# REAL EXCHANGE RATE TRENDS IN TRANSITIONAL COUNTRIES

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# Real exchange rate trends in transitional countries

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## Abstract

The paper presents an analysis of the determinants of the real exchange rate with emphasis on its long-term aspects and searching for the equilibrium paths. It introduces the behavioural models of exchange rates (especially the BEER and the NATREX), that are alternatives to the often-used fundamental models of the FEER type. Authors constructed the theoretical and econometric behavioural model, which could analyse the medium-term and long-term dynamics of the real exchange rate. This paper also introduces real exchange rate as an indicator of convergence for transitional countries to EU countries and analyses the link between real exchange rate and double speed economy or deindustrialisation, respectively. This analysis is relevant almost for all transitional countries now. The paper explains the appreciation trend of real exchange rates in transitional economies. It is identifying the set of factors that let to sustainable real appreciation of the Czech Koruna and also the set of factors that possibly caused unsustainable real depreciation in the past. There is also a set of arguments against any other rapid real appreciation of the Czech Koruna. The paper also tried to fuel these arguments by an econometric analysis, which used our behavioural model of the equilibrium real exchange rate. It was shown that the Czech real exchange rate was especially determined by real fundamental factors: productivity, terms of trade and world interest rates and foreign direct investment.

**Keywords**: real exchange rate, transition, Czech Republic, competitiveness

**JEL Classification**: E58, E65, F31, F41

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## Outline

# 1. INTRODUCTION

The *real exchange rate* is one of the most important indicators of value in the economy. Its changes influence all consumers and producers. For a long time, the development of the real exchange rate has been analysed in economic literature from the point of view of *the purchasing power parity* (PPP). As the PPP implies, any real exchange rate changes must be interpreted in relation to the constant real exchange rate as deviations from the equilibrium level. The history of the real exchange rate and its analysis during the last ten years confirm that real exchange rates are non-stationary and assessment from the PPP point of view is not highly acceptable. PPP theory can still be considered as the final criterion for the relative value of the individual currencies, but not as a suitable criterion for *the equilibrium real exchange rate*. The reasons for this is the existence of real shocks and variations in capital flows. Exchange rate analysis in transitive economies must also face up to the fact that real rates show specific trends in the transformation trajectory. The objective of economic theory is to explain what factors and processes influence the development of the real exchange rate in advanced and transitional economies.

Understanding the long-term determinants of the real exchange rate is also important from the macroeconomic point of view. Exchange rate developments after the break-up of the Bretton Woods System has brought about not only higher volatility of real exchange rates but also time inconsistency, i.e. expressive, long-term deviations from the equilibrium values. These deviations can have a significant negative impact on the real economy. The other impulse for studying the real exchange rate is the current trend in transitional economies. During the 1980s and 1990s, it was shown that central banks often ignore the large changes in real exchange rates and maintain inappropriate exchange rate regimes. This type of policy leads to excessive indebtedness, financial crisis, financial problems for companies, unsatisfactory development of the balance of payments and speculative attacks on the fixed exchange rate parity. This situation had also stirred up a large wave of interest in finding the equilibrium values of the real exchange rate.

For several years, most of economists also have been active participants in the discussion on various aspects of convergence processes. At the end of the day, we have to admit that after 10 years of transition the accession countries can still be described as economies with 3 problems: relatively low productivity, relatively low price level, and week currency. We know that successful transition and accession requires higher productivity, higher price level and thus real appreciation of currency. Given that, we often face questions, which are sometimes difficult to ask: “How to achieve real appreciation?” How to model equilibrium trajectory of real exchange rate? Will real appreciation lead to lower external competitiveness and higher external deficit? Is real appreciation compatible with low inflation? We our paper, we try to address these questions. We will not deliver answers, we just hope to stimulate discussion.

The primary aim of working paper is to analyse the long-term determinants of the real exchange rate and to apply econometric methods for identifying which of these determinants

influence the real exchange rate in the Czech economy and how. The secondary aim is to evaluate (theoretically and empirically) the real exchange rate of the Czech Koruna during economic transformation.

## 2. DETERMINANTS OF THE REAL EXCHANGE RATE

The real exchange rate affects external competition, spending composition and the intertemporal evolution of consumption and savings through the current account. The equilibrium real exchange rate can be defined as the real exchange rate, which is consistent in all periods with the equilibrium in the non-tradable goods market and with the intertemporal solvency of the current account[1]. Development of the equilibrium real exchange rate depends on: *the terms of trade*, *growth of total productivity in the tradable and non-tradable sectors*, *savings and investment, changes in consumer preferences, the composition of government spending, the structure of customs duties, foreign capital inflows,* etc. We can also study in detail the determinants of the equilibrium real exchange rate from the supply, demand and specific factors point of view (see Frait and Komárek 1999 or Komárek 2000)

### 2.1 Decomposition of the Real Exchange Rate

The basic determinants of the real exchange rate are in a standard way derived from its decomposition. The real exchange rate can be written in logarithmic form as follows:

$$r = e + p^* - p, \qquad (1)$$

where $r$ is the real exchange rate, $e$ is the nominal exchange rate, $p^*$ is the foreign price level and $p$ is the domestic price level. We expected that this relationship is valid for tradable goods as well:

$$r_T = e + p_T^* - p_T. \qquad (2)$$

The price levels are given by the weighted average price indices of tradable and non-tradable goods[2]:

$$p = \omega . p_N + (1 - \omega)p_T \qquad (3a)$$

$$p^* = \varpi^* . p_N^* + (1 - \varpi^*)p_T^*. \qquad (3b)$$

When we insert equations (2), (3a) and (3b) into equation (1), we obtain the general equation of the actual real exchange rate:

$$r = r_T + \varpi(p_T - p_N) - \varpi^*(p_T^* - p_N^*)$$

$$= (e + p_T^* - p_T) + \varpi(p_T - p_N) - \varpi^*(p_T^* - p_N^*). \qquad (4)$$

[1] The intertemporal solvency of the current account is the condition where the current account is composed in sum of several time periods. This condition can be denoted as the condition of maintaining the current account.

[2] The equations are formulated in log-linear functional form. Small letters denote natural logarithms (with the

This equation suggests three potential sources of real exchange rate changes. Firstly, it is the change of the real exchange rate of tradable goods. Secondly, it is the movement of tradable and non-tradable relative prices between domestic and foreign economies. Finally, there is the time variability of the weights of tradable and non-tradable goods in both economies.

### 2.2 Changes in the Real Exchange Rate for Tradable Goods

The real exchange rate for tradable goods would be constant only under the assumption that all tradable goods on international markets are perfect substitutes. It is known that several factors in reality exist, which lead to the breakdown of this condition and are indicative of the systematic variability of the real exchange rate for tradable goods.

***National Savings and Investment***

The real exchange rate for tradable goods ($r_T$) is the key determinant of the current account, which is primarily defined as the difference between national savings and investment. The relevant part of net national savings is the balance of public finance. The effect of fiscal policy on the real exchange rate is not unambiguous. In the traditional Mundell-Fleming model, stronger fiscal policy causes an increase in national savings, a fall in real interest rates and real exchange rate depreciation (and at the same time, a surplus on the current account). The stock models (portfolio models), on the other hand, imply that if fiscal consolidation is permanent, then net foreign assets increase and the real exchange rate appreciates. This second variant is more relevant for the long run. Another variant for determining the real exchange rate is net private savings. Determining private savings is a more problematic issue. Demographic effects are the main factors, especially the age structure of the population. It generally holds that an increase in net private savings should demonstrate the real appreciation of the exchange rate.

***Terms of Trade***

Improvements in the terms of trade logically lead to appreciation of the real exchange rate. The terms of trade of small, open, industrial-oriented economies mainly depend on key raw material prices, and therefore they are exogenous. A price decrease in raw materials should cause real appreciation. The inverse effect can be observed for countries that export raw materials. In transitional economies, the terms of trade should improve endogenously as well, through export price growth (through better quality goods and services, marketing innovations, etc.).

***World Real Interest Rates***

Another exogenous determinant of the real exchange rate for small, open economies is the real interest rates of advanced countries. If an increase in world real interest rates is not associated with an increase in domestic real interest rates, the effect of world real interest rates on real

exception of symbols for interest rates).

exchange rates will be different in the short and long run. The short-term effect is real appreciation of the domestic currency, which is caused by the net outflow of capital. The long-term effect does not have to be same in all cases; it depends on whether or not the country is a net international debtor or creditor. If a country is a net debtor, an increase in world real interest rates would cause the current account to deteriorate. The economy would respond to this situation by depreciation of the real exchange rate, which conversely improves the current account. If a country is a net creditor, the opposite situation would occur.

## 3. REAL EXCHANGE RATE AS AN INDICATOR OF CONVERGENCE

The real exchange rate development can be seen as a common denominator of real convergence process since the external purchasing parity of transitional countries‘ currencies is determined primarily by their relative productivities. The real appreciation also implies convergence of price levels of these countries to their counterparts in the EU. Exchange rate developments in transitional countries (especially in the Czech Republic, Poland and Hungary) can be analysed through an examination of the initial phase of transformation and through more advanced transformation phases.[3]

***The initial transformation phase***

The initial transformation phase was first characterised by sharp devaluation of the nominal and real exchange rate. The reason for this devaluation was a sharp increase in demand for foreign assets (due to liberalisation in the money market), an expected inflationary hike (due to price liberalisation) and the tendency of central banks to set initial devaluation at a sufficiently high level (see Halpern and Wyplosz, 1997, p. 436–7).

Halpern and Wyplosz (1997) also illustrate four reasons why we might observe a real exchange appreciation. Firstly, domestic producers of traded goods improve the quality of their products (this effect results in an improvement in the terms of trade). Secondly, wages in the non-tradable good sectors rise relative to wages in the traded good sector are lower than those ones in the traditional industry-based tradable good sector. Thirdly, initially wages far exceed productivity in the traded good sector (therefore the subsequent correction of these imbalances leads to a real appreciation as prices in nontradable goods absorb the rise in costs). Finally, it is due to the Ballasa and Samuelson effect. Similar interpretation can be founded in the Economic Survey of Europe, United Nations, 2000, No.1, p. 55-59.

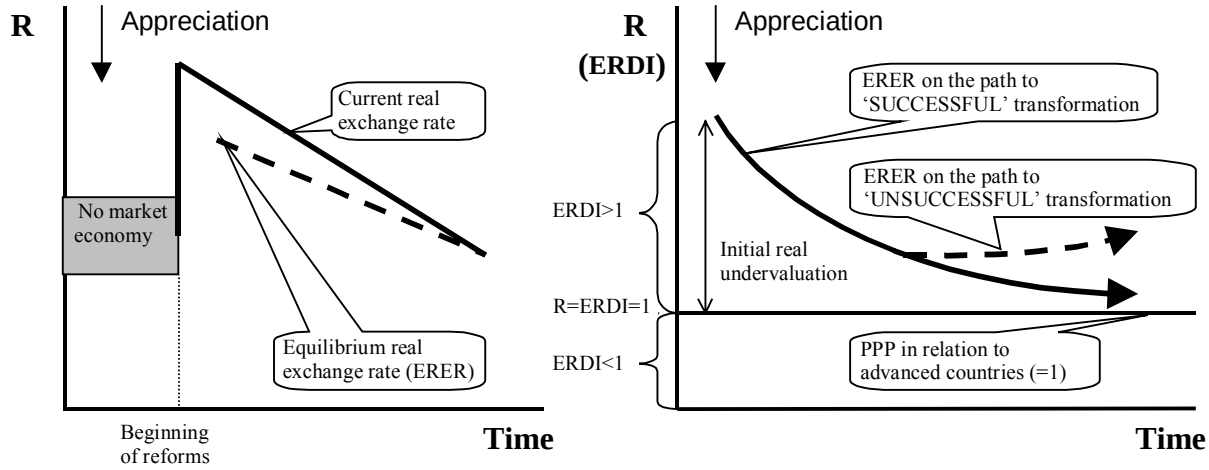
Several years of real appreciation had occurred as two results: (i) gradual corrected of excessive initial devaluation (see above) and (ii) the natural process of convergence of the real exchange rate as a result of the transformation process. This process demonstrates Figure 1

[3] The analysis of determination of the real exchange rate in transitional economies is mentioned in Halpern and Wyplosz (1995), Halpern (1996) or in Czech literature in Kreidl (1997), Lazarova (1997) or Smidkova (1998).

especially the left-hand side, which describe the initial transformation phase[4]. The right-hand side then demonstrates the advanced transformation phase. In this figure is the real exchange rate and also the ERDI (The Exchange Rate Deviation Index)[5] on the vertical axis. Time is on the horizontal axis. The decrease in the index of the real exchange rate (R) is the real appreciation of the Czech Koruna with respect to the direct quotation.

*Figure 1: The theoretical paths of the real exchange rate in transitional economies*[6]

*a) Initial Phases of Transformation* *b) Advanced Phases of Transformation*




***The advanced transformation phase***

The advanced transformation phase will develop if the path of the real exchange rate approaches the equilibrium real exchange rate. This phase is characterised by the existence of an alternative exchange rate scenario with different development for the real exchange rate and the relationship between the nominal and real exchange rate.

This real exchange rate can fluctuate around the equilibrium real exchange rate path. The right-hand side of Figure 1 demonstrates that the trend of the real exchange rate does not have to be only decreasing as in initial transformation phase. If the real exchange rate decreases and it still approaches the unitary value determined by PPP theory, the transformation would be *successful.* This successful transformation is demonstrated by a bold straight curve with a decreasing slope again on the right-hand side of Figure 1.

[4] In respect to growth theory, this movement could be understood as the dynamic path of the leading economy to a steady state while the transitional economy converges with advanced economies. The claim that the declining trend of the real exchange rate is caused by convergence towards the purchasing power parity does not, however, say anything about the character of this trend. For an answer to this question, we must look at the determinants of the real exchange rate (see Chapter 1).

[5] ERDI=E/PPP (The calcualtion for the direct variant of the exchange rate quotation, i.e X units of CZK/ 1 unit of DEM).

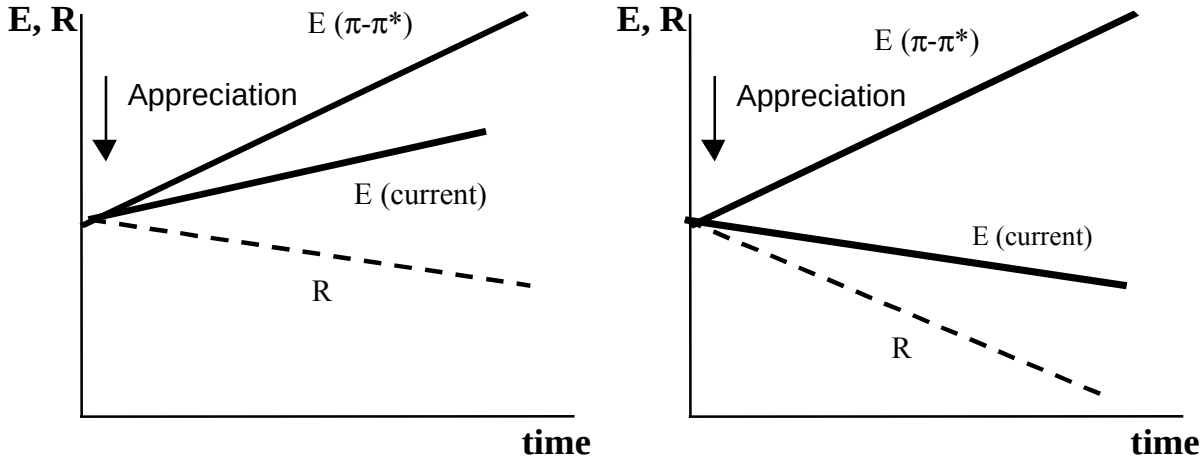
[6] The similar picture as Figure 2.1 (a) presents also Halpern and Wyplosz 1997, p. 437.

Conversely, if the transformation is *unsuccessful*, the reverse trend of real depreciation can occur (a bold dotted curve). This reverse trend will exist for at least several periods until other structural and institutional reforms are implemented. The 'theoretical' end of transformation will be when the real exchange rate is nearly the unitary value determined by PPP theory (a straight line in right-hand side Figure 1).

In the more advanced period the developments in the individual economies might differ significantly. Generally, the success in transition should be confirmed by the appreciation trend that would lead real exchange rate towards purchasing power parity. It seems that on this journey, the individual countries have a certain option of the way how the process evolves. This applies especially for 2 aspects of the process: 1) the speed of real appreciation, 2) the materialisation via inflation or via nominal exchange rate.

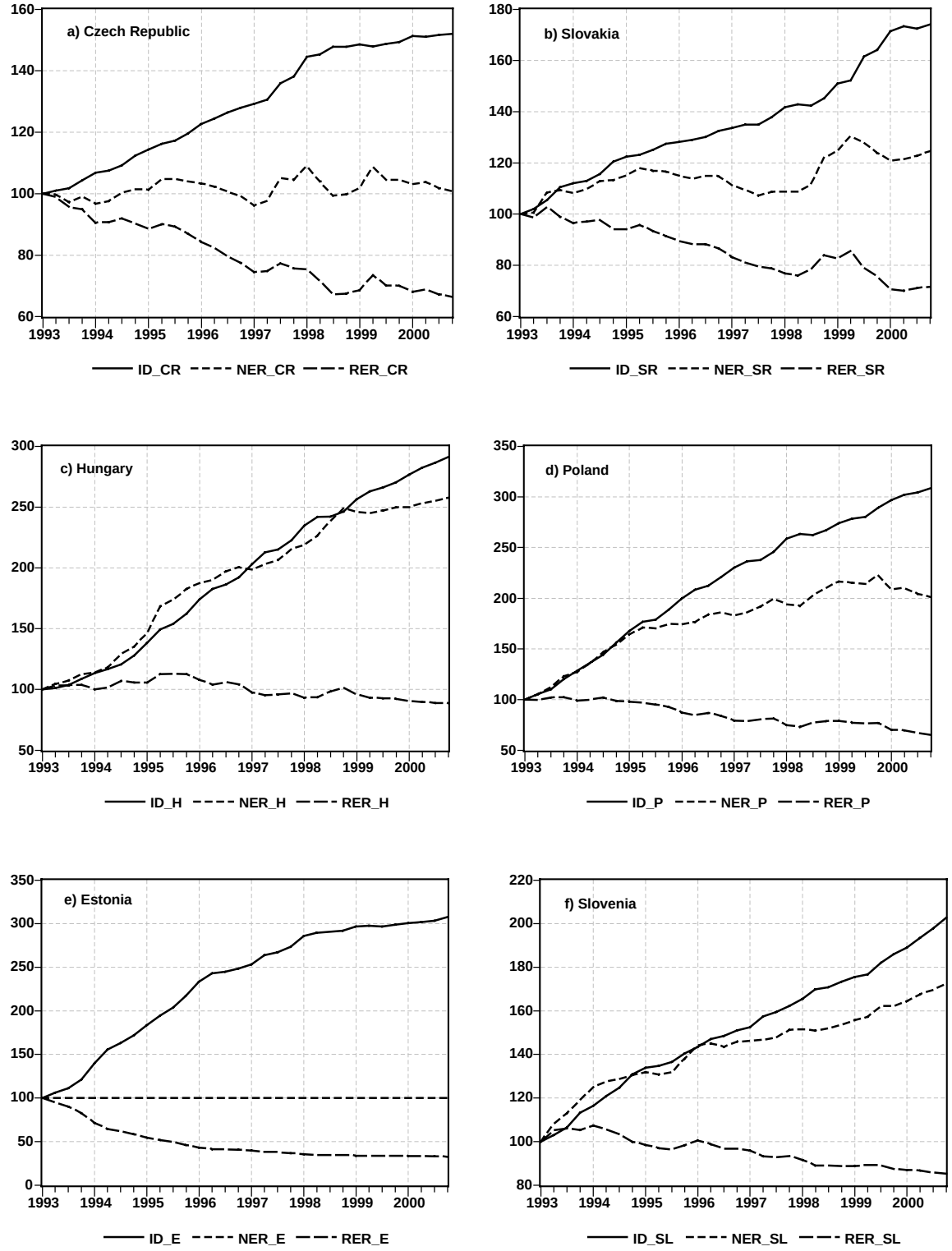
On the theoretical level, the two situations might occur. In the first one, the country runs relatively high inflation and the nominal exchange rate depreciates, even though slower compared to the inflation differential. This creates real exchange rate appreciation. In the second one, the country runs relatively low inflation and the nominal exchange rate appreciates. This would also lead to real appreciation, presumably a faster one. These scenarios describe Figure 2.

*Figure 2: Alternative exchange rate scenarios*




The development of inflation differentials, nominal and real exchange rates of several accession countries are shown in Figure 3.

*Figure 3: Inflation differentials, nominal and real exchange rates of accession countries*




*Source: authors' calculations based on data from the IMF IFS CD-ROM and the Czech National Bank.*

Looking at graphs in Figure 3, we can deduce the following generalisations: (i) Significant nominal exchange rate depreciation prevails in countries that based the policy on the exchange rate flexibility at the beginning of the 1990s - Slovenia, Hungary, Poland. (ii) The countries with fixed exchange rate generally really achieved lower inflation (The Czech Republic, Slovakia, Estonia). (iii) A trend towards real appreciation can be found in all accession countries, even though with profound differences. The strongest one is confirmed in Estonia and significantly applies also to the Czech Republic, Poland and Slovakia. On the other hand, Hungary and Slovenia experienced only mild real appreciation. (iv) Looking at the convergence process, in the last two years real appreciation seems to be rather slow. This suggests that the accession countries face serious structural problems that prevent faster adjustment of their economies. We hope that the following phase of accession effort will be reflected in a faster trend towards real appreciation. (v) Since 1999, there is a clear switch from nominal exchange rate depreciation to nominal exchange rate stability or even appreciation. We argue that, given the political priorities, nominal exchange rate appreciation may become a strong instrument of convergence.

# 4. ANALYSIS OF THE EXCHANGE RATE IN TRANSITIONAL ECONOMIES

Nominal and real exchange rates of transitional economies are influenced by standard and specific factors. Standard factors also influence the exchange rate in highly advanced countries (see Komárek 2000, Frait and Komárek 1999). These include savings and investment, terms of trade, world real interest rates, balance of public finance, foreign debt, foreign direct investment etc. Specific factors are characteristic of transitional countries only. They are composed of processes that are combined with the principle of transformation (i.e. with market development, market deregulation, internal and external liberalisation, relative price changes, etc.). These specific factors are reflected in the long-term exchange rate trends[7].

## 4.1 Exchange Rate Developments in several transitional economies.

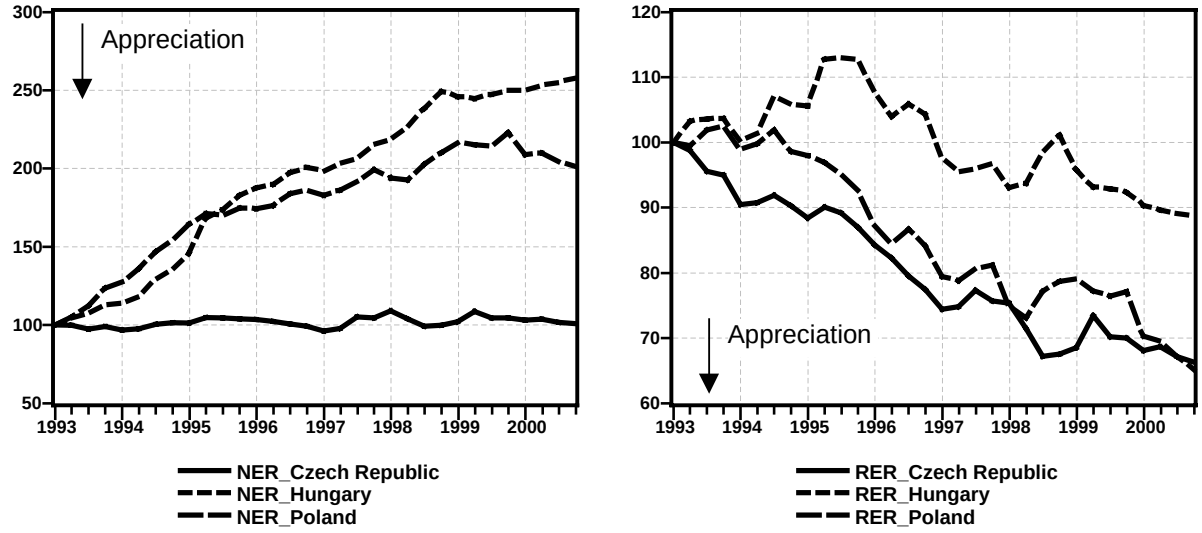
It is interesting to compare the exchange rate policies of the Czech Republic, Poland and Hungary. Even though macroeconomic developments in Poland and Hungary are not without problems, they appear to be more stable than in the Czech Republic. Both neighbouring countries opted for a rather pragmatic approach and flexibly applied a “crawling peg” exchange rate regime. The authorities of the exchange rate regime commit themselves to keeping the exchange rate at a certain level, and at same time, they gradually change this level in a transparent way and with advanced notification. This should fix the market’s expectations and maintain flexibility (for more in-depth descriptions, see Frait, 1999).

[7] The key factor for explaining as well as introducing an exchange rate regime in transitional economies is understanding exchange rate trends.

Figure 4 (left side) clearly shows that while the Czech Republic kept its nominal exchange rate more or less fixed, Hungary and Poland gradually devalued their nominal currencies over time. As in other areas of the economy, it is the real variables that really matter. Figure 4 (right side) further compares the development of the real exchange rates of the three currencies.

*Figure 4: Exchange rates of the Czech Republic, Poland and Hungary*

*a) nominal exchange rates* *b) real exchange rates*




*Source: authors' calculations based on data from the IMF IFS CD-ROM and the Czech National Bank.*

At the beginning of transformation in 1991, all three currencies sharply appreciated in real terms due to an inflationary shock, and they continued to appreciate well into 1993. After this year, development started to diverge. Hungary basically started to fix their real exchange rate, while Poland allowed for mild appreciation. The Czech Republic went in the direction of rapid appreciation of the real exchange rate. All three currencies weakened as a result of uncertainties on international markets, but the real exchange rates returned to their levels during the following months. In the middle of 1998, Hungary and Poland allowed for real depreciation as a reaction to the worsening situation in the world economy and a general weakening of the currencies of transitional countries. The Czech authorities, which were obsessed with deflation, supported real appreciation. It is quite likely that the differences mentioned in the exchange rate policies of the three countries were mirrored in the differences that were seen in real economic activity.

### 4.2 The evaluation of the real exchange rate development in the Czech Republic

***Why does the Czech Koruna's real exchange rate appreciate?***

The long-term decreasing trend of the real exchange rate follows from the figures above, especially from the right-hand side of Figures 3(a) and 4 (right). This trend can be caused by

several factors. They can be reviewed intuitively (see below) or reviewed by an econometric model (see Chapter 8). Real appreciation was apparently caused by the Czech economy's tendency to eliminate excessive devaluation from the end of 1990. During 1993, the exchange rate reverted to the initial pre-devaluation level at the end of 1990. The opinion that devaluation was excessive is not generally maintained.

The real appreciation of the Czech Koruna during 1993–1997 has usually been explained by rapidly rising productivity, which is congruent with the Balassa-Samuelson effect. In our opinion, this explanation is too simplified, because a part of real appreciation can be explained only by developments in industrial productivity. But if we want to explain the whole real appreciation of the Koruna after 1993 by productivity alone, we would have to assume a negative increase in the productivity of non-tradable goods. This, though, would be too strong of an assumption, even if the productivity of some services actually decreased (for example, many services maintained by the government).

In addition to industrial productivity (also the eventual decrease in the productivity of some services), there were a number of factors involved in the real appreciation of the Koruna after 1993. In relation to sustainability and competitiveness, real appreciation was balanced in relation to certain factors, and unbalanced in relation to others.

Equilibrium factors include: (i) favourable development of terms of trade, (ii) an increase in the capital equipment of some sectors and major companies due to investment of international corporations, (iii) an increase in some non-tradable goods due to the need to cover investment costs (telephone and information networks), (iv) overall development of the services sector.

Disequilibrium factors include: (i) a decrease in productivity (for some services maintained by the government) for example judicial services and state administration, (ii) the consumption boom during 1994–96 (positive expectations), (iii) excessive development of the financial sector and other service sectors, (iv) strong short-term capital inflow around 1995, (v) the wealth effect incited by voucher privatisation, (vi) an increase in government spending by using privatisation revenues, (vii) the problematic mix of macroeconomic policy during 1997–1998 which resulted in an increase in real interest rates and an inflow of short-term capital.

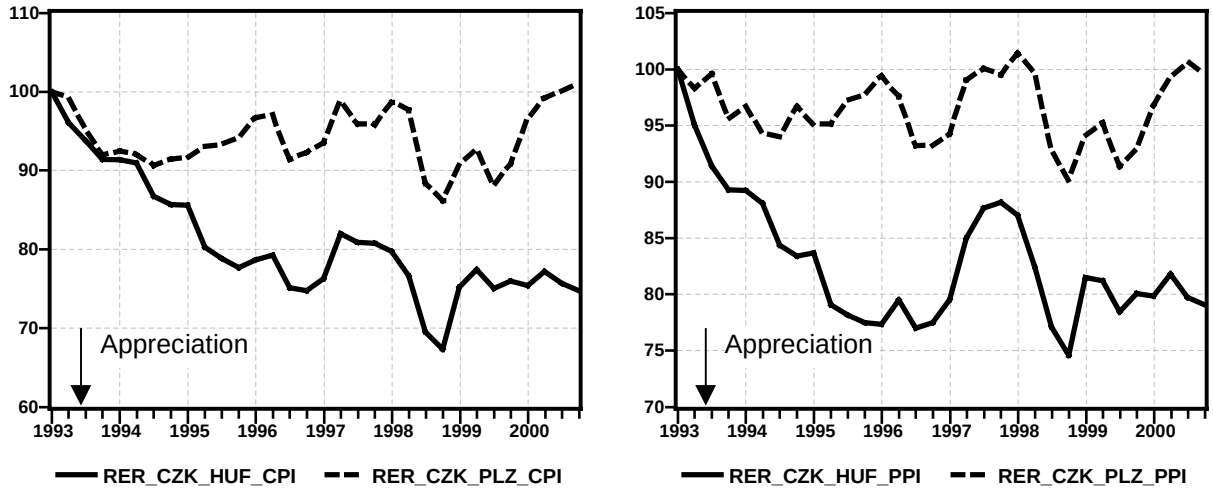
In certain aspects, the authorities tried to prevent even faster real appreciation and an equilibrium adjustment for the internal terms of trade (with price regulation, freeze of nominal wages, subsidies for the consolidation of banks and companies, etc.). By the same token, it is probable that real appreciation could lead to the inverse of the Balassa-Samuelson effect for some companies or sectors. For this reason, it is obvious that any evaluation of the real exchange rate is very difficult in the Czech Republic.

***Was the real appreciation of the Czech Koruna too rapid?***

No definite answer to this question can be obtained with an econometric analysis nor with an intuitive analysis. When applying the Balassa-Samuelson approach only, it would be possible to conclude that real appreciation during 1997-1999 was too fast compared with the productivity differential. The nominal depreciation of the Koruna during 1997 considerably slowed down the trend of real appreciation, but during 1998, the faster trend of real appreciation resurfaced once again. A specific problem can also involve real appreciation of the Koruna vis-à-vis the currencies of its central European partners or competitors, in particular Poland and Hungary (see Figure 5). The initial appreciation of the Koruna in relation to these two currencies can be explained by the different timing of transformation and by the excessive depreciation of the Koruna during 1990. However, rapid appreciation during 1998 cannot be explained so easily.

*Figure 5: The Czech real exchange rates compared with the Hungarian and Polish rates*

*a) for CPI indices* *b) for PPI indices*




*Source: authors' calculations based on data from the IMF IFS CD-ROM and the Czech National Bank.*

We can summarise that real appreciation was evidently too quick during 1996–1998 and resulting real overvaluation might have been one of the reasons for severe recession of the Czech economy during 1998-1999. It could be assumed that nominal depreciation at the beginning of 1999 was a move towards equilibrium level of exchange rate development. Nevertheless, we should warn against any further quick "jump-style" real appreciation of the Czech Koruna, because improvements in the productivity of firms in the tradable sectors have decreasing yields. The assumptions of continued real appreciation (or resumption of successful transformation) are: (i) creating institutional assumptions for restructuring and recovery of companies' investments, (ii) creating investment assumptions for transport infrastructure (without the existence of

corruption), (iii) creating an effective regulatory framework for price estimation of network services, (iv) limiting government support for the losses of companies and banks.

This deduction was made without sophisticated theoretical or empirical analysis. Therefore, we will show the sets of the approaches for the model of equilibrium real exchange rate (see chapter 7), and we will estimate this exchange rate by an econometric model (see chapter 8).

## 5. REAL EXCHANGE RATE AND EXTERNAL COMPETITIVENESS

The real exchange rate is a key indicator of external competitiveness. Real appreciation of the real exchange rate is often interpreted as a loss of price competitiveness. The relationship between the real exchange rate and competitiveness is not one-sided. On the one hand, real appreciation can be interpreted as a decrease in competitiveness. This can occur if the real exchange rate becomes overvalued in relation to the equilibrium real exchange rate. On the other hand, real appreciation can reflect increasing competitiveness (due to an increase in productivity). It can be concluded that the changes in the real exchange rate have to be studied in the context of fundamental determinants. Only then can it be determined whether real appreciation is caused by a decrease or increase in competitiveness.

Evaluating the influence of real exchange rate changes on competitiveness is further complicated by the fact that tradable goods are not homogenous. If this happens, then the origin and the effective use of the given goods will not be important. As most tradable goods are not homogenous, it is necessary to examine the competitiveness of domestic goods with respect to the main trading partners, different world regions and different groups of producers. The real exchange rate can develop differently in relation to individual countries even if competitiveness towards these countries remains the same. The competitiveness of a country in sectors depends not only on the real exchange rate but also on the productivity of the sector among countries, the structure of customs duties or the relative prices of each economy.

There is another issue that is important primarily for transitional economies. On account of an increase in productivity in the individual sectors, the countries change over to more sophisticated commodity groups with stronger competition. This higher productivity of the countries, of course, does not automatically mean higher competitiveness nor does it justify real appreciation, because the countries compete at different levels than before. The countries accommodate easier to higher commodity groups if they have relatively weak exchange rates. Therefore, authorities (central banks and governments) of transitional countries have to observe how fast the real exchange rate appreciates and whether this appreciation does not obstruct the competitiveness of the perspective, traditional sectors as well as newly developing sectors.

A typical problem faced by a transition economy is linked to the move to the more sophisticated product groups with tougher competition. Under this process, the higher productivity may not imply higher external competitiveness and also may not justify stronger real

exchange rate because the producers are forced to compete on a very different level than before. In other words, it is much easier to penetrate to higher product leagues with relatively undervalued currency than with relatively strong one.

## 6. REAL EXCHANGE RATE, DOUBLE-SPEED ECONOMY AND DEINDUSTRIALIZATION

The discussion about sustainability of the real appreciation in transition economy may be complicated by the phenomenon of the so-called double-speed economy. This term is used to describe the situation when there are two different sectors in the economy. The first one is the sector comprised of dynamic companies usually with foreign ownership ("new" sector henceforth) and the second sector is the one comprised of the traditional companies owned by the local investors and government ("old" sector henceforth). Trend for the real appreciation is in line with the performance of the foreign sector and we may say that it is caused by it (through the capital inflows to the sector and its export capability). In theory, the part of the old sector should adjust to the new sector by an increase in productivity, and the rest that is not able to do so should leave the market. In the reality of the transition economy with its weak institutional framework (barriers to bankruptcies, poor court performance, prohibitive transaction costs, week financial system etc.), the inefficient domestic firms are not often able to increase productivity and lower costs (and often they are not motivated to do so), they are not thus forced to leave the market and through the bank system and government bailouts they burden extra cost on the relatively efficient firms.

Taking into account the links between both sectors, the excessive cost structure and low competitiveness may be transferred from the old to the new sector. In the long run the situation in both sectors may deteriorate and the economy may suffer from low growth and lack of convergence. The trend towards real appreciation may thus have rather asymmetric effects in the economy and some these effects can motivate the policymakers to slow down the real appreciation process. However, this may turn to be rather counterproductive especially in periods of strong FDI inflows aimed at green field investments. The new capacities in the new sector require not only capital and management skills, but also trained employees. If these employees are kept in the old sector by the means of structural and industrial policy, the restructuring process is being artificially delayed and its cost are higher than necessary. This suggest that the real exchange rate policy in the accession countries might be a razor's edge one with the run between the risks of losing competitiveness and losing the momentum in restructuring.

At this point, we should also stress the relation between the changes in real exchange rate and deindustrialisation of the economy. This is a typical feature of the transition economy given on one hand the need for reduction in size of production of „socialist style" industrial conglomerates and on the other hand desired development of the services industries. Deindustrialisation itself is not a negative process and the real appreciation is not usually a prime cause of it. Generally, both

deindustrialisation and real appreciation are simultaneously determined by the productivity gains in industrial production (Rowthorn and Ramaswamy, 1998; Tatom, 1992). However, in a certain point of time, it is rather difficult for the policymakers of transition countries to tell whether the actual deindustrialisation trends reflect the equilibrium potential growth in productivity or unsustainable disequilibrium real appreciation. This is another challenge for the central bank policy.

## 7. BEHAVIOURAL MODELS FOR THE REAL EXCHANGE RATE

The current account and the capital account determine the real exchange rate, which reflect the tradable position on the world market and also the tendency to be a world debtor or a creditor. The interaction between the permanent structural components of the current account and the capital account determine the long-term real exchange rate. On a concrete level, we can identify many factors that can determine the evolution of the real exchange rate. These fundamental factors include the determinants of net foreign assets and also all factors that determine the current account.

The present analysis of the real exchange rate is divided into two main branches. Various terms are used for these branches. We prefer to use the terms *fundamental* and *behavioural*. *The fundamental models* are used in particular for the objects of macroeconomic policy. The most applicable fundamental concept is called the Fundamental Equilibrium Exchange Rate (FEER). Williamson (1983 and especially 1994) demonstrated this. The models include the effect of normative economics, and they work with a relatively shorter-term horizon. *The behavioural models* are only of secondary importance to macroeconomic policy. They include the effect of positive economics and work on a relatively longer-term scale. In many respects, both approaches have parallel characteristics and parallel modelling procedures. The behavioural models are analysed in this chapter. The next chapter constructs the econometric behavioural model of the equilibrium exchange rate, whose core is the behavioural approaches presented in this chapter.

Included in the behavioural models are the Behavioural Real Exchange Rate supported by Clark and MacDonald (1998), the Natural Real Exchange Rate (NATREX) popularised especially by Stain and Allen (1995), the Long-run Equilibrium Real Exchange Rate from the flow and stock point of view presented by Faruqee (1995) and Edward's equilibrium real exchange rate (see Edwards, 1988). The increase in popularity of the behavioural approaches is given by the condition that, with a longer time series, new econometric methods and with correctly defined models, the behaviour of the real exchange rate can be better explained by means of fundamental factors in a reduction form[8]. The behavioural models do not embrace the

[8] The behavioural models usually identify the group of exogenous fundamental variables, which determines the internal and external balance. The reduction form, which connects the real exchange rate with these determinants, is thus derived. On this account, we do not need to search the competent sustainable levels of the current account and the external position, because they are endogenous to the system.

equilibrium real exchange rate from the point of view of internal and external balances, but rather from a point of view consistent with the relevant variables. The secondary target is to calibrate the explicative variables on a sustainable level and to review the sustainability of the current real exchange rate from the macroeconomic policy point of view.

### 7.1 The Behavioural Equilibrium Exchange Rate

Clark and MacDonald (1998)[9] present the concept of the real exchange rate, which they denoted as *the Behavioural Equilibrium Exchange Rate* (BEER). The BEER is the real exchange rate estimated by means of the reduction model form. This form is based on the following type of equation:

$$r_t = \alpha Z_1 + \beta Z_2 + \gamma T + \varepsilon \qquad = r^E + \gamma T + \varepsilon, \qquad (5a)$$

where $r_t$ is the actual (current) value of the real exchange rate, $Z_1$ is the vector of the fundamental determinant, at which a long-term persistent effect can be expected, $Z_2$ is the vector of the fundamental determinant with a medium-term effect (e.g. consistent with the course of the cycle), $T$ is the vector of temporal factors with a short-term effect and ε is random error. We must differentiate the actual (current) level of the real exchange rate $r_t$ from the actual (current) equilibrium level of the real exchange rate $r^E$, which is given by the present values of both groups of fundamental determinants:

$$r^E = \alpha Z_1 + \beta Z_2. \qquad (5b)$$

Since those current values of fundamental determinants can be different from the sustainable or desirable levels (conforming with the FEER), it can be defined as the sustainable equilibrium level of the real exchange rate $r^F$, which is based on persistent long-run levels of fundamental determinants ($Z^F_1$ a $Z^F_2$):

$$r^F = \alpha Z^F_1 + \beta Z^F_2. \qquad (5c)$$

The problem of this concept is evidently the identification and choice of short-term factors, medium-term and long-term fundamentals and the calibration of the sustainable values of these fundamentals.

MacDonald (1997) divides the determinants of the real exchange rate into two groups. The first group is called *the fundamental factors exclusive of real interest rates*, i.e. group $Z_1$. We can insert, in accordance with the description of dependencies above, terms of trade *tot*, the sectors or aggregate productivity[10] *prod*, the balance of public finance *fisc*, net private savings *sav* and net

[9] The model, which we would like to present is a combination of two very similar studies (MacDonald 1997; Clark and MacDonald 1998). These two studies are logically synthesised in that several fractional measures of the real exchange rate and inconsistency are supplementary derived.

[10] Productivity is often comprehended as the internal terms of trade *tnt* calculated as the PPI/CPI.

foreign assets *nfa*[11]. Improvements in all of these factors would make the domestic currency appreciate in the long run (leading to an increase in the real exchange rate).

The second group ($Z_2$) logically reflects the real interest differential (RID), which, in turn, reflects the condition of real uncovered interest parity[12]:

$$r_t = r^e_{t+k} - (i_t - i^*_t) + \sigma_t = r^e_{t+k} - (i_t - i^*_t) + (\lambda_t + k) \qquad (6)$$

where $r^e_{t+k}$ is the expected real exchange rate in time t+k, *i* is the *ex ante* real interest rate, $\sigma_t = (\lambda_t + k)$ is the risk premium on the domestic currency with a time variable component and a component that is given by maturity. The symbol t+k defines the maturity of the bond. Equation (6) described the current real exchange rate as the function of the future expected real exchange rate, the real interest differential and the risk premium. We can think of the risk premium as a positive function of the relative supply of domestic and foreign debt $s_t = (debt_t/debt^*_t)$. This is congruent with the theoretical literature undertaken by the portfolio models of the exchange rate. An increase in domestic debt supply in relation to foreign debt supply thus increases the risk premium, which requires devaluation of the current real exchange rate.

The BEER model is suitable as the base for econometric analysis. We can now derive the BEER owing to the fact that the unobservable expected real exchange rate in equation (2) is considered to be the real exchange rate determined by the long-term fundamentals $Z_{1t}$. Therefore, we can approximate this real exchange rate by the long-term element of the equilibrium real exchange rate $r^L$:

$$r^L_t = r^e_{t+k} = \alpha Z^e_{1t} = \alpha Z_{1t} \qquad (7)$$

Thereafter, it holds that the actual equilibrium real exchange rate is given by the following relationship:

$$r^E_t = r^L_t - r^S_t = r^L_t - [(i_t - i^*_t) - \sigma_t]. \qquad (8)$$

The general BEER equation ($r^E_t$) can be rewritten in this form:

$$BEER = r^E(tot, prod, fisc, sav, nfa, i\text{-}i^*, debt/debt^*). \qquad (9)$$

As long as the systematic relationship exists between the real exchange rate and the basic fundamental factors, then the variables are cointegrated, and the BEER, obtained by their estimate, can be thought of as the equilibrium real exchange rate in the behavioural meaning[13].

[11] NFA is the magnitude determined by the determinants of national savings and investment, e.g. especially by demographic factors or by fiscal policy. The convenient approximation is net foreign debt modified by fiscal data.

[12] The first group of factors represents the long-term determinants while the real interest differential generates short-term and medium-term dynamics.

[13] This version of BEER is very simple. It would be suitable to incorporate other equations into this equation, which would connect, for example, the existing government debt with fiscal deficits or fiscal deficits with the current account. These equations could be connected with other variables, which would definitely be sustainable in the sense of the flow of the internal and external balance. This system should have the characteristics of the BEER as well as the FEER.

With respect to the methodology used, it can be said that deviations of the actual real exchange rate from the BEER are not sustainable in the long run, because the cointegration of relationships sometimes brings the real exchange rate back to the trajectory, which corresponds to long-term sustainable factors[14]. The result is that the level of the actual real exchange rate is sustainable if and only if the values of the fundamental factors are sustainable.

It also holds that the BEER does not identify which of the fundamental factors are sustainable and which are not. If needed, it would be necessary to calibrate the fundamental factors on the medium-term sustainable level, which show appurtenances of the FEER without losing the valuable appurtenances of the BEER. This instrument makes it possible to calculate total misalignment. We can calibrate relatively simply the factors, which ensure the internal balance – low inflation and potential income. However, the calibration of fundamental factors is very difficult for the external balance. The reasons for this are twofold. Firstly, the model is established on the uncovered interest rate parity (there we do not know for sure the external financial limitation). Secondly, the model includes the readjustment mechanism in which the real exchange rate in the long run reacts to changes in government debt and to net foreign assets.

Clark and MacDonald (1998) estimate the BEER for the USA, Japan and Germany. They use the annual time series during the period 1960–1996 by means of the Johansen methods. MacDonald (1997) used a similar approach with the expectation of the quarterly time series. From the tests, it can be concluded that the majority of deviations in the real exchange had been caused by fundamental factors. The idea that real exchange rates had developed imbalances is also confirmed. The calibration of sustainable values was practised by means of the Hodrick-Prescott filter. The possibility of estimating *ex ante* the equilibrium real exchange rate was indicated by virtue of some assumptions about the development of public finance and net foreign assets.

One problem with the BEER is that it reflects the long- and medium-term factors. If we would like to look at misalignment from the long-term point of view, then we must also exclude the medium-term factors from the analysis (the real interest differential and risk premium). Under these assumptions, the BEER would be close to the other measure of the real exchange rate, which is called the NATREX.

### 7.2. The Natural Real Exchange Rate

Stein and Allen (1995) defined another approach for modelling the real exchange rate, which they called *the Natural Real Exchange Rate* (NATREX). The real exchange rate interacts with

[14] Clark and MacDonald (1998, page 33) in this connection refer to the appreciation of the USD in the 1980s. The BEER explains only part of this appreciation. The inexplicable part of this appreciation is considered to be inconsistency, because it does not reflect the identifiable economic factors embedded in the model, but rather the unobservable temporal and circumstantial factors. Rapid appreciation of the USD can be regarded as a non-equilibrium incident, because the current real exchange rate returns back to the BEER whose trajectory was moved closer to the trajectory of the current real exchange rate in 1987–1996.

the NATREX approach by relating to the current account and capital account. The capital account that is primarily determined by productivity and by savings interacting with the current account and the current account thereafter interacts with the real exchange rate. The emphasis of the NATREX is on the stock equilibrium, because the steady state develops in a situation when domestic capital stock and net foreign assets are in long-term equilibrium values. The NATREX is the long-term equilibrium ER, which is equal to the balance of payments in the absence of cyclical factors, speculative capital flows and changes in monetary reserves. This is a fluctuating medium- to long-term real exchange rate, which is determined by real fundamental factors. Between these factors, we can insert thrift (savings)[15], productivity, and facilities of labour by capital and foreign debt (and for small, open economies also exogenous terms of trade and world real interest rates), which influence desirable long-term capital flows and change the equilibrium real exchange rate. The actual real exchange rate then accommodates to the equilibrium real exchange rate.

In contrast to the FEER, the NATREX is a positive conception. It is the equilibrium real exchange rate which is determined by real fundamental factors and existing macroeconomic policies. These policies do not need to be optimal, and the NATREX therefore does not need to be the optimal real exchange rate from a societal point of view. The NATREX is based on the explicit modelling of the equilibrium real exchange rate according to the development of their determinants. On the contrary, the FEER is based on the modelling of the current account with the intention of identifying the statistically consistent relationship between the current account and the real exchange rate.

The NATREX is concentrated on the change of savings, investment and long-term capital flows, and then causes changes in physical capital stocks, foreign debt and wealth to show up in the changes in the fluctuating equilibrium real exchange rate. One of the key aspects is emphasis on the trajectory of the real exchange rate, i.e. distinction of the initial and long-term effects of changing the fundamental determinants on the equilibrium real exchange rate. In this sense, the NATREX begins similarly as in the Edward's model (see Edward, 1988), with the definition of the fundamental determinants of the real exchange rate and thereafter precedes it in order to establish the long-term implication of savings, investment and capital flows.

The models of the NATREX started in some hypothetical intracyclical medium run where prices are confirmed and real income returns to its intracyclical potential levels[16]. The medium-term equilibrium is an artificial construction, to which the economy orients itself, though, which never really occurs. For this reason, we can not observe the NATREX, but only the current real exchange rate, which adjusts itself to the NATREX. The medium-term equilibrium can be described by the following equation:

$$I - S + CA = 0, \qquad (10)$$

[15] Thrift (rate of savings) has the same meaning as the rate of time preference in growth theory.

[16] This medium-term equilibrium corresponds to the long-term equilibrium in the monetary models.

where *I* is intended investment, *S* is intended savings and *CA* is the intended current account. All of the variables are gauged. When real output reaches the potential level, inflation reaches its expected level and the real exchange rate clears the goods and services market. From these assumptions, we can expect equilibrium in the goods and service market and also in the balance of payments.

Intended investments and savings (which are independent of the real exchange rate) are connected with the existing stock of capital, net debt towards foreign countries and wealth. Investment (I), savings (S) and net capital flows (I - S) produce changes in the stock of physical capital (k), net foreign debt (F) and wealth (W = k - F). These changes then change intended savings, investment and the current account. All of these, in turn, have an impact on changes in the real exchange rate. The exogenous changes of fundamental determinants (Z), i.e. the changes in the propensity to saving, productivity, the terms of trade and foreign real interest rates (s, a, tt, i*)[17], influence the NATREX in two way. Firstly, they change *I, S* and *CA*, which cause short-term NATREX changes. Secondly, they change the rate of accumulation of *k*, *F* and *W*, which change also the NATREX trajectory (it shifts to a new long-term level). The NATREX is the function of the exogenous (Z) and endogenous (X) determinants at all point other than the long-term equilibrium. The complete model of the NATREX determines the medium-term equilibrium real exchange rate (R=NATREX), its consecutive trajectory and also any long-term equilibrium real exchange rate in a steady state ($R^{\Theta}$). However, the economy is permanently exposed to fundamental shocks, which direct the NATREX to a new equilibrium level, and a steady state is never reached. In other words, the equilibrium real exchange rate is not stationary, because its fundamental determinants are not stationary.

The real exchange rate can be described in three phases:

$$R_t = R_t(Z, X, C) \qquad (11a)$$

$$R = R(Z, X) \qquad (11b)$$

$$R^{\Theta} = R^{\Theta}(Z), \qquad (11c)$$

where *C* represents short-term cyclical and speculative factors. We are able to estimate the real exchange rate on the trajectory between *R* and $R^{\Theta}$ as the function of exogenous fundamental factors (even though we can only observe $R_t$)[18]. Hence, the empirical estimate is the simultaneous

[17] The terms of trade can be temporarily endogenous in a transitional economy, while the exporters reach higher prices by reason of marketing improvement, a stronger position, raising the quality, etc., or while the importers negotiate lower import prices due to more experience, higher credibility, etc.

[18] From the theoretical point of view, the NATREX is the moving equilibrium on the trajectory to a steady state. Every new shock changes the long-term equilibrium and also the NATREX trajectory. Even though the economic agents fully understand the economy structure and know with certainty the trajectory which corresponds to the current fundamental factors, they cannot forecast the future changes of the NATREX. The reason is that they cannot forecast the future changes of fundamental determinants. From the empirical point of view, the estimated change in the RER equals zero, and this expectation has *de facto* zero value in the NATREX models, because the fundamental shocks are non-stationary.

test that the NATREX (R) moves towards $R^{\Theta}$. This can be explained by the fundamental factors $Z$ in accordance with the theoretical assumptions of the model and also that $R_t$ changes to a fluctuating R. For another description of the NATREX trajectory in reaction to the changes of fundamental determinants, see for example Stein and Allen, 1995 or Frait and Komárek, 1999. Lim and Stein (1995) present the NATREX model for a small, open economy (Australia).

### 7.3 Other Variants of the Behavioural Models

Faruqee (1995) analyses the long-term equilibrium real exchange rate from the flow and stock point of view, which has some parallel characters with the NATREX. The real exchange rates of the USD and JPY are modelled on the Johansen method in the empirical part of this working paper. We use them for modelling terms of trade, net foreign assets and productivity. Feyzioglu (1997), in the case of Finland, applied a similar model by means of the Johansen method. In contrast to our study, Feyzioglu worked with the foreign real interest rate instead of net foreign assets.

We can add to the behavioural models works written by Edwards (1989) and papers referring to his work, e.g. Elbadawi (1994), Haplern and Wyplosz (1997) or Lazarova and Kreidl (1997).

Elbadawi (1994) models the real exchange rate for Ghana, India and Chile. He used terms of trade, the measure of openness, net capital flows in relation to GDP, the share of government spending in GDP and the growth rate of export. Elbadwi applied the simple Engle-Granger method of cointegration. He estimated the cointegration vector by means of the Ordinary Least Square (OLS) method, and then he obtained through the medium of the Beveridge-Nelson decomposition the permanent part of fundamental determinants and also their sustainable values. The difference between the estimated equilibrium real exchange rate and the actual level of the real exchange rate is denoted as a misalignment. Furthermore, he estimated the short-term Error Correction dynamics, including macroeconomic policies and market disturbances, which are not in the group of fundamental factors.

Haplern and Wyplosz (1997) estimated the equilibrium real exchange rate for the former socialist economies. Real appreciation rises due to an increase in productivity, elimination of intersectoral imbalances in the labour market and distortion in the capital market. This model includes too many a*d hoc* specifications, because it is related to earlier transformational phases. Conclusions pointed more to monetary policy management than to debates about price competitiveness and the external balance.

Lazarova and Kreidl (1997) used the Edward's approach in the case of the Czech Republic for 1990–1996. They chose defining variables of the real exchange rate such as: terms of trade, the share of government spending in GDP, capital inflows, GDP growth, the relationship of investment to GDP, an increase in domestic credits and nominal devaluation of the Czech Koruna. They used the calculated parameters together with fundamental factors and

approximated values obtained on the basis of the Hodrick-Prescott filter for the estimation of the equilibrium exchange rate.

# 8. AN EMPIRICAL ANALYSIS OF THE EQUILIBRIUM REAL EXCHANGE RATE FOR THE CZECH REPUBLIC

## 8.1 Characteristics of the Approach

The empirical model that estimates the equilibrium real exchange rate is a combination of the *Natural Real Exchange Rate* (NATREX) and *the Behavioural Equilibrium Exchange Rate* (BEER) approaches, though aspects of the NATREX are more prevalent. Estimating the BEER model type is limited by the fact that we are not able to construct the long-term interest rate differential, and that the quality of Czech financial data is lacking. Similarly, when we try to apply our model to several transition countries, lack of quality data (especially terms of trade and GDP) block our efforts.

For this reason, only four factors and only for the Czech Republic are used, which are also included in the NATREX*: terms of trade, productivity, world real interest rates and foreign direct investment.*[19] We standardise on a unitary base the exogenous foreign component of the real exchange rate $P^*_N/P^*_T$ from equation (4). This simplification is justified in respect to keeping the model from becoming too complicated. It will be necessary to work with the foreign component in the future when the longer time series is scaleable.

For the empirical analysis, we use quarterly data from 1993:1 to 2000:4. It would be more suitable to use semi-annual or annual data. The short history of the Czech economy does allow us to proceed in any other way. Nevertheless, we have 32 observations, which for cointegration is an extremely short time series that limits and strongly complicates our econometric efforts. The other restrictive factor is approximating productivity and savings.

It is also supposed that some structural breaks could occur during the monitored period. The reason can be, first and foremost, that the assumption of our behavioural model is the relatively high mobility of capital. For this reason, our model would be applied to the Czech Republic as of 1995, when the capital account was more liberalised. The Czech economy began to embody standard macroeconomic behaviour. We also suppose that the application of our model to the data coming in before 1995 has a special methodological reason and its practical nature would be useful only after several years.

A question can also be raised concerning the switch from a fixed exchange rate regime to a floating regime. The exchange regime is not essential for determining the equilibrium real

[19] Our aim was also to avoid data mining and the *ad hoc* specification used by Halpern and Wyplosz (1997).

exchange rate, because exchange rate expectations are irrelevant. Exchange rate regimes influence the speed by which the real exchange rate is regressing to its equilibrium level[20].

### 8.2 Time Series

Thereafter, quarterly data for the period from 1993:1 to 2000:3 were used for the estimate. With the exception of the real interest rate, the time series was transferred to the indices and converted into logarithm form. The following time series was used:

*1. The real exchange rate (r)* – the index of the CZK/DEM exchange rate, deflated by the relevant consumer price index (CPI). The quarterly indices were obtained by averaging the monthly indexes.[21] The decrease in the index is real appreciation of the CZK with respect to the direct quotation.

*2. Terms of trade (tot)* – the standard ratio of the selective export and import indices[22].

*3. Productivity (pr)* – the seasonally adjusted quarterly index of real GDP in 1994 prices (CSO database). The approximation of this factor is an issue for all empirical studies relating to the real exchange rate. From a theoretical point of view, the estimate of total productivity factors should be introduced separately for tradable and non-tradable goods. The first solution is to use the sector productivity of labour (in industry). The second solution is to approximate total labour productivity for the whole economy by real GDP per capita. Both solutions were explored. For the construction of productivity, we were faced with the problem of not having a consistent time series in industry (the CSO changed its methodology many times). For the construction of the GDP index, we also had to deal with the problem of the quarterly index of employment not being the same for the whole period. Since the number of employees did not significantly change, the use of the GDP index was not a great complication. We do not think that real GDP can be strongly endogenous to the real exchange rate nor that it would allow differentiation of productivity.

*4. The rate of savings (s)* – the gross rate of savings obtained from nominal GDP[23] as an approximation of savings. The calculation was made from quarterly data calculated on an annual basis. This approximation is also not very appropriate. It would be better to use the rate of savings from disposable income in the Czech Statistical Office's methodology or the rate of financial savings in the Czech National Bank's methodology. These time series are available only in an annual format. Furthermore, we are sceptical about the quality of basic fundamental data,

[20] An important finding from the empirical application of the NATREX approach is that in a flexible exchange rate regime, the real exchange rate returns back to the equilibrium more rapidly, and the fundamentals factors affect it more directly than in a fixed exchange rate regime.

[21] These indices were computed from the nominal exchange rate (The Czech National Bank database), the Czech consumer price index (The Czech Statistical Office database), the German consumer price index (Deutsche Bundesbank Web) and the American consumer price index (The New York FED Web). The decrease in the index is the real appreciation of the CZK with respect to the direct quotation.

[22] The Czech Statistical Office database.

[23] The Czech Statistical Office database.

because the rates of savings register quite large jumps that are difficult to interpret from the economic point of view. This variable does not work out very well.

*5. The world real interest rate (i)* – the index of quarterly average 3-month LIBOR rates for the DEM deflated by the index of quarterly averages of the consumer price index one period in advance[24]. It would be preferable to use long-term interest rates. However, MacDonald (1997) proved that the choice of short- or long-term interest rates does not play an important role for the DEM or USD.

*6. The foreign direct investments (fdi)* – the percentage ratio of foreign direct investments and nominal GDP calculated from 4Q moving averages.

The present cointegrated equation of the real exchange rate is based on the following form:

$$r = f(tot, pr, s, i, fdi). \qquad (12)$$

We also experiment with the other economic factors – excluding the variables mentioned in the last equation – which are used in the empirical analysis of the real exchange rate. Since setting the relative real interest differential is practically impossible, we try to use the nominal interest differential. Its impact on the real exchange rate does not appear statistically significant. The explanation in our opinion concerns the fact that there is a bilateral relationship between the real exchange rate and nominal interest rates: the nominal exchange rate is contained in the central bank's target function and reaction function, and exchange rate policy is implemented through interest rates. In addition, several fundamental changes have occurred in Czech exchange and monetary policy. It can be said that Czech interest rates react to nominal development of the exchange rate in variable and asymmetric time series. The relationship between nominal interest rates and exchange rates is hard to identify in this situation.

We likewise try to identify the relationship between foreign indebtedness and real exchange rates. We used gross foreign indebtedness or the net investment position. This relationship also indicates low significant as well as the wrong sign. We suspect that the reaction of the real exchange rate to changes in foreign indebtedness is slow, its dynamics are problematic and there is a medium-term endogenous relationship between both variables. The short-term and long-term effect can often be the inverse of the long-term effect. This long-term effect is achieved more by way of annual data (see Clark and MacDonald, 1998).

Before we started the econometric analysis, we scanned the existence of unit roots in all time series. As a result of the unit root tests, we discovered that all time series, except the saving rate, are really integrated by level one, and that they are stationary in the first differential. According to the ADF test, the savings rate is integrated by the level zero. We also performed the Phillips-Peron test, which, on the contrary, does not reject the existence of the unit roots in the level rank. In regard to the length of the time series and also to their described quality above, the

[24] IMF IFS CD-ROM.

determination of the level of integration is very controversial. In another analysis, we expected that all the time series have the character I(1) or we can work without the savings rate. In this paper we chose the second variant.[25]

### 8.3 Estimation of the cointegrated equation

A number of methods can be used for the cointegration analysis. The simplest is the two-step method, which was suggested by Engle and Granger. Taking the controversial aspects of this method into account (see Enders 1995, p. 385), we decided not to use it, even though the results of estimating the cointegration equation and also the error correction equation turn out well. We further try to choose between the Johansen method (Johansen, 1988), the ARDL method (Pesaran et al, 1996) and the dynamic OLS method. The application of all methods is complicated by very short time series. For these reasons, our objective is not only to test the chosen model, but also the method that would be best for the existing time series.

The advantage of the ARDL method is that the long-term relationship between the selected variables can be directly identified. It enables us to avoid the problem of the Johansen method that arises when more than one cointegrated vector is found. The other advantage of the ARDL method is that this method can be used irrespective of whether the regressors have the character I(1) or I(0). This is very useful, especially for small samples where the traditional test of unit roots is very weak. The method involves two steps. In the first step, the existence of a long-term relationship is tested by the calculation of the F-statistic, which suggests the significance of the lagged level of variables in the error correction form of the basic ARDL model. For the non-standard separation of this statistic, the authors of this method offer the competent critical values as two sets for the different systems (from the viewpoint of classifying the constant and trend). One set assumes that all variables belong to the I(1) type, and the other estimates assume that all variables belong to the I(0) type. As long as the value is out of the range of their two values, the decision can be made without knowledge of the integration of the time series. If the value is in the range of these two values, a specific result cannot be obtained. It would then be necessary to test the unit root and the cointegration by the standard process. The second step for this method is the estimate of the coefficient of the cointegrated equation and the error correction equation with the application of OLS to ARDL.

The estimated result for the ARDL method is mentioned in detail in the Appendix. The estimated results when applying the Johansen method, the ARDL method, and the dynamic OLS method are similar to the ARDL estimation belowe. All the coefficients in the cointegration equation have the correct signs and have a 5 % significance level.

$$R = 260 - 0.48\,tot - 0.39pr - 1.52\,fdi + 3.96\,i \qquad (13)$$
$$(28.27)\quad (0.215)\quad (0.879)\quad (0.349)\quad (1.513)$$

[25] Our previous estimations work with the first variant – see Frait and Komárek (1999) or Komárek (2000).

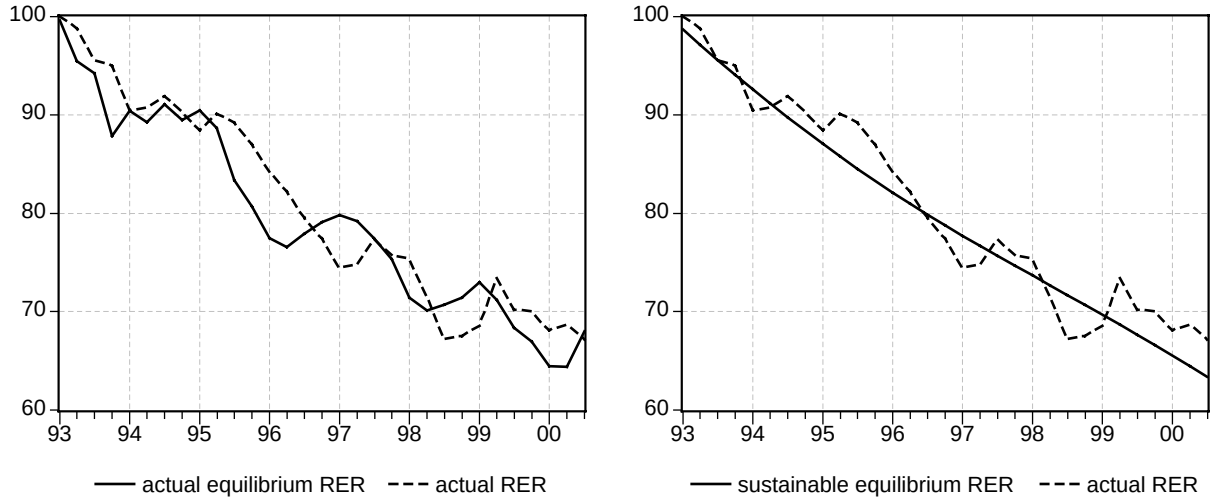
The tests of serial correlation, functional form, normality and heteroscedasticity also work out favourably. Globally, we believe that the estimate of the equilibrium real exchange rate equation by way of the ARDL method is preferable. Finally, we can say that the real exchange rate is determined in particular by real fundamental factors, e.g. productivity, terms of trade and world interest rates as well as one transitional variable: foreign direct investment.

### 8.4 The Misalignment of the Real Exchange Rate

The aim of this simulation is not to establish how exactly the Czech Koruna is overvalued or undervalued. Rather, we are trying to determine if the current real exchange rate trend is consistent with the equilibrium real exchange rate path. By using the equilibrium component of the real exchange rate through the ARDL method (Figure 6) we can try to compare the evaluation of the actual real exchange rate and the equilibrium real exchange rate. With the BEER approach, we will distinguish between two types of deviation, i.e. misalignments. The first deviation will be the short-rum *current* misalignment (speculative), which is determined by the deviation of the actual real exchange rate from the *actual equilibrium real exchange* rate which is estimated by virtue of the actual values of the fundamental determinants.

The second deviation will be the medium-run *total* misalignment (cyclical and speculative) determined by the deviation of the actual real exchange rate from the estimated *sustainable equilibrium real exchange rate* based on the sustainable values of fundamental determinants. We proceed with the conversion of sustainable values as the most significant part of the published analysis of the equilibrium real exchange rate, i.e. by means of applying the Hodrick-Prescott filter to the original time series.

*Figure 6: Actual and total misalignment of the real CZK exchange rate (ARDL method)*



The left side of Figure 6 shows that the path of the real exchange rate was relatively close to the estimated equilibrium real exchange rate path of variation during the 1997 exchange rate crisis. The right side suggests that the real exchange rate followed more or less the same path, initially being overvalued, then undervalued at the end of the crises in May 1997, and then overvalued once again[26]. Total misalignment varies somewhat from actual misalignment. One interpretation could be that macroeconomic policy was not especially sustainable or stabilised during 1996–1998. We should emphasise that, by reason of the statistical approach used, the large undervaluation after the May speculative attack was "too large" and the overvaluation during 1998 was conversely "too small". It seems that during 1999 the Czech Koruna has been slightly undervalued again, especially from the medium-term view. However, given the properties of the chosen method and the data series, we should use this result with care. We can conclude that real exchange rate of Koruna is driven by the fundamental real factors suggested by the theory and that the developments of these factors justify the continuation of a slow real appreciation trend.

### 8.5 The time dimension for estimating the real exchange rate

Our estimated equilibrium real exchange rate of the Czech Koruna is based on the NATREX philosophy. The estimate of the NATREX by means of quarterly data is problematic from the time point of view. The exogenous change of investment and savings always generates a new trajectory for the real exchange rate, which reflects sequential changes of capital stock and foreign debt. The goal of an empirical analysis is to catch these changes in the trajectories. We need to use the cointegration analysis to do this. The cointegration analysis is able to estimate the long-term effect of independent variables and also the deviation of dependent variables from the long-term equilibrium when the adjustment process requires a certain amount of time. The long-term cointegration equation of the NATREX should estimate the effect of the fundamental determinant on the NATREX in a steady state, and the estimate of the deviation correction should show the medium-term reaction of the NATREX when the stock of real assets is changing.

If the estimates provide ambiguous results, this can be supervened by two factors. The first factor is the different reaction of the long-term real exchange rate according to the competitive (alternative) theory. The second is defined as the problem of the capture points in the NATREX and not in the trajectory of the steady state. It is highly probable that the estimated cointegrated equation captures the NATREX at some point on the trajectory to a steady state when capital stock and the foreign debt are still endogenous. There can be three main reasons for this. First, the cointegration equation can estimate the long-term relationships only if the data sample is long

[26] It is not possible to denote the deviation of the equilibrium real exchange rate from the actual real exchange rate as pure undervaluation or overvaluation. This estimated deviation of the equilibrium real exchange rate from the real exchange rate could reflect not only cyclical and speculative inconsistency, but also an error in the model specification (for example including irrelevant variables and omitting the relevant variables). This type of problem usually concerns the behavioural model type of the real exchange rate.

enough to demonstrate the readjustment of a large number of observations. If the time series is too short, then the estimated equations reflect only the short- and medium-term relationships rather than the long-term relationships. Secondly, each exogenous factor is approximated, i.e. differentiating the exogenous changes of savings from the endogenous changes of the rate of savings. Thirdly, it could involve the artificial character of the expectancy of the medium-term period. The correction of errors should ideally capture the medium-term reaction of the real exchange rate in the change in a fundamental determinant at a constant state of activity. The state of activity changes quickly in reality after the exogenous change of savings and investment, i.e. before the conditions of the medium-term intracyclical equilibrium are satisfied. Therefore, the level of readjustment that the cointegration equations really picks up cannot be known. Also, it cannot be ruled out that the cointegration equation estimates the points for the individual shocks at a different place on a trajectory. We are aware of this problem and also believe that semi-annual or annual data are more suitable for researching the long-term equilibrium component of the real exchange rate. This type of model can only be practically applied after a period of ten years.

## 9. CONCLUSION

The primary objective of this working paper was to analyse the determinants of the real exchange rate with emphasis on its long-term aspects and searching for the equilibrium paths. We introduced the behavioural models of exchange rates (especially the BEER and the NATREX), which are the new complements (alternatives) to the often used fundamental models of the FEER type. We constructed the theoretical and econometric behavioural model, which could analyse the medium-term and long-term dynamics of the real exchange rate.

Another goal of this working paper was to introduce real exchange rate as an indicator of convergence for transitional countries to EU countries. We also analysed the connection between real exchange rate and double speed economy or deindustrialisation, respectively. This analysis is very relevant almost for all transitional countries.

The final goal of this working paper was to explain the appreciation tendency of real exchange rates in transitional economies. We noticed that real appreciation was generally characteristic of the transitional economies in the initial phase of transformation. However, in the future phases of transformation, some barrier could exist inhibiting the continuation of smooth appreciation to the unitary values given by the PPP towards highly developed countries. If transformation is successful, the real exchange rate of a transitional country would move towards appreciation. If transformation is unsuccessful, the reverse trend could be observed – the currency would depreciate. This scenario will hold until some other structural and institutional reforms have been implemented. We found that this evaluation was quite difficult in the case of the Czech economy. We identified the set of factors that led to sustainable real appreciation of the Czech Koruna and also the set of factors that possibly caused unsustainable real depreciation. We also introduced the

set of arguments warning against any other rapid real appreciation of the Czech Koruna. One conclusion could be that real appreciation was too rapid and unbalanced starting from 1997. Our model outputs also indicate an undervaluation of our currency and an expected real appreciation of the Czech Koruna during 2001. Indeed, the current real exchange rate development confirms this scenario.

We also tried to fuel these arguments by an econometric analysis, which used our behavioural model of the equilibrium real exchange rate. It was shown that the Czech real exchange rate was especially determined by real fundamental factors: productivity, terms of trade and world interest rates and foreign direct investment. The development of these factors should be monitored by policy makers, who could more easily assess undervaluation or overvaluation of the Czech Koruna by using these factors. On the other hand, they must remember that the real exchange rate reacts to changes in these four factors with relatively complicated dynamics.

Finally, one recommendation for policy makers would be the following. Sharp real appreciation (large overvaluation of the real exchange rate) can negatively affect real economic activity (together with finite price flexibility) and can also point to or create an exchange rate crisis. The presented behavioural models can indicate or provide an answer to some of the problems, but a complete solution to these problems can only be found after a complex analysis has been made.

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# Appendix

Estimated Long Run Coefficients using the ARDL Approach
ARDL(1,1,0) selected based on Akaike Information Criterion

Dependent variable is R
31 observations used for estimation from 1993Q1 to 2000Q3

| Regressor | Coefficient | Standard Error | T-Ratio[Prob] |
|---|---|---|---|
| GDP | -.38646 | .087924 | -4.3954[.000] |
| FDI | -1.5294 | .34935 | -4.3778[.000] |
| TOT | -.48151 | .21510 | -2.2385[.035] |
| I | 3.9577 | 1.5126 | 2.6164[.015] |
| INPT | 259.7677 | 28.2702 | 9.1887[.000] |

Autoregressive Distributed Lag Estimates
ARDL(1,1,0) selected based on Akaike Information Criterion

Dependent variable is R
31 observations used for estimation from 1993Q1 to 2000Q3

| Regressor | Coefficient | Standard Error | T-Ratio[Prob] |
|---|---|---|---|
| R(-1) | .48917 | .11683 | 4.1868[.000] |
| GDP | -.042132 | .12008 | -.35087[.729] |
| GDP(-1) | -.15529 | .10711 | -1.4497[.160] |
| FDI | -.78125 | .25184 | -3.1021[.005] |
| TOT | -.24597 | .13969 | -1.7608[.091] |
| I | 2.0217 | .88055 | 2.2960[.031] |
| INPT | 132.6981 | 37.8535 | 3.5056[.002] |

| | | | |
|---|---|---|---|
| R-Squared | .96009 | R-Bar-Squared | .95012 |
| S.E. of Regression | 2.3049 | F-stat. F( 6, 24) | 96.2341[.000] |
| Mean of Dependent Variable | 81.7735 | S.D. of Dependent Variable | 10.3201 |
| Residual Sum of Squares | 127.5058 | Equation Log-likelihood | -65.9068 |
| Akaike Info. Criterion | -72.9068 | Schwarz Bayesian Criterion | -77.9258 |
| DW-statistic | 2.0323 | Durbin's h-statistic | -.11845[.906] |

Diagnostic Tests

| Test Statistics | LM Version | F Version |
|---|---|---|
| A:Serial Correlation | CHSQ(4)= 4.6131[.329] | F(4,20)= .87412[.497] |
| B:Functional Form | CHSQ(1)= 6.5562[.010] | F(1,23)= 6.1689[.021] |
| C:Normality | CHSQ(2)= 1.2559[.534] | Not applicable |
| D:Heteroscedasticity | CHSQ(1)= .022162[.882] | F(1,29)= .020747[.886] |

A:Lagrange multiplier test of residual serial correlation
B:Ramsey's RESET test using the square of the fitted values
C:Based on a test of skewness and kurtosis of residuals
D:Based on the regression of squared residuals on squared fitted values

```
          Error Correction Representation for the Selected ARDL Model
          ARDL(1,1,0) selected based on Akaike Information Criterion
********************************************************************************
 Dependent variable is dR
 31 observations used for estimation from 1993Q1 to 2000Q3
********************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 dGDP                     -.042132            .12008            -.35087[.729]
 dFDI                      -.78125            .25184            -3.1021[.005]
 dTOT                      -.24597            .13969            -1.7608[.091]
 dI                         2.0217            .88055             2.2960[.030]
 dINPT                     132.6981           37.8535             3.5056[.002]
 ecm(-1)                   -.51083            .11683            -4.3723[.000]
********************************************************************************
 List of additional temporary variables created:
 dR   = R-R(-1)
 dGDP = GDP-GDP(-1)
 dFDI = FDI-FDI(-1)
 dTOT = TOT-TOT(-1)
 dI   = I-I(-1)
 dINPT = INPT-INPT(-1)
 ecm = R + .38646*GDP +  1.5294*FDI +  .48151*TOT   -3.9577*I -259.7677*INPT
********************************************************************************
 R-Squared                      .49376   R-Bar-Squared                    .36720
 S.E. of Regression            2.3049   F-stat.    F(  5,  25)    4.6817[.004]
 Mean of Dependent Variable   -1.3768   S.D. of Dependent Variable      2.8975
 Residual Sum of Squares     127.5058   Equation Log-likelihood       -65.9068
 Akaike Info. Criterion      -72.9068   Schwarz Bayesian Criterion    -77.9258
 DW-statistic                  2.0323
********************************************************************************
 R-Squared and R-Bar-Squared measures refer to the dependent variable
 dRK and in cases where the error correction model is highly
 restricted, these measures could become negative.
```