)	-10.14 (6.5)	0	0	0	-0.1837 (6.5)	0
β_2	-0.0086 (1.5)	**1**	0	0	0	0	0.0046 (3.3)	0	0	0
β_3	**1**	-12.35 (17.0)	12.35 (17.0)	0	0	-0.2614 (10.5)	0	0.6941 (12.3)	0	0
β_4	0.7404 (6.5)	0	0	0	0	0	-0.2927 (11.1)	**1**	0	0
α_1	**-0.146** (5.2)	.	.	-	-	-0.227 (3.4)	-	0.172 (2.8)	-	-
α_2	-4.590 (6.2)	**-0.911** (5.3)	.	-	-	-6.583 (3.7)	-	.	-	-
α_3	**-0.288** (5.8)	-0.047 (4.2)	-0.002 (3.7)	-	-	-0.380 (3.2)	-	-0.288 (2.6)	-	-
α_4	-0.106 (2.7)	.	0.001 (2.5)	-	-	.	-	**-0.309** (3.5)	-	-

LR = 0.124

AR(1) = 0.176 AR(2) = 0.743 DH = 0.785

AR(3) = 0.736 AR(4) = 0.076 ARCH(1) = 0.801 ARCH(2) = 0.801

t-ratios are reported in parentheses. Dots stand for the parameters with *t*-ratios smaller than 2. *P*-values are reported for LR, AR, DH and ARCH tests.

Figures' captions:

Fig. 1.1 Zloty/euro nominal exchange rate, levels and growth rates (right hand scale)

Fig. 1.2 PPI-based zloty/euro real exchange rate, levels and growth rates (right hand scale)

Fig. 1.3 PPI in manufacturing in Poland, levels and growth rates (right hand scale)

Fig. 1.4 PPI in manufacturing in euro zone, levels and growth rates (right hand scale)

Fig. 1.5 Three-month interbank nominal interest rates WIBOR 3M and EURIBOR 3M

Fig. 1.6 PPI-based zloty/euro real exchange rate and real interest rates differential (right hand scale)

Fig. 2.1 PPI-based zloty/euro real exchange rate and risk premium proxy (right hand scale)

Fig. 2.2 PPI-based zloty/euro real exchange rate and the BS effect approximation (right hand scale)

Fig. 2.3 PPI-based zloty/euro real exchange rate and the relative terms of trade (right hand scale)

Fig. 2.4 PPI-based zloty/euro real exchange rate and net foreign liabilities (right hand scale)

Fig. 2.5 PPI-based zloty/euro real exchange rate and foreign direct investments (right hand scale)

Fig. 2.6 PPI-based zloty/euro real exchange rate and other financial liabilities (right hand scale)