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Dissertation Paper

Purchasing Power Parity. A Survey on East European Countries (1995-2001)

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1. Introduction

In this paper I tried to apply the theory of purchasing power parity (all the three forms of it: absolute, semi-strong and relative) to explore the behavior of Romania's, Hungary's, Poland's and Czech Republic's bilateral exchange rates with United States. The study is based on a sample of monthly data for the period 1995:01 – 2001:12.

The PPP hypothesis has been widely discussed and analyzed since it was first put forward by Cassel, and criticism of its validity has been intense on both theoretical and empirical grounds. Yet its intuitive appeal and simplicity make the PPP hypothesis one of the most popular economic theories of all the time. A strict interpretation of this concept is that, in the long run, exchange rate trends are determined predominantly by relative price developments at home and abroad.

1.1. Purchasing Power Parity – theory and evidence

The purchasing power parity condition is very important in international finance because when it holds, it implies some indifference between two alternative choices. When it doesn't hold it indicates opportunities for arbitrage in goods that will finally lead to market forces favoring one financial alternative over another. It is very important for a decision-maker to establish if PPPs hold or not, because this will tell him to make a decision or another. They can be compared to market exchange rates and the extent to which a country's currency is "over" or "under" valued can be monitored over time, in terms of what can actually be purchased in the other country. Those comparisons provide a measure of the volatility of currencies on exchange markets.

Purchasing power parity continues to serve as an equilibrium condition in the theory of exchange rate determination and in exchange rate policy.

The theory of purchasing power parity is based on the notion of arbitrage across goods markets and the **Law of One Price**. This law states that on the assumptions of a Perfect Capital Market (no transaction costs, no trade barriers and complete certainty) homogenous goods will sell for the same price on the home and foreign market after conversion into a common numeraire:

$$P_i = SP_i^* \quad (1)$$

Here P_i is the price of a good i expressed in domestic currency, S is the nominal exchange rate expressed in units of domestic currency per unit of foreign currency (or the price of the foreign currency) and P_i^* is the price of good i expressed in foreign currency. If this law holds for one good, than it should hold for a basket of goods, too:

$$P_t = S_t P_t^* \quad (2)$$

Here P_t is the domestic price index at time t, P_t^* is the foreign price index at time t and (2) represents the equation for the absolute purchasing power parity. This postulates that variation in prices between countries will be matched by exchange rates; that is, nominal exchange rates will reflect differences in inflation rates among countries. Although there is little empirical evidence to support the application of this result of the "law of one price" in the short run, there is evidence of the PPP relation in the "long run". An alternative representation, where continuous compounding is assumed, is:

$$s_t = p_t - p_t^* \quad (3)$$

where s_t, p_t and p_t^* are the natural log of S_t, P_t and P_t^* respectively.

A representative basket of goods is generally used to construct price indices. The problem here is that these baskets have different weights in different countries, so the question is: are those price levels comparable across countries or not?

Purchasing power parities can be thought of as interspatial price indexes and the methodology and data requirements belong to the methodology of index number theory. For example, to calculate intertemporal price indexes used to measure price change for one country, one needs to price a representative basket of goods and services with the expenditure patterns in the country determining the items selected. Likewise, to calculate PPPs, one needs to price a representative basket of goods and services across countries. In the interspatial case, however, this becomes difficult to implement, as the different countries can have very different expenditure patterns. The availability of common representative products is dependent on the number of countries, the extent to which their markets and expenditure patterns are similar, and the type of specification used to define selected products. Even between similar economies there remain important differences in expenditure patterns due to differences in climate, tastes, packaging, regulations, customs, traditions, and the like. Therefore, it's very important in order to calculate purchasing power parity to establish a list of goods and services to include in the price index.

There are three types of price indexes employed in the literature. Export or import price indices have been used by the researchers who consider of great importance the role of the non-tradable goods (goods that are so costly to ship that they do not enter the international trade). Researchers who believe that broader price indexes best capture the price changes in the economy opt for such indexes as the Labor Cost Index or the Consumer Price Index (CPI). Steindel (1997) argues that there are currently no better broad price indexes in the United States than the CPI. Those who believe a heavier weight needs to be placed on the tradable sector may use the Wholesale Price Index. In this paper I used Consumer Price Index because it is likely to be the most accurately calculated, due to the great emphasis placed on this index.

First, researchers focused on the absolute form of the PPP, the notion that the equilibrium nominal exchange rate is such that the domestic and external purchasing powers of a currency are equal. Thus, under absolute PPP, the real exchange rate, defined as $Q=SP^*/P$, is fixed and, in a strict interpretation is equal to one.

A weaker version of PPP, based on the relaxation of the homogeneity and symmetry conditions can be expressed as:

$$s_t = \alpha + \beta p_t - \gamma p_t^*$$

where the coefficients α, β and γ are positive constants. A semi-strong form, which imposes the restriction $\beta=\gamma$, shows a stable relationship between the nominal exchange rate and prices. This would mean that a growth of 1% in bilateral relative prices will determine a depreciation of the domestic currency of (β/100)%.

After 1970 researchers have focused on the relative PPP. Let's suppose that absolute PPP holds only if we include in the equation (2) an another parameter, *v*. In this case the equation will become:

$$P_t = vS_tP_t^* \quad (4)$$

Starting from this equation we can write:

$$\frac{P_{t+1}}{P_t} = \frac{vS_{t+1}P_{t+1}^*}{vS_tP_t^*} \quad (5)$$

which can be rewritten as:

$$1 + \Delta\%P = (1 + \Delta\%S)(1 + \Delta\%P^*) \quad (6)$$

where $\Delta\%P$, $\Delta\%S$ and $\Delta\%P_t^*$ represent the percentage change in the variables. Rearranging terms in equation (6) and considering small percentage changes in prices and exchange rates we have:

$$\Delta\%S = \Delta\%P - \Delta\%P^* \quad (7)$$

which represents the classic statement of relative PPP.

Since the 1980s, with the advent of the new time series econometrics, researchers began to focus on the dynamic properties of real exchange rates. In particular, long run PPP is deemed to hold when the real exchange rate is stationary.

More recently, there have been investigations of cointegration PPP, which requires only that the nominal exchange rate and domestic and foreign price indexes have a stable relationship over time, but not necessarily satisfies the traditional interpretation of PPP.

Empirical support for long run PPP has been established by many researchers. Niso Abuaf and Philippe Jorion (1990) analyzed 80 years of USD/GBP and USD/FRF exchange rates and concluded that the nominal exchange rate had no tendency to return to any particular level over the entire period. On the contrary, the real exchange rate proved a clear tendency to return to its central value. Maurice Obstfeld (1995) studied the exchange rate changes and inflation over a period of 20 years (1973-1993) using data for

22 OECD countries and concluded that the long-run variation in exchange rate changes across countries is largely dependent on differences in rates of inflation.

Alan Taylor investigated PPP since the late nineteenth century for a panel of 20 countries over one hundred years. The evidence for long-run PPP was favorable using univariate and multivariate tests of higher power. McCloskey and Zecher (1984) argued that PPP worked very well under the Anglo-American gold standard before 1914. Diebold, Husted and Rush (1991) explored a very long run of nineteenth century data for six countries, and found support for PPP based on the low-frequency information lacking in short-sample studies. Lothian and M. P. Taylor verified studied two centuries of dollar-franc-sterling data and verified PPP. Lothian (1990) also found evidence that real exchange rates were stationary for JPY, USD, GBP and FRF for the period 1875-1986. Lee (1978) and Officer (1982) found strong evidence in favor of PPP based on analysis of long time-series running from 1914 to the managed float of the 1970s, too.

Recent empirical research, mostly based on the time-series analysis of short spans of data for the floating-rate era led many to conclude that PPP failed to hold, and that the real exchange rate followed a random walk, with no mean-reversion property (the tendency for a series to wander away from its stationary value and then return at later points in time). However, new and higher-powered techniques have been used and proved that in the long run PPP does indeed hold: it appears from these studies that real exchange rates exhibit mean reversion with half-life of deviations of four to five years.

Razzaghipour, Fleming and Heaney found evidence of PPP analyzing quarterly-series of five countries of East Asia during the period 1971:4-1997:2. Tang and Butiong (1994) also examined the bilateral exchange rates of eleven developing Asian countries during the period of 1973-1990 using an error correction model and found strong evidence for PPP being a long run constraint for five of the countries. Hardouvelis and Malliaropulos (2000) test long run PPP as a relationship between the exchange rate and long-run equilibrium price differentials and apply this methodology to monthly data for the Greek drachma, finding support for their version of PPP.

1.2. The use of Purchasing Power Parity

One of the most frequent uses of PPPs is in the computation of GDP and GDP per capita across countries. Although GDP per capita has often been criticized as an incomplete statistic of economic well-being, it remains a cornerstone indicator of economic performance of individual countries. Policy and analytical interest in this indicator goes a long way to explain the importance of PPPs as a statistical tool. It is to be noted in passing that market exchange rates are particularly ill-suited for comparisons of living standards. This emerges from the fact that exchange rates tend to exhibit large swings over the short periods of time, implying rapid shifts of living standards between countries which cannot possibly have occurred.

Generally, the gap between high-income and low-income countries narrows when PPPs are used instead of exchange rates.

PPPs are also a tool to measure the relative size of economies. On the basis of each country's GDP as a percentage of total GDP of all countries considered, the ten largest economies covered by the comparisons are United States, Japan, Germany, France, Italy, United Kingdom, the Russian Federation, Mexico, Canada and Spain. It is also confirmed that the 15 European Union countries as a group are virtually the same economic size as the United States. Generally, there is a market difference in determining the size of economies, depending on whether exchange rates or PPPs are used to compare GDP data; the discrepancy is particular present in the group of low income countries. For example, on an exchange rate basis, the Russian Federation corresponds to less than one per cent of total GDP in the OECD area. Corrected for differences in the price level, this number rises to 3.5 per cent.

Although GDP per capita comparisons command significant interest among analysts, they are not the only pertinent statistic based on PPPs. One other useful indicator that also requires PPP-based volume comparisons of output is the level of labour productivity, i.e., output per employed person. Estimates of relative productivity levels provide insights into the possible scope for further gains in productivity and competitiveness and also place a country's growth experience in the perspective of its current level of income and productivity.

Another key statistic derived from PPP measures is comparative price levels of the ratio between PPPs and current exchange rates. If PPPs and exchange rates coincide, it can be concluded that, on average, one unit of a currency buys as much in the country under consideration as it does in the reference country. When PPP exceed exchange rates, it can be concluded that one unit of the currency under consideration buys less domestically than on other markets and vice versa.

The price level effect is particularly visible in countries with low income per capita: there, exchange rates often exceed PPP rates by a substantive margin, indicating a comparatively low price level. Partly, this is due to the economic importance of non-traded goods and services that are bought relatively cheaply in low-income countries. It has long been noted that there is a positive correlation between comparative price levels and GDP per capita: the richer a country, the higher its relative price levels tend to be, and vice versa.

The remainder of this paper is structured as followed: Section 2 presents the data and the methods I used to verify if the absolute, semi-strong and relative forms of PPP do hold. Section 3 presents the data and econometric results obtained for four bilateral exchange rates: ROL/USD, HUF/USD, CZK/USD and PLZ/USD. Section 4 summarizes and concludes.

2. Data and methods

Bilateral exchange rates between the East European countries and United States dollar, spanning the first month of 1995 to the twelfth month of 2001 were extracted from the time series published by every central bank (Central Bank of Romania, Central Bank of Poland, Central Bank of Hungary, Central Bank of Czech Republic and New York Fed). The exchange rates are monthly average units of national currency per USD. The consumer price indexes that I used for Romania, Czech Republic, Hungary, Poland and United States cover the same period (1995:01-2001:12) and are set to 100 in 1994:12 for all the countries. All initial data sets were normalized by dividing them with the corresponding value in 1995:01. In order to linearize the relationships after normalizing the series I converted them to natural logarithm. All the time series I used are shown in Table 1.1. from Appendix 1.

In order to see if the absolute PPP and the semi-strong PPP hold I used the Johansen Test for Cointegration. In this way I studied the existence of unrestricted stationary relationships linking bilateral nominal exchange rates and consumer price indexes. Johansen's cointegration model framework has the advantage of allowing for joint determination of nominal exchange rates and CPIs, takes into account short term dynamics of these variables while allowing for the return of the system to a long-term equilibrium in line with PPP theory.

In order to apply this test all the variables I use have to be integrated of order one (I(1)). The purpose of cointegration test is to determine if a group of non-stationary series are cointegrated or not. The presence of a cointegrating relation forms the basis of the VEC specification. The methodology developed by Johansen starts from considering a VAR of order p:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \ldots A_p y_{t-p} + B + \varepsilon_t \qquad (8)$$

where y_t is a vector of non-stationary variables, B is a constant and ε_t is a vector of random disturbances assumed to be identically and independently normally distributed. All A_i terms represent coefficient matrices. We can rewrite the equation (8) as followed:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + B + \varepsilon_t \qquad (9)$$

where $\Pi = \sum_{i=1}^{p} A_i - I$, and $\Gamma_i = -\sum_{j=i+1}^{p} A_j$.

The purpose of the cointegration model is to establish the number of long run stationary relations among the variables contained in y_t. In other words in this way we may determine the number of cointegrated vectors by studying the rank of the matrix Π.

If the matrix mentioned above has rank zero, this means that there is no cointegrating relationship between the variables. On the contrary, if the matrix Π has the rank equal to n (the dimension of the vector y_t) then y_t is stationary. If the rank of Π is bigger than one, but less than n, then the matrix can be decomposed into to full rank matrices: $\alpha \in M_{nxr}$ and $\beta \in M_{rxn}$ with $\Pi = \alpha\beta`$. The α matrix represents the matrix of adjustment or error-correction coefficients. Its elements indicate the speed at which endogenous variables return to equilibrium after a shock on the exogenous ones. The β matrix is called the matrix of cointegrating vectors and r is the number of cointegrating relations.

To determine the number of cointegrating relations conditional on the assumptions made about the trend, we can proceed sequentially from r=0 to r=k-1 until we fail to reject the null hypothesis. In order to test the null hypothesis we have to calculate the followed statistic:

trace-statistic = $-T\sum_{i=r+1}^{n} Log(1-\lambda_i)$,

and to compare it with the 5% or 1% critical values from Osterwald-Lenum (1992). Each λ_I represents the i-th largest eigenvalue of the matrix Π.

In order to verify the relative form of PPP I used an OLS estimation and I checked through a Wald test if the coefficients estimated this way can be 1 or –1.

For the special case of a linear regression model

$y = x\beta + \varepsilon$

and linear restrictions

$H_0 : R\beta - r = 0$

where R is a qxk matrix, and r is a q vector, respectively, the Wald statistic reduces to:

$$W = (Rb-r)`\left(s^2 R(X`X)^{-1} R`\right)^{-1}(Rb-r).$$

3. Data and Econometric Results

One way to test the PPP hypothesis is to ask: are the real exchange rates stationary, that is, mean reverting? Researchers testing the existence of mean-reversion in real exchange rate series typically concluded that they are random walk process. However such tests were subsequently criticized on the basis of the low power of univariate unit root test; and for implicitly imposing potentially invalid restrictions. As a result, research on PPP mainly focused on the investigation of the existence and the nature of a long-run relationship between nominal exchange rates and relative prices.

3.1.Testing the strong form of PPP

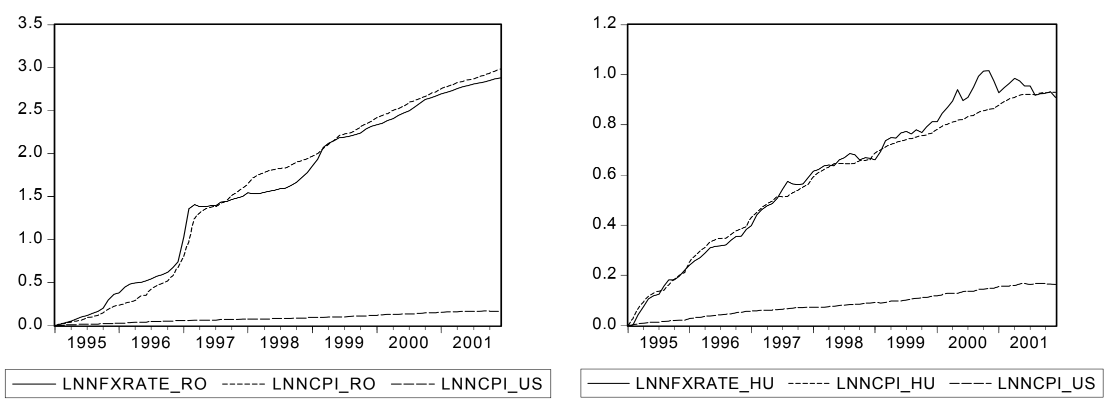
This approach involves the application of cointegration techniques on an equation like:

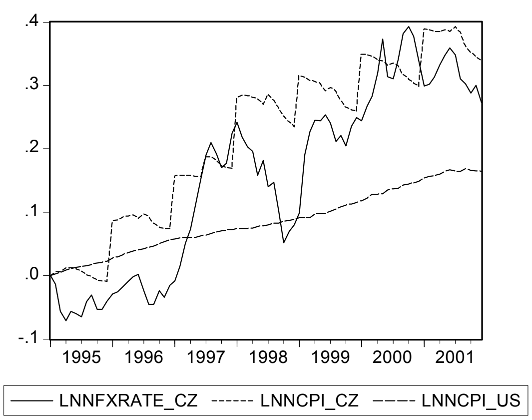
$$s_t = \alpha + \beta_1 p_t + \beta_2 p_t^* + \varepsilon_t \qquad (10)$$

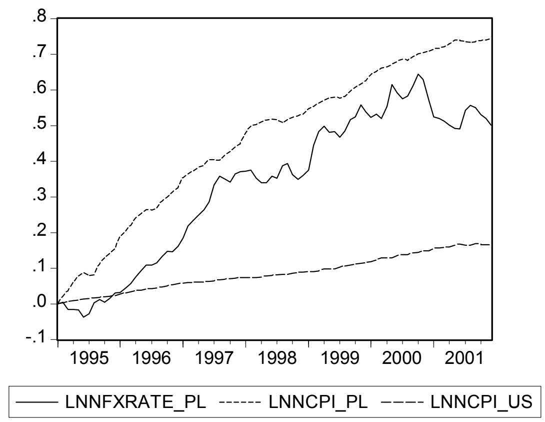
In the above equation s_t is the logarithm of the nominal exchange rate, α is a constant term, p_t and p_t^* are the logarithms of the domestic and foreign price level respectively and ε_t is a white noise term.

In this part of the Section 3 I'm going to apply Johansen's (1998) multivariate cointegration methodology to investigate the validity of the PPP hypothesis regarding: ROL/USD, HUF/USD, CZK/USD and PLZ/USD.

Graph 1. Nominal exchange rates and consumer price indexes







I began analysis by testing the order of integration of the variables involved. Table 1 presented bellow shows the results of applying the Phillips-Perron (PP) unit root tests. As we can see the logarithms of all the nominal exchange rates and all the consumer price indexes are integrated of order one whereas their first differences are stationary.

Table 1. PP tests on nominal exchange rates and consumer price indexes

Country	**Variable**	**Level**	**1st difference**
Romania	s_t	-1.692939	-3.604720
	p_t	-0.959428	-2.753291
Czech Re.	s_t	-2.530902	-6.404310
	p_t	-2.773596	-9.044448
Hungary	s_t	-0.443143	-5.552282
	p_t	-2.245420	-2.832301
Poland	s_t	-0.711193	-5.755575
	p_t	-1.240731	-3.348088
U.S.A.	p_t^*	-1.477803	-4.040837

MacKinnon critical values for rejection of hypothesis of a unit root are:

	Level	1st difference
1% critical value	-4.0713	-2.5912
5% critical value	-3.4639	-1.9442
10%critical value	-3.1581	-1.6178

I also tested the order of integration by using the augmented Dickey-Fuller (ADF) test and I obtained almost the same results. These results are shown in Appendix 2 – Table 2.1. The number of lagged differences to include in the ADF regression was determined by minimizing both the Akaike information criterion and the Schwartz Criterion.

Both PP Test and ADF Test show that nominal exchange rates and consumer price indexes are integrated of order one. Hence, I can proceed in testing for cointegration.

The Johansen test for cointegration is known to be quite sensitive to the number of lags. In order to determine the optimal number of lags for every country I used Eviews 4. The results I have obtained are presented in Appendix 2 – Tables 2.2.-2.5., but they are summarized as follows: 6 lags for Romania, 1 lag for Czech Republic, 7 lags for Poland and 9 lags for Hungary. I choused as selection criteria LR test statistic and Akaike information criterion, except for the case of Czech Republic where I choused Akaike and Scwartz information Criterion.

Since the optimal number of lags for the unrestricted VAR was found to be n, I carried out Johansen cointegrations test with n-1 lags in differences.

I'll begin by testing the long-run PPP hypothesis for the ROL/USD bilateral exchange rate. Because of the large geographical distance between those two countries that implies important transportation costs and because of the relative small amount of trade with United States I'm expecting the absolute PPP theory not to hold. One of the most important assumptions of the theory is not fulfilled.

I carried out a Johansen cointegration test with 5 lags in difference including a linear deterministic trend in the data. The results I obtained are displayed in Table 2 (full output in Appendix 2 – Table 2.6.):

Table 2. Johansen cointegration test for Romania

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None *	0.238821	30.14110	29.68	35.65
At most 1	0.062167	8.855936	15.41	20.04
At most 2 *	0.048156	3.849620	3.76	6.65
*(**) denotes rejection of the hypothesis at the 5%(1%) level Trace test indicates 1 cointegrating equation(s) at the 5% level				

The trace statistic (presented in Section 2) rejects the null hypothesis of no cointegration between the nominal exchange rate and CPI for Romania and USA at 5% significance level and indicates the existence of one cointegration relationship (30.14110>29.68). The long-run relationship obtained can be written as:

lnnfxrate_ro=0.686291*lnncpi_ro + 5.150962*lnncpi_us +0.047947 (11)

From this equation we can see that none of the two coefficients of CPIs are according to the theory. If PPP would hold, these coefficients should be almost 1 and –1 respectively.

Having established the cointegration relationship, I estimated the Vector Error Correction representation that shows the short-run dynamics and the speed of adjustment to the long-run relationship. The speed of adjustment coefficients that I obtained are: -0.290755 for lnnfxrate_ro, 0.045321 for lnncpi_ro and 0.006291 for lnncpi_us. As we can see, the nominal exchange rate adjusts quicker to a deviation on the long run equilibrium than the price indexes. Prices are more rigid than exchange rates, they move slower.

In order to verify if the linear combination I obtained (11) is indeed stationary I calculated the equilibrium error:

error_ro = lnnfxrate_ro – 0.686*lnncpi_ro – 5.151*lnncpi_us – 0.048 (12)

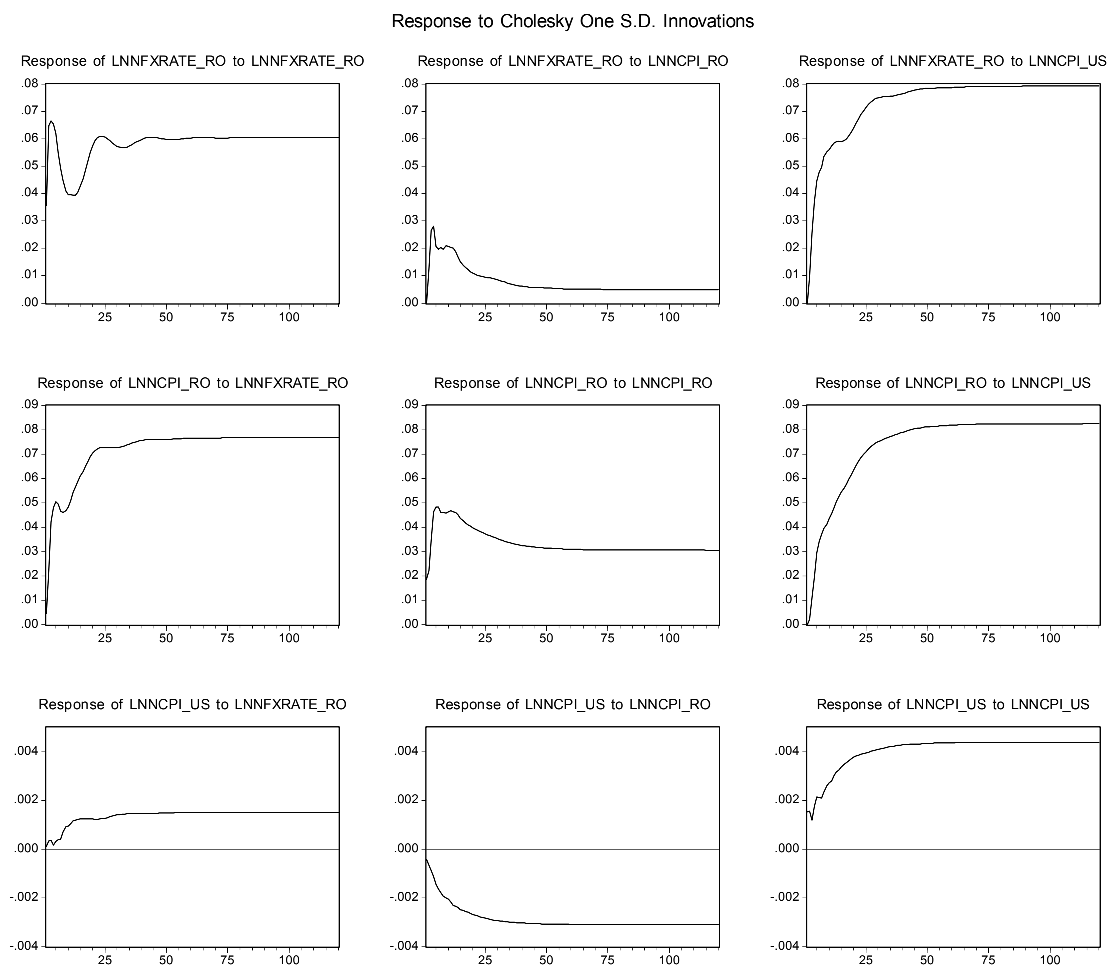
and after using the unit root tests I had the confirmation of its stationarity. The results of ADF and PP tests are shown below:

Table 3. Unit root test for error_ro

ADF Test Statistic	-3.335391	1% Critical Value*	-2.5912
		5% Critical Value	-1.9442
		10% Critical Value	-1.6178
PP Test Statistic	-2.717201	1% Critical Value*	-2.5909
		5% Critical Value	-1.9441
		10% Critical Value	-1.6178

In order to see the predicted behavior of the underlying variable to one SD innovation I looked upon the impulse response functions (Graph 2) generated from the unrestricted VAR I have estimated before. As we can see all the variables go to an equilibrium value on the long-run.

Graph 2. Impulse response functions for Romania



Now I will test the long-run PPP hypothesis for the CZK/USD bilateral exchange rate. As I have shown before the nominal exchange rate and the CPIs for the Czech Republic and USA are all integrated of order one. Therefore I can proceed to establish if there is a cointegration relationship using one lag. The Johansen test with no deterministic trend indicates that null hypothesis of no cointegration equation can be rejected at both 5% and 1% levels of significance, as follows (full output: Appendix 2 – Table 2.7.):

Table 4. Johansen cointegration test for Czech Republic

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.312883	47.29511	34.91	41.07
At most 1	0.122493	16.52460	19.96	24.60
At most 2	0.068398	5.809628	9.24	12.97
*(**) denotes rejection of the hypothesis at the 5%(1%) level Trace test indicates 1 cointegrating equation(s) at both 5% and 1% levels				

Hence, there is a long-run relationship that has the form shown below:

lnnfxrate_cz = 0.557164*lnncpi_cz + 2.123911*lnncpi_us – 0.533709 (13)

In this case the theory of absolute PPP doesn't hold either, the coefficients of both CPIs being at long distance from 1 and –1. But finding a long-run relationship means that the weaker version of the theory that is based on the relaxation of the homogeneity and symmetry conditions does hold.

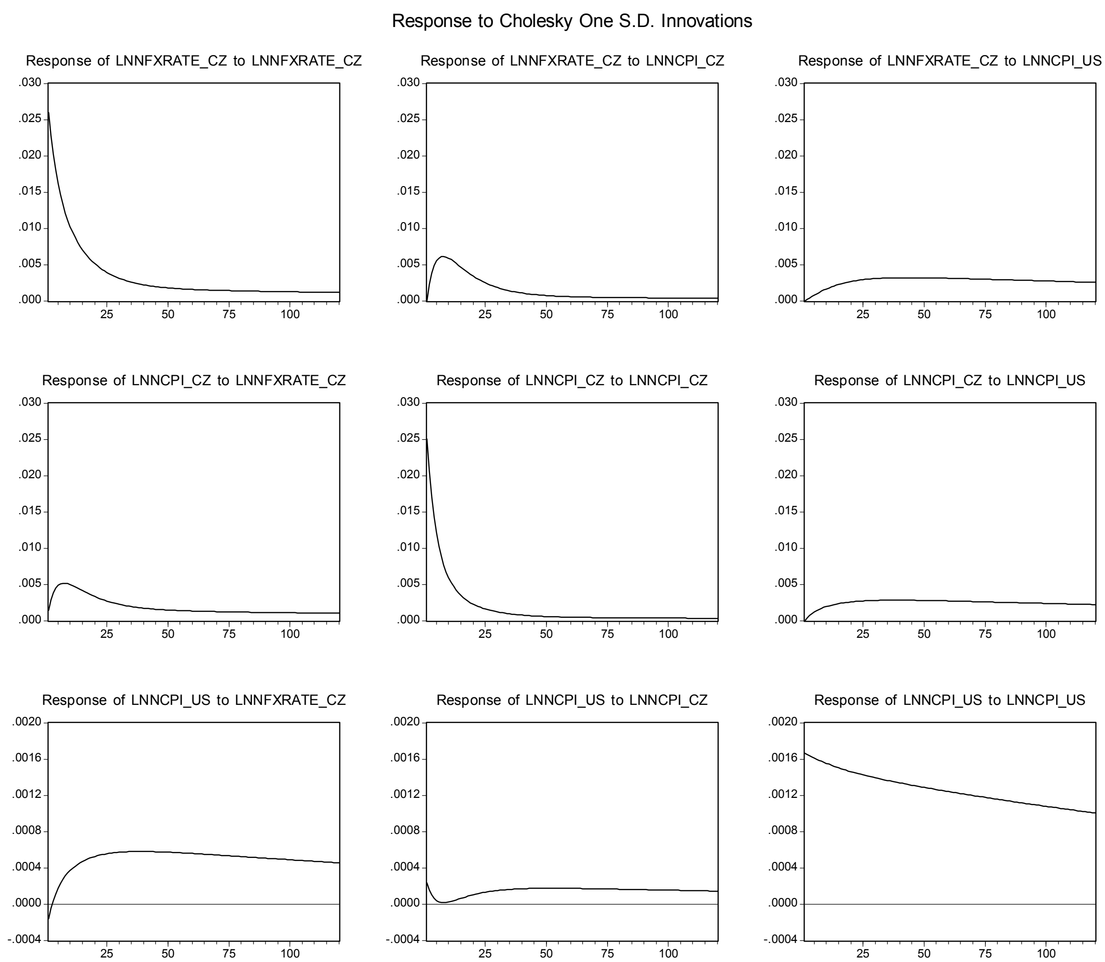
The estimated Vector Error Correction is given in Appendix 2 – Table 2.7. and as we can see the speed of adjustment coefficients are: -0.007399 for lnnfxrate_cz, 0.009814 for lnncpi_cz and 0.004550 for lnncpi_us.

Unit root tests and graphs for the equilibrium error and impulse response functions are provided below (Table 5 and Graph 3):

Table 5. Unit root test for error_cz

ADF Test Statistic	-2.624078	1% Critical Value*	-3.5111
		5% Critical Value	-2.8967
		10% Critical Value	-2.5853
PP Test Statistic	-2.661301	1% Critical Value*	-3.5101
		5% Critical Value	-2.8963
		10% Critical Value	-2.5851

Graph 3. Impulse response functions for Czech Republic



In this case, too, we can see that on the long-run, after three or four years the nominal exchange rate and the consumer price indexes will reach an equilibrium level.

In the last part of this subsection I present the results I have obtained for Hungary-USA and Poland-USA exchange rates and consumer price indexes.

The Johansen cointegration tests that I performed indicate in both cases the existence of one cointegration equation at 5% level with no deterministic trend in the data. The full output of these tests are presented in Appendix 2 – Tables 2.10.-2.12.

The long-run relationships obtained after estimating the VECs are:

$$lnnfxrate\_pl = 2.022191*lnncpi\_pl - 2.126875*lnncpi\_us - 0.644911 \quad (14)$$

for Poland, and

$$lnnfxrate\_hu = 1.123420*lnncpi\_hu - 0.695194*lnncpi\_us \quad (15)$$

for Hungary.

If in case of Poland the size of the coefficients estimated doesn't let us accept that absolute PPP theory holds, in case of Hungary we can see an approximation with the theoretical values. But still we cannot conclude that absolute PPP theory holds.

Both the Polish zloty and the Hungarian forint have been pegged during the analyzed period, the first one to a basket comprising the US dollar (45%) and the Euro (55%) beginning with January 1, 1999 and the latter one to the euro with effect from October 1, 2001. Previously Hungary conducted a crawling band regime, devaluing the central parity on a daily basis the preannounced rate. The intervention band has been widened to +/-15% on 3 May 2001 (+/-2.25% earlier). These might be some reasons for absolute PPP theory not to hold.

The results obtained from verifying the order of integration for the calculated equilibrium errors are presented in the Table 7.

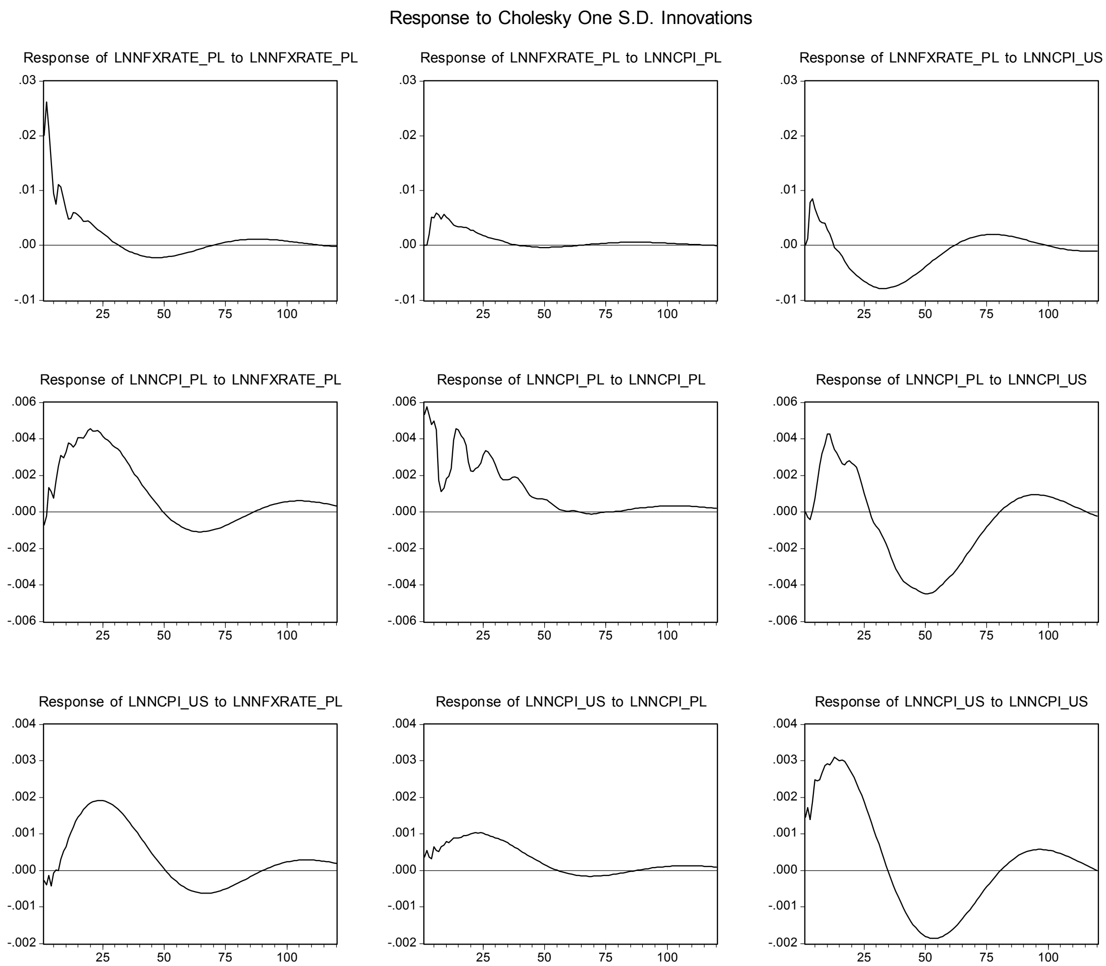
Table 7. Unit root test for error_pl and error_hu

Poland	ADF Test Statistic	-3.728235	1% Critical Value*	-4.0727
			5% Critical Value	-3.4645
			10% Critical Value	-3.1585
	PP Test Statistic	-3.472047	1% Critical Value*	-4.0713
			5% Critical Value	-3.4639
			10% Critical Value	-3.1581
Hungary	ADF Test Statistic	-2.117974	1% Critical Value*	-2.5912
			5% Critical Value	-1.9442
			10% Critical Value	-1.6178
	PP Test Statistic	-1.917907	1% Critical Value*	-2.5909
			5% Critical Value	-1.9441
			10% Critical Value	-1.6178

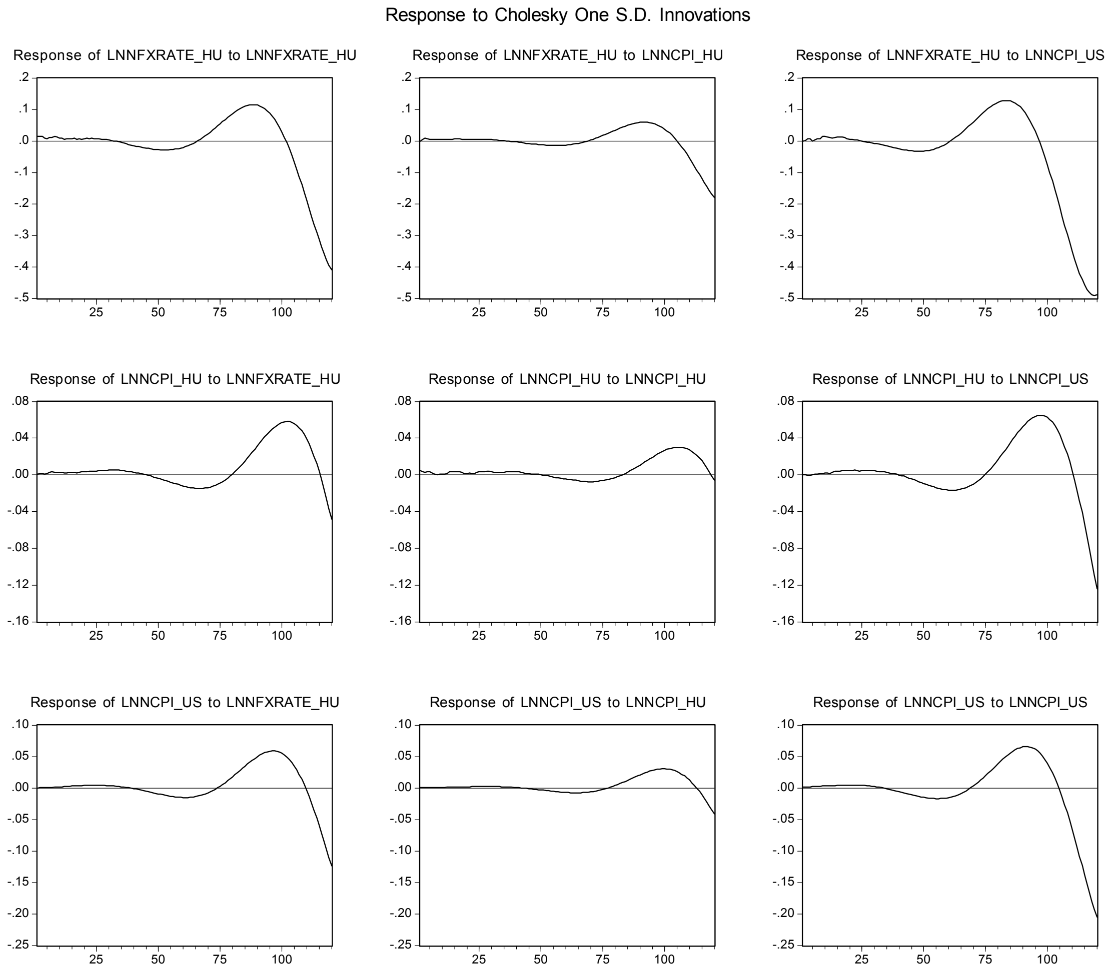
As we can see these errors prove to be stationary at 5% level of significance after performing both PP and ADF tests.

As about the impulse response functions (Graph 4 and Graph 5) we may conclude that for Poland it will take a long time to reach the equilibrium level, while for Hungary the result will be moving off.

Graph 4. Impulse response functions for Poland



Graph 5. Impulse response functions for Hungary



3.2. Testing the semi-strong form of PPP

For testing the semi-strong form of PPP I applied the cointegration techniques on an equation like:

$$s_t = \alpha + \gamma d_t + \varepsilon_t \qquad (16)$$

where $d_t = p_t - p_t^*$ represents bilateral relative prices (in logs), and the rest of the notations remain the same as before except γ, the parameter on prices.

MacDonald and Marsh (1994) advocate this semi-strong version that requires only a symmetry restriction on prices.

In order to test for cointegration I constructed first bilateral relative prices series defined as the ratio of the consumer price index of the home country and that of the foreign country; sine all the series I use are expressed in logarithmic form, constructing the bilateral price series involved subtracting from national Consumer Price Index the foreign CPI. If cointegration holds between the bilateral nominal exchange rate and the bilateral relative prices, then these two variables do not drift arbitrarily apart and purchasing power parity is verified as a long run equilibrium condition.

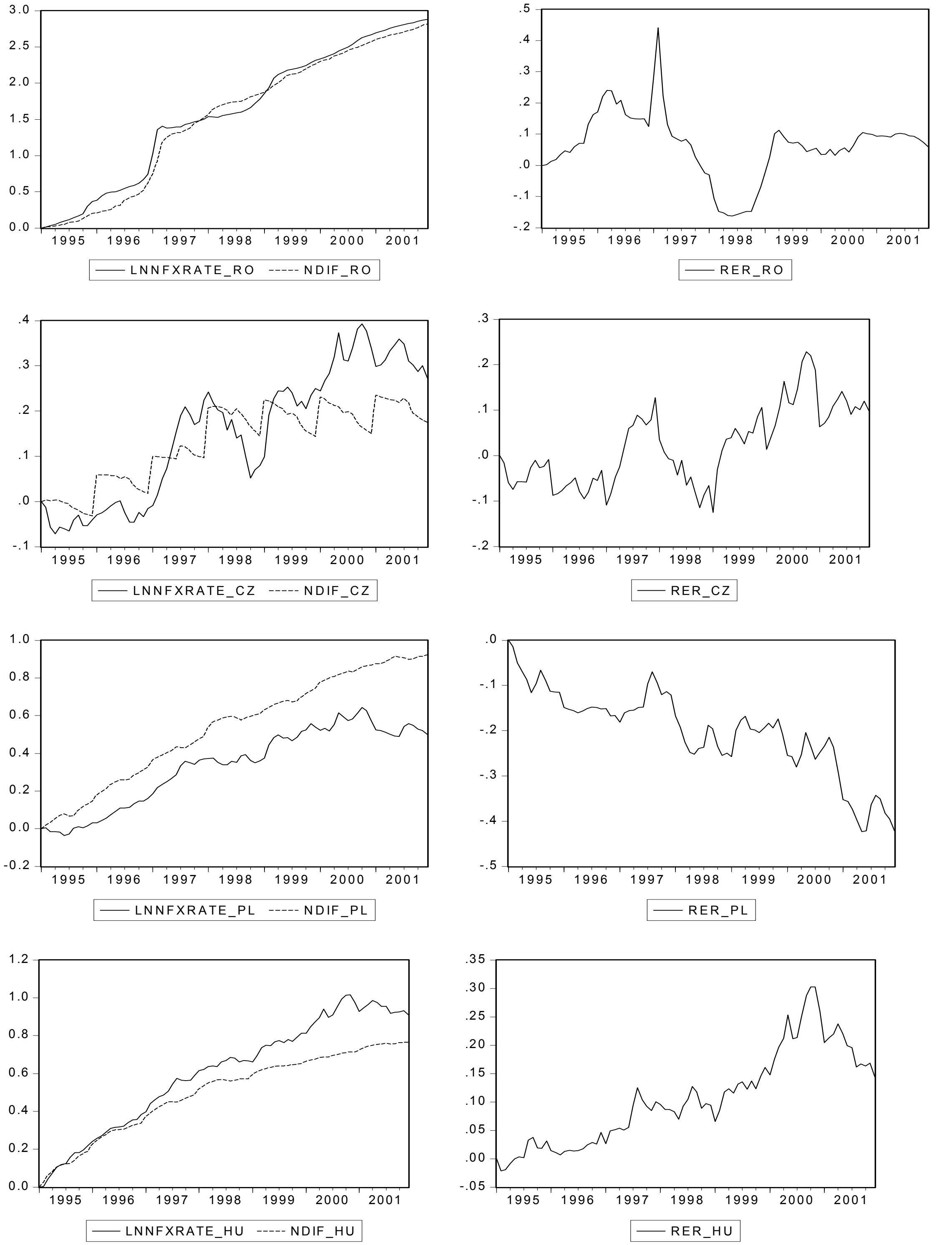
Before I can test the cointegration between the nominal exchange rates and bilateral relative prices I must assess their order of integration. In that respect I performed Augmented Dickey-Fuller unit root test on the bilateral relative prices. The results are reported in Table 8. As about the exchange rates, I showed the results in subsection 3.1.

Table 8. ADF tests for bilateral relative prices

	ADF Test Statistic	**Critical values**		
		1%	**5%**	**10%**
ndif_ro (1 lag)	-1.517107	-4.0727	-3.4645	-3.1585
dndif_ro (0 lags)	-2.937144	-2.5912	-1.9442	-1.6178
rer_ro (2 lags)	-1.484116	-2.5915	-1.9442	-1.6178
ndif_cz (0 lags)	-1.810165	-3.5101	-2.8963	-2.5851
dndif_cz (0 lags)	-9.188934	-2.5912	-1.9442	-1.6178
rer_cz (0 lags)	-1.734112	-2.5909	-1.9441	-1.6178
ndif_pl (1 lag)	-1.097155	-4.0727	-3.4645	-3.1585
dndif_pl (1 lag)	-3.134822	-2.5915	-1.9442	-1.6178
rer_pl (1 lag)	-3.354781	-4.0727	-3.4645	-3.1585
ndif_hu (2 lags)	-1.245060	-4.0742	-3.4652	-3.1589
dndif_hu (2 lags)	-2.630884	-2.5919	-1.9443	-1.6179
rer_hu (1 lag)	-2.148677	-4.0727	-3.4645	-3.1585

I performed also the ADF test for the real exchange rates. Were these test to point that the real exchange rates were stationary, we would have concluded that PPP in its

Graph 6. Nominal exchange rates, real exchange rates and bilateral relative prices



pure form holds as a long run equilibrium relationship. Unfortunately, as we can see from the Graph 6, too, the null of a unit root cannot be rejected at 1% level of significance.

Performing the Johansen cointegration test with the number of lags determined using the same technique as in subsection 3.1. (see Appendix 3 – Tables 3.1.-3.4.) I conclude that for Romania and Czech Republic there is no cointegration relationship between nominal exchange rates and bilateral relative prices. The output of these tests are shown in Appendix 3 – Tables 3.5., 3.6. The null hypothesis of no cointegration couldn't be rejected in neither of those cases. As about Poland and Hungary the tests indicate the existence of one cointegration equation for each as you can see from the Table 9:

Table 9. Johansen cointegration tests for Poland and Hungary

Poland				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.463406	52.99429	19.96	24.60
At most 1	0.063612	5.060822	9.24	12.97
*(**) denotes rejection of the hypothesis at the 5%(1%) level Trace test indicates 1 cointegrating equation(s) at both 5% and 1% levels				
Hungary				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.232023	24.34241	15.41	20.04
At most 1	0.046949	3.750790	3.76	6.65
*(**) denotes rejection of the hypothesis at the 5%(1%) level Trace test indicates 1 cointegrating equation(s) at both 5% and 1% levels				

Estimating the VECs I determined the long-run relationships as follows:

$$lnnfxrate\_pl = 1.010470*ndif\_pl - 0.447240 \quad (17)$$

and

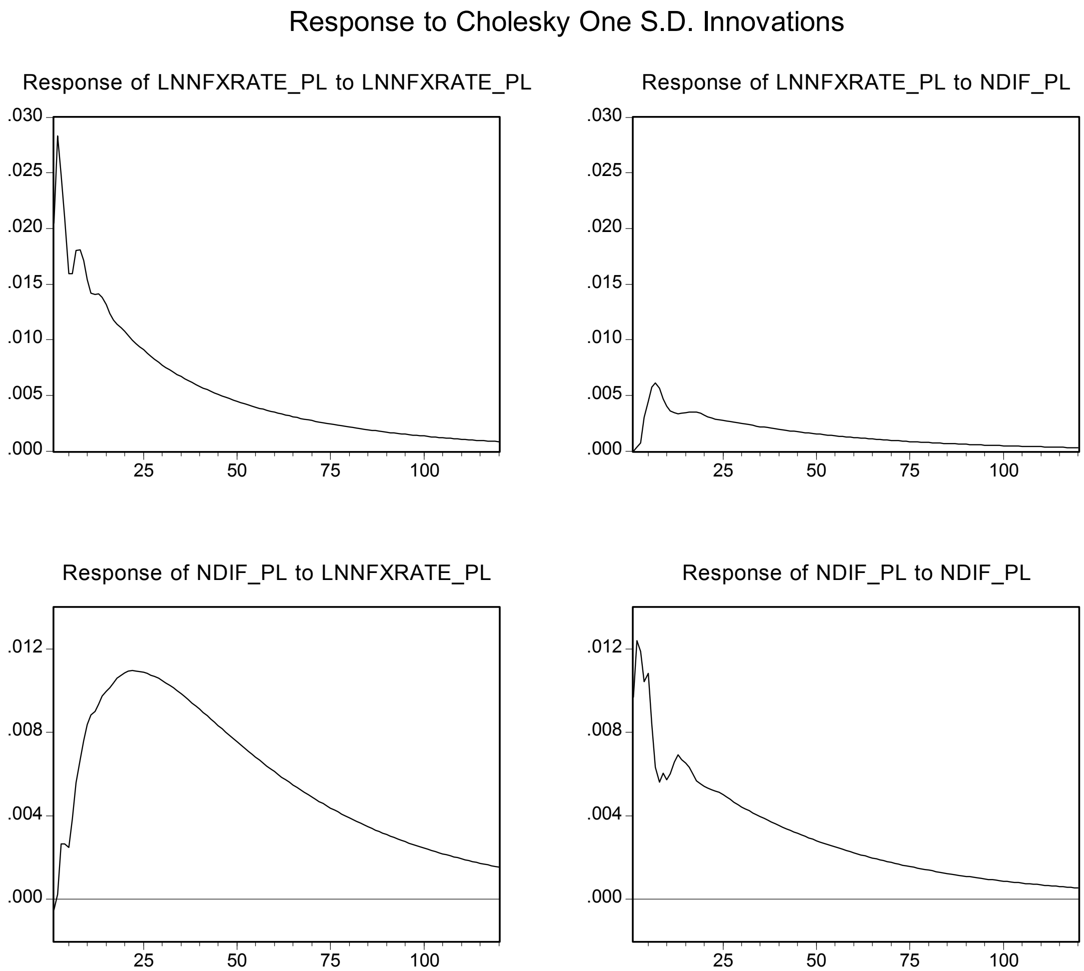
$$lnnfxrate\_hu = 2.652475*ndif\_hu - 1.229366 \quad (18)$$

Notice the fact that in case of Poland the coefficient of ndif_pl in the cointegrating relationship has the expected sign and is very close to its theoretical value of 1, having a small standard deviation (0.09238). The speed of adjustment coefficients derived from the estimated VEC are 0.014318 for lnnfxrate_pl and 0.073381 for ndif_cz. It would seem that relative prices adjust quicker to a deviation from the long run equilibrium that the exchange rate does; this is rather odd, but can be motivated by arbitrage on the goods market and price flexibility.

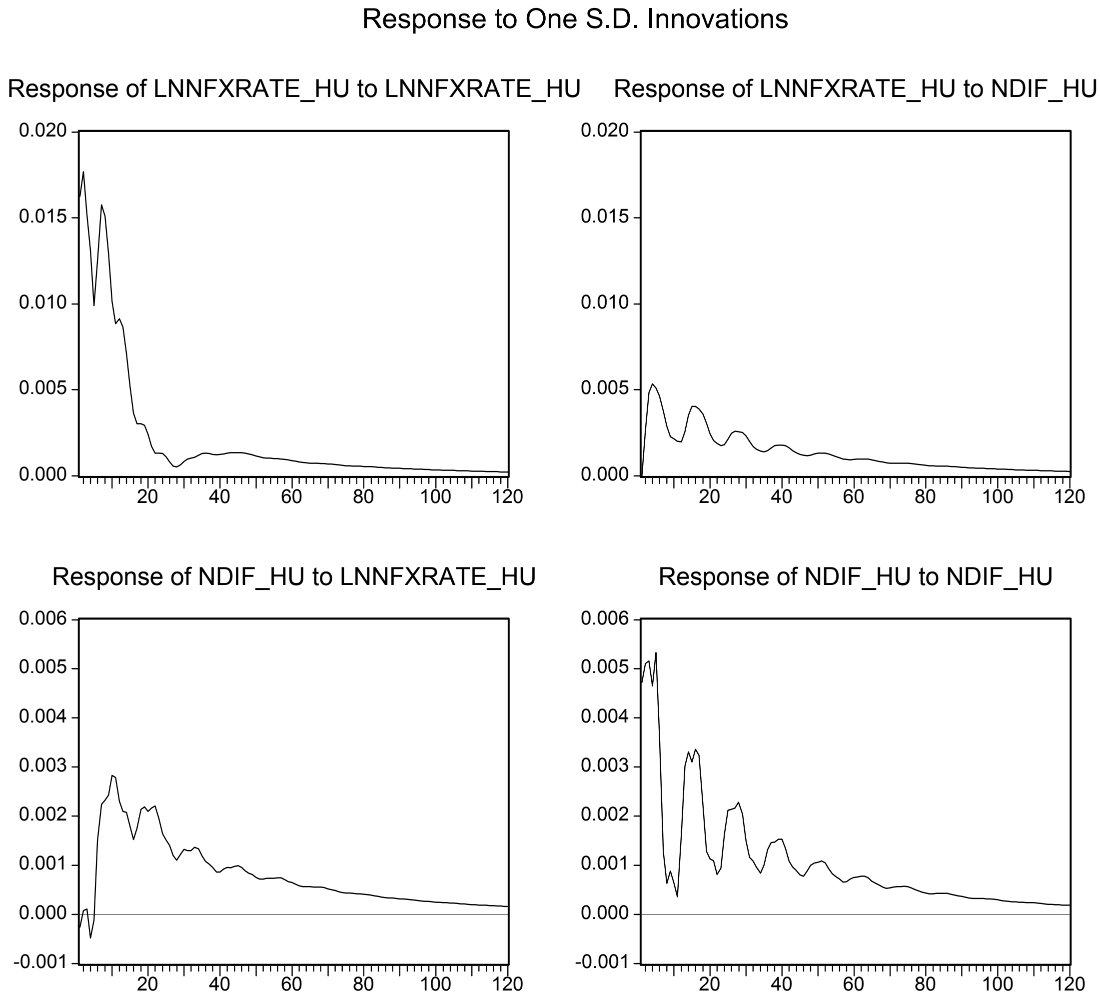
In case of Hungary the coefficient is far from the theoretical value so the semi-strong form of PPP doesn't hold.

The impulse response functions for Poland and Hungary are shown in the Graph 7 and Graph 8.

Graph 7. Impulse response functions for Poland



Graph 8. Impulse response functions for Hungary



3.3. Testing the relative form for PPP

For testing the relative form of PPP I use the equation (7) from Section 1. The time-series that I use are: the percentage growth of nominal exchange rates, of CPIs from the domestic countries and of CPI from USA, covering the same period: 1995:1-2001:12.

The first step was to verify if these time-series are stationary or not. In this purpose I used ADF test with the number of lags indicated by Akaike and Schwarz information criterion. The results are shown in the Table 10:

Table 10. ADF test for the growth of nominal exchange rates and CPIs

	ADF Test Statistic	Critical values		
		1%	5%	10%
dfxrate_ro (2 lags)	-2.885920	-2.5919	-1.9443	-1.6179
dcpi_ro (0 lags)	-3.028379	-2.5912	-1.9442	-1.6178
dfxrate_cz (0 lags)	-6.383729	-2.5912	-1.9442	-1.6178
dcpi_cz (0 lags)	-9.046063	-2.5912	-1.9442	-1.6178
dfxrate_pl (1 lag)	-5.956909	-2.9515	-1.9442	-1.6178
dcpi_pl (1 lag)	-6.426192	-4.0742	-3.4652	-3.1589
dfxrate_hu (0 lags)	-5.537619	-2.5912	-1.9442	-1.6178
dcpi_hu (1 lag)	-5.828259	-4.0742	-3.4652	-3.1589
dcpi_us (2 lags)	-1.712843	-2.5919	-1.9443	-1.6179

As you can see, the null hypothesis of existence of unit roots has been rejected in all the cases at 1% level, except for the CPI of USA where the rejection is only at 10% level of confidence, level that I will accept. So the time-series are stationary.

Considering this I can estimate using the Ordinary Least Squares Method the coefficients of the equation from below:

$$y_t = \alpha + \beta_1 x_{1t} + \beta_2 x_{2t} + \varepsilon_t \quad (19)$$

where, y_t is the growth of nominal exchange rates, x_{1t} is the growth of the nationa CPI, x_{2t} is the growth of foreign CPI, α is the constant term, β_1 and β_2 are the coefficients to be estimated and ε_t is the residual.

The full output of the OLS estimations is shown in Appendix 4 – Tables 4.1.-4.4. Looking at the correlograms I realized that for Romania, Czech Republic and Poland the residuals followed an autoregressive process of order 1 (AR(1)).

After estimating the equation for Romania we can see that coefficient of the growth of the foreign CPI is not significant and the residuals are positive correlated (Durbin-Watson statistic is less than two). I introduced in the equation a dummy variable (dummy97) that takes the value of 1 in March 1997 when the foreign exchange market had been liberalized. Applying the Wald test (see Table 11) we can conclude that the null hypothesis (c(1)=1 and c(2)=-1) can be rejected.

Table 11. Wald test for Romania

Equation: EQ_ROMANIA			
Null Hypothesis:	C(1)=1 C(2)=-1		
F-statistic	2.934718	Probability	0.059117
Chi-square	5.869436	Probability	0.053146

In the case of Czech Republic the coefficient of the growth of the home CPI it's not significant and the residuals are also positive correlated. As about the Wald test (see Table 12) the null hypothesis can be rejected with a probability of 100%.

Table 12. Wald test for Czech Republic

Equation: EQ_CZECH			
Null Hypothesis:	C(1)=1 C(2)=-1		
F-statistic	60.35474	Probability	0.000000
Chi-square	120.7095	Probability	0.000000

As about Poland the residuals are also positive correlated and the Wald test that I performed indicates that the relative PPP theory doesn't hold for this country either.

Table 13. Wald test for Poland

Equation: EQ_POLAND			
Null Hypothesis:	C(1)=1 C(2)=-1		
F-statistic	8.293522	Probability	0.000542
Chi-square	16.58704	Probability	0.000250

Finally, I analyze the growth of the Hungary-USA exchange rate and the growth of the corresponding CPIs. One more the Wald test rejected the hypothesis of the relative PPP theory.

Table 14. Wald test for Hungary

Equation: EQ_HUNGARY			
Null Hypothesis:	C(1)=1 C(2)=-1		
F-statistic	1.958467	Probability	0.147780
Chi-square	3.916934	Probability	0.141075

4. Conclusions

Tests performed in this paper for the East European developing countries (Romania, Czech Republic, Poland and Hungary) indicate that the absolute, semi-strong and relative forms of PPP relative to US dollar do not hold.

The reasons why PPP does not hold are plenty. One of them refers to the fact that the assumption of no transaction costs is unrealistic. The large geographical distance between United States and the East European countries I have studied is very important. This implies sometimes very big transportation costs. In this case arbitrage will not take place to take advantage of a deviation from parity unless the absolute magnitude of the deviation is greater than the transport costs involved in undertaking the arbitrage. This constraint has the effect of creating a “neutral band” within which no arbitrage transactions will occur. So we’ll find the persistence of deviations from the PPP that are smaller than transport cost.

The lack of commercial barriers imposed by the governments (like taxes) in order to protect the domestic economy represents another assumption not found in real life. These tariffs reduce the effective amount of funds available for arbitrage by an amount $(1-\tau)$ where τ is the percentage tariff rate. Collecting a tax will widen the neutral band within which no profitable arbitrage opportunities are available making more difficult the PPP theory to hold.

According to Romania, another aspect that makes PPP not to hold is the Romanian National Bank policy, which lately played a big part on the foreign exchange market buying US dollars in order to increase the currency reserve which grew up to almost 4 billion US dollars in the last few years. Also Romanian National Bank intervened on the foreign exchange market almost every time there were pressures on the national currency to appreciate.

Another problem with the PPP theory is represented by the costs of nontraded-goods. Many items that are homogeneous, nevertheless sell for different prices because they require a non-tradable input in the production process. As an example consider why the price of a McDonald's Big Mac hamburger sold in downtown New York city is higher than the price of the same product in the New York city suburbs. Because the rent for restaurant space is much higher in the city center, the restaurant will pass along its higher costs in the form of higher prices.

The law of one price assumes that individuals have good, even perfect, information about the prices of goods in other markets. Only with this knowledge will profit-seekers begin to export goods to the high price market and import goods from the low priced market. Consider a case in which there is imperfect information. Perhaps some price deviations are known to traders but other deviations are not known. Or maybe only a small group of traders know about a price discrepancy and that group is unable to achieve the scale of trade needed to equalize the prices for that product. In either case, traders without information about price differences will not respond to the profit opportunities and thus prices will not be equalized. Thus, the law of one price may not hold for some products which would imply that PPP would not hold either.

Notice that in the PPP equilibrium stories, it is the behavior of profit-seeking importers and exporters that forces the exchange rate to adjust to the PPP level. These activities would be recorded on the current account of a country's balance of payments. Thus, it is reasonable to say that the PPP theory is based on current account transactions. This contrasts with the interest rate parity theory in which the behavior of investors seeking the highest rates of return on investments motivates adjustments in the exchange rate. Since investors are trading assets, these transactions would appear on a country's capital account of its balance of payments. Thus, the interest rate parity theory is based on capital account transactions. The amount of daily currency transactions is more than ten times the amount of daily trade. This fact would seem to suggest that the primary effect on the daily exchange rate must be caused by the actions of investors rather than importers and exporters. Thus, the participation of other traders in the foreign exchange market, who are motivated by other concerns, may lead the exchange rate to a value that is not consistent with PPP.

Appendix 1

Table 1.1. The normalized series converted to natural logarithm

	ROMANIA		HUNGARY		POLAND		CZECH REP.		USA
Month	s_t	p_t	s_t	p_t	s_t	p_t	s_t	p_t	p_t
Jan-95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Feb-95	1.01	1.01	1.00	1.03	1.00	1.02	0.99	1.01	1.00
Mar-95	1.03	1.02	1.04	1.07	0.98	1.04	0.94	1.01	1.00
Apr-95	1.05	1.04	1.08	1.10	0.98	1.06	0.93	1.01	1.01
May-95	1.08	1.05	1.11	1.12	0.98	1.08	0.95	1.01	1.01
Jun-95	1.10	1.06	1.13	1.14	0.96	1.09	0.94	1.01	1.01
Jul-95	1.12	1.09	1.13	1.15	0.97	1.08	0.94	1.01	1.01
Aug-95	1.15	1.10	1.17	1.15	1.00	1.08	0.96	1.00	1.02
Sep-95	1.18	1.12	1.20	1.17	1.01	1.12	0.97	1.00	1.02
Oct-95	1.22	1.16	1.20	1.20	1.00	1.14	0.95	0.99	1.02
Nov-95	1.35	1.21	1.22	1.22	1.02	1.15	0.95	0.99	1.02
Dec-95	1.44	1.25	1.25	1.24	1.03	1.17	0.96	0.99	1.02
Jan-96	1.46	1.27	1.27	1.29	1.03	1.21	0.97	1.09	1.03
Feb-96	1.56	1.29	1.29	1.32	1.05	1.23	0.98	1.09	1.03
Mar-96	1.62	1.31	1.31	1.34	1.06	1.25	0.98	1.10	1.03
Apr-96	1.64	1.34	1.33	1.37	1.08	1.27	0.99	1.10	1.04
May-96	1.65	1.41	1.36	1.39	1.10	1.29	1.00	1.10	1.04
Jun-96	1.68	1.42	1.37	1.41	1.12	1.30	1.00	1.09	1.04
Jul-96	1.72	1.53	1.37	1.41	1.12	1.30	0.98	1.10	1.04
Aug-96	1.77	1.59	1.38	1.42	1.12	1.31	0.96	1.10	1.04
Sep-96	1.80	1.63	1.40	1.44	1.14	1.33	0.96	1.09	1.05
Oct-96	1.86	1.68	1.43	1.46	1.16	1.35	0.98	1.08	1.05
Nov-96	1.96	1.78	1.43	1.47	1.16	1.37	0.97	1.08	1.05
Dec-96	2.10	1.96	1.47	1.48	1.17	1.38	0.98	1.08	1.06
Jan-97	2.79	2.23	1.49	1.54	1.20	1.42	0.99	1.17	1.06
Feb-97	3.88	2.65	1.55	1.57	1.24	1.44	1.01	1.17	1.06
Mar-97	4.07	3.46	1.59	1.60	1.27	1.45	1.05	1.17	1.06
Apr-97	3.97	3.70	1.61	1.62	1.28	1.47	1.08	1.17	1.06
May-97	3.99	3.86	1.63	1.64	1.30	1.48	1.12	1.17	1.06
Jun-97	4.04	3.95	1.66	1.67	1.33	1.50	1.17	1.17	1.06
Jul-97	4.03	3.98	1.72	1.67	1.40	1.49	1.21	1.21	1.07
Aug-97	4.19	4.12	1.77	1.67	1.43	1.50	1.23	1.21	1.07
Sep-97	4.24	4.25	1.76	1.70	1.42	1.52	1.21	1.20	1.07
Oct-97	4.34	4.53	1.75	1.72	1.41	1.53	1.19	1.19	1.07
Nov-97	4.40	4.73	1.76	1.74	1.44	1.55	1.19	1.19	1.07
Dec-97	4.48	4.94	1.81	1.76	1.45	1.57	1.25	1.18	1.08
Jan-98	4.67	5.18	1.85	1.81	1.45	1.62	1.27	1.32	1.08
Feb-98	4.63	5.55	1.86	1.84	1.45	1.64	1.24	1.33	1.08
Mar-98	4.62	5.76	1.89	1.86	1.42	1.65	1.22	1.33	1.08

Apr-98	4.72	5.92	1.90	1.88	1.40	1.67	1.22	1.32	1.08
May-98	4.77	6.06	1.89	1.90	1.40	1.67	1.17	1.32	1.08
Jun-98	4.83	6.14	1.94	1.91	1.43	1.68	1.20	1.31	1.08
Jul-98	4.90	6.22	1.95	1.91	1.42	1.67	1.15	1.33	1.08
Aug-98	4.94	6.25	1.99	1.90	1.47	1.66	1.16	1.32	1.09
Sep-98	5.10	6.42	1.98	1.91	1.48	1.68	1.11	1.30	1.09
Oct-98	5.28	6.67	1.93	1.93	1.44	1.69	1.05	1.29	1.09
Nov-98	5.58	6.80	1.95	1.93	1.42	1.69	1.07	1.27	1.09
Dec-98	5.93	6.95	1.95	1.94	1.43	1.70	1.08	1.26	1.09
Jan-99	6.39	7.16	1.94	1.99	1.45	1.73	1.10	1.37	1.10
Feb-99	6.91	7.36	2.00	2.01	1.56	1.74	1.21	1.37	1.09
Mar-99	7.91	7.84	2.09	2.04	1.62	1.75	1.26	1.36	1.10
Apr-99	8.33	8.21	2.11	2.06	1.64	1.77	1.28	1.36	1.10
May-99	8.58	8.65	2.11	2.07	1.62	1.78	1.28	1.35	1.10
Jun-99	8.87	9.09	2.15	2.08	1.62	1.78	1.29	1.34	1.10
Jul-99	8.96	9.24	2.17	2.10	1.60	1.78	1.27	1.35	1.11
Aug-99	9.07	9.35	2.14	2.11	1.62	1.79	1.24	1.34	1.11
Sep-99	9.21	9.65	2.18	2.12	1.68	1.81	1.25	1.32	1.11
Oct-99	9.41	10.06	2.16	2.13	1.69	1.83	1.23	1.30	1.12
Nov-99	9.82	10.46	2.21	2.14	1.75	1.85	1.27	1.30	1.12
Dec-99	10.13	10.76	2.25	2.15	1.71	1.87	1.28	1.30	1.12
Jan-00	10.33	11.23	2.25	2.19	1.69	1.90	1.28	1.42	1.12
Feb-00	10.53	11.47	2.33	2.21	1.70	1.92	1.31	1.42	1.13
Mar-00	10.81	11.68	2.39	2.23	1.68	1.94	1.33	1.41	1.14
Apr-00	11.13	12.24	2.45	2.25	1.74	1.94	1.38	1.40	1.14
May-00	11.48	12.46	2.56	2.26	1.85	1.96	1.45	1.40	1.14
Jun-00	11.84	12.81	2.45	2.27	1.81	1.97	1.37	1.39	1.14
Jul-00	12.16	13.36	2.48	2.30	1.78	1.98	1.36	1.40	1.15
Aug-00	12.62	13.60	2.58	2.31	1.79	1.98	1.40	1.39	1.15
Sep-00	13.29	13.98	2.70	2.34	1.84	2.00	1.46	1.37	1.15
Oct-00	13.82	14.37	2.75	2.35	1.90	2.01	1.48	1.36	1.16
Nov-00	14.13	14.78	2.76	2.36	1.87	2.02	1.46	1.35	1.16
Dec-00	14.42	15.14	2.65	2.37	1.77	2.03	1.40	1.35	1.16
Jan-01	14.78	15.71	2.53	2.41	1.69	2.04	1.35	1.48	1.17
Feb-01	15.10	16.07	2.58	2.44	1.68	2.05	1.35	1.47	1.17
Mar-01	15.37	16.39	2.62	2.46	1.67	2.06	1.37	1.47	1.17
Apr-01	15.70	16.83	2.68	2.48	1.65	2.07	1.39	1.47	1.17
May-01	16.04	17.12	2.65	2.50	1.64	2.09	1.41	1.47	1.18
Jun-01	16.30	17.39	2.59	2.51	1.63	2.09	1.43	1.47	1.18
Jul-01	16.53	17.62	2.60	2.51	1.72	2.08	1.42	1.48	1.18
Aug-01	16.78	18.00	2.50	2.51	1.74	2.08	1.36	1.47	1.18
Sep-01	17.02	18.35	2.52	2.52	1.73	2.08	1.35	1.44	1.18
Oct-01	17.33	18.79	2.52	2.53	1.70	2.09	1.33	1.42	1.18

Nov-01	17.62	19.29	2.54	2.53	1.68	2.09	1.35	1.41	1.18
Dec-01	17.77	19.72	2.48	2.53	1.65	2.10	1.31	1.40	1.18

Appendix 2

Table 2.1. ADF test for nominal exchange rates and consumer price indexes

	ADF Test Statistic	Critical values		
		1%	5%	10%
lnnfxrate_ro (3 lags)	-2.258792	-4.0756	-3.4659	-3.1593
dlnnfxrate_ro (2 lags)	-2.935320	-2.5922	-1.9443	-1.6179
lnncpi_ro (1 lag)	-1.508789	-4.0727	-3.4645	-3.1585
dlnncpi_ro (1 lag)	-2.350734	-2.5915	-1.9442	-1.6178
lnnfxrate_cz (1 lag)	-2.762903	-4.0727	-3.4645	-3.1585
dlnnfxrate_cz (1 lag)	-5.422746	-2.5915	-1.9442	-1.6178
lnncpi_cz (1 lag)	-2.713272	-4.0727	-3.4645	-3.1585
dlnncpi_cz (1 lag)	-6.540104	-2.5915	-1.9442	-1.6178
lnnfxrate_pl (2 lags)	-0.560377	-4.0742	-3.4652	-3.1589
dlnnfxrate_pl (1 lag)	-5.981128	-2.5915	-1.9442	-1.6178
lnncpi_pl (1 lag)	-1.158228	-4.0727	-3.4645	-3.1585
dlnncpi_pl (3 lags)	-1.992845	-2.5922	-1.9443	-1.6179
lnnfxrate_hu (1 lag)	-1.034491	-4.0727	-3.4645	-3.1585
dlnnfxrate_hu (1 lag)	-4.643873	-2.5915	-1.9442	-1.6178
lnncpi_hu (2 lags)	-1.237540	-4.0742	-3.4652	-3.1589
dlnncpi_hu (1 lag)	-3.058606	-2.5915	-1.9442	-1.6178
lnncpi_us (0 lags)	-1.334844	-4.0713	-3.4639	-3.1581
dlnncpi_us (1 lag)	-3.120513	-2.5915	-1.9442	-1.6178

Table 2.2. Determination of optimal number of lags for Romania

VAR Lag Order Selection Criteria
Endogenous variables: LNNFXRATE_RO LNNCPI_RO LNNCPI_US
Exogenous variables: C
Sample: 1995:01 2001:12
Included observations: 74

Lag	LogL	LR	FPE	AIC	SC	HQ
0	207.2131	NA	8.05E-07	-5.519274	-5.425866	-5.482013
1	652.2696	841.9987	6.13E-12	-17.30458	-16.93095	-17.15554
2	693.6793	74.98513	2.56E-12	-18.18052	-17.52667*	-17.91969*
3	703.5606	17.09206	2.50E-12	-18.20434	-17.27026	-17.83173
4	717.5437	23.05309	2.20E-12*	-18.33902	-17.12471	-17.85462
5	723.7108	9.667446	2.40E-12	-18.26245	-16.76793	-17.66627
6	735.8967	18.11416*	2.23E-12	-18.34856*	-16.57381	-17.64059
7	738.4513	3.590288	2.71E-12	-18.17436	-16.11938	-17.35460
8	741.3964	3.900251	3.29E-12	-18.01071	-15.67551	-17.07917
9	745.7842	5.455064	3.86E-12	-17.88606	-15.27063	-16.84273
10	755.1267	10.85745	4.00E-12	-17.89532	-14.99967	-16.74020

Table 2.3. Determination of optimal number of lags for Czech Republic

VAR Lag Order Selection Criteria
Endogenous variables: LNNFXRATE_CZ LNNCPI_CZ LNNCPI_US
Exogenous variables: C
Sample: 1995:01 2001:12
Included observations: 74

Lag	LogL	LR	FPE	AIC	SC	HQ
0	362.1073	NA	1.22E-08	-9.705603	-9.612195	-9.668342
1	700.1664	639.5712	1.68E-12*	-18.59909*	-18.22546*	-18.45004*
2	708.0169	14.21587	1.74E-12	-18.56803	-17.91417	-18.30719
3	711.9632	6.825984	2.00E-12	-18.43144	-17.49736	-18.05882
4	722.3378	17.10413*	1.93E-12	-18.46859	-17.25429	-17.98419
5	726.6092	6.695657	2.22E-12	-18.34079	-16.84626	-17.74460
6	733.2344	9.848290	2.40E-12	-18.27661	-16.50185	-17.56864
7	743.5258	14.46362	2.37E-12	-18.31151	-16.25653	-17.49175
8	748.0765	6.026507	2.74E-12	-18.19126	-15.85605	-17.25972
9	760.4613	15.39732	2.59E-12	-18.28274	-15.66731	-17.23941
10	771.6843	13.04295	2.56E-12	-18.34282	-15.44717	-17.18771

Table 2.4. Determination of optimal number of lags for Poland

VAR Lag Order Selection Criteria
Endogenous variables: LNNFXRATE_PL LNNCPI_PL LNNCPI_US
Exogenous variables: C
Sample: 1995:01 2001:12
Included observations: 74

Lag	LogL	LR	FPE	AIC	SC	HQ
0	385.7133	NA	6.46E-09	-10.34360	-10.25019	-10.30634
1	824.6280	830.3792	5.81E-14	-21.96292	-21.58929*	-21.81387*
2	836.0639	20.70823	5.45E-14	-22.02875	-21.37490	-21.76792
3	842.7180	11.50976	5.83E-14	-21.96535	-21.03127	-21.59274
4	853.3806	17.57889	5.60E-14	-22.01029	-20.79598	-21.52589
5	858.2660	7.658191	6.32E-14	-21.89908	-20.40455	-21.30290
6	870.6354	18.38698	5.86E-14	-21.99015	-20.21539	-21.28218
7	888.4903	25.09325*	4.70E-14*	-22.22947*	-20.17449	-21.40971
8	897.3781	11.77033	4.85E-14	-22.22643	-19.89123	-21.29489
9	902.7896	6.727813	5.54E-14	-22.12945	-19.51402	-21.08612
10	908.7940	6.978106	6.29E-14	-22.04849	-19.15284	-20.89338

Table 2.5. Determination of optimal number of lags for Hungary

VAR Lag Order Selection Criteria
Endogenous variables: LNNFXRATE_HU LNNCPI_HU LNNCPI_US
Exogenous variables: C
Sample: 1995:01 2001:12
Included observations: 74

Lag	LogL	LR	FPE	AIC	SC	HQ
0	386.5429	NA	6.32E-09	-10.36603	-10.27262	-10.32876
1	827.8571	834.9187	5.33E-14	-22.05019	-21.67656*	-21.90115*
2	837.4344	17.34261	5.25E-14	-22.06579	-21.41194	-21.80496
3	845.6270	14.17109	5.38E-14	-22.04397	-21.10989	-21.67136
4	855.1950	15.77425	5.33E-14	-22.05932	-20.84502	-21.57492
5	858.8144	5.673569	6.23E-14	-21.91390	-20.41937	-21.31772
6	880.4408	32.14738	4.49E-14	-22.25516	-20.48040	-21.54719
7	895.0386	20.51583	3.94E-14	-22.40645	-20.35147	-21.58669
8	913.2934	24.17536	3.15E-14	-22.65658	-20.32138	-21.72504
9	931.1953	22.25630*	2.57E-14*	-22.89717*	-20.28174	-21.85384
10	934.3989	3.723106	3.15E-14	-22.74051	-19.84486	-21.58540

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 2.6. Johansen cointegration test for Romania

Sample: 1995:01 2001:12
Included observations: 78
Test assumption: Linear deterministic trend in the data
Series: LNNFXRATE_RO LNNCPI_RO LNNCPI_US
Lags interval: 1 to 5

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.238821	30.14110	29.68	35.65	None *
0.062167	8.855936	15.41	20.04	At most 1
0.048156	3.849620	3.76	6.65	At most 2 *

*(**) denotes rejection of the hypothesis at 5%(1%) significance level
L.R. test indicates 1 cointegrating equation(s) at 5% significance level

Unnormalized Cointegrating Coefficients:

LNNFXRATE_RO	LNNCPI_RO	LNNCPI_US
-2.517660	1.727848	12.96837
-0.443834	0.775963	-8.339995
0.040549	-0.256231	2.034686

Normalized Cointegrating Coefficients: 1 Cointegrating Equation(s)

LNNFXRATE_RO	LNNCPI_RO	LNNCPI_US	C

1.000000	-0.686291 (0.04205)	-5.150962 (0.87199)	-0.047947
Log likelihood	773.5274		

Table 2.7. Estimated VEC for (lnnfxrate_ro, lnncpi_ro, lnncpi_us)

D(LNNFXRATE_RO) = - 0.2907547863*(LNNFXRATE_RO(-1) - 0.6862912733*LNNCPI_RO(-1) - 5.150961917*LNNCPI_US(-1) - 0.04794697665) + 0.9798504677*D(LNNFXRATE_RO(-1)) - 0.715630526*D(LNNFXRATE_RO(-2)) + 0.3987505767*D(LNNFXRATE_RO(-3)) - 0.02010604964*D(LNNFXRATE_RO(-4)) + 0.3951618513*D(LNNFXRATE_RO(-5)) + 0.620328767*D(LNNCPI_RO(-1)) + 0.1276815544*D(LNNCPI_RO(-2)) - 0.355187963*D(LNNCPI_RO(-3)) - 0.4572106337*D(LNNCPI_RO(-4)) + 0.2971998072*D(LNNCPI_RO(-5)) + 4.837993163*D(LNNCPI_US(-1)) + 3.177777702*D(LNNCPI_US(-2)) + 1.69965485*D(LNNCPI_US(-3)) + 0.504789438*D(LNNCPI_US(-4)) - 2.792475451*D(LNNCPI_US(-5)) - 0.02509245054

D(LNNCPI_RO) = 0.0453207507*(LNNFXRATE_RO(-1) - 0.6862912733*LNNCPI_RO(-1) - 5.150961917*LNNCPI_US(-1) - 0.04794697665) + 0.4140074194*D(LNNFXRATE_RO(-1)) - 0.03618840998*D(LNNFXRATE_RO(-2)) - 0.255531141*D(LNNFXRATE_RO(-3)) - 0.06038974788*D(LNNFXRATE_RO(-4)) - 0.04567100852*D(LNNFXRATE_RO(-5)) + 0.2530252818*D(LNNCPI_RO(-1)) + 0.4248832999*D(LNNCPI_RO(-2)) + 0.1269288892*D(LNNCPI_RO(-3)) - 0.1488072012*D(LNNCPI_RO(-4)) + 0.08421678589*D(LNNCPI_RO(-5)) + 1.636301145*D(LNNCPI_US(-1)) + 2.728500187*D(LNNCPI_US(-2)) - 0.5998073633*D(LNNCPI_US(-3)) + 1.022056226*D(LNNCPI_US(-4)) - 2.142415246*D(LNNCPI_US(-5)) + 0.004280139555

D(LNNCPI_US) = 0.006291130401*(LNNFXRATE_RO(-1) - 0.6862912733*LNNCPI_RO(-1) - 5.150961917*LNNCPI_US(-1) - 0.04794697665) + 0.001195734952*D(LNNFXRATE_RO(-1)) - 0.001603451068*D(LNNFXRATE_RO(-2)) + 0.002425195995*D(LNNFXRATE_RO(-3)) + 0.003093132199*D(LNNFXRATE_RO(-4)) - 0.01010358754*D(LNNFXRATE_RO(-5)) - 0.008847765966*D(LNNCPI_RO(-1)) - 0.01591815256*D(LNNCPI_RO(-2)) + 7.110363272e-05*D(LNNCPI_RO(-3)) + 0.007061071856*D(LNNCPI_RO(-4)) + 0.008055961783*D(LNNCPI_RO(-5)) + 0.05074119816*D(LNNCPI_US(-1)) - 0.2424440435*D(LNNCPI_US(-2)) + 0.4081486169*D(LNNCPI_US(-3)) + 0.2375381225*D(LNNCPI_US(-4)) + 0.197605476*D(LNNCPI_US(-5)) + 0.001104046951

Table 2.8. Johansen cointegration test for Czech Republic

Sample: 1995:01 2001:12
Included observations: 82
Test assumption: No deterministic trend in the data
Series: LNNFXRATE_CZ LNNCPI_CZ LNNCPI_US
Lags interval: 1 to 1

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.312883	47.29511	34.91	41.07	None **
0.122493	16.52460	19.96	24.60	At most 1
0.068398	5.809628	9.24	12.97	At most 2

*(**) denotes rejection of the hypothesis at 5%(1%) significance level
L.R. test indicates 1 cointegrating equation(s) at 5% significance level

Unnormalized Cointegrating Coefficients:

LNNFXRATE_CZ	LNNCPI_CZ	LNNCPI_US	C
0.453419	-0.252629	-0.963023	0.241994
1.951553	-2.070303	-0.380633	0.157147
-0.862068	-1.801182	6.174077	0.013245

Normalized Cointegrating Coefficients: 1 Cointegrating Equation(s)

LNNFXRATE_CZ	LNNCPI_CZ	LNNCPI_US	C
1.000000	-0.557164	-2.123911	0.533709
	(0.93296)	(2.49595)	(0.36344)
Log likelihood	783.1281		

Table 2.9. Estimated VEC for (lnnfxrate_cz, lnncpi_cz, lnncpi_us)

D(LNNFXRATE_CZ) = - 0.007399003598*(LNNFXRATE_CZ(-1) - 0.5571642272*LNNCPI_CZ(-1) - 2.123910877*LNNCPI_US(-1) + 0.5337092732) + 0.3326271786*D(LNNFXRATE_CZ(-1)) + 0.1511737549*D(LNNCPI_CZ(-1)) + 1.75752095*D(LNNCPI_US(-1))

D(LNNCPI_CZ) = 0.009814160202*(LNNFXRATE_CZ(-1) - 0.5571642272*LNNCPI_CZ(-1) - 2.123910877*LNNCPI_US(-1) + 0.5337092732) + 0.1444492271*D(LNNFXRATE_CZ(-1)) - 0.03367971593*D(LNNCPI_CZ(-1)) + 0.1887649466*D(LNNCPI_US(-1))

D(LNNCPI_US) = 0.004549679719*(LNNFXRATE_CZ(-1) - 0.5571642272*LNNCPI_CZ(-1) - 2.123910877*LNNCPI_US(-1) + 0.5337092732) - 0.0009751669295*D(LNNFXRATE_CZ(-1)) - 0.002662968159*D(LNNCPI_CZ(-1)) + 0.1143994998*D(LNNCPI_US(-1))

Table 2.10. Johansen cointegration test for Poland

Sample: 1995:01 2001:12
Included observations: 76
Test assumption: No deterministic trend in the data
Series: LNNFXRATE_PL LNNCPI_PL LNNCPI_US
Lags interval: 1 to 7

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.481465	67.09009	34.91	41.07	None **
0.144478	17.17720	19.96	24.60	At most 1
0.067580	5.317867	9.24	12.97	At most 2

*(**) denotes rejection of the hypothesis at 5%(1%) significance level
L.R. test indicates 1 cointegrating equation(s) at 5% significance level

Unnormalized Cointegrating Coefficients:

LNNFXRATE_PL	LNNCPI_PL	LNNCPI_US	C
1.835776	-3.712288	3.904466	1.183911
-3.220260	4.832239	-10.14059	-0.422439
-1.582787	-0.691088	10.96620	-0.116973

Normalized Cointegrating Coefficients: 1 Cointegrating Equation(s)

LNNFXRATE_PL	LNNCPI_PL	LNNCPI_US	C
1.000000	-2.022191	2.126875	0.644911
	(0.28204)	(0.97097)	(0.13292)
Log likelihood	911.0401		

Table 2.11. Estimated VEC for (lnnfxrate_pl, lnncpi_pl, lnncpi_us)

D(LNNFXRATE_PL) = - 0.04036419297*(LNNFXRATE_PL(-1) - 2.022190661*LNNCPI_PL(-1) + 2.126875215*LNNCPI_US(-1) + 0.6449106971) + 0.495007583*D(LNNFXRATE_PL(-1)) - 0.1293892853*D(LNNFXRATE_PL(-2)) - 0.05388162017*D(LNNFXRATE_PL(-3)) - 0.1291402978*D(LNNFXRATE_PL(-4)) + 0.1925203409*D(LNNFXRATE_PL(-5)) + 0.003062334063*D(LNNFXRATE_PL(-6)) - 0.05091211014*D(LNNFXRATE_PL(-7)) + 0.5219669784*D(LNNCPI_PL(-1)) + 0.02781567556*D(LNNCPI_PL(-2)) + 0.342160105*D(LNNCPI_PL(-3)) - 0.1251768166*D(LNNCPI_PL(-4)) + 0.4017093727*D(LNNCPI_PL(-5)) - 0.2752631613*D(LNNCPI_PL(-6)) + 0.5934835077*D(LNNCPI_PL(-7)) + 0.4035078414*D(LNNCPI_US(-1)) + 4.151977287*D(LNNCPI_US(-2)) - 2.421588625*D(LNNCPI_US(-3)) - 0.6629754854*D(LNNCPI_US(-4)) - 1.775168471*D(LNNCPI_US(-5)) - 1.508379283*D(LNNCPI_US(-6)) + 1.381147672*D(LNNCPI_US(-7))

D(LNNCPI_PL) = 0.06101562661*(LNNFXRATE_PL(-1) - 2.022190661*LNNCPI_PL(-1) + 2.126875215*LNNCPI_US(-1) + 0.6449106971) - 0.04097330186*D(LNNFXRATE_PL(-1)) - 0.01877065317*D(LNNFXRATE_PL(-2)) - 0.0699449129*D(LNNFXRATE_PL(-3)) - 0.03234688639*D(LNNFXRATE_PL(-4)) + 0.01853754948*D(LNNFXRATE_PL(-5)) - 0.05950447588*D(LNNFXRATE_PL(-6)) + 0.08772681484*D(LNNFXRATE_PL(-7)) + 0.04878045752*D(LNNCPI_PL(-1)) + 0.004491097166*D(LNNCPI_PL(-2)) -

0.007071998541*D(LNNCPI_PL(-3)) + 0.1433611674*D(LNNCPI_PL(-4)) -
0.07918343867*D(LNNCPI_PL(-5)) - 0.4685424334*D(LNNCPI_PL(-6)) -
0.06746076067*D(LNNCPI_PL(-7)) - 0.4060618702*D(LNNCPI_US(-1)) +
0.02376812128*D(LNNCPI_US(-2)) - 0.3341304254*D(LNNCPI_US(-3)) +
0.4300089305*D(LNNCPI_US(-4)) + 0.4869418941*D(LNNCPI_US(-5)) +
0.3833479766*D(LNNCPI_US(-6)) + 0.1966932551*D(LNNCPI_US(-7))

D(LNNCPI_US) = 0.002890273018*(LNNFXRATE_PL(-1) - 2.022190661*LNNCPI_PL(-1) +
2.126875215*LNNCPI_US(-1) + 0.6449106971) - 0.007951504009*D(LNNFXRATE_PL(-1)) +
0.006039526464*D(LNNFXRATE_PL(-2)) - 0.02155028776*D(LNNFXRATE_PL(-3)) +
0.03696512096*D(LNNFXRATE_PL(-4)) - 0.02946244229*D(LNNFXRATE_PL(-5)) +
0.01101148208*D(LNNFXRATE_PL(-6)) + 0.01125461806*D(LNNFXRATE_PL(-7)) +
0.001190419042*D(LNNCPI_PL(-1)) - 0.02425494755*D(LNNCPI_PL(-2)) -
0.017007277*D(LNNCPI_PL(-3)) + 0.04197460459*D(LNNCPI_PL(-4)) -
0.03653833092*D(LNNCPI_PL(-5)) + 0.04082945007*D(LNNCPI_PL(-6)) -
0.02744420963*D(LNNCPI_PL(-7)) + 0.2528199214*D(LNNCPI_US(-1)) -
0.2026574149*D(LNNCPI_US(-2)) + 0.4374412951*D(LNNCPI_US(-3)) +
0.1895015986*D(LNNCPI_US(-4)) + 0.09304870157*D(LNNCPI_US(-5)) -
0.1511530897*D(LNNCPI_US(-6)) + 0.1193541581*D(LNNCPI_US(-7))

Table 2.12. Johansen cointegration test for Hungary

Sample: 1995:01 2001:12
Included observations: 74
Test assumption: No deterministic trend in the data
Series: LNNFXRATE_HU LNNCPI_HU LNNCPI_US
Lags interval: 1 to 9

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.238779	27.76385	24.31	29.75	None *
0.092527	7.574298	12.53	16.31	At most 1
0.005250	0.389534	3.84	6.51	At most 2

*(**) denotes rejection of the hypothesis at 5%(1%) significance level
L.R. test indicates 1 cointegrating equation(s) at 5% significance level

Unnormalized Cointegrating Coefficients:

LNNFXRATE_HU	LNNCPI_HU	LNNCPI_US
4.855466	-5.454728	3.375489
6.017830	-3.346298	-20.59468
-1.792162	2.135273	1.653253

Normalized Cointegrating Coefficients: 1 Cointegrating Equation(s)

LNNFXRATE_HU	LNNCPI_HU	LNNCPI_US
1.000000	-1.123420	0.695194
	(0.14604)	(1.06643)
Log likelihood	914.2528	

Table 2.13. Estimated VEC for (lnnfxrate_hu, lnncpi_hu, lnncpi_us)

D(LNNFXRATE_HU) = - 0.2366759823*(LNNFXRATE_HU(-1) - 1.123420155*LNNCPI_HU(-1) + 0.6951936788*LNNCPI_US(-1)) + 0.2981580494*D(LNNFXRATE_HU(-1)) + 0.1408791248*D(LNNFXRATE_HU(-2)) - 0.1374268646*D(LNNFXRATE_HU(-3)) + 0.08100524522*D(LNNFXRATE_HU(-4)) + 0.4860635318*D(LNNFXRATE_HU(-5)) - 0.02108759325*D(LNNFXRATE_HU(-6)) + 0.1799154051*D(LNNFXRATE_HU(-7)) + 0.381969713*D(LNNFXRATE_HU(-8)) - 0.1219436291*D(LNNFXRATE_HU(-9)) + 0.4030081132*D(LNNCPI_HU(-1)) - 0.07220258538*D(LNNCPI_HU(-2)) - 0.5813762782*D(LNNCPI_HU(-3)) - 0.1028315605*D(LNNCPI_HU(-4)) - 0.2031325398*D(LNNCPI_HU(-5)) - 0.2560033732*D(LNNCPI_HU(-6)) + 0.1208383356*D(LNNCPI_HU(-7)) - 0.5921538353*D(LNNCPI_HU(-8)) - 0.4023481722*D(LNNCPI_HU(-9)) + 0.3393745404*D(LNNCPI_US(-1)) + 3.769481138*D(LNNCPI_US(-2)) + 0.09892637957*D(LNNCPI_US(-3)) - 2.830693918*D(LNNCPI_US(-4)) + 2.565406288*D(LNNCPI_US(-5)) - 1.196117071*D(LNNCPI_US(-6)) + 0.3523440259*D(LNNCPI_US(-7)) + 5.401000873*D(LNNCPI_US(-8)) - 0.2461781037*D(LNNCPI_US(-9))

D(LNNCPI_HU) = - 0.05000773191*(LNNFXRATE_HU(-1) - 1.123420155*LNNCPI_HU(-1) + 0.6951936788*LNNCPI_US(-1)) - 0.008498087477*D(LNNFXRATE_HU(-1)) + 0.01136336839*D(LNNFXRATE_HU(-2)) - 0.03038546435*D(LNNFXRATE_HU(-3)) + 0.07175210078*D(LNNFXRATE_HU(-4)) + 0.1193051114*D(LNNFXRATE_HU(-5)) + 0.0965030465*D(LNNFXRATE_HU(-6)) - 0.02056965328*D(LNNFXRATE_HU(-7)) + 0.0633961115*D(LNNFXRATE_HU(-8)) + 0.05904285313*D(LNNFXRATE_HU(-9)) + 0.01005083006*D(LNNCPI_HU(-1)) + 0.2866755381*D(LNNCPI_HU(-2)) + 0.2406691994*D(LNNCPI_HU(-3)) + 0.1788422201*D(LNNCPI_HU(-4)) - 0.3195159714*D(LNNCPI_HU(-5)) - 0.4340278112*D(LNNCPI_HU(-6)) - 0.3518979993*D(LNNCPI_HU(-7)) + 0.353755896*D(LNNCPI_HU(-8)) + 0.1545987514*D(LNNCPI_HU(-9)) + 0.1710023093*D(LNNCPI_US(-1)) - 0.5197118433*D(LNNCPI_US(-2)) + 0.7955152547*D(LNNCPI_US(-3)) + 0.5349140237*D(LNNCPI_US(-4)) + 0.8228678686*D(LNNCPI_US(-5)) - 0.1293973481*D(LNNCPI_US(-6)) - 0.03680164122*D(LNNCPI_US(-7)) - 0.5462756529*D(LNNCPI_US(-8)) + 1.213066825*D(LNNCPI_US(-9))

D(LNNCPI_US) = 8.33354705e-05*(LNNFXRATE_HU(-1) - 1.123420155*LNNCPI_HU(-1) + 0.6951936788*LNNCPI_US(-1)) + 0.004912487283*D(LNNFXRATE_HU(-1)) + 0.02160806257*D(LNNFXRATE_HU(-2)) - 0.02637482427*D(LNNFXRATE_HU(-3)) + 0.03851455667*D(LNNFXRATE_HU(-4)) - 0.008006817027*D(LNNFXRATE_HU(-5)) + 0.02529881264*D(LNNFXRATE_HU(-6)) - 0.008708306224*D(LNNFXRATE_HU(-7)) + 0.02275681828*D(LNNFXRATE_HU(-8)) + 0.0038868297*D(LNNFXRATE_HU(-9)) - 0.04752920626*D(LNNCPI_HU(-1)) + 0.03011052144*D(LNNCPI_HU(-2)) - 0.01688043449*D(LNNCPI_HU(-3)) + 0.008052955628*D(LNNCPI_HU(-4)) - 0.00381042826*D(LNNCPI_HU(-5)) + 0.00537367421*D(LNNCPI_HU(-6)) - 0.01748295035*D(LNNCPI_HU(-7)) + 0.008522946179*D(LNNCPI_HU(-8)) - 0.003700791659*D(LNNCPI_HU(-9)) + 0.3296530063*D(LNNCPI_US(-1)) - 0.3483645551*D(LNNCPI_US(-2)) + 0.5304157693*D(LNNCPI_US(-3)) - 0.001025760828*D(LNNCPI_US(-4)) + 0.3003157986*D(LNNCPI_US(-5)) - 0.09405995445*D(LNNCPI_US(-6)) - 0.02078459589*D(LNNCPI_US(-7)) + 0.1356653407*D(LNNCPI_US(-8)) - 0.1287106376*D(LNNCPI_US(-9))

Appendix 3

Table 3.1. Determination of optimal number of lags for Romania (semi-strong form)

VAR Lag Order Selection Criteria
Endogenous variables: LNNFXRATE_RO NDIF_RO
Exogenous variables: C
Sample: 1995:01 2001:12
Included observations: 76

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-30.41791	NA	0.008045	0.853103	0.914438	0.877615
1	285.2126	606.3428	2.21E-06	-7.347700	-7.163694	-7.274162
2	327.0007	78.07785	8.17E-07	-8.342125	-8.035449*	-8.219562
3	334.0687	12.83395	7.54E-07	-8.422861	-7.993515	-8.251273
4	342.0023	13.98815*	6.81E-07*	-8.526376*	-7.974360	-8.305764*
5	345.0915	5.284102	6.99E-07	-8.502407	-7.827721	-8.232770
6	348.5571	5.745604	7.10E-07	-8.488344	-7.690987	-8.169681
7	349.3548	1.280652	7.76E-07	-8.404075	-7.484048	-8.036388
8	352.4872	4.863436	7.98E-07	-8.381243	-7.338546	-7.964531

Table 3.2. Determination of optimal number of lags for Czech Re. (semi-strong form)

VAR Lag Order Selection Criteria
Endogenous variables: LNNFXRATE_CZ NDIF_CZ
Exogenous variables: C
Sample: 1995:01 2001:12
Included observations: 76

Lag	LogL	LR	FPE	AIC	SC	HQ
0	175.5951	NA	3.56E-05	-4.568292	-4.506957	-4.543779
1	342.6009	320.8270	4.88E-07	-8.857919	-8.673914*	-8.784382*
2	348.1579	10.38276*	4.68E-07*	-8.898892*	-8.592216	-8.776330
3	348.2357	0.141306	5.20E-07	-8.795677	-8.366331	-8.624089
4	350.0266	3.157535	5.51E-07	-8.737541	-8.185525	-8.516929
5	350.8044	1.330611	6.01E-07	-8.652749	-7.978063	-8.383111
6	352.4801	2.778031	6.41E-07	-8.591581	-7.794225	-8.272919
7	357.1473	7.492155	6.32E-07	-8.609140	-7.689114	-8.241453
8	358.3751	1.906246	6.83E-07	-8.536186	-7.493490	-8.119474

Table 3.3. Determination of optimal number of lags for Poland (semi-strong form)

VAR Lag Order Selection Criteria
Endogenous variables: LNNFXRATE_PL NDIF_PL
Exogenous variables: C
Sample: 1995:01 2001:12
Included observations: 76

Lag	LogL	LR	FPE	AIC	SC	HQ
0	117.0802	NA	0.000166	-3.028426	-2.967091	-3.003914
1	430.1382	601.4008	4.87E-08	-11.16153	-10.97753*	-11.08799
2	438.0341	14.75300	4.40E-08	-11.26406	-10.95738	-11.14149*
3	440.5129	4.500860	4.58E-08	-11.22402	-10.79468	-11.05244
4	443.8099	5.813127	4.67E-08	-11.20552	-10.65351	-10.98491

5	445.0275	2.082740	5.04E-08	-11.13230	-10.45762	-10.86266
6	449.9783	8.207993	4.93E-08	-11.15732	-10.35997	-10.83866
7	463.8377	22.24800*	3.81E-08	-11.41678	-10.49676	-11.04910
8	468.0925	6.606077	3.81E-08*	-11.42349*	-10.38079	-11.00677

Table 3.4. Determination of optimal number of lags for Hungary (semi-strong form)

VAR Lag Order Selection Criteria
Endogenous variables: LNNFXRATE_HU NDIF_HU
Exogenous variables: C
Sample: 1995:01 2001:12
Included observations: 74

Lag	LogL	LR	FPE	AIC	SC	HQ
0	162.8053	NA	4.44E-05	-4.346088	-4.283816	-4.321247
1	456.0393	562.6923	1.79E-08	-12.16322	-11.97641*	-12.08870
2	464.1445	15.11521	1.60E-08	-12.27418	-11.96282	-12.14997
3	465.0349	1.612342	1.74E-08	-12.19013	-11.75423	-12.01625
4	466.6828	2.894966	1.86E-08	-12.12656	-11.56611	-11.90299
5	467.6684	1.678177	2.02E-08	-12.04509	-11.36010	-11.77184
6	480.5907	21.30435	1.59E-08	-12.28624	-11.47670	-11.96330
7	494.5731	22.29611	1.22E-08	-12.55603	-11.62195	-12.18341
8	505.3372	16.58263*	1.02E-08*	-12.73884*	-11.68022	-12.31655*
9	507.2461	2.837501	1.09E-08	-12.68233	-11.49916	-12.21035
10	508.2280	1.406510	1.19E-08	-12.60076	-11.29304	-12.07909

Table 3.5. Johansen cointegration test for Romania (semi-strong form)

Sample: 1995:01 2001:12
Included observations: 80
Series: LNNFXRATE_RO NDIF_RO
Lags interval: 1 to 3

Data Trend:	None	None	Linear	Linear	Quadratic
Rank or No. of CEs	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Selected (5% level) Number of Cointegrating Relations by Model (columns)					
Trace	0	0	0	0	0

Table 3.6. Johansen cointegration test for Czech Republic (semi-strong form)

Sample: 1995:01 2001:12
Included observations: 82
Series: LNNFXRATE_CZ NDIF_CZ
Lags interval: 1 to 1

Data Trend:	None	None	Linear	Linear	Quadratic
Rank or No. of CEs	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Selected (5% level) Number of Cointegrating Relations by Model (columns)					
Trace	0	0	0	0	0

Table 3.7. Johansen cointegration test for Poland (semi-strong form)

Sample: 1995:01 2001:12
Included observations: 77
Test assumption: No deterministic trend in the data
Series: LNNFXRATE_PL NDIF_PL
Lags interval: 1 to 6

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.463406	52.99429	19.96	24.60	None **
0.063612	5.060822	9.24	12.97	At most 1

*(**) denotes rejection of the hypothesis at 5%(1%) significance level
L.R. test indicates 1 cointegrating equation(s) at 5% significance level

Unnormalized Cointegrating Coefficients:

LNNFXRATE_PL	NDIF_PL	C
1.273475	-1.286809	0.569549
2.609852	-1.692821	0.048741

Normalized Cointegrating Coefficients: 1 Cointegrating Equation(s)

LNNFXRATE_PL	NDIF_PL	C
1.000000	-1.010470	0.447240
	(0.09238)	(0.12170)
Log likelihood	466.4346	

Table 3.8. Estimated VEC for (lnnfxrate_pl, ndif_pl)

D(LNNFXRATE_PL) = 0.01431809153*(LNNFXRATE_PL(-1) - 1.010469899*NDIF_PL(-1) + 0.4472395156) + 0.3970121179*D(LNNFXRATE_PL(-1)) - 0.2852306563*D(LNNFXRATE_PL(-2)) + 0.03307408258*D(LNNFXRATE_PL(-3)) - 0.187827552*D(LNNFXRATE_PL(-4)) + 0.09439241982*D(LNNFXRATE_PL(-5)) + 0.08529537259*D(LNNFXRATE_PL(-6)) - 0.03232609677*D(NDIF_PL(-1)) + 0.01221008998*D(NDIF_PL(-2)) + 0.2611633397*D(NDIF_PL(-3)) - 0.03852020094*D(NDIF_PL(-4)) + 0.1851123702*D(NDIF_PL(-5)) - 0.121671165*D(NDIF_PL(-6))

D(NDIF_PL) = 0.07338068699*(LNNFXRATE_PL(-1) - 1.010469899*NDIF_PL(-1) + 0.4472395156) - 0.05144517896*D(LNNFXRATE_PL(-1)) +

0.01120970315*D(LNNFXRATE_PL(-2)) - 0.09789799689*D(LNNFXRATE_PL(-3)) - 0.07558210707*D(LNNFXRATE_PL(-4)) + 0.01282346736*D(LNNFXRATE_PL(-5)) - 0.02936931907*D(LNNFXRATE_PL(-6)) + 0.1693673408*D(NDIF_PL(-1)) + 0.01569425241*D(NDIF_PL(-2)) - 0.03876654271*D(NDIF_PL(-3)) + 0.08516262601*D(NDIF_PL(-4)) - 0.1090007874*D(NDIF_PL(-5)) - 0.4629617323*D(NDIF_PL(-6))

Table 3.8. Johansen cointegration test for Hungary (semi-strong form)

Sample: 1995:01 2001:12
Included observations: 76
Test assumption: No deterministic trend in the data
Series: LNNFXRATE_HU NDIF_HU
Lags interval: 1 to 7

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.541533	66.09440	19.96	24.60	None **
0.085882	6.824503	9.24	12.97	At most 1

*(**) denotes rejection of the hypothesis at 5%(1%) significance level
L.R. test indicates 1 cointegrating equation(s) at 5% significance level

Unnormalized Cointegrating Coefficients:

LNNFXRATE_HU	NDIF_HU	C
0.938251	-2.488686	1.153454
-3.394593	4.443984	-0.131305

Normalized Cointegrating Coefficients: 1 Cointegrating Equation(s)

LNNFXRATE_HU	NDIF_HU	C
1.000000	-2.652475	1.229366
	(0.51365)	(0.45779)
Log likelihood	512.1518	

Table 3.9. Estimated VEC for (lnnfxrate_hu, ndif_hu)

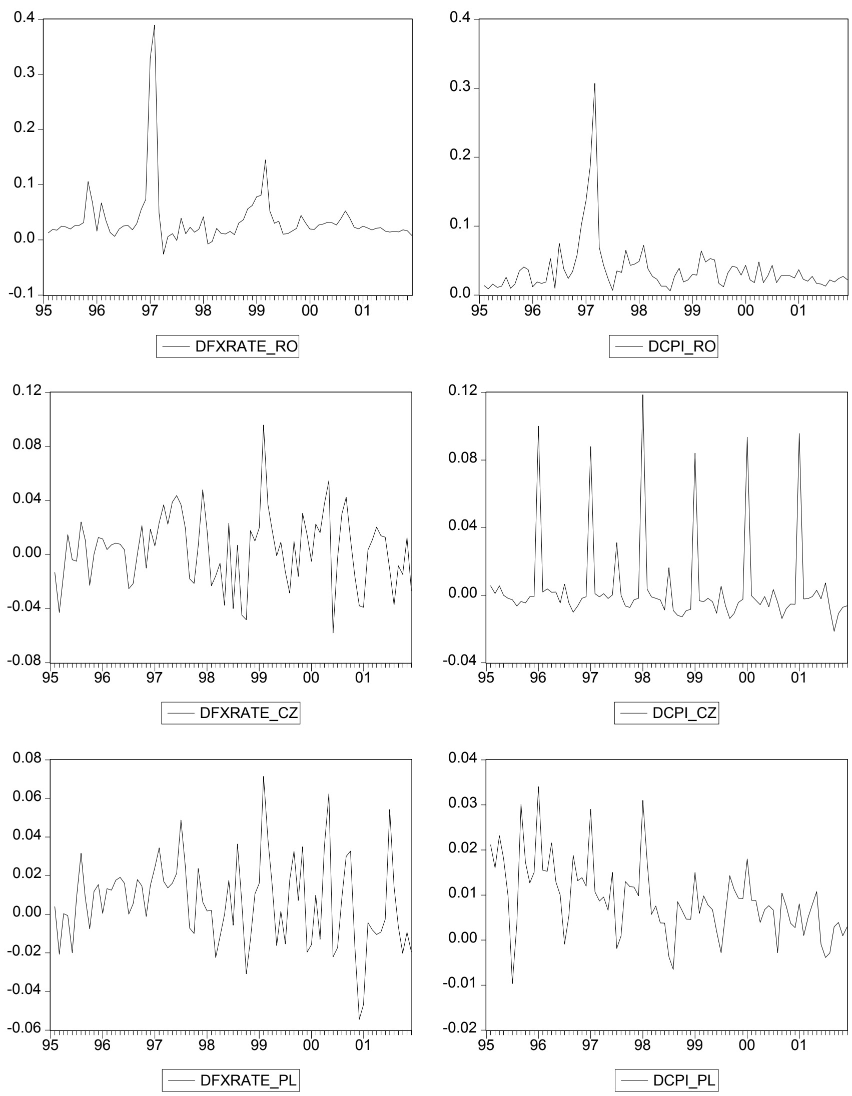
D(LNNFXRATE_HU) = - 0.005497219556*(LNNFXRATE_HU(-1) - 2.65247458*NDIF_HU(-1) + 1.229366404) + 0.1584826009*D(LNNFXRATE_HU(-1)) - 0.1392156957*D(LNNFXRATE_HU(-2)) - 0.02729351303*D(LNNFXRATE_HU(-3)) - 0.09408636661*D(LNNFXRATE_HU(-4)) + 0.246059966*D(LNNFXRATE_HU(-5)) + 0.09811404295*D(LNNFXRATE_HU(-6)) + 0.1072547917*D(LNNFXRATE_HU(-7)) + 0.6736939918*D(NDIF_HU(-1)) + 0.3329889305*D(NDIF_HU(-2)) + 0.001883731872*D(NDIF_HU(-3)) + 0.1478034778*D(NDIF_HU(-4)) - 0.2277228816*D(NDIF_HU(-5)) - 0.05495183715*D(NDIF_HU(-6)) + 0.09282180497*D(NDIF_HU(-7))

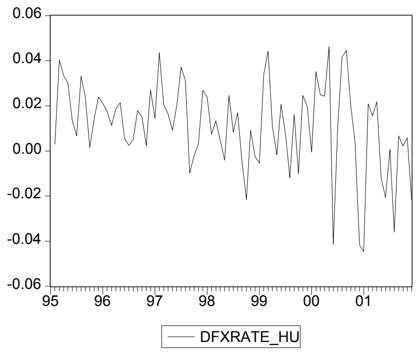
D(NDIF_HU) = 0.03723054549*(LNNFXRATE_HU(-1) - 2.65247458*NDIF_HU(-1) + 1.229366404) - 0.02420576313*D(LNNFXRATE_HU(-1)) - 0.03941495496*D(LNNFXRATE_HU(-2)) - 0.06694851427*D(LNNFXRATE_HU(-3)) - 0.01599720763*D(LNNFXRATE_HU(-4)) + 0.05675418251*D(LNNFXRATE_HU(-5)) + 0.02354050234*D(LNNFXRATE_HU(-6)) + 0.007430310541*D(LNNFXRATE_HU(-7)) - 0.05317471876*D(NDIF_HU(-1)) - 0.06786780112*D(NDIF_HU(-2)) +

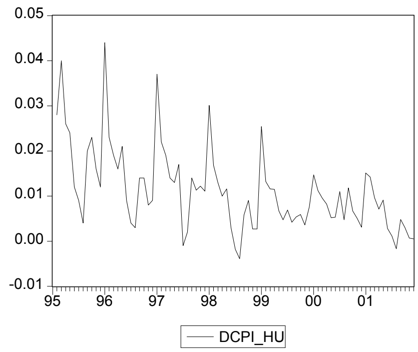
0.0713407206*D(NDIF_HU(-3)) + 0.2080451456*D(NDIF_HU(-4)) - 0.2244156136*D(NDIF_HU(-5)) - 0.4069095092*D(NDIF_HU(-6)) - 0.3892532421*D(NDIF_HU(-7))

Appendix 4

Graph 1. The plot of the growth of nominal exchange rates and of CPIs







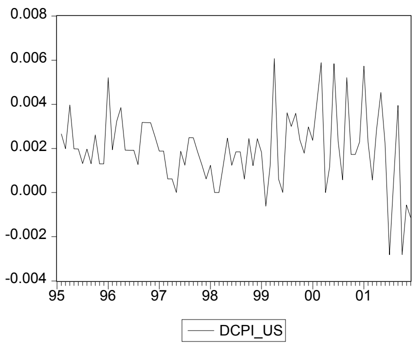


Table 4.1. OLS estimation for Romania

Dependent Variable: DFXRATE_RO
Method: Least Squares
Sample(adjusted): 1995:03 2001:12
Included observations: 82 after adjusting endpoints
Convergence achieved after 17 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DCPI_RO	1.441633	0.186418	7.733327	0.0000
DCPI_US	0.935242	2.371850	0.394309	0.6944
DUMMY97	-0.385495	0.051071	-7.548178	0.0000
C	-0.014492	0.010531	-1.376118	0.1728
AR(1)	0.354268	0.120943	2.929219	0.0045

R-squared	0.620423	Mean dependent var	0.036883
Adjusted R-squared	0.600705	S.D. dependent var	0.056969
S.E. of regression	0.035999	Akaike info criterion	-3.751618
Sum squared resid	0.099786	Schwarz criterion	-3.604867
Log likelihood	158.8163	F-statistic	31.46434
Durbin-Watson stat	1.860417	Prob(F-statistic)	0.000000

Inverted AR Roots	.35

Table 4.2. OLS estimation for Czech Republic

Dependent Variable: DFXRATE_CZ
Method: Least Squares
Sample(adjusted): 1995:03 2001:12
Included observations: 82 after adjusting endpoints
Convergence achieved after 7 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DCPI_CZ	-0.064435	0.099534	-0.647362	0.5193
DCPI_US	-2.092252	1.657075	-1.262618	0.2105
C	0.008106	0.005320	1.523691	0.1316
AR(1)	0.343691	0.108289	3.173819	0.0022

R-squared	0.121388	Mean dependent var	0.003843
Adjusted R-squared	0.087596	S.D. dependent var	0.026544
S.E. of regression	0.025355	Akaike info criterion	-4.464130
Sum squared resid	0.050144	Schwarz criterion	-4.346729
Log likelihood	187.0293	F-statistic	3.592141
Durbin-Watson stat	1.958837	Prob(F-statistic)	0.017271
Inverted AR Roots	.34		

Table 4.3. OLS estimation for Poland

Dependent Variable: DFXRATE_PL
Method: Least Squares
Sample(adjusted): 1995:03 2001:12
Included observations: 82 after adjusting endpoints
Convergence achieved after 5 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DCPI_PL	0.002853	0.324303	0.008796	0.9930
DCPI_US	-3.375148	1.358318	-2.484800	0.0151
C	0.012650	0.004978	2.540992	0.0130
AR(1)	0.394150	0.107843	3.654855	0.0005

R-squared	0.188240	Mean dependent var	0.006315
Adjusted R-squared	0.157019	S.D. dependent var	0.022327
S.E. of regression	0.020499	Akaike info criterion	-4.889317
Sum squared resid	0.032777	Schwarz criterion	-4.771916
Log likelihood	204.4620	F-statistic	6.029173
Durbin-Watson stat	1.793403	Prob(F-statistic)	0.000953
Inverted AR Roots	.39		

Table 4.4. OLS estimation for Hungary

Dependent Variable: DFXRATE_HU
Method: Least Squares
Sample(adjusted): 1995:02 2001:12
Included observations: 83 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DCPI_HU	0.596563	0.231386	2.578219	0.0118
DCPI_US	-1.661401	1.267730	-1.310532	0.1938
C	0.007752	0.003801	2.039535	0.0447

R-squared	0.082698	Mean dependent var	0.011209
Adjusted R-squared	0.059765	S.D. dependent var	0.019396
S.E. of regression	0.018807	Akaike info criterion	-5.073658
Sum squared resid	0.028297	Schwarz criterion	-4.986230
Log likelihood	213.5568	F-statistic	3.606121
Durbin-Watson stat	1.644034	Prob(F-statistic)	0.031659

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