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Application of Panel Data Models to Exchange Rates' Modeling for Scandinavian and Central and Eastern European Countries

A b s t r a c t. In the paper the purchasing power parity (PPP) theory for 6 states belonging to OECD, namely Denmark, Norway, Sweden, Poland, Czech Republic and Hungary, was examined. In order to do that the IPS panel unit root test was employed. After establishing that the exchange rates permanently deviate from the long-term equilibrium rate and the PPP theory is at variance with the data, two panel models were estimated to identify factors that influence exchange rates of Scandinavian and CEFTA countries.

K e y w o r d s: purchasing power parity, long-term equilibrium exchange rate, panel models with fixed individual effects.

1. Introduction

Literature referring to the exchange rates and calculation of their real equilibrium levels is very rich. A methodology related to this problems is depicted in the work of Hinkel and Montiel (1999) while a review of the results of the empirical investigations can be found in the article of Edwards and Savastano (1999). At least three concepts have been used so far in the analyses to determine the equilibrium exchange rate, namely: Purchasing Power Parity theory (Johansen, Juselius, 1992; MacDonald, Nagayasu, 1998), fundamental theory (Williamson, 1983, 1994) and behavioral theory (Clark, MacDonald, 1998, 2004). Development of the econometric estimation methods for the non-stationary panel data has caused that cointegration models for this kind of data are used in many works (Habermeier, Mesquita, 1999; MacDonald, Ricci, 2001). Into this stream an empirical investigation described in the article may be included. The investigation constitutes an attempt to determine dependencies between exchange rate and macroeconomic factors for three Scandinavian (Denmark, Norway and Sweden) and three CEFTA countries (Czech Republic, Hungary and Poland) by means of panel data models. Such set of countries was

selected in order to check if some differences concerning the exchange rate modeling between the developed and the developing European countries that have not adopted a common currency will occur.

2. Purchasing Power Parity Theory and The Foreign Exchange Rate of OECD Countries

Investigation concerns the inverse real exchange rate of the euro in relation to the currencies of three Scandinavian countries (Danish krone, Norwegian krone and Swedish krone) and in relation to the currencies of three CEFTA countries (Czech krone, Polish zloty, Hungarian forint). The analysis is based on the data spanning the period from the first quarter of 1999 to the fourth quarter of 2008 (40 observations)[1]. The real exchange rate RER_{dc} is calculated on the basis of formula:

$$RER_{dc} = \frac{E_{dc}P_f}{P_d},$$
(1)

where:

E_{dc} represents a simple nominal exchange rate,

P_d denotes a domestic price level,

P_f denotes a foreign price level.

As price deflators the Producer Price Indices (PPI) have been used.

Verification of the non-stationarity of the foreign exchange rates has been performed on the panel data[2] (the first panel comprised Scandinavian countries and the second one – Central and Eastern European Countries) with the aid of IPS unit root test (Im, Pesaran, Shin, 1997, 2003) that has a relatively high power and satisfactory properties for short time series and small number of

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[1] Quarterly data are used because the data concerning GDP (used in further analysis) are not available in monthly frequency.

[2] Until the moment of proposing the non-stationarity examination techniques for panels the analyses of bilateral exchange rates have provided very little evidence on the PPP theory. For instance the literature review made by Edwards and Savastano (1999) shows that in the case of developing countries the hypothesis that the real exchange rate series contain (at least) one unit root could not be rejected in 40 out of 54 individual country tests of RER stationarity. In turn, in the case of the empirical study of real effective exchange rates for the 51 largest economies in the world for the 1971-1997 period the relative version of the PPP theory was confirmed only for 14 countries at 10% significance level and merely for 2 at 1% significance level. Research carried out for the panel data with the help of IPS test have shaken the previous conclusions in favor of the PPP theory – at 5% significance level the null hypothesis of non-stationarity was rejected for all 51 countries (Habermeier, Mesquita, 1999). Utilization of the panel non-stationarity examination techniques enables data range extension by adding the observations of the variables from other states and decreases *ipso facto* the risk of structural changes occurring.

cross-section data as the results of separate analysis of the currency exchange rate for each of six investigated OECD countries have not provided much evidence on the PPP theory – at 10% significance level there was no basis for rejection the null hypothesis of non-stationarity of the examined foreign exchange rates[3].

Table 1. The results of the panel stationarity test (1999 1st quarter – 2008 4th quarter)

Countries	Deterministic component	LM statistic	p-value
Scandinavian	Constant	0.104	0.504
	constant + trend	0.604	0.727
Central and Eastern European	Constant	-1.358	0.087
	constant + trend	-0.405	0.343

On the basis of values of statistics presented in Table 1 one may say that at 5% significance level there is no basis for rejection the null hypothesis of non-stationarity of the investigated foreign exchange rates. It may be treated as an evidence of the fact that Purchasing Power Parity theory is false in the cases of Scandinavian and CEFTA countries[4].

In order to verify if the global financial crisis has contributed to the failure of the PPP hypothesis the analysis has been carried out for datasets containing 32 and 36 observations.

Table 2. The results of the panel stationarity test (1999 1st quarter – 2006 4th quarter)

Countries	Deterministic component	LM statistic	p-value
Scandinavian	Constant	-0.985	0.162
	constant + trend	0.337	0.633
Central and Eastern European	Constant	-1.253	0.105
	constant + trend	0.238	0.594

Table 3. The results of the panel stationarity test (1999 1st quarter – 2007 4th quarter)

Countries	Deterministic component	LM statistic	p-value
Scandinavian	Constant	-0.623	0.267
	constant + trend	-0.459	0.323
Central and Eastern European	Constant	-1.459	0.072
	constant + trend	-0.010	0.496

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[3] Analysis has been also performed for monthly data and it has not provided much support for the PPP theory – the null hypothesis of non-stationarity was rejected only in the case of Hungarian forint exchange rate (at 1% significance level). In the case of the monthly and quarterly data concerning the inverse real exchange rate of the U.S. dollar in relation to the currencies of six investigated OECD countries the null hypothesis was not rejected (at 10% significance level) even once.

[4] Empirical research with the help of the IPS test has been also carried out for monthly data concerning the inverse real exchange rate of the euro and for monthly and quarterly data concerning the inverse real exchange rate of the U.S. dollar in relation to the currencies of six examined OECD countries. The PPP theory has not received much support from these studies as at 5% significance level the null hypothesis of non-stationarity was rejected only once (in the case of monthly exchange rates of Central and Eastern European Countries against the euro).

On the basis of values of the statistics presented in Tables 2 and 3 one may say that the structural change that occurred at the end of the time series had no influence on the results of the research - at 5% significance level there is no basis for rejection the null hypothesis of non-stationarity of the investigated foreign exchange rates.

3. Reasons of the Exchange Rate Volatility

In connection with the conclusion presented in the previous part of this article the question of the reasons of the exchange rate deviations from the PPP should be raised.

One of the most known conceptions explaining behavior of the real exchange rates in the long-run is so-called Balassa-Samuelson effect (Balassa, 1964). The essence of the B-S effect is that the increase of the productivity in the tradable goods sector causes inflation in the non-tradable goods sector and raises *ipso facto* overall price index, which – in turn – leads to an appreciation of the real exchange rate. The B-S hypothesis concerns the catching-up economies, including transition countries entering the European Union. The phenomenon occurring has been confirmed in many researches (Rogoff, 1996), in which the significant positive influence of the economic growth on the real exchange rate has been demonstrated.

Another potential exchange rate determinant is government expenditure. It moves the internal demand towards the non-tradable items causing the increase of their prices and the real exchange rate appreciation (Habermeier, Mesquita, 1999).

A different factor influencing the real exchange rate is terms of trade defined as a ratio between export and import prices. The rise of this index value (caused either by the increase of the export prices or by the decrease of the import prices) means a decline of the domestic products competitiveness and leads to a depreciation of the exchange rate (Baffes, Elbadawi, O'Connell, 1997; Habermeier, Mesquita, 1999).

The real exchange rate changes may be also explained by the behavior of the real interest rate. Relatively higher national rate of interest, boosting the foreign currency supply, contributes to the drop of the national currency rate, that is its appreciation (Brook, Hagreaves, 2001; Chortareas, Driver, 2001).

4. Panel Data Models for the Real Exchange Rates of the OECD Countries

Below two panel data models will be presented[5]. The first of them concerns Scandinavian countries (Denmark, Norway and Sweden) and the second one – Central and Eastern European Countries (Czech Republic, Hungary and Poland). In both cases an explained variable is the real exchange rate of the examined countries against the euro (the nominal rate deflated by the Producer Price Index – PPI). Among the explanatory variables are: relative economic growth[6] (representing the B-S effect), trade balance in relation to GDP (evidencing the competitiveness of a given economy) and relative real interest rate. It is expected that in accordance with the above-mentioned mechanisms the signs of the parameter estimates for all three explanatory variables will be negative.

Table 4. The results of the model estimation for the group of Scandinavian countries

Variable	Parameter estimate	Student's t-statistic	p-value	R^2
constant	8.801	68.79	0.0000***	
interest rate	0.128	4.058	0.0000***	80.12%
trade balance/GDP	-6.682	-5.021	0.0000***	

The results of estimation of the panel data model with fixed individual effects for developed Scandinavian countries point to the existence of the significant relationship between real exchange rate and both the trade balance and the relative real interest rate. In the case of the relative real interest rate the sign of the parameter estimate is at variance with the predictions, which can be explained among other things by the influence of the world interest rates or different kinds of expectations. On the other hand, in accordance with the predictions the impact of the relative economic growth on the exchange rate in the case of Scandinavian countries turned out to be statistically insignificant.

In the case of the panel data model with fixed individual effects for developing countries belonging to CEFTA a direction of influence of the explanatory variables is in accordance with the earlier formulated expectations: the increase of the relative GDP as well as the trade surplus contribute to the decrease of the exchange rate, that is its appreciation. Moreover, the influence of the relative real interest rate on the exchange rate is also negative, albeit statistically insignificant, which leads to the conclusion that in the case of Central and Eastern European Countries behavior of the interest rates affects the exchange rate much more weakly than behavior of other macroeconomic factors.

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[5] Panel data models, contrary to the time series models, allow one to investigate general relationships for fixed groups of chosen countries.

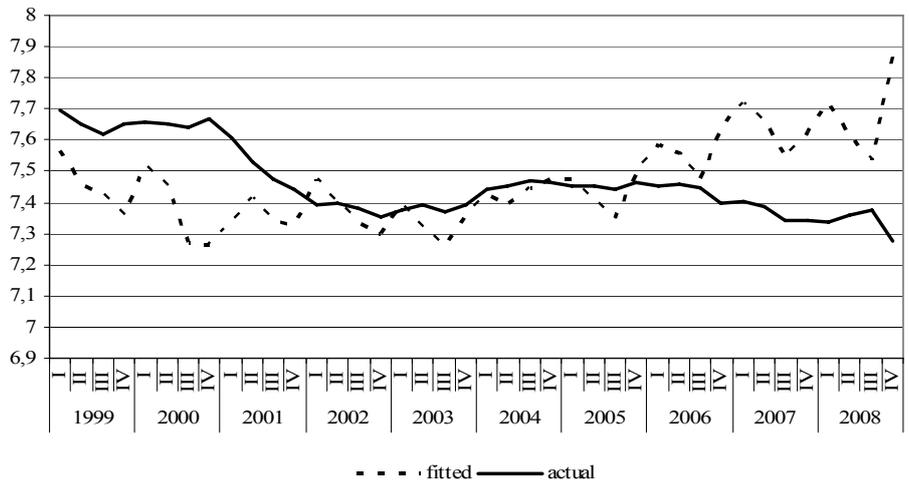[6] The term 'relative' means in this case comparison with the euro area.

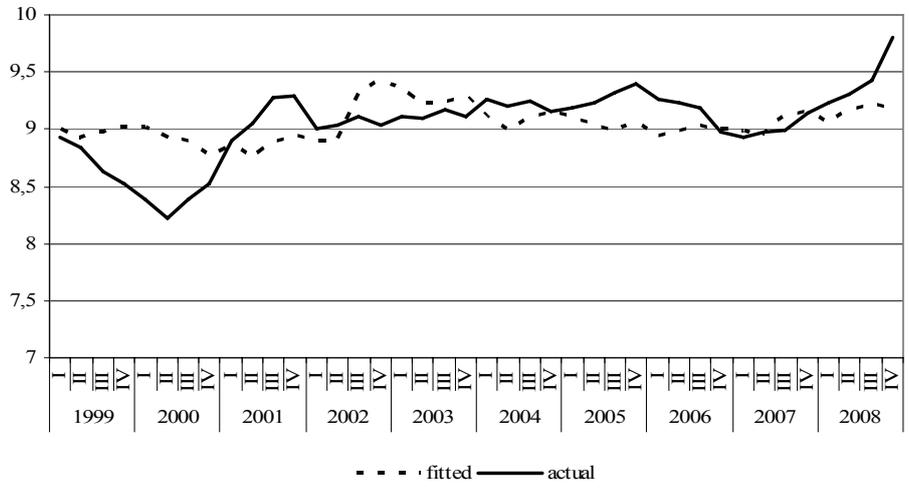Figure 1. Fitted and actual values of the exchange rate of the Danish krone (1999 1st quarter – 2008 4th quarter)

Figure 2. Fitted and actual values of the exchange rate of the Swedish krone (I quarter 1999 1st quarter – 2008 4th quarter)
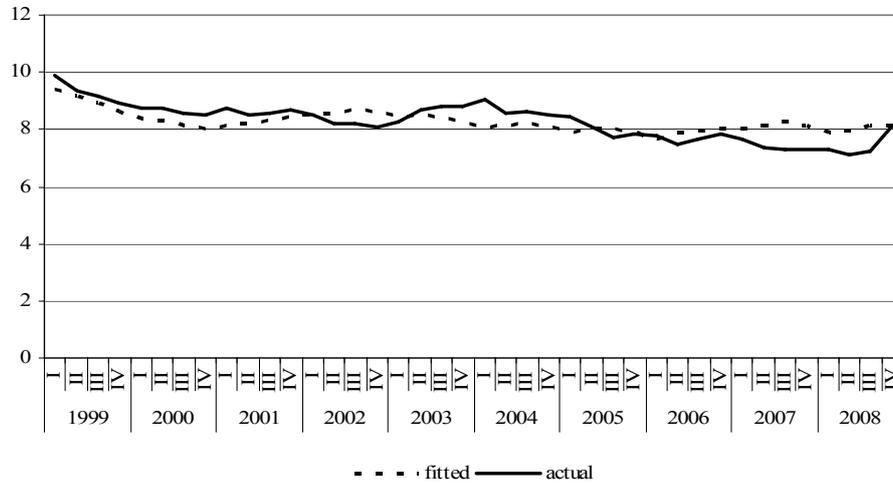
Figure 3. Fitted and actual values of the exchange rate of the Norwegian krone (1999 1st quarter – 2008 4th quarter)

Table 5. The results of the model estimation for the group of Central and Eastern European Countries

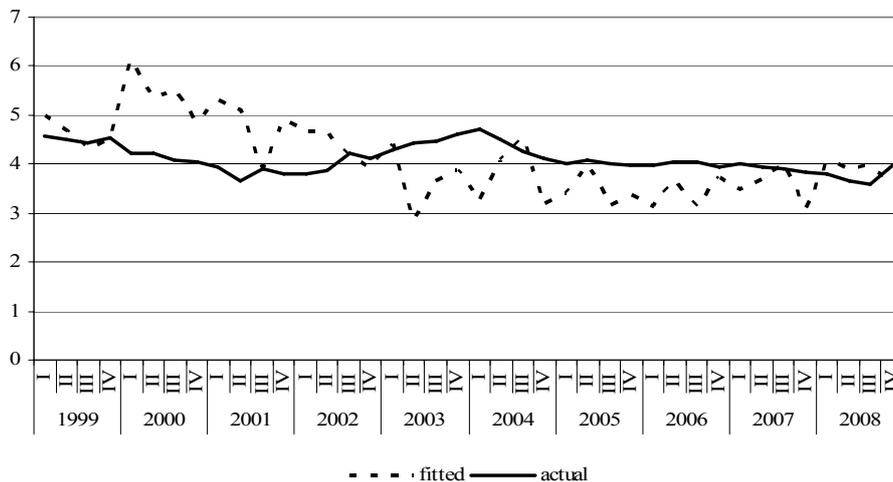| Variable	Parameter estimate	Student's t-statistic	P-value	R^2
constant	12.615	71.86	0.0000***	
relative economic growth	-0.754	-3.607	0.0005***	99.07%
trade balance/GDP	-24.800	-5.507	0.0000***	

Figure 4. Fitted and actual values of the exchange rate of the Polish zloty (1999 1st quarter – 2008 4th quarter)
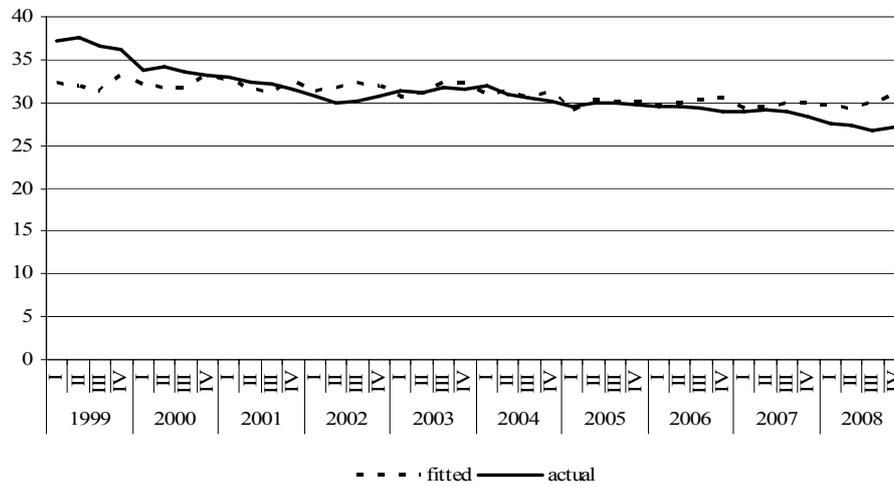
Figure 5. Fitted and actual values of the exchange rate of the Czech krone (1999 1st quarter – 2008 4th quarter)
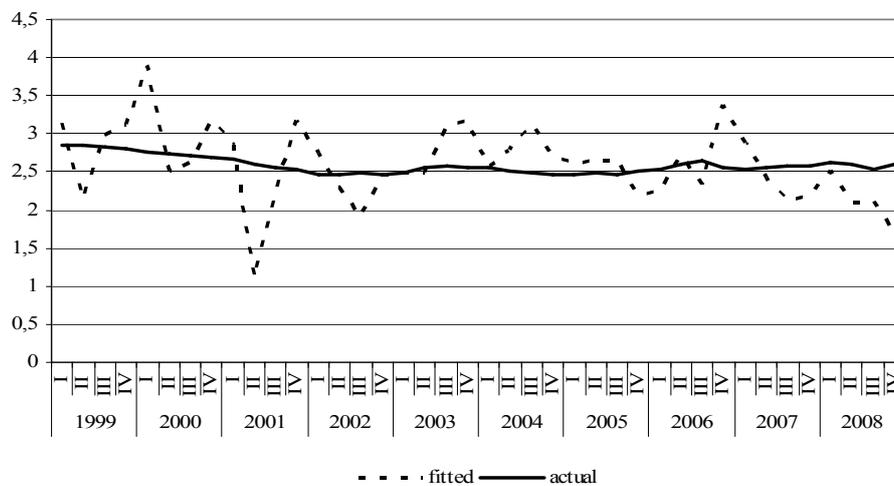

Figure 6. Fitted and actual values of the exchange rate of 100 Hungarian forints (1999 1st quarter – 2008 4th quarter)

Summary

The main conclusion drawn from the analysis carried out in this paper is rejection of the hypothesis that the exchange rates of the examined Scandina-

vian and CEFTA countries in the years 1999-2008 were shaping according to the purchasing power parity theory. The results obtained indicate that the real exchange rate of six OECD countries is determined by such economic factors as economic growth, trade balance and interest rates.

Further research concerning exchange rates may, first of all, focus on widening the cross-section of the panels with other countries, for instance Bulgaria, Romania, Croatia and Ukraine in the case of Central and Eastern European Countries. Another possibility is taking into account in the models additional variables such as net foreign assets, real wages, private consumption, government spending, budget deficit, public debt or foreign direct investments (Bęza-Bojanowska, MacDonald, 2009). Finally, these models may be employed in forecasting.

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Zastosowanie modeli panelowych do modelowania kursów walutowych dla krajów skandynawskich i Europy Środkowo-Wschodniej

Z a r y s   t r e ś c i. W artykule podjęto próbę empirycznej weryfikacji teorii parytetu siły nabywczej w odniesieniu do sześciu krajów członkowskich OECD: Danii, Norwegii i Szwecji oraz Czech, Polski i Węgier. W związku z tym, że uzyskane wyniki nie potwierdziły prawdziwości weryfikowanej teorii, celem pracy stało się zidentyfikowanie czynników wpływających na poziom kursów walutowych państw skandynawskich oraz państw Europy Środkowo-Wschodniej w latach 1999-2008 oraz wskazanie różnic między nimi.

S ł o w a   k l u c z o w e: teoria parytetu siły nabywczej (*Purchasing Power Parity*, PPP), długookresowy kurs równowagi, modele panelowe z ustalonymi efektami indywidualnymi.