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PURCHASING POWER PARITY IN

TRANSITION ECONOMIES

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APPLICATION FOR THE CZECH REPUBLIC

Diploma thesis

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DECLARATION

I hereby declare that this diploma thesis entitled with
“Purchasing Power Parity in Transition Economies
– Application for the Czech Republic”
is my own work, except where explicitly stated otherwise
in the text or in the bibliography.

Prague, 23rd April 2007

Author's signature_____

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ABSTRACT

The goal of this diploma thesis is to assess purchasing power parity (PPP) under the conditions of transition process. The thesis provides a survey of the purchasing power parity theory and concentrates on the relative version. It outlines main causes of possible deviations and modifications of the model.

The thesis provides a survey of the exchange rate development in selected countries. In the empirical part four transition economies are tested for the PPP theory: the Czech Republic, Hungary, Poland and Slovakia. Results for transition countries vis-à-vis the Czech Republic are compared with results for transition countries vis-à-vis the USA. Using graphical analysis, Dickey-Fuller test for a unit root (1979, 1981) and Engel-Granger test for cointegration (1987) moderate support for the relative version of PPP is found. The theory performs slightly better for transition economies vis-à-vis the Czech Republic.

Given productivity shocks, inflexible exchange rate regimes, regulated prices of energy or housing and restrictive monetary policy, structural shifts causing deviations from long-run equilibrium exchange rate are highly probable. Therefore results for transition countries vis-à-vis the Czech Republic and transition countries vis-à-vis the USA will be compared. If the results vary considerably this may reflect transition countries being different from market economies.

The diploma thesis concludes with analysis of the role of the exchange rate under conditions of a small open economy. The overall analysis is implemented within the context of real and nominal convergence towards European Union and future accession to the European Monetary Union. The speed of real convergence of the Czech Republic towards the average level of the EU is not accompanied with corresponding pace of price level convergence. Entering the ERM II presents further limitation to nominal convergence. Exchange rate is therefore an important tool in convergence process prior to setting the central parity for the Czech koruna. Here the concept of the PPP might be helpful as a long-run benchmark.

Keywords: Purchasing Power Parity, Exchange Rate, Czech Republic, Convergence, Balassa-Samuelson Effect

ABSTRAKT (IN CZECH)

Cílem diplomové práce je zhodnotit teorii parity kupní síly za podmínek transformace vybraných bývalých centrálně plánovaných ekonomik. Diplomová práce poskytuje přehled teorie parity kupní síly. Důraz je kladen především na relativní verzi. Dále jsou rozebrány příčiny možných odchylek od konceptu a modifikace této teorie.

Vybrané země jsou nejprve rozebrány z pohledu vývoje měnových režimů. V empirické části je testována parita kupní síly pro čtyři tranzitivní ekonomiky: Česká republika, Maďarsko, Polsko a Slovensko. Výstupy pro měnové kurzy vůči české koruně jsou srovnány s výsledky obdrženy při testování měn všech čtyř tranzitivních ekonomik vůči americkému dolaru. Na základě grafické analýzy, Dickey-Fullerova testu jednotkového kořene (1979, 1981) a Engel-Grangerovy kointegrační metody (1987) je přijat závěr, že relativní verze parity kupní síly je do určité míry konzistentní s vývojem měnových kurzů v tranzitivních ekonomikách.

S přihlédnutím ke změnám v produktivitě, pevným měnovým režimům, regulovaným cenám energie či bydlení a restriktivní měnové politice tranzitivních ekonomik jsou strukturální změny způsobující odchylky od dlouhodobého rovnovážného měnového kurzu velmi pravděpodobné. Výrazná různorodost výsledků pro tranzitivní ekonomiky vůči české koruně a výstupu pro země Vysegradské čtyřky vůči americkému dolaru může potvrzovat domněnku, že se transformující ekonomiky odlišují od ekonomik tržních.

Závěrem práce diskutuje roli měnového kurzu za podmínek malé otevřené ekonomiky. Celková analýza je provedena v kontextu reálné a nominální konvergence České republiky k Evropské unii a následnému vstupu do unie měnové. V průběhu konvergence k standardům Evropské unie je patrný trend rychlejší reálné konvergence. Vstup České republiky do ERM II znamená další omezení procesu nominálního sbližování. Dříve tedy než Česká republika vstoupí do další fáze ekonomické integrace představuje měnový kurz důležitý nástroj nominální konvergence. Z dlouhodobého hlediska zde může koncept parity kupní síly posloužit jako výchozí orientační bod pro stanovení centrální parity.

Klíčová slova: parita kupní síly, měnový kurz, Česká republika, konvergence, Balassa-Samuelsův efekt

1. INTRODUCTION

Our willingness to pay a certain price for foreign money must ultimately and essentially be due to the fact that this money possesses a purchasing power as against commodities and services in that country. On the other hand, when we offer so and so much of our own money, we are actually offering a purchasing power as against commodities and services in our country. Our valuation of a foreign currency in terms of our own, therefore, mainly depends on the relative purchasing power of the two currencies in their respective countries.

Gustav Cassel (1922, p.138-139)

Purchasing Power Parity (PPP) represents one of the earliest theories of exchange rate determination. It states that the exchange rate should adjust to align the differences between domestic and foreign price levels. Conventional wisdom may be summarized as follows. There are substantial deviations from PPP in the short-run. In the very long-run real exchange rates¹ may converge to parity, though the rate at which real exchange rate adjusts to the PPP exchange rate is extremely slow (Rogoff, 1996).

Recent empirical literature on the question of whether PPP holds in transition economies yields mixed results. Choudhry (1999) finds mixed support for the relative PPP in countries with large differences in inflation rates (transition economies against the US dollar) but also among the transition countries with comparable inflation. Christev and Noorbakhsh (2000) and Sideris (2006) find some evidence in favor of long-run equilibrium but with coefficients violating the symmetry and proportionality conditions suggested by PPP. Finally, Hofler et al. (2005) tested for PPP in Croatia but did not support the theory.

In the first half of the 1990s the transformation process from a centrally planned to a market oriented economy started in Central and Eastern European countries. In the second half of the 1990s transition process was accelerated to be crowned with entering the European Union by eight transition economies in May 2005.

Economic, political and social reforms accompanied with increasing trade openness and redirecting of trade from the former Soviet Union to the Western markets have had a substantial impact on how countries have formed their exchange rate policies. In the early

¹ Real exchange rate is calculated as nominal exchange rate adjusted for differences in national price levels.

stage of transition all four countries in our sample adopted some kind of fixed exchange rate, since mid-1990s however moved towards more flexible ones.

The purpose of this dissertation is to revisit the theory of purchasing power parity under the conditions of transition process. Four transition economies were chosen to be tested for the PPP theory: the Czech Republic, Hungary, Poland and Slovakia.

Given productivity shocks, inflexible exchange rate regimes, regulated prices of energy or housing and restrictive monetary policy, structural shifts causing deviations from long-run equilibrium exchange rate are highly probable. Therefore results for transition countries vis-à-vis the Czech Republic and transition countries vis-à-vis the USA will be compared. If the results vary considerably this may reflect transition countries being different from market economies (Halpern and Wyplosz, 1998).

Quarterly data from 1993 to 2005 have been applied to examine the relationship between exchange rate and inflation differential², using the unit root tests and cointegration method. In order to model better the relationship between exchange rate and price levels dummy variables³ and lagged values⁴ of nominal exchange rate were applied.

The thesis is organized as follows. Section 2 summarizes the theory on PPP. Section 3 discusses what the possible reasons for PPP deviations are. Section 4 shows how the PPP doctrine can be modified to explain deviations from the theory. Section 5 describes transformation history of four transition countries. Section 6 provides a discussion of the future role of exchange rate under process of convergence towards the European Union. Section 7 gives literature review of papers testing PPP in transition economies. Section 8 outlines the econometric approach adopted and discusses the empirical results. Section 9 concludes.

² Inflation differential is defined in part 7.1.

³ Dummy variables try to capture structural changes such as a change of exchange rate regime or foreign financial crisis.

⁴ The idea behind is that it takes time when the exchange rate adjusts to ensure that the parity of price levels in the two countries. These lags in adjustments should be captured in the model as lagged ER values. Two lagged periods are considered – quarter and halfyear lag.

2. THEORY OF PPP

Purchasing Power Parity represents one of the earliest theories of exchange rate determination. It was first proposed by Spanish academics of the Salamanca school in sixteenth century (Rogoff, 1996). Then it was discussed by classical economists such as John Stuart Mill or David Ricardo. Finally PPP theory is attributed to a Swedish economist Gustav Cassell. He first applied the theory of PPP practically (Cassel, 1922). After the WWI and fall of the gold standard, returning to prewar exchange rates was nearly impossible because of countries' different experiences with inflation rates. To maintain PPP Cassell proposed to set exchange rates adjusted for inflation differentials.

Before we proceed to empirical evidence on PPP the theory of PPP will be reviewed. There are several variants of PPP and certain assumptions have to be met to secure the validity of the doctrine. Violation of these assumptions usually leads to deviation of PPP theory and is also discussed below.

2.1. Law of One Price

The general idea behind the LOP is that with help of commodity arbitrage goods in two countries should cost the same amount of money when converted to a common currency:

$$P_i = E \times P_i^*$$

where P_i is the price of good i in domestic currency, P_i^* is the foreign-currency price of good i and E is the exchange rate⁵. The statement implies parity in the purchasing power of the unit of currency across the two economies. The exchange rate then must adjust to ensure that the parity holds for the particular good. The PPP doctrine is built on restrictive assumptions of identical products and no transaction costs such as tariffs or transportation costs.

The simple way how to test for LOP is to take one good of globally invariable standard of value if possible. In this manner in 1986 *The Economist* introduced a Big Mac Index (Pilbeam, 1992). It compares prices of a Big Mac around the world in a common

⁵ Direct quotation of the exchange rate will be used for TRE vis-à-vis USD, i.e. amount of domestic currency per unit of foreign currency (USD). For the relationship of TRE vis-à-vis CZK, direct quotation will be used also.

currency, the U.S. Dollar, at the market exchange rate. The U.S. price of the Big Mac is taken as a benchmark. It is then a simple measure of whether the foreign currency is overvalued or undervalued relative to the USD.

Big Mac Index is quite popular however there are several reasons why the prices of burgers might differ across countries. First, intermediate inputs into the Big Mac such as labor or property cannot be easily arbitrated (Pakko and Pollard, 1996). Second, transaction costs might prevent commodity arbitrage. Finally, a question of what position the Big Mac has in various countries arises. In the USA or Western countries McDonald's Big Mac is viewed as a kind of "standard" good. In less developed or transition countries (especially in the early stage of transition process) people might perceive Big Mac as a western "luxury" good with corresponding higher price.

Big Mac Index for three transition countries is presented in Table 1. In April 2001 the average price of a McDonald's Big Mac was \$ 2.54. In the Czech Republic it was 56 korunas. Dividing Big Mac price in korunas by its price in dollars we obtain the implied PPP exchange rate of **22** korunas per dollar. However the actual exchange rate is **39** korunas per dollar implying **44 %** undervaluation of the Czech koruna. Also for Hungary and Poland domestic currency is undervalued against the dollar in terms of PPP.

Table 1: The Hamburger Standard

Country	Big Mac Prices		Implied PPP of the dollar*	Actual USD exchange rate 17.4.2001	Under (-) / over (+) valuation against USD, %
	In local currency	In dollars			
USA (\$)	2,54	2,54	-	-	-
Czech Republic (Koruna)	56	1,43	22	39	-44
Hungary (Forint)	399	1,32	157	303	-48
Poland (Zloty)	5,9	1,46	2,32	4,03	-42

* Purchasing Power Parity: local price divided by price in the USA

Source: *The Economist*, 21st April 2001 (transferred from Gujarati, 2003)

2.2. Absolute version of PPP

Absolute or strong variation of PPP suggests that a price of a basket of goods in one country must equal to price of identical basket of goods in other country after conversion into one currency. In general, price levels in the two countries expressed in terms of one currency should equal:

$$P_t = E_t \times P_t^*$$

where P_t and P_t^* stand for domestic and foreign price levels, respectively, E_t is the nominal exchange rate and t subscripts denote time. Increase in domestic price level will lead to a proportional depreciation of the national currency.

Apart from problems with constructing comparable price indices⁶ one more impediment has to be taken into account when testing for the absolute version. Usually price indices refer to a base year (for example year 2000 equals 100). Such price indices cannot indicate how large the absolute deviation was in the base year. Therefore, it has to be assumed that the strict PPP held over some time (Rogoff, 1996; Taylor and Taylor, 2004). Other possibility is to turn to a relative version of PPP.

2.3. Relative version of PPP

The relative or weak version of PPP can be expressed as follows:

$$\% \Delta E_t = \% \Delta P_t - \% \Delta P_t^*,$$

where $\% \Delta E_t$ is the percentage change in the exchange rate, $\% \Delta P_t$ and $\% \Delta P_t^*$ are inflation rates at home and abroad, respectively. It states that the percentage change in the exchange rate between two countries should equal to the difference in changes of their price levels, so called inflation differential. For the relative variation of PPP to be the case the absolute version does not have to hold. Relative PPP will be used to examine the PPP in transition countries.

⁶ Problem with constructing comparable price indices is common also for the relative version of PPP discussed below.

3. WHAT ARE THE CAUSES OF DEVIATION OF PPP?

PPP doctrine lies on very strict assumptions. Problems of non-traded goods and services, differences in price indices and consumer baskets, transaction costs, differences in nature of prices and exchange rates, productivity differentials and real and nominal disturbances need to be taken into consideration as these may cause discrepancies between the theory and empirical results.

3.1. Non-tradable goods and services

PPP theory is applied to all types of goods. Here we should distinguish between tradables and nontradables. Nontradable goods do not enter the trade internationally or cannot be traded internationally at profit. Good example is services such as haircut or housekeeping or goods such as real estates or local food. One would expect the PPP doctrine to hold better for tradable goods since their prices are kept in line with international competitive prices. Nevertheless the distinction between tradables and nontradables is troublesome if we consider that many nontraded goods enter the production of traded goods as their inputs. Tests examining empirical evidence on PPP are mixed in using price indices. Some researchers use producer or wholesale price indices that are dominated by tradables, whereas others use consumer price indices that weigh both tradable and nontradable goods⁷.

3.2. Difference in price indices and consumer baskets

PPP is expected to hold for identical bundles of goods. Across countries goods in baskets are of a different weight and composition. This statistical problem becomes more significant when we test PPP theory in developing economies vis-à-vis the developed ones. For example food has higher weighting⁸ in less developed countries than in developed economies and vice versa for consumer goods (Pilbeam, 1992). People across countries tend to have different tastes and consumption patterns. For example Czech consumers prefer Škoda cars and thus spend higher proportion of their income on Škoda cars.

⁷ For PPI, see Tawadros (2002), Hofler and al. (2004). For CPI, see Choudhry (1999), Christev and Noorbakhsh (2000), Sideris (2006).

⁸ Higher weight of basic goods such as food in a basket means that people in less developed countries have to spend higher proportion of their income on these. In developed countries food expenditures on the contrary take up smaller part of people's income.

However the Americans tend to drive Ford or Dodge. To compare price levels across countries is then difficult and less precise.

3.3. Transaction costs

Because of transport costs or barriers to trade such as tariffs or inspection requirements there might be differences in goods' prices across countries. Transaction costs act as a barrier of price equalization because they increase the price of commodity arbitrage. For this being the case one would expect prices to diverge within a range determined by transaction costs. Furthermore, PPP doctrine is likely to hold among the neighboring countries when these economies are geographically close and trade linkages among them are high, i.e. low transport costs and little tariffs.

3.4. Differences in nature of exchange rates and prices

Different speed of adjustment of prices in the exchange rate market and the goods market accounts for highly volatile exchange rates and quite stable prices. The exchange rate may be thought of as an asset price which reacts rather quickly in response to new information or expectations. Prices on the other hand are more sticky and reflect all news slowly. This may cause higher departures from purchasing power parities and exchange rate volatility in the short run. Over time prices adjust, move together with exchange rates move in and PPP is likely to hold.

The "stickiness" of national price levels does not have to reflect market imperfections. Rather it may reflect the cost of price adjustments arising from existing contracts and agreements (Frenkel, 1981). As Dornbusch (1976) suggests PPP theory is based on commodity arbitrage and has no or just little role for capital movements and international capital markets. With respect to different characteristics of prices and exchange rates mentioned above deviations from PPP represented by exchange rate changes can be substantial and prolonged.

3.5. Productivity differentials

Aggregate price levels in developed countries tend to be higher than in less developed poor countries when converted to a common currency. We can say that developed country's currency can buy more in less developed country than at home. Higher price indices in developed countries are explained mainly by higher prices of

nontradables in these countries (Officer, 1976). Consequently, higher prices of nontraded goods in rich countries were explained by higher productivity of labor in traded sector compared to less developed countries (Balassa, Samuelson, 1964). The Balassa-Samuelson theory is discussed in below part 4.1.

3.6. Disturbances: Nominal vs. real shocks

Real disturbances such as increase in productivity can bring about permanent deviations of PPP (Halpern & Wyplosz, 1997, 1998). Nominal shocks such as high inflation rates on the other hand are likely to cause only temporary deviations (Frenkel, 1981) which will diminish in the long run and PPP might hold.

Transition economies are subject to both monetary and real shocks. Analysis of the shocks may shed some light on the behavior of exchange rates and prices. As suggested by the Balassa-Samuelson hypothesis real productivity shocks may bring about changes in relative prices of tradable and non-tradable goods. Transition to a market economy may present such shock that might subsequently induce changes in the real exchange rate resulting in permanent deviation from PPP.

4. MODIFICATIONS TO PPP

In order to present a complex view of PPP doctrine three theories that try to explain long-run deviations from PPP will be discussed briefly. All three modifications to PPP are useful in outlining factors that are likely to interfere in the relationship of price levels and exchange rates. Nevertheless they remain also a subject of debate and should not be taken as a universal explanation of possible long-run PPP deviations.

4.1. The Balassa-Samuelson hypothesis

Bela Balassa (1964) and Paul Samuelson (1964) try to explain long-run deviations from Purchasing Power Parity. The hypothesis suggests that price levels in rich countries tend to be higher than price levels in poor countries when converted to a common currency. The explanation is that rich countries have higher productivity in tradable goods sector. The nontradable sector (health care, education, financial services, etc.) is generally more service-intensive so there is less space for technological progress and increasing productivity.

In a small open economy increase in productivity of tradables will have no effect on their domestic price level since it is linked with the world price level. But higher productivity in traded goods sector will be translated into rising wages in this sector. Under the assumption of wage equalization across sectors, wages in nontraded goods sector will rise too. If this would not happen, thanks to inter-sectoral labor mobility⁹, workers would shift towards better-paid jobs, i.e. towards the traded goods sector. To remain profitable producers of nontradables raise their prices to match higher wages. This in turn raises price level in nontraded goods sector. As mentioned above, in a small open economy price inflation in traded goods sector is driven by world prices and the nominal exchange. Under assumption of fixed exchange rate¹⁰ price inflation in tradables is the same as abroad. Price inflation in nontraded goods is equal to price inflation of tradables plus a price increase of nontradables caused by higher productivity in tradables sector (Halpern and Wyplosz, 2001). The outcome is real appreciation of the currency (in countries with higher productivity growth in tradables sector).

⁹ Inter-sectoral mobility is however limited by geographical, social or institutional factors.

¹⁰ Under floating exchange rate the same result is obtained.

During the catch-up process transition countries are expected to experience higher productivity growth in traded than in non-traded goods sector.

4.2. Current Account Deficit and Government Spending

It has been suggested and backed by empirics that current account deficits are correlated with long-run currency depreciation (Obstfeld and Rogoff, 1995). Current account displays international flows of goods, services, revenues and transfers. Current account deficit means that country spends more abroad than it sells abroad. To finance the deficit country will borrow abroad which is likely to be associated with depreciation of domestic currency.

Another modification to PPP argues that government spending is likely to influence the real exchange rate. Government spending is usually put in nontraded goods. As Froot and Rogoff (1991) argue, if government increases its spending it leads to appreciation of the real exchange rate. Fiscal policy can thus affect real exchange rates.

5. TRANSITION FROM CENTRALLY PLANNED TO A MARKET ECONOMY

Until 1990 all centrally planned economies (CPE) were members of the Council of Mutual Economic Assistance¹¹. These countries used internal domestic prices, capital controls and exchange rates to direct trade and to conduct payments among themselves (Christev and Noorbakhsh, 2000). Prevailing conditions in former CPE were completely different when compared to Western Europe and the USA. Domestic prices were not market-based and did not provide useful information. Exchange rates were artificially set by the government and did not reflect the situation at foreign exchange markets. Enterprises were isolated from western competition and technical development and were protected by the state. Demand for their products was guaranteed by domestic markets or by trade with Comecon. As a consequence of such policy Central and Eastern European countries could hardly compete in world markets in early stages of transition.

Four transition economies were chosen to be tested for the PPP theory: the Czech Republic, Hungary, Poland and Slovakia. Countries seem similar in their time path and aim of the transition process, i.e. the transformation from a centrally planned economy into a market-oriented one. They however differ in individual approach to transformation and application of reforms¹².

To begin with, all four countries are located in Central European region. In 1991 these countries formed an agreement called Visegrad Four (with former Czechoslovakia) to establish a framework for common trade and political cooperation.

Second, these countries started the transformation process in the early 1990's and were exposed to financial, banking or political crises.

Economic transformation was also accompanied with increasing trade openness, redirecting the trade from former Soviet Union towards the Western markets and with the increasing impact of world economy on domestic development through trade and investment.

Furthermore, in the early stage of transition exchange rate regimes adopted by the Visegrad four were some kind of fixed regime (see Table 2). To maintain the given

¹¹ The Comecon was founded in 1949 and dissolved in 1991. It was mutual agreement among the former socialist countries. In 1990 it included Bulgaria, Cuba, Czechoslovakia, the German Democratic Republic, Hungary, Mongolia, Poland, Romania, USSR, Vietnam and Yugoslavia as an associate member.

¹² Countries' individual approach is described in section 5.1 to 5.4. in more detail.

exchange rate and to prevent the real appreciation market interventions were frequently used. Since mid-1990s countries follow more or less similar path of loosening the fixed regime. Poland and the Czech Republic follow floating regimes. Slovakia entered ERM II and Hungary sticks to a crawling peg however with fluctuating band of $\pm 15\%$ in both countries. In May 2004 all countries became members of the European Union. Entering the EU is likely to be understood as a step before entering the Eurozone. It brings substantial commitments in maintaining stable economic environment and tightening the exchange rate regime again.

In addition, currencies of countries in our sample experienced real appreciation during the whole sample period. The reason is mainly initial undervaluation connected with uncertainty about the appropriate equilibrium exchange rate (Halpern and Wyplosz, 1998) and Balassa-Samuelson effect reflecting higher productivity growth in traded goods sector discussed above. Alternative reason for undervaluation could be support of own exports and suppressing of domestic demand for imported goods.

Finally, these countries also changed the aim of exchange rate stability for price stability to be the main target of the monetary policy of each national bank. Inflation targeting was gradually adopted by all four economies to fulfill the commitment of price stability (Kočenda and Valachy, 2006).

Table 2: Exchange rate Regimes in selected Transition countries

*	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Czech Republic	1	1	1	3	4	4	4	4	4	4	4	4	4
Hungary	1	3	3	3	3	3	3	3	3	3	3	3	3
Poland	2	2	3	3	3	3	3	5	5	5	5	5	5
Slovakia	1	1	1	3	3	4	4	4	4	4	4	4	ERMII

* Exchange rate regime description:

1: **Fixed peg**, peg to another currency or currency basket within a band of **at most $\pm 1\%$**

2: **Crawling peg**, peg with central parity periodically adjusted in fixed amounts at a fixed, pre-announced rates

3: **Crawling bands**, crawling pegs combined with bands of **more than $\pm 1\%$**

4: **Managed float** with no pre-announced exchange rate path, active intervention without pre-commitment to a pre-announced target or path for the exchange rate

5: **Independent float**, market-determined exchange rate and monetary policy independent of exchange rate policy

Source: Kočenda 1998, National banks' reports

The process of economic transition started in 1990s with liberalization of the foreign exchange markets and partial or full currency convertibility. Main characteristics of these economies were initial deep undervaluation of the national currency, sudden price liberalization that allowed for high inflation rates. On the other hand prices of public utilities or housing adjusted very slowly.

Economic strategy adopted by each CPE was aimed first at stabilization, i.e. control for the budget deficit and money supply, second at liberalization, i.e. elimination of state interventions and finally at restructuring of institutions, industries and labor markets¹³.

Transition period can be divided into three phases according to the goal of monetary strategy and choice of exchange rate regime (Herczynska, 1998).

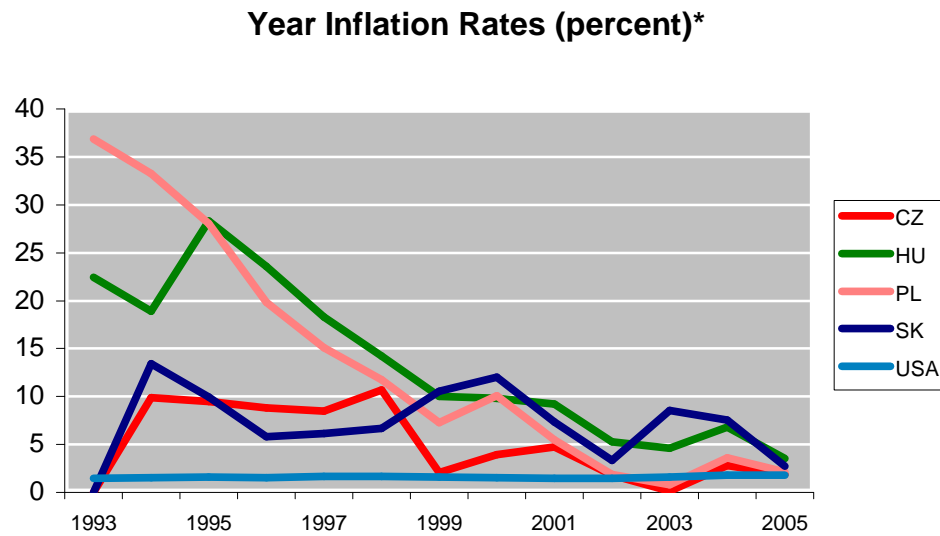
In the **first phase** between 1990 and 1994/1995 the main focus was on stabilization of the economy. The early stage of the transition of the centrally planned economies of Central Europe was characterized by disorganization, institutional changes and economic restructuring which caused a substantial fall in GDP and high inflation rates. Tight exchange rate regimes were used to combat inflation. Hungary and Poland opted for crawling pegs and bands, respectively, anchored to a currency basket. The Czech Republic and Slovakia fixed their currencies also to the basket of currencies¹⁴.

As can be seen from the Figure 1 inflation rates were substantially high in 1990s. With exception of the Czech Republic all countries faced year inflation rates over 5 % until 2001. Inflation rate for the United States is also included in the table to illustrate better the situation in transition economies.

¹³ Restructuring of the economy contained transformation of organizations, tax and legal system, price liberalization and removal of quantitative restrictions on trade, privatization and others.

¹⁴ Exact composition of the baskets is presented in Tables 1 to 4.

Figure 1: Year inflation rates in transition countries



* Year inflation rates as percentage per annum

Source: IMF, 2006

During the **second phase** by the end of 1990s high inflationary pressures were suppressed and the first economic reforms brought about a partial recovery of economic growth and gradual capital account liberalization connected with capital inflows. The need for stabilization become less necessary and loosening of exchange rate regimes came into play. In case of Slovakia, Hungary and the Czech Republic – countries with fixed exchange rates - capital inflows put appreciation pressure on domestic currencies and required large interventions by central banks. As a consequence, Slovakia and the Czech Republic adopted floating regime in 1997 and 1998, respectively.

Final phase can be characterized as pre-accession phase reflecting institutional and economic arrangements connected with the future entry into Eurozone. Slovakia is in this respect a pioneer in entering ERM II. Poland and the Czech Republic use a floating exchange rate regime and Hungary maintains conventional crawling band.

5.1. Czech Republic

To start the transformation process Czechoslovakia (the Czech and Slovak Republic since 1993) was in better position than Hungary or Poland since foreign indebtedness and rate of inflations were quite low.

At the beginning of the economic transition the Czech Republic introduced fixed exchange rate regime, in February 1996 fluctuation band was widened from $\pm 0.5\%$ to $\pm 7.5\%$. The exchange rate volatility was quite low under the fixed exchange rate regime as shown in Figure 2.

Figure 2: Currency development in the Czech Republic



Source: IMF, 2006

Since October 1995 the Czech koruna became fully convertible, i.e. tradable in foreign exchange markets without quantitative or qualitative restrictions. Nevertheless, this act was not coupled with any loosening of the exchange rate regime (Kočenda, 1998). Because of the appreciating pressures the fluctuation band was finally widened up to $\pm 7.5\%$ in February 1996.

The Czech Republic was first of the four countries to adopt floating exchange rate regime. In May 1997 managed float with German mark (Euro at present) as reference currency was introduced. The forces behind were mainly the effect of the Asian currency crisis, domestic financial crisis (increasing current account deficit and outflow of short-term capital), speculative pressure and subsequent political instability. Credit crunch of commercial banks as well as recall of the government in 1998 also influenced the movements of exchange rate substantially.

Czech koruna has experienced two sharp appreciations followed with depreciations. First, surprisingly, in 1998 despite the crisis in Russia in August that year, koruna appreciated above its pre-floating level. Second wave of sharp appreciation started in 2001 and ended in the end of 2002 and is most likely associated with high inflow of foreign capital (FDIs mainly). Slight depreciation in 2003 may be connected with deterioration of Czech fiscal discipline.

Table 3: Development of exchange regime in the Czech Republic

February 1993	Split of Czechoslovakia, Czechoslovak koruna is replaced by Czech koruna. Peg regime $\pm 0,5\%$ with currency basket: 45.52% DEM, 31.34% USD, 12.35% ATS, 4.24% GBP, 6.55% CHF
May 1993	Currency basket changed: 65% DEM, 35% USD
February 1996	Widening of the band to $\pm 7.5\%$
May 1997	Adoption of managed floating with reference currency DEM (EUR at present)

5.2. Slovakia

Slovak koruna as an independent currency was launched after the split of Czechoslovakia in January 1993. After the monetary split of Czechoslovakia, Slovak koruna was devalued by 10 %. Fixed exchange rate regime was adopted until September 1998 with bands ± 0.5 %. They were gradually widened to ± 1.5 % in 1994, to ± 5 % in July 1996 and to ± 7 % in January 1997.

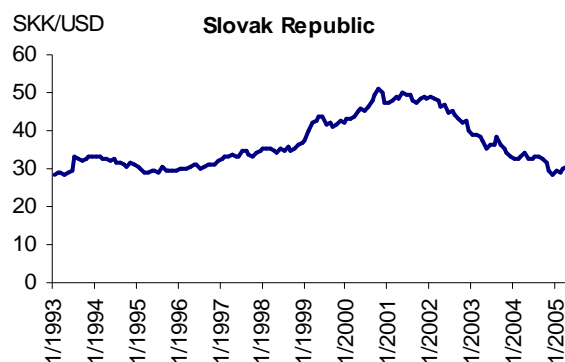
Czech financial crisis in May 1997 and increasing government spending led to depreciation of the currency. In 1998 macroeconomic instability, Russian financial crisis, speculative attacks, devaluation expectations and parliamentary elections led to strong depreciation pressures. To maintain the fixed exchange rate regime Slovak National Bank had to sell substantial amount of foreign exchange reserves. Finally in October 1998 the National Bank of Slovakia adopted floating exchange rate policy. However, devaluation process continued also in the following year with its peak in May 1999. This trend was reversed by the end of the year thanks to restriction of domestic demand and accelerated government reforms adopted after 1998.

Macroeconomic situation in Slovakia in the 1990s shows some disproportions, satisfactory GDP growth at reasonable inflation rates in comparison with other transition countries on one side, on the other side high unemployment rate and external instability.

Slovak GDP growth culminated in 1995 and then was decreasing for following four years (see Table 7). Since 2000 favorable performance of Slovak economy and inflow of foreign capital was reflected by gradual appreciation of Slovak koruna against the U.S. dollar (see Figure 3). Higher volatility after the adoption of floating in 1998 is evident slightly lower than in the Czech Republic. In November 2005 Slovakia entered ERM II. Slovak National Bank is committed to stay in a fluctuation band of ± 15 % determined by

Exchange Rate Mechanism II and to not to devalue its currency against any other ERM II member two years before entering the Eurozone.

Figure 3: Currency development in Slovakia



Source: IMF, 2006

Table 4: Development of exchange regime in Slovakia

February 1993	Split of Czechoslovakia, Czechoslovak koruna is replaced by Slovak koruna. Peg regime $\pm 0,5\%$ with currency basket: 49.6% DEM, 36.1% USD, 3.7% ATS, 9% CHF, 2.9% FRF
July 1993	10 % devaluation
July 1994	Widening of the band to $\pm 1.5\%$, Currency basket changed: 40% USD, 60% DEM
January 1996	Widening of the band to $\pm 3 \%$
July 1996	Widening of the band to $\pm 5 \%$
January 1997	Widening of the band to $\pm 7 \%$
October 1998	Adoption of managed float
January 1999	Reference currency EUR
November 2005	Entering ERM II

5.3. Hungary

At the beginning of Hungarian transition process a crawling-peg arrangement was put in place in January 1990. Currency basket contained 11 foreign currencies (see Table 3). In August 1993 the amount of currencies in the basket was reduced to American dollar and German mark.

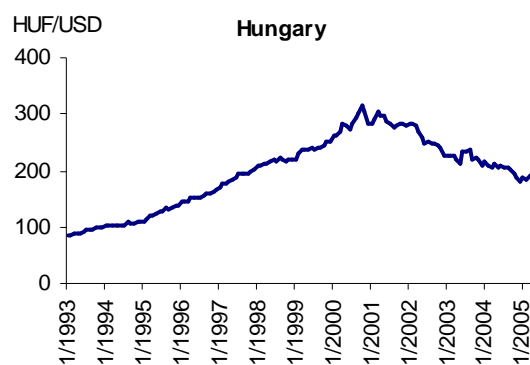
Under the crawling peg regime Hungarian forint was officially devalued at a pre-announced rate. Thus, the central parity of forint was not constant as it was in the case of

Czech or Slovak koruna but was exposed to official devaluations. In December 1994 the band of crawling peg was widened to $\pm 2.25\%$.

Combination of disinflation policy and tight exchange rate regime led to continuous real appreciation causing loss of competitiveness at international markets and capital inflows. To sustain economic development in March 1995 a gradualist macroeconomic stabilization policy with substantial budget cuts was introduced in order to reduce inflation and control for fiscal discipline and current account deficit. As a part of the reform Hungarian forint was devalued in March 1995 by 9 %. Russian financial crisis in 1998 as well as Brazilian currency devaluation put further pressure on the currency.

In May 2001 fluctuation margin was widened from $\pm 2.5\%$ to $\pm 15\%$. The increase in volatility of exchange rate is evident. Further response was a sharp appreciation of the forint (see Figure 4) which could reflect an initial undervaluation or inflow of foreign capital. In May 2001 Hungarian monetary authorities also changed the monetary strategy from a crawling band to inflation targeting policy. The inflation decreased almost by a half by the end of the year 2002 (see Figure 1).

Figure 4: Currency development in Hungary



Source: IMF, 2006

Table 5: Development of exchange regime in Hungary

February 1990	Crawling peg regime with band $\pm 0.3\%$, Currency basket: 42.6% USD, 25.6% DEM, 10.4% ATS, 4.9% CHF, 3.8% ITL, 3.5% FRF, 2.9% GBP, 2.0% SEK, 1.7% NLG, 1.5% FIM, 1.1% BEC
August 1993	Reduction of currencies in the basket: 50% USD, 50% DEM
July 1994	Widening of the band to $\pm 1.5\%$, Currency basket changed: 40% USD, 60% DEM
May 1994	Currency basket: 30% USD, 70% ECU
August 1994	Widening of the band to $\pm 1.25\%$
December 1994	Widening of the band to $\pm 2.25\%$
March 1995	9 % devaluation
January 1997	Currency basket: 30% USD, 70% DEM
January 1999	Currency basket: 30% USD, 70% EUR
January 2000	Currency basket: 100% EUR
May 2001	Widening of the band to $\pm 15\%$

5.4. Poland

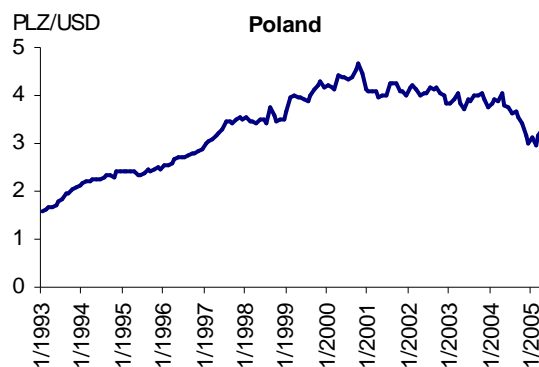
Poland started its transformation process from the worst position compared to the rest of the countries in the sample. The initial macroeconomic situation could be characterized with near-hyperinflation, massive shortages and high external deficit (Herczynska, 1998).

In the beginning of transition process in October 1991 Poland adopted a crawling peg with a crawling rate. In the 1992 Polish zloty was devalued by 12 %. As a consequence of tight monetary and fiscal policy GDP decreased substantially. During transformation process Poland faced very high inflation rates which in turn decreased international competitiveness of their exports.

In the second half of 1990's government policy shifted from stabilization to growth stimulation (Dibooglu and Kutan, 2001) and was dominated by fast growth of GDP driven by expansion of establishing private sector (Balcerowicz, 2000). In 1995 the crawling band was widen to $\pm 7\%$. Nevertheless Russian crisis in 1998 and slowdown in economic activity in the EU contributed to slow-down of the Polish GDP and gave rise to sizeable current account deficit in 1999.

The National Bank of Poland adopted inflation targeting in 1999 as a tool to reach price stability. Since April 2000 Polish zloty is a floating currency and is not subject to any restriction. As in case of all three countries after adoption of floating the exchange rate volatility has increased. In 2005 strong appreciation tendencies are clear from the Figure 5..

Figure 5: Currency development in Poland



Source: IMF, 2006

Table 6: Development of exchange regime in Poland

October 1991	Crawling peg regime , Currency basket: 45% USD, 35% DEM, 10% GBP, 5% FRF, 5% CHF
February 1992	Devaluation by 12%
August 1993	Devaluation by 7.4%
May 1995	Crawling band of $\pm 7\%$
December 1995	Revaluation by 6%
February 1998	Widening of the crawling band to $\pm 10\%$
October 1998	Widening of the crawling band to $\pm 12.5\%$
January 1998	Currency basket: 45% USD, 55% EUR
March 1999	Widening of the crawling band to $\pm 15\%$
April 2000	Floating Exchange rate regime

Table 7: GDP growth, % per annum

Country	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
CZ	-	-	-	4.2	-0.7	-1.1	1.2	3.9	2.6	1.5	3.2	4.7	6.0	5.3
HU	-0.6	2.9	1.5	1.3	4.6	4.9	4.2	6.0	4.3	3.8	3.4	5.2	4.1	4.6
PL	-	-	-	6.2	7.1	5.0	4.5	4.2	1.1	1.4	3.8	5.3	3.2	4.5
SK	7.2	6.2	5.8	6.1	4.6	4.2	1.5	2.8	3.2	4.1	4.2	5.4	6.1	6.1

Source: Eurostat, 2007

6. LITERATURE REVIEW

Several papers discuss the behavior of exchange rate under conditions of transition process. Their suggestions are mixed according to explanations and reasoning used and whether nominal or real shocks are considered. It serves as a good illustration of how many factors are likely to influence the exchange rate movement.

Frenkel (1981) and **Davutyan and Pippenger (1985)** consider nominal shocks. They suggest that in the time of big inflation changes inflationary expectations substantially influence variations in interest rates. High interest rates in turn induce depreciating currency. Therefore if shocks to the economy are of a monetary origin, PPP is expected to hold in the long run.

On the contrary, **Halpern and Wyplosz (1998)** conclude that deteriorating external indebtedness, characteristic for transition countries since the second half on 1990s, results in real depreciation.

If real shocks prevail in the economy systematic deviations from PPP are likely to be the end result. **Halpern and Wyplosz (1997)** argue that exchange rates should appreciate as transition countries experience growth in productivity and real wages. They suggest that exchange rates were initially undervalued and during the transition process they only returned to an equilibrium level. Authors conclude that during the “catch-up” phase of transition shocks to real exchange rates were largely permanent.

Furthermore, during the transition to the market economy we would expect currency to exhibit an upward trend as a result of initial undervaluation and liberalization of capital account inducing capital inflows (**Krajnyák and Zettelmayer, 1998, Brada, 1998, Halpern and Wyplosz, 1998**).

Empirical literature examining the relationship between ER and CPI in transition countries of Central and East Europe may be summarized as follows.

Thacker (1995) applies unit root tests for stationarity of the real exchange rates for Hungary and Poland. In his paper he failed to find the empirical evidence for PPP in these two countries.

Choudhry (1999) uses cointegration technique and tests for the relationship between relative prices and exchange rates of Poland, Russia, Romania and Slovenia with

respect to the US dollar. All four countries show high inflation rates¹⁵ and only outcomes for Slovenia and Russia support the validity of relative PPP with respect to the US dollar. This paper is unique in a way it tests PPP also among the emerging transition countries. The evidence in favor of the hypothesis is found between Russia and Poland, between Russia and Slovenia and between Slovenia and Poland. The first two pairs of countries show large differences in inflation rates. Third pair of countries experienced comparable inflation rate. Finally, no support for the absolute version of PPP is found.

Christev and Noorbakhsh (2000) examined long-run movements of exchange rates and prices for six Central and East European countries also with help of cointegration technique¹⁶. Even though the cointegrating vector values did not take the theoretically expected magnitudes they found some evidence in favor of long-run equilibrium.

Using several unit root tests and applying endogenous structural breaks **Hofler et al. (2005)** tested stationarity of the real exchange rate for Croatia. Their results did not support the theory of PPP. They rather contribute to the evidence that currency in transition countries experiencing growth in productivity and real wages should appreciate in real terms.

With help of cointegration technique¹⁷ **Sideris (2006)** investigated the long-run PPP for seventeen European transition economies¹⁸ vis-à-vis the US dollar. His results suggest a long-run equilibrium relationship between relative prices and exchange rates. However the cointegrating vector coefficients violate the symmetry and proportionality conditions suggested by the PPP theory. In the case of the Czech Republic Sideris included a dummy variable for May 1997 when the Czech Republic changed the fixed exchange rate regime for a floating. For Slovakia he introduced a dummy for 1st quarter 1999 that should absorb the effects of the Russian crisis.

¹⁵ During the testing period 1991-1997 monthly inflation rates were 2.,39% in Poland, 6.75% in Romania, 11.13% in Russia and 2.64% in Slovenia (0.233% for the USA).

¹⁶ Here authors used the Johansen and Stock and Watson cointegration methods.

¹⁷ First the Johansen cointegration technique is used to test individually for PPP vis-à-vis US dollar. Second PPP is tested for the whole set of countries with help of the Larsson *et al* panel cointegration methodology.

¹⁸ These are Esthonia, Latvia, Lithouania, Bulgaria, Croatia, the Czech Republic, Hungary, Macedonia, Poland, Romania, the Slovak Republic, Slovenia, Belarus, Georgia, Moldova, Russia and Ukraine.

7. EMPIRICAL EVIDENCE ON PPP

7.1. Methodology and data

The sample contains four transition countries: Czech Republic, Hungary, Poland, Slovakia and one western country: USA. First, the relationship between exchange rate and inflation differential will be tested between transition countries and the USA, a country with substantially lower rate of inflation. Then, the relationship will also be examined among high inflation countries, i.e. Czech koruna will be taken as a reference currency. Finally, results for transition countries vis-à-vis the USA and transition countries vis-à-vis the Czech Republic will be compared. If the results vary considerably this may reflect transition countries being different from market economies (Halpern and Wyplosz, 1998). We would expect the theory to hold among TRE. Since these countries experienced similar rate of inflation and went through process of convergence.

Observations are quarterly data from January 1993 to December 2005. The data on the exchange rate and consumer price levels were taken from the International Monetary Fund's International Financial Statistics 2005.

Variables are index of nominal exchange rate (ER) and inflation differential (I_d) between the two particular countries. ER was calculated as a chain index:

$$ER = \frac{E_t}{E_{t-1}},$$

where E is the nominal exchange rate and t subscripts stand for time. I_d variable stands for inflation differential and was calculated as follows:

$$I_d = \frac{1 + \pi_d}{1 + \pi_f},$$

where π_d is inflation rate in domestic country and π_f is inflation rate in the foreign country¹⁹. In the model variables were put in natural logarithms and placed in a first difference form.

In order to improve the overall characteristics of the model and to better capture the relationship among exchange rate and inflation differential lagged values of ER and dummy variables (DV) were considered. DV were applied for outliers or specific quarters

¹⁹ Consumer price index was taken as a measure of inflation rate in particular countries.

suggested by visual check and/or backed by economic or historical reasons. They try to capture structural changes such as a change of an exchange rate regime, widening of a fluctuation band, foreign financial crisis²⁰ or domestic political turmoil.

To test for PPP several techniques such as correlation, unit root tests or cointegration methods can be used.

The **correlation method** was used in the early empirical studies of PPP in 1970s and usually did not support the theory (Sideris, 2006).

In the late 1980s more sophisticated **tests of unit root** were developed. In the simplest form unit root tests for stationarity examine following regression:

$$q_t = \alpha q_{t-1} + \varepsilon_t,$$

where q_t is the exchange rate over time, ε_t is error term and α is an unknown parameter. If α equals unity, there is a unit root and variable is not stationary. This means that the exchange rate would follow a random walk and would not be determined by inflation differential. Our best prediction about the path of the exchange rate would then equal to a constant plus a random element (Gujarati, 2003). If we cannot reject the hypothesis of a unit root, i.e. α equals unity, long-run PPP is not likely to hold.

As suggested by Abuaf and Jorion (1990), problem of unit root tests is their low power against the alternative hypothesis of a stable near random walk model. Further criticism concludes that exchange rate stationarity tests impose a priori the symmetry and proportionality restrictions on variables which in turn can bias PPP tests towards not accepting the hypothesis (Brismis et al, 2005).

Recent empirics use the method of **cointegration**. The basic idea is that if an economic theory suggests a relationship between two variables these tend to move together. To test for cointegration, deviations from the relationship between exchange rate and inflation differential are examined. If the deviations revert to a stable fixed mean, variables are likely to be cointegrated. Otherwise they follow a random walk.

Both unit root tests for stationarity and cointegration methods provide mixed results²¹ of PPP doctrine.

²⁰ The second half of 1990's was rich on financial crisis: the Asian crisis in 1997, the Russian crisis in August 1998 and the Brazilian crisis in January 1999. All these provoked large capital movements in foreign exchange marktes and were very likely to influence also currencies of the countries in our sample.

To revisit the theory empirically following procedure is applied. Exchange rate and inflation differential as time series are expected to be non-stationary variables. To test for their stationarity graphical analysis, Dickey-Fuller and Augmented Dickey-Fuller tests²² are applied. In Dickey-Fuller test we examine the null hypothesis of a unit root. If the computed value exceeds the critical value, we may reject the null hypothesis and data is stationary, i.e. nontrended.

To test for cointegration the Engel-Granger method is applied. It examines residuals of the regression for a unit root and tests the following regression:

$$er_t = \alpha_0 + \alpha_1 i_d + \varepsilon_t,$$

where er_t is the first difference of logged²³ index of nominal exchange rate, i_d stands for the first difference of logged inflation differential defined above, ε_t is the error term and t subscript stands for time. With help of Dickey-Fuller and augmented Dickey-Fuller test residuals from cointegrated²⁴ regression will be examined for the unit root. If we may reject the hypothesis of a unit root of residuals, we may conclude that variables ER and I_d are cointegrated, i.e. there is stable and long-run relationship between them.

7.2. Graphical Evidence on PPP

Figure 6 plots chain indices of the nominal exchange rate and the CPI ratio of four transition economies vis-à-vis the U.S. Dollar.

First, I_d line presenting the inflation differential between transition economies and the USA is higher than unity in all four graphs. This reflects higher inflation rate in TRE compared to the USA. During the whole sample period the I_d line is approximating to unity. In other words, inflation differential dies out.

Second, Figure 6 illustrates the market exchange rate being more volatile than the I_d during the whole sample period.

²¹ For Dickey-Fuller unit root test, see Stiegerwald (1996) and Abauf and Jorion (1990). For cointegration, see Sideris (2005) and Taylor M. (1988).

²² In Dickey-Fuller test we examine whether the relationship between Y and Y_{t-1} displays a unit root. In the Augmented Dickey-Fuller tests lags of the variable are included.

²³ The change in the log of a variable approximates to the percentage change in the variable. Therefore variables are put into logs and then difference once.

²⁴ According to the definition of cointegration, if two variables are cointegrated, it means they have a long-run equilibrium relationship. If this holds their expected difference is said to be zero over time. (Gujarati, 2003)

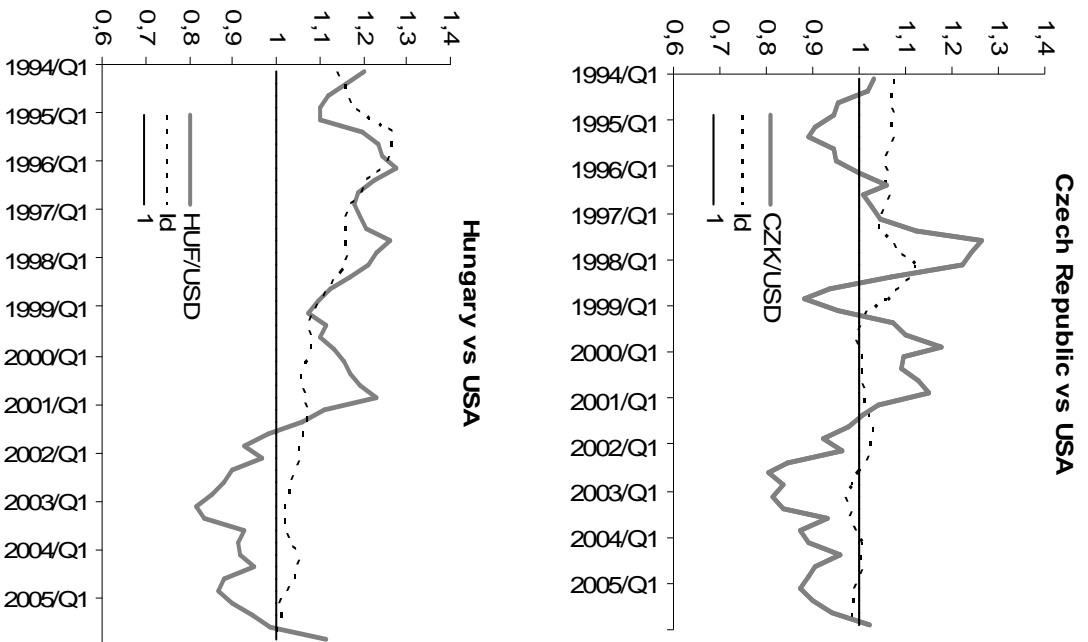
Furthermore, if the relative version of PPP would hold, we would expect the ER line to more or less copy the I_d line. This was partially the case in the first part of the tested period. However, from the year 2001 on the inflation differential presented by I_d curve oscillates around 1 but ER is below 1 suggesting appreciating currency in nominal terms. The theory seems to hold worst for the CZK vis-à-vis USD and is quite satisfactory for HUF and PLN vis-à-vis USD.

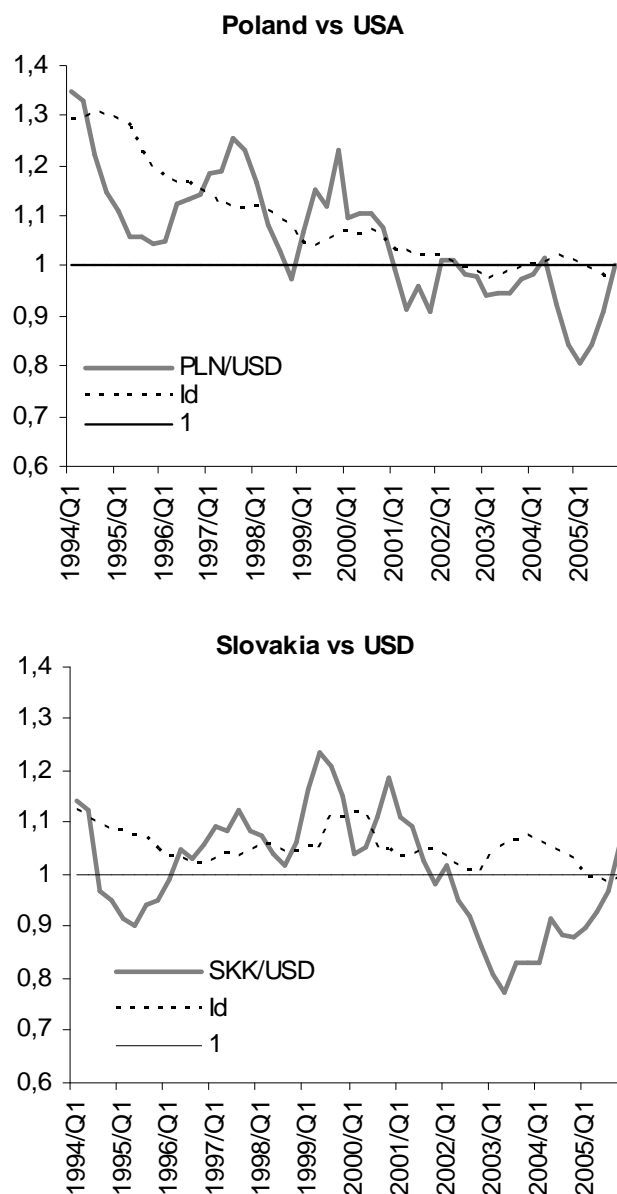
Fourth, despite the variety of exchange rate regimes adopted by transition countries all economies in the sample follow similar time path. Initial undervaluation of the currency is rectified by domestic inflation growth especially in the early stage of transition. Nominal depreciation was then outstripped by fast increasing domestic price level which resulted in appreciating exchange rate in real terms. This may implicate two things. First, initial exchange rates were not set at their equilibrium level. Real appreciation can be viewed as an approach towards currency's long-run equilibrium. Second, during the transformation and convergence process the inflationary channel played more important role than the exchange rate channel. Therefore countries followed similar time path no matter what exchange rate regime they had adopted. For example if we take the graph of CZK/USD we can observe how the appreciation channels were changing during the time period. First, the inflationary channel played the major role. Apart from two sharp depreciations the currency was appreciating in real terms²⁵. Around the year 2001 influence of inflationary channel decreased and exchange rate channel was likely to be the main driving force.

To sum it up, the graphical analysis for TRE vis-à-vis the USA is not very supportive for the relative version of PPP. Otherwise the ER would follow the I_d line. In fact ER appreciated in real terms. This would be however in line with the Balassa-Samuelson hypothesis discussed above.

²⁵ The ER line is below the I_d line suggesting lower depreciation at higher inflation differential.

Figure 6: Chain indices of ER and I_d vis-à-vis USD





Quarterly observations 1993 – 2005, source: IMF, 2006

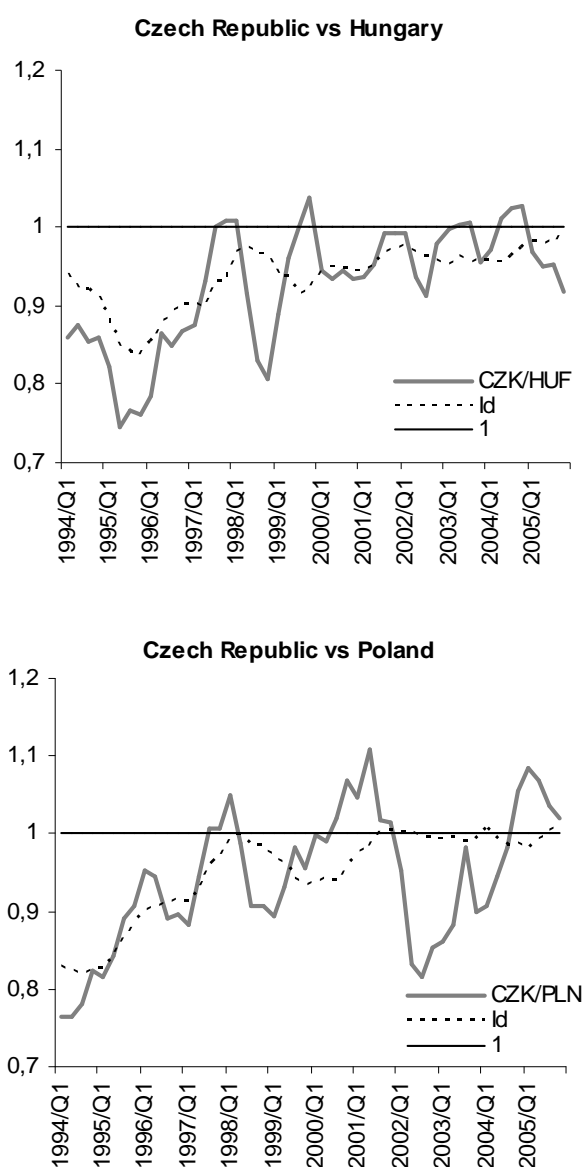
Figure 7 depicts the nominal exchange rate and the CPI ratio of three transition countries vis-à-vis the Czech Republic.

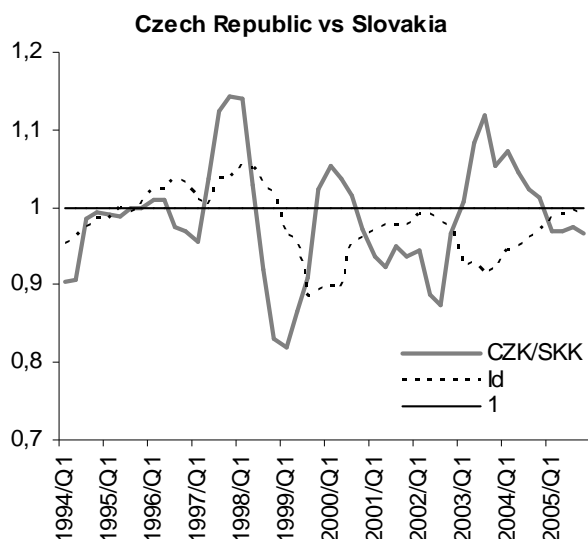
To start with, the inflation differential between transition economies and the Czech Republic is smaller than unity. This reflects lower inflation rate in the Czech Republic compared to TRE. Similar to the trend in the Figure 6 the I_d line is approximating to unity during the sample period and the inflation differential dies out.

Second, as can be seen from all three graphs the ER line roughly follows the I_d curve. This might be consistent with the relative version of PPP. It performs slightly worse for the Czech Republic vis-à-vis Slovakia in the end of sample period.

To conclude, the graphical evidence on PPP among TRE is more supportive than vis-à-vis the USA. The nominal exchange rate follows more or less the inflation differential which is likely to act as an exchange rate determinant.

Figure 7: Chain indices of ER and I_d vis-à-vis CZK





Quarterly observations 1993 – 2005, source: IMF, 2006

7.3. Empirical Analysis

Nominal exchange rate and inflation differential are both said to be non-stationary variables. To determine the order of integration of ER and I_d indices the Dickey-Fuller test was implemented to test for a unit root. All variables came out stationary after the second logarithmic differencing except for ER variable CZK vis-à-vis HUF. It was found to be $I(1)$. To save space detailed results for this unit root test is reported in the appendix, table 10 and 11.

Despite both ER and I_d variables being integrated of order two, first difference will be used in a cointegration analysis. If the first difference of variables is used their linear combination cancels out the trend. Regression residuals become stationary (integrated of order zero) and we may conclude that the ER and I_d tend to move together in the long run, i.e. they are cointegrated.

To test for cointegration the Engle-Granger method (1987) was applied. With help of Dickey-Fuller and augmented Dickey-Fuller test residuals from cointegrated regression were examined for the unit root. The hypothesis of a unit root of residuals may be rejected for most of the regression results at 5 % level of significance. Unit root may not be rejected in case of HUF against USD²⁶.

²⁶ For detailed results, see Appendix, table 12.

To sum it up, except for HUF against USD there is evidence of some long-run relationship between the exchange rate and inflation differential. Some difference in regression results between low inflation country (USA) and transition country and between two high inflation countries was not found. Expected magnitudes and signs of the coefficients are discussed below. Most regressions tend to have problems with serial correlation²⁷. Highly significant coefficients (see table 8) also indicate problems with correlated residuals. This might cause the t- and F-statistics to be invalid. Possible remedy is outlined in Table 9 below.

Table 8 presents cointegrated regression for both groups of countries, vis-à-vis the U.S. dollar and vis-à-vis the Czech koruna. Overall evidence is not very supportive for both groups of countries. With respect to diagnostic tests only two regressions – SKK/USD and CZK/PLN – perform better²⁸.

The coefficient α_0 is a small number for any regression. The coefficient α_1 is substantially lower than unity for three out of four regressions vis-à-vis USD. It may implicate violation of the relative version of PPP.

Regression results for TRE against the Czech Republic are also not very supportive with respect to the expected magnitudes. However, problem with serial correlation might again result in wrong conclusions. Therefore, stress would be laid on modified cointegrated models presented in Table 9 and discussed below.

²⁷ „Serial correlation is correlation between times series such as u_1, u_2, \dots, u_{10} and v_2, v_3, \dots, v_{11} , where u and v are two different time series.” (Gujarati, 2003, p.443)

²⁸ Serial correlation might be rejected for CZK/PLN and SKK/USD at 5 % and 10 % level of significance, respectively. For detailed diagnostic tests see Appendix, table 13.

Table 8: Cointegrated regression results

OLS Estimation: $ER = \alpha_0 + \alpha_1 I_d$
sample period 1994Q2 - 2005Q4

	α_0	α_1	α_0	α_1
	(s.e.)	(s.e.)	(s.e.)	(s.e.)
HUF/USD			CZK/HUF	
	0.8691E-3***	0.83614***	0.9033E-3***	0.43731***
	(0.0067427)	(0.50289)	(0.0069134)	(0.45558)
PLN/USD			CZK/ PLN	
	-0.0078547***	-0.26102***	0.0034169***	0.63289***
	(0.0094325)	(0.72742)	(0.0075434)	(0.58307)
SKK/USD			CZK /SKK	
	-0.0024502***	-0.34764***	0.0014259***	-0.036122***
	(0.0078144)	(0.44751)	(0.0072229)	(0.33609)
CZK/USD				
	0.8664E-3***	0.57334***		
	(0.0093953)	(0.70994)		

*, **, *** significant at 1 %, 5 % and 10 % level of significance, respectively

s.e. stands for standard error

Modified regression results for TRE vis-à-vis U.S. dollar and vis-à-vis CZK are outlined in Table 9. In order to improve the overall characteristics of the cointegrated model lagged values of the index of nominal exchange rate and dummy variables were applied. 3-month lag of the ER was considered first. No substantial improvement was obtained. For the final model 6-months lagged ER was finally applied for both groups of countries. Half year seems to be long enough for the ER to accommodate the changes in inflation rates between the two countries.

Surprisingly, imposition of a dummy variable did not improve diagnostic tests substantially. DV was kept only in the model for CZK/PLN. It stands for the change of exchange rate regime in the Czech Republic in the second quarter of 1997 and came out significant at 10 % level if significance.

Table 9: Modified regression results with 6-month lagged ER variable

OLS Estimation: 6 months-lagged $ER = \alpha_0 + \alpha_1 I_d$			
sample period 1994Q4 - 2005Q4			
	α_0	α_1	
	(s.e.)	(s.e.)	
HUF/USD			CZK/HUF
	-0.0041626***	0.32486***	0.5617E-3***
	(0.0065886)	(0.48713)	(0.0068831)
PLN/USD			CZK/ PLN
	-0.0016732***	1.3454**	0.0014172***
	(0.0089885)	(0.68079)	(0.0076922)
			DV97Q2***
SKK/USD			CZK /SKK
	-0.0032613***	0.64205***	0.0013292***
	(0.0076365)	(0.43375)	(0.0071741)
CZK/USD			
	0.0013706 ***	2.4906	
	(0.0081481)	(0.60314)	

*, **, *** significant at 1 %, 5 % and 10 % level of significance, respectively
s.e. stands for standard error

Similar to previous table, results for TRE vis-à-vis the USA are not very supportive. Coefficient α_1 does not take the expected value for any regression. Outcome for CZK vis-à-vis USD provides very little evidence. I_d variable came out insignificant at standard levels of significance. Already from graphical analysis the evidence in favor of relative PPP was very weak. Czech Republic had system of fixed exchange rate regime and undervalued prices were strongly regulated²⁹. All this may cause real appreciation and was likely to contribute to deviations from PPP.

Results for TRE against the Czech Republic meet better the requirements of the theory. Coefficients are close to the values suggested by the PPP theory ($\alpha_0 = 0$ and $\alpha_1 = 1$). I_d variable, however, came out significant only at 1 % level of significance in any model.

Comparison of results in table 9 suggests that there is some difference between the two groups. Obtained results are better and more consistent for CZK than for USD as the reference currency. Inflation rate in case of USD does not seem to play such important role

²⁹ Some prices, such as housing or energy, are still regulated now.

of exchange rate determinant as in case of CZK. More important could be the influence of higher volatility of USD in foreign markets or convergence process of transition economies.

8. THE ROLE OF EXCHANGE RATE IN CONVERGING CZECH REPUBLIC

At this point, after more than fifteen years of economic, political and institutional transformation the transitory process seems to be at the end. Entering the European Union in May 2004 only confirms this. As a member of the EU the Czech Republic committed itself to implement economic reforms leading to a stable macroeconomic environment and subsequent introduction of Euro.

Purpose of this chapter is to analyze the role of the exchange rate and its regime under conditions of a small open economy with close economic relations to its geographical neighbors and trading partners. The overall analysis is implemented within the context of convergence towards European Union and future accession to the European Monetary Union. From this point of view stability of the exchange rate and a type of its regime are key elements of successful monetary policy.

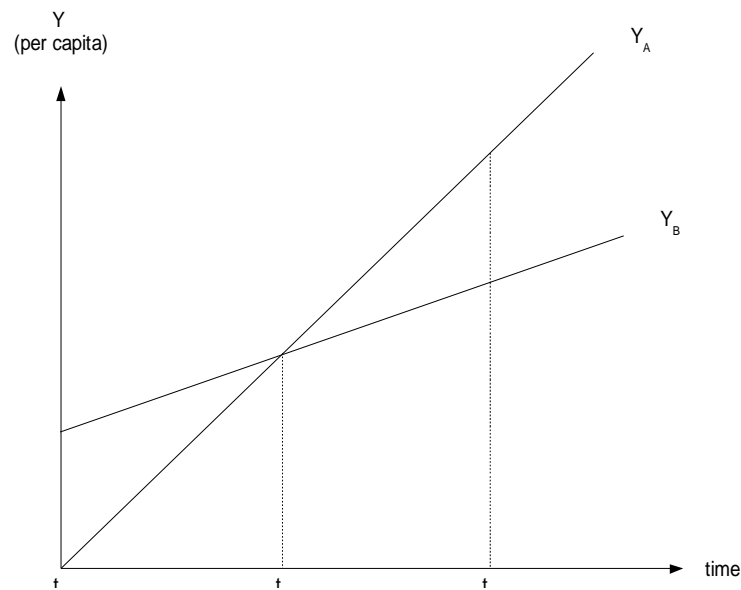
Before proceeding further a formal definition of convergence is provided. Under the term convergence one understands diminishing difference between two or more variables over time:

$$|y_{A,t} - y_{B,t}| > |y_{A,t+1} - y_{B,t+1}|,$$

where y_A and y_B are relevant economic variables in two particular countries A and B, t and $t+1$ stand for two subsequent time periods.

Economic convergence can be defined as permanent convergence in income per capita across particular countries. The word permanent is crucial since temporary convergence is not very helpful in the long run (Pentecost, 2002). Figure 6 depicts the level of income per capita in two economies A and B over time. In the first period from t_0 to t_1 economies are converging. However between t_1 and t_2 they are diverging. The picture demonstrates that in the short run we may not be sure whether converging tendencies are not only temporary. Therefore the issue of time is quite important when assessing economic convergence.

Figure 8: Economic convergence



The process of convergence of the Czech Republic towards the European (Monetary) Union can be divided into two parts. First, country must catch up in terms of economic performance, which is usually expressed an increase in their per capita income (real convergence). Second, economy is expected to approximate its price level to that in the EU countries (nominal convergence). EU authorities set various criteria and recommendations that should guide countries on their road towards convergence.

Copenhagen criteria are perceived as a basis for the real convergence. Apart from political requirements such as effective legal system or fulfillment of human rights these consist also of economic criteria defined as follows:

1. the existence and functioning of a market economy;
2. the ability to face competitive pressures and market forces in the European Union.

Under these requirements one can understand steps such as finishing structural reforms, privatization, strengthening of a banking system, development of domestic financial markets or orientation of the foreign trade to the EU countries. Follow-up of these broadly defined criteria should lead to a higher economic growth and to closing of the

efficiency gap between the Czech republic and the EU. In contrast with Maastricht criteria no particular values that should be targeted were set.

Maastricht criteria (European Commission, 1997) present a set of conditions that need to be fulfilled while targeting sustainable nominal convergence. The concept of nominal convergence can differ according to what nominal values are chosen. In order to join the Eurozone a country must meet five convergence criteria:

1. its inflation rate is not more than 1,5 % higher than the average of three lowest inflation rates in the EMS;
2. its long-term interest rate is not more than 2 % higher than the average observed in the three lowest inflation countries;
3. it has not experienced a devaluation during the two years preceding the entry in the union;
4. its government budget deficit is not higher than 3 % of its GDP;
5. its government debt has moved significantly towards the norm of 60 % of GDP.

Chronological order of accessing the EU first and entering the Eurozone later creates an official order in what both sets of criteria should be fulfilled, i.e. first real then nominal convergence. However, two approaches to the relationship between the real and nominal convergence can be found in literature.

To start with, it is believed that in the long run real convergence facilitates nominal convergence. Thus, policy pursuing both real and nominal convergence in the same time is likely to be ineffective or inconsistent. When the stress is put on nominal convergence criteria such as low inflation or government budget deficit they are likely to become counterproductive with respect to the real convergence. The growth of the economy might slow down and closing the productivity gap is likely to take longer time.

Alternatively, according to the European Central Bank (ECB) both real and nominal convergence processes should be understood more or less as complementary (ECB, 2000). The ECB suggests to put stress on both processes equally and in the same time. This should also commit each country to implement macroeconomic policy consistent in the medium-term with the one of the Eurozone.

8.1. Real Convergence

As was mentioned before, the term real convergence can be understood as decreasing regional differential between levels of GDP per capita in time.

In the context of this debate it should be mentioned that the Czech economy showed very promising growth rates in 1995-96. Thanks to good macroeconomic conditions the Czech koruna became fully convertible since October 1995, i.e. tradable in foreign exchange markets without quantitative or qualitative restrictions. But this growth period also witnessed widening imbalances and ended with a speculative attack on the koruna in 1997, political crisis, fiscal and monetary restrictions and protracted period of economic slowdown. What we can learn from that period is that blindly pursuing real convergence and struggle for economic growth will not speed up the catch up process of the EU. The growth of the economy has also to be sustainable. At present, the Czech economy has already recovered from the recession and once again embarked on a growth path, but there are rising concerns about the danger of the so called twins deficits³⁰ that contribute to the vulnerability of the economy.

Figure 7 depicts the level of real convergence of the EU 25 in 2006. The volume index of GDP per capita in Purchasing Power Standards³¹ (PPS) is expressed in relation to the European Union (EU-25) average set to equal 100. If the index of a country is higher than 100, this country's level of GDP per head is higher than the EU average and vice versa. The comparison is based on the survey carried by Eurostat.

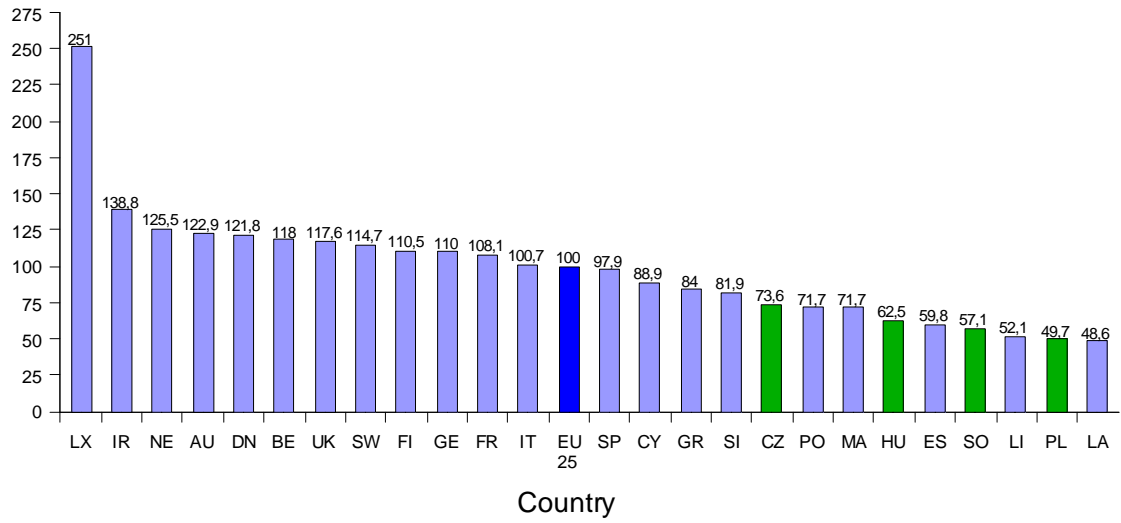
In 2006 the Czech Republic was nearly at 70 % of the average of the EU, which is the highest value in comparison with Visegrad four countries.

30 Twin deficit consists of deficit on the current account of the balance of payments and of government budget deficit.

31 Basic figures are expressed in PPS, i.e. a common currency that eliminates the differences in price levels between countries. This allows for meaningful volume comparisons of GDP between countries.

Figure 9: Real convergence

GDP in PPS



Source: Eurostat, 2006

8.2 Nominal Convergence

Nominal convergence can be achieved via two channels – exchange rate channel³² and inflationary channel³³. First inflationary channel is discussed in the context of converging price levels. Next, exchange rate channel and a concept of equilibrium exchange rate is considered. Finally the interaction and possible implication after closing the exchange rate channel as a result of entering ERM II is outlined.

8.2.1. Convergence of price levels

A natural starting point for analyzing price levels convergence is to examine the comparative price level (CPL). CPL is defined as a ratio of domestic and foreign price level converted into one currency:

$$CPL = \frac{P_t}{E_t \times P_t^*},$$

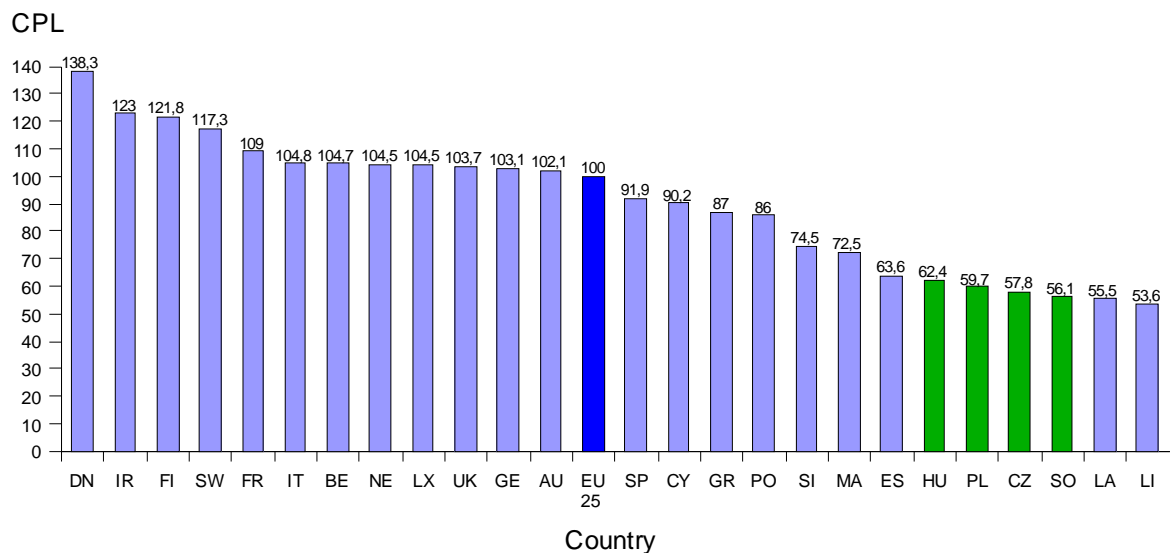
³² Via nominal appreciation of the exchange rate

³³ Via positive inflationary differential

where P_t and P_t^* stand for domestic and foreign price levels, respectively, E_t is the exchange rate expressed in Purchasing Power Standard³⁴ (PPS) and t subscripts denote time. The ratio is shown in relation to the EU average (EU25 = 100).

Figure 8 gives an overview of comparative price level for the EU 25. If the index of the comparative price levels shown for a country is higher than 100, the country concerned is relatively expensive as compared with the EU average and vice versa. In 2006 the Czech Republic was nearly at 58 % of the average of the EU, which is the third highest value in comparison with Visegrad four countries.

Figure 10: Comparative price level in EU 25



Source: Eurostat, 2006

There has been a growing interest in exploring the links between the price developments and the catching-up process with EU income-per-capita levels upon which most accession countries have embarked. It is observed that the price levels in the candidate countries lag behind those of the EU member states. This fact then tends to foster concerns whether the disinflation strategy only postpones the necessary increase in prices to bring them to the EU level. Low-inflation strategy can in the end turn out to be counterproductive by exposing the economy to the danger of a massive price jump upon the entry to the EU.

34 PPPs are currency conversion rates that convert economic indicators expressed in national currencies to a common currency, called Purchasing Power Standard (PPS), which equalises the purchasing power of different national currencies.

There are even doubts about the consistency of the Maastricht criteria which require in parallel the price and exchange rate stability while candidate country supposedly needs to close the price gap either by way of higher inflation or by way of nominal appreciation.

The convergence of price levels to the one of the EU is discussed in two ways - within the context of the mechanism of the law of one price and the Balassa-Samuelson effect.

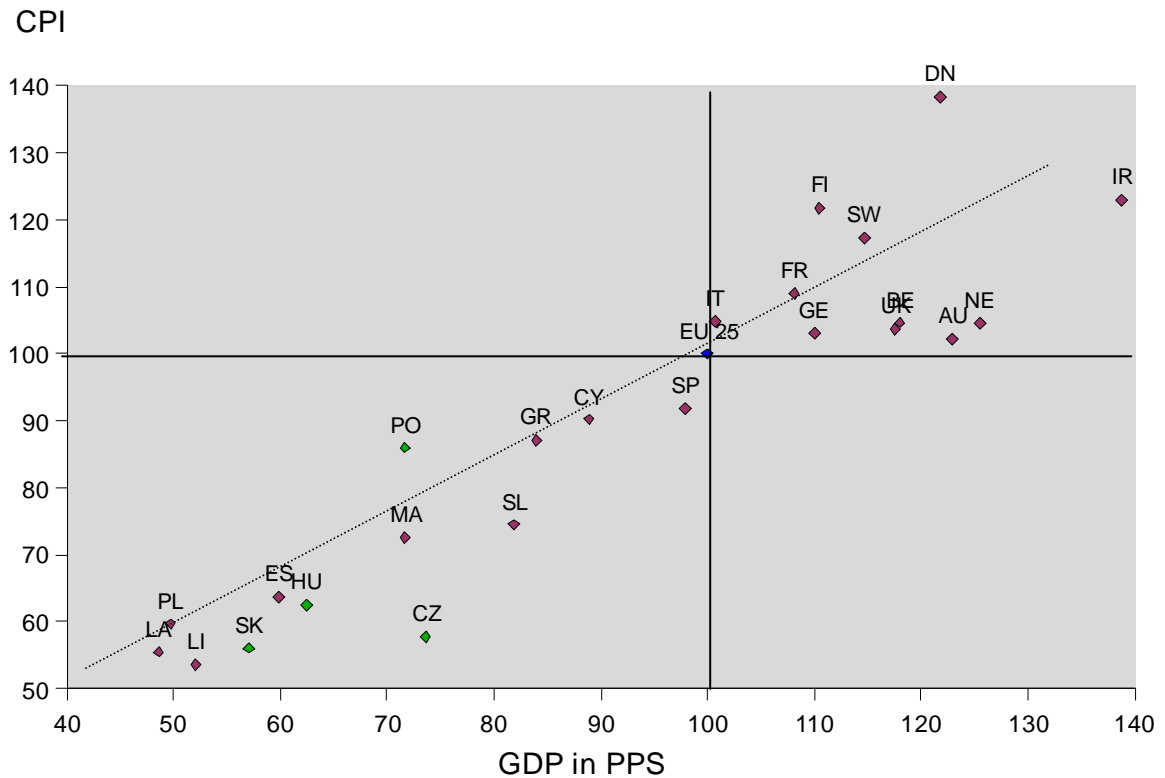
To begin with, theoretical concept behind converging price levels is presented by the law of one price³⁵. Thanks to price arbitrage prices of goods are equalized at home and abroad. With comparing prices over the borders we can measure the price gap in particular countries or regions. The question is whether measured price gap can be taken as a real value of subsequent price jump.

From the figure 9 we can observe strong correlation between the economic level and the price level. If this should be the case, then we should not measure the price gap as the distance of the Czech price level from the average of the EU. Rather we should take the vertical distance from the regression line. For example, if the regression line would have the slope of 45°, the Czech Republic with 70 % of the economic development of the EU should then get its price level also to the 70 % of the EU. Remaining 30 % gap between the Czech and the EU price level should not be caught up by price convergence but rather by a catch up in productivity. Therefore when the price level is at 57 % of the European one, the space for catching up is not 43 % ($100 - 57$ %) but 13 % ($70 - 57$ %).

What more, the graph illustrates that substantial differences are also among former members of the EU. Simply put, evaluation of the price gap should not be based only on statistical comparison but should consider also various microeconomic factors such as transportation costs, different consumer preferences or quality of products. Therefore if price differentials persist among products that can be traded easily one may interpret it in a way that their prices were already equalized. From this point of view stimulating higher inflation will not solve the problem of price gap. Higher inflation would only increase prices in the whole.

35 Detailed explanation of the concept was given in section 2.1.

Figure 11: CPI and GDP in PPS



Source: Eurostat, 2006

Second approach is the one of Balassa and Samuelson. They suggest that higher productivity growth is accompanied with real appreciation of the exchange rate and with higher rates of inflation³⁶. The model in some sense advocates higher inflation rates for accession countries as an unavoidable phenomenon after joining the EU and the EMU.

However one can expect decreasing importance of the effect because of two reasons. First, the clear line between tradables and nontradables is becoming less evident thanks to increasing competition in international markets and technological progress resulting in decreasing transaction costs.

Hereafter, as was also mentioned earlier the theory has one big flaw since it abstracts from capital flows. When a capital account is introduced another important factor influencing inflation rate and exchange rate is obtained. The effect of the capital account is even more striking when we consider small open economy like the Czech Republic.

³⁶ The mechanism of the Balassa-Samuelson effect is as follows: higher labor productivity in tradable sector increases the wages in both tradable and nontradable sectors. Otherwise workers would not be willing to work in sector with lower wages. Higher inflation is to follow and under flexible exchange rate regime the currency is likely to appreciate in real terms..

Growing inflation differential³⁷ drives up the interest rate differential. Higher interest rate in turn attracts short-term capital. Exchange rate appreciates and inflation decreases. Stronger currency discourages foreign demand and the economic growth might slow down. The final effect are converging price levels but also economic fluctuations arising from overshooted exchange rate.

However, the Balassa-Samuelson effect should not be used as an excuse for inflation generated by an overheating economy driven by an excessive growth of wages or fiscal expansion. As the model suggests, converging price levels should come hand in hand with converging labour productivity.

In addition, one should not forget that the Balassa-Samuelson effect abstracts from the capital flows. Once these flows are introduced, one can see a new set of consequences of a higher inflation rate and resulting higher interest rate differential.

To sum it up, the advantage of low inflation is evident. Low inflation resulting in low interest rate differential discourages an inflow of speculative capital. Stable inflation environment promotes inflows of foreign direct investments (FDI). FDI present important source of financing current account deficits characteristic for transition economies. Finally, low inflation keeps real appreciation of the currency at a reasonable pace. Thus, monetary authorities must find inflation rate sufficiently low but not restricting economic growth.

8.2.2. Convergence of exchange rates

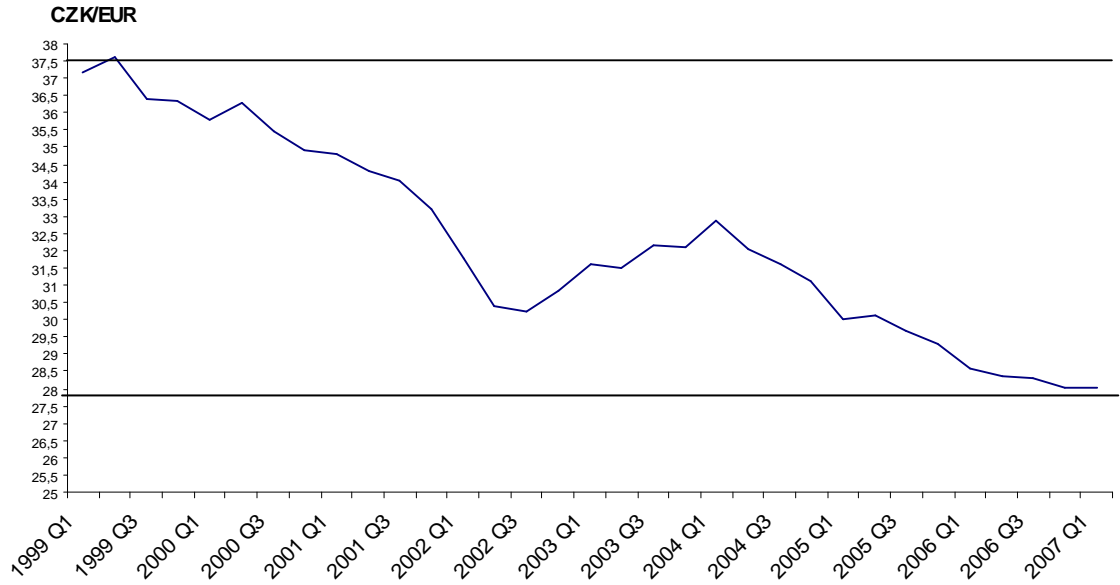
Upon their entry into the ERM II³⁸, candidate countries will no longer be able to use national monetary policy tools to promote the process of real convergence. As a matter of fact, an exchange rate can only be used as a monetary policy tool prior to the admission to the ERM II, and even then subject to certain restrictions, since from their accession to the EU onwards, countries must consider their exchange rate policies as a matter of common interest. Candidate countries employing a flexible exchange rate mechanism – as is the case of the Czech Republic at the present time – will upon their admission to the ERM II realize their exchange rate policy in room defined by the width of fluctuation band.

³⁷ Inflation can be growing for example as a result of the Balassa-Samuelson effect.

³⁸ The ERM II (Exchange Rate Mechanisms II) is a mechanism for fixing the participating currencies against the euro within a fluctuation band. Each currency participating in ERM II has a defined central rate (parity) against the euro and a fluctuation band for movements around the central rate. In the event of exchange rate pressures, both the national central bank and the European Central Bank (ECB) will intervene to keep the exchange rate within the fluctuation band.

Figure 10 depicts the development of CZK/EUR. As one can see fluctuations of the CZK/EUR exchange rate over the past few years have been smaller than the hypothetical band of $\pm 15\%$. Nonetheless, the deviations from the average rate have been quite significant. The crown has showed an appreciation trend and after closing the exchange rate channel it might be a source of distortions.

Figure 12: Nominal exchange rate CZK vis-à-vis EUR



Source: CNB, 2007

Because of high inflation rates transition economies faced during the process of transformation (see Figure 1) nominal exchange rates are likely to differ substantially from the real values. For the purpose of analyzing exchange rate convergence real exchange rates are used since they provide us with better information about a real strength of the currency.

Real exchange rate is defined in the equation:

$$RER_t = \frac{E_t \times CPI_t^*}{CPI_t},$$

where RER_t stands for real exchange rate, E_t presents the nominal exchange rate vis-a-vis the US Dollar, CPI_t^* and CPI_t are foreign and domestic consumer price indices, respectively and t stands for time.

Development of real exchange rate is of a high importance especially with respect to eventual adoption of Euro in the New EU Member states³⁹. In order to do so, countries are obliged to stay in the exchange rate mechanism ERM II. One of the following steps is therefore to set the exchange rate (central parity) before countries commit themselves to peg their national currencies to Euro.

Setting the parity correctly is likely to be one of the crucial factors of stable economic environment in NMS. As suggested by the European Central bank (2003), the decision on setting the central rate should be based on economic research and corresponding economic indicators. European Central Bank states that: *“The central rate should reflect the best possible assessment of the equilibrium exchange rate at the time of entry into the mechanism. This assessment should be based on a broad range of economic indicators and developments while also taking account of the market.”*

Exchange rate is said to be at its equilibrium level as it is *“continuously determined by supply and demand in the foreign exchange market.”* (Horváth, Komárek, 2007). Thus the concept of equilibrium exchange rate is a set of conditions under which the exchange rate market is balanced. When the current exchange rate is misaligned, i.e. not at its equilibrium level, we expect market forces not to work properly. Factors that are likely to cause such deviations are mainly transaction costs and asymmetric information⁴⁰. What also needs to be considered is a time horizon of the equilibrium exchange rate (Horváth, Komárek, 2007). It is believed that in the short run exchange rates are more likely to be misaligned than in the medium and long run. It is consistent with the purchasing power theory which is also expected to perform better in the longer run.

8.3 Relationship between real and nominal convergence

Comparison of indicators of performance and price levels suggests that there is a certain relationship between nominal and real convergence. This relationship can be seen as mutual without explicit causality direction. When we put data for both nominal and real convergence together we can see that the speed of real convergence of the Czech Republic towards the average level of the EU is not accompanied with corresponding pace of price level convergence. This might be perceived as inconsistency in convergence dynamics. As

39 New Member states are states that entered the European union in May 2004 are the Czech Republic, Slovakia, Poland, Hungary, Slovenia, Malta, Cyprus, Latvia, Lithuania and Estonia. While Slovenia already joined Eurozone, Slovakia is in ERM II, the rest of the countries are in a preparatory phase to join the ERM II.

40 These factors are similar to factors causing the violation of PPP. For detailed description see Section 3.

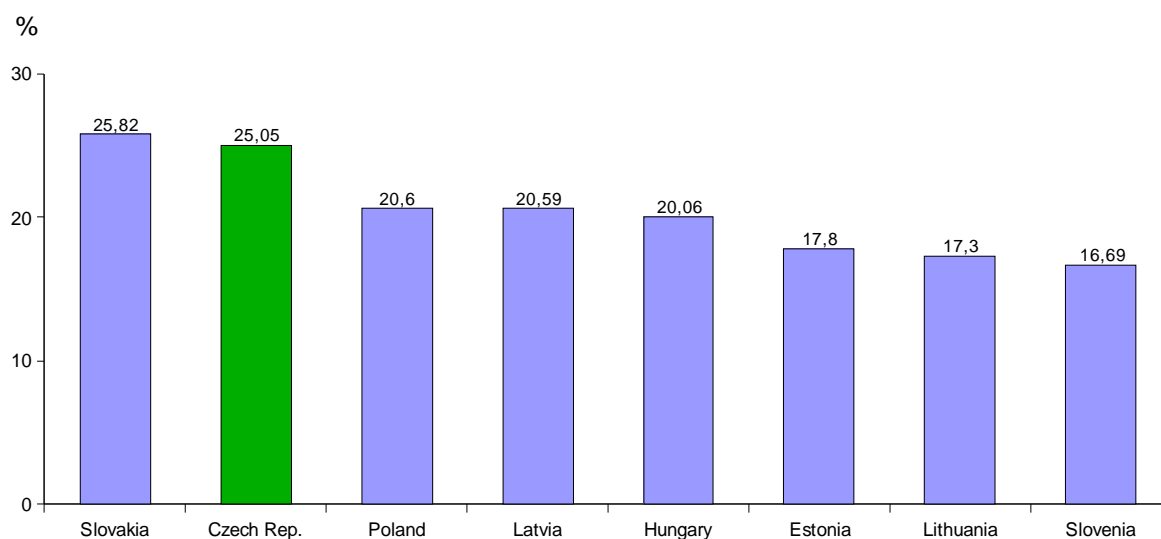
was shown the CPL is still biased toward lower level in comparison with the per capita income.

Pazour (2005) suggests several reasons for slower nominal convergence of the Czech Republic in comparison with other Central European countries:

1. structure of consumers' demand
2. price deformations caused by administrative prices

Graph XY depicts the ratio of administrative price in consumption basket used for CPI calculations. The Czech Republic has one of the highest ratio among new member countries⁴¹. Czech households spend about a quarter of their income on goods and services whose prices are regulated by government. This can to some extent contribute to the overall price level development and slow down the process of nominal convergence.

Figure 13: Ratio of administrative prices in consumption basket



Source: Eurostat, 2006

Successful convergence process will therefore require growth of prices to be faster than the one of the Eurozone with productivity growth as a driving force behind.

Above mentioned discrepancy between nominal and real convergence can otherwise have substantial implications for the Czech economy with respect to further macroeconomic development and acceptance of common European currency.

41 Here, we subtract from Bulgaria and Romania – countries that entered the EU in January 2007.

After restriction or closing the exchange rate channel more stress is put on convergence through inflationary channel. Monetary authorities committed to maintain stable price level development can in such case negatively influence economic growth and thus the real convergence. In the case of the Czech Republic it is even more striking because of its dynamic discrepancy in convergence process.

It should be mentioned that authorities can choose from the approaches when restricting the exchange rate channel. Either they can commit themselves to a narrower fluctuation band than $\pm 15\%$ and apply restrictive and monetary and fiscal policy, which might lead to a slowdown of economic performance. Or they can take the advantage of the whole fluctuation band and let exchange rate to partially absorb the pressure on prices.

The Czech Republic plans to adopt the euro by 2010. With respect to the Maastricht exchange rate criterion it will remain in the ERM II for two years to some extent fixed exchange rate regime. Entering the ERM II presents a limitation and later on a closing of one of the channels of nominal convergence. Thanks to the asymmetry between nominal and real convergence this might be reflected in higher pressures on domestic prices. Monetary policy bounded by Maastricht requirements will in turn enforce restrictive monetary policy with possible downturn of economic performance as the end result. How founded this doubt would be depends among other factors on the monetary policy before entering ERM II and on how the central parity for the Czech koruna would be set.

9. CONCLUSION

The purpose of this dissertation was to revisit the relationship between exchange rate and inflation differential under the condition of transition process. Four transition economies were tested: the Czech Republic, Hungary, Poland and Slovakia. The study revisited the evidence on PPP with help of graphical analysis, DF, ADF tests and Engel-Granger cointegration method. Quarterly data from 1993 to 2005 have been applied. Dummy variables and lagged values of nominal exchange rate were considered to improve the model characteristics.

Finally, results for transition countries vis-à-vis the Czech Republic and for transition countries vis-à-vis the USA were compared to find out whether transition countries vary from market economies considerably.

Findings can be summarized as follows:

- (i) Graphical evidence on PPP is more supportive among TRE where the nominal exchange rate follows more or less the inflation differential. Thus in this case inflation rate is likely to act as an exchange rate determinant.
- (ii) Empirical evidence on a long-run relationship between the exchange rate and inflation differential was found for all regressions except for HUF vis-à-vis USD. Exchange rate and price ratio tend to move together. To test for cointegration the Engel-Granger method was applied. Regression residuals were examined for a unit root.
- (iii) Most of the regressions had problems with serial correlation. To improve the diagnostic tests 6-months lagged value of ER was applied. Surprisingly, imposition of a dummy variable did not improve diagnostic tests substantially. DV was kept only in the model of CZK/PLN and stands for the change of exchange rate regime in the Czech Republic in 1997.
- (iv) Some difference in regression results between low inflation country (USA) and transition country and between two high inflation countries was found. Suggested model performed better for CZK as a reference currency for the coefficients were closer to expected values and came out significant.

The results are consistent with mixed evidence on the relative version of PPP. Given productivity shocks, inflexible exchange rate regimes, regulated prices of energy or housing and restrictive monetary policy deviations from long-run equilibrium exchange

rate are highly probable. However as was shown mainly in case of TRE vis-à-vis the Czech Republic the inflation differential is likely to act as an exchange rate determinant.

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APPENDIX

To save space only some unit root tests for variables and unit root tests for residuals are reported in the appendix. The rest of results is available on request.

Tables 10 and 11 give results on the unit root test of ER variable CZK vis-à-vis HUF. All computed t-statistics are higher than the critical value when we took the first difference. Thus, we may reject the null hypothesis of a unit root ER variable was found to be integrated of order one, i.e. $I(1)$.

Table 10: Unit root test for variable ER (in natural logarithm)

Unit root tests for variable LNER		
43 observations used in the estimation of all ADF regressions.		
Sample period from 1995Q2 to 2005Q4		
The Dickey-Fuller regressions include an intercept but not a trend		The Dickey-Fuller regressions include an intercept and a linear trend
Test Statistic		
DF	-2.1191	-2.2122
ADF(1)	-2.9559	-3.7092
ADF(2)	-2.5526	-3.3834
ADF(3)	-2.1424	-2.9440
ADF(4)	-1.4644	-1.6825
95% critical value for the augmented Dickey-Fuller statistic		
	-2.9303	-3.5162

Table 11: Unit root test for the first difference of ER (in natural logarithm)

Unit root tests for variable D1ER		
42 observations used in the estimation of all ADF regressions.		
Sample period from 1995Q3 to 2005Q4		
The Dickey-Fuller regressions include an intercept but not a trend		The Dickey-Fuller regressions include an intercept and a linear trend
Test Statistic		
DF	-5.1474	-5.2792
ADF(1)	-4.9920	-5.1301
ADF(2)	-5.2150	-5.3885
ADF(3)	-6.6957	-6.8683
ADF(4)	-3.7810	-3.9090
95% critical value for the augmented Dickey-Fuller statistic		
	-2.9320	-3.5189

Residuals from cointegrated regression were examined for the unit root. Hypothesis of a unit root of residuals may not be rejected in case of HUF against USD. From table 12 we can see that except for DF statistics the computed t-statistics are smaller than the critical value.

Table 12: Unit root tests for residuals of cointegrated regression HUF/USD

Unit root tests for residuals	
Based on OLS regression of D1ER on CON and D1I _d	
47 observations used for estimation from 1994Q2 to 2005Q4	
Test Statistic	
DF	-4.6371
ADF(1)	-2.9493
ADF(2)	-1.8665
ADF(3)	-2.9141
ADF(4)	-2.8328
95% critical value for the augmented Dickey-Fuller statistic	
-3.4848	

Table 13: Diagnostic tests for cointegrated regressions

OLS Estimation: $ER = \alpha_0 + \alpha_1 I_d$					
Sample Period	Regression	Diagnostic tests			
		Serial Correlation [P-value]	Functional Form [P-value]	Normality [P-value]	Heteroscedasticity [P-value]
1994Q2 - 2005Q4	CZK/USD	10.5328 [.032]	.64886 [.421]	.89686 [.639]	3.1746 [.075]
1994Q2 - 2005Q4	HUF/USD	10.1937 [.037]	.17827 [.673]	.62583 [.731]	.89452 [.344]
1994Q2 - 2005Q4	PLN/USD	11.1752 [.025]	.22659 [.634]	1.3461 [.510]	2.3719 [.124]
1994Q2 - 2005Q4	SKK/USD	5.5187 [.238]	.060933 [.805]	.43095 [.806]	.47343 [.491]
1994Q2 - 2005Q4	CZK/HUF	17.9896 [.001]	.018369 [.892]	.32742 [.849]	4.7174 [.030]
1994Q2 - 2005Q4	CZK/PLN	8.8860 [.064]	2.7857 [.095]	4.0321 [.133]	.48362 [.487]
1994Q2 - 2005Q4	CZK/SKK	23.2970 [.000]	.55857 [.455]	.48702 [.784]	.044162 [.834]

Table 14: Diagnostic tests for models with 6-month lag of ER variable

OLS Estimation: 6 months-lagged $ER = \alpha_0 + \alpha_1 I_d$					
Sample Period	Regression	Diagnostic tests			
		Serial Correlation [P-value]	Functional Form [P-value]	Normality [P-value]	Heteroscedasticity [P-value]
1994Q4 - 2005Q4	CZK/USD	2.6834 [.612]	.012965 [.909]	.0072522 [.996]	.0083160 [.927]
1994Q4 - 2005Q4	HUF/USD	7.7136 [.103]	1.1136 [.291]	.14234 [.931]	.47460 [.491]
1994Q4 - 2005Q4	PLN/USD	5.0116 [.286]	.48321 [.487]	.032908 [.984]	1.7427 [.187]
1994Q4 - 2005Q4	SKK/USD	5.6118 [.230]	.039458 [.843]	.23877 [.887]	.060163 [.806]
1994Q4 - 2005Q4	CZK/HUF	14.9090 [.005]	1.1569 [.282]	.43056 [.806]	.0044993 [.947]
1994Q4 - 2005Q4	CZK/PLN*	8.6721 [.070]	2.0242 [.155]	3.5780 [.167]	.022660 [.880]
1994Q4 - 2005Q4	CZK/SKK	17.6721 [.001]	.027784 [.868]	.74122 [.690]	.35850 [.549]

* DV97Q2 stands for dummy variable imposed in the second quarter of 997