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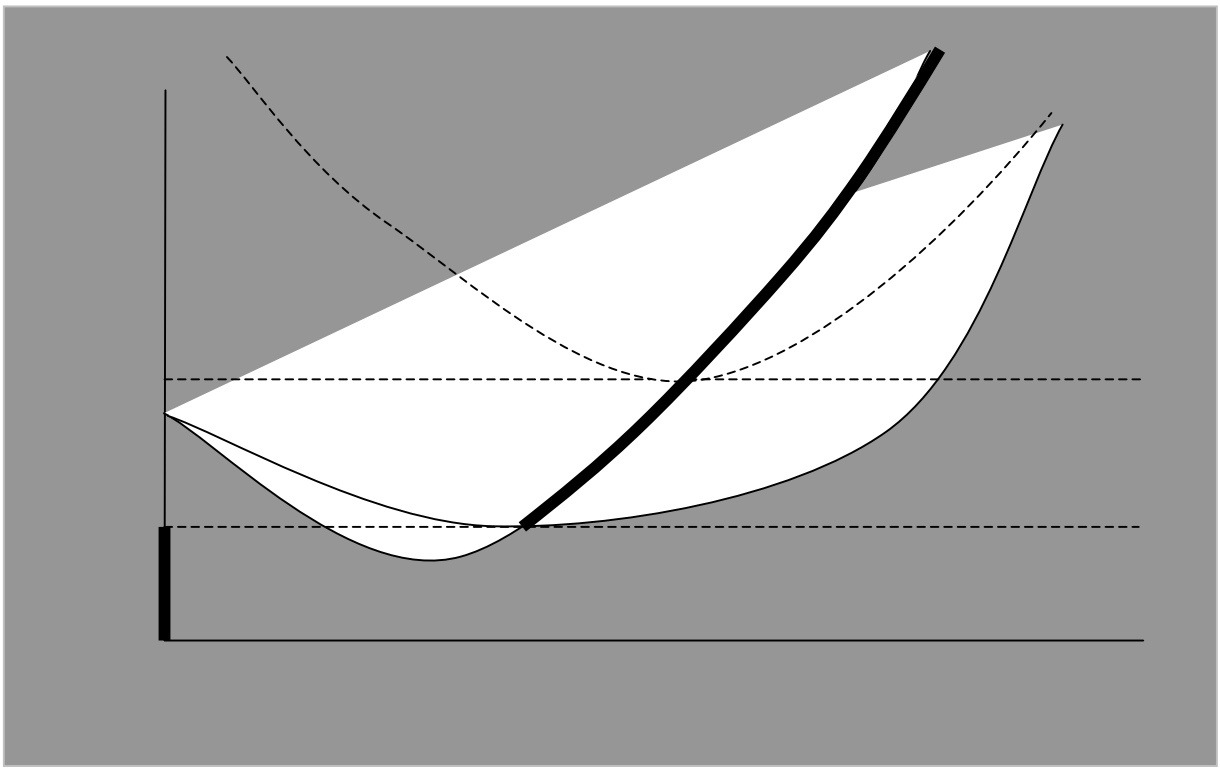

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Real Equilibrium Exchange Rate Estimates: To What Extent Are They Applicable for Setting the Central Parity?

ROMAN HORVÁTH[1]

Abstract

The objective of this paper is twofold. First, we provide an introduction on estimation and methodology of the real equilibrium exchange rate. Second, we discuss to what extent are these estimates applicable for setting the central parity. Given the uncertainty surrounding the estimates, they are informative in the sign rather than the size of the misalignment of exchange rate, but may serve as useful consistency checks for the decision about setting the central parity. We argue that policy makers shall consider the estimates in their decision-making only if the real exchange rate is substantially misaligned (i.e. more than 10% as a rule of thumb).

Keywords: E5, F4

JEL Classification: equilibrium exchange rate, monetary policy, ERM II

Common abbreviations:
EER – Equilibrium exchange rate
NEER – Nominal equilibrium exchange rate
REER – Real equilibrium exchange rate
RER – Real exchange rate

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1. Introduction

This short paper discusses the empirical approaches to estimating the equilibrium exchange rates in connection to the setting the central parity in the ERM II. These estimates are useful for various closely related reasons. First, it is useful to understand whether the current exchange rate is different from its equilibrium value, as this provides information on the likely future exchange rate development. Second, in case when the authorities want to peg the value of the currency (e.g. such as in the case of ERM II entry), it is useful to know the equilibrium exchange rate as precisely as possible. This is important in order to draw the "best" strategy for entering the ERM II and as a by-product to minimize the costs associated with potentially restoring the equilibrium via real sector.

In this regard, according to the European Central Bank (2003), *"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 for the market rate."* Thus, one may ask to what extent we are able to estimate precisely the equilibrium exchange rate and which are these indicators that influence the dynamics of the exchange rate in new member states (NMSs thereafter). In this paper, we discuss to what extent the estimates of EER may provide a guideline for setting the central parity at the ERM II entry for the Czech koruna.

The paper is organized as follows. In section 2, we shortly discuss the concept of equilibrium exchange rate, both from methodological and operational point of view. Section 3 contains a brief overview of the theoretical underpinnings of the equilibrium exchange rate estimation. Section 4 provides a discussion of the empirical approaches to estimating the real equilibrium exchange rates. Section 5 offers some arguments of how the estimates of the equilibrium level of the Czech koruna may (not) be used for setting the central parity. In this section, we provide some suggestions how to discriminate among various approaches, but also emphasize the limitations of these approaches, i.e. large uncertainty associated with the estimates. Section 6 concludes.

2. The Concept of Equilibrium Exchange Rates

2.1 Methodology of Equilibrium Exchange Rate

While there is abundant literature estimating the real equilibrium exchange rate (REER) in the NMSs, it is actually quite difficult to define the concept of equilibrium exchange rate appropriately and most of studies tackle this methodological issue only implicitly (notable

exemption is Driver and Westaway, 2005 or Maeso-Fernandez *et al.*, 2004). Typically, when the authors estimating REER find that the current exchange rate is not at its equilibrium level (i.e. is misaligned), they obviously do not imply that market forces are not at work. They rather mean that it is reasonable to expect that exchange rate will have a tendency to move in certain direction in the future. As a result, the concept of equilibrium exchange rate goes beyond simple truism saying that the exchange rate is always at its equilibrium value, as it is continuously determined by supply and demand at the foreign exchange market. Thus, the REER is a normative concept, to a certain extent, specifying the conditions when the exchange rate is considered to be at the equilibrium level.

Naturally, one may immediately ask which factors may cause the deviation from this normative equilibrium. The consensus in the contemporary literature on the exchange rates is that either the barriers to cross-country commodity arbitrage due to various transaction costs (see for example, Cincibuch and Podpiera, 2004), or different information set and heterogeneous beliefs of market participants are among the main culprits of this deviation (Sarno and Taylor, 2002). Apparently, while the former is rather medium run issue, the latter is much more oriented on the short-term period.

Therefore, additional aspect of the equilibrium exchange rate is its time horizon. It may happen that exchange rate is fairly valued at some time horizon, but misaligned at the other horizons. Typically, exchange rate may be misaligned in the short-run reflecting different opinion of the market participants about the prospects of the FX market. Regarding the Czech koruna, some studies claim that the current exchange rate is largely fairly valued at medium-term horizon (for example, Komarek and Melecky, 2005), however it is still expected that certain real exchange rate appreciation may be expected in the long term (as purchasing power parity will hold to a large extent in the very long run). Therefore, it is necessary to understand the time horizon of the estimated REER in drawing policy conclusions. For our purposes, with some level of simplification, one may distinguish among short-term, medium-term and long-term equilibrium.

Williamson (1983) defines the short-term equilibrium as the one prevailing if the market is fully informed and rational. Second, medium-term equilibrium concept is defined when the economy is at internal and external balance (Driver and Westaway, 2005). Internal balance may be defined in terms of zero output gap and inflation at the target level, while external balance can be thought of as sustainable net flows of resources between countries when in internal balance. Thus, this equilibrium is of special relevance for policy makers. Third, the

long-term equilibrium is defined as when the stock-flow equilibrium is achieved and thus the changes of asset stocks are zero.

2.2 Operational Aspects of Equilibrium Exchange Rate

Except the difficulties of defining the equilibrium level of real exchange rate at the methodological level, there are also operational issues. In order to calculate the real exchange rate, the measure of domestic and foreign price level is required. For domestic price level, generally one may use consumer price index, producer price index or unit labor costs. This is analogous for the foreign price level; one more caveat is specifying which foreign price levels should be used. Typically, one may use the foreign price level of main trading partner or construct artificial foreign price level as the weighted average of foreign price levels, where the weights are specified in terms of the volume of bilateral trade links.

If the development among various measures of price levels differs substantially (e.g. rising PPI and stagnating CPI), it typically leads to different conclusions about the magnitude of exchange rate misalignment. As a result, it is advisable to use more RER measures in order to examine the robustness of the results to various specifications.[2] Obviously, if a country targets yearly change of CPI, CPI-based RER might be preferable. Ideally, one would like to construct the real exchange rate with the use of respective price level in the tradable sectors to capture the competitiveness of the economy, to a greatest extent. Such effort is presented in Sarno and Chowdhury (2003).[3] Lipschitz and MacDonald (1991) discuss the pros and cons of various price indexes in assessing the competitiveness in a greater detail.

Once having the current real exchange rate and REER defined, the difference of these two is interpreted as the exchange rate misalignment (disparity or disequilibrium, alternatively). Literature also distinguishes between so-called actual and total misalignment.[4] Both actual and total misalignment is the difference between the actual and fitted values of RER. However, total misalignment uses the equilibrium values of explanatory variables rather than its actual values (as is the case for calculating actual misalignment) for determining the misalignment. Theoretically, the results of total misalignment are more consistent than actual misalignment, as it disentangles the equilibrium state from the actual conditions. Nevertheless, in practice there is a great uncertainty in (former) transition economies about

[2] Similar operational issues arise for explanatory variables/fundamentals.

[3] Interestingly, Sarno and Chowdhury (2003) find that the real exchange rate reverts back to its equilibrium value faster, if it is based on the tradable sectors price levels, as compared to CPI based real exchange rate.

[4] See, for example, Babetskii and Egert (2005) for an application.

the equilibrium values of fundamentals affecting the exchange rate. As a result, this uncertainty may be transmitted into the estimate of the misalignment. In other words, this problem may have an effect on the estimated size of misalignment. Additional caveat is that increasing the number of explanatory variables may lead to a smaller estimated actual misalignment (but not necessarily total misalignment).

In addition, researchers (e.g. Babetskii and Egert, 2005) tend to use some filter such as Hodrick-Prescott filter in order to estimate the equilibrium trend in the fundamentals. It is known that these filters suffer from so-called end point bias. As a result, the current estimated value of misalignment is biased as well. This is so, because all explanatory variables (fundamentals) are affected by the end-point bias, which is in turn transferred into the misalignment. This decreases the advantages of the total misalignment in determining the magnitude of current misalignment of the exchange rate. Nevertheless, one may compute the confidence intervals of the estimated misalignment in order to decrease the surrounding uncertainty.

Besides, for considerations about setting the central parity for ERM II, one may need the estimate of nominal equilibrium exchange rate (NEER) rather than the REER. However, the model of equilibrium exchange rate typically uses the real exchange rate (except monetary model). Therefore, it is necessary to recalculate the NEER from REER. To do this, some estimate of equilibrium domestic and foreign inflation rates is needed. In case of inflation targeting country such as the Czech Republic, targeted inflation may be considered as the equilibrium one. Nevertheless, if the actual inflation differs from the targeted for a longer period of time, it is advisable to consider actual inflation for calculating the NEER as well. Calculation of NEER is critical, if inflation rates differ substantially. However, the benefits of recalculating the NEER from the REER are rather limited in case of the Czech Republic, as the inflation differential with respect to its main trading partners is generally small.

3. Theoretical Foundations of Equilibrium Exchange Rate Estimations

In this section we provide a short description of the main theoretical underpinnings of REER models.[5] Typically, the REER models generalize uncovered interest rate parity (UIP) condition by including additional relevant factors.

[5] Detailed description of various models is beyond the scope of this paper. For more throughout surveys of the theoretical aspects of the REER, see Driver and Westaway (2005), Egert (2003) or MacDonald (2000). Driver and Westaway (2005, p.20) provide a table summarizing the various empirical approaches to estimate the REER.

The basic modeling approach is the purchasing power parity (PPP). The so-called absolute version of this approach states that the foreign and domestic price level should equal adjusted to nominal exchange rate in order to eliminate the cross-country commodity arbitrage.[6] Thus, the PPP is supposed to determine the long-term nominal exchange rate. However, the PPP may not hold for a number of reasons such as different consumer and production patterns (reflected in different consumer baskets), the extent of non-tradable goods, imperfect competition or pricing to market (Egert, 2003, p. 40). Additionally, PPP is not particularly suited for an analysis of the countries at different stage of economic development. Poorer countries tend to have cheaper non-tradable products. If they catch up the richer countries, we observe the trend appreciation of their real exchange rate, as described by the Balassa-Samuelson effect. Notably, this appreciation may be medium-term or long-term equilibrium phenomenon. It is also noteworthy that the appreciation may be also caused by the goods quality improvements or price deregulation. Chart 1, presented in the Appendix, explains typical factors behind the trend appreciation of real exchange rate in transition economy.

For policy purposes, it is useful to work with the medium-term REER models, as they largely match with the monetary policy target horizon. Typically, the models link the exchange rate (either nominal exchange rate, real exchange rate or real effective exchange rate) to a number of fundamentals. The choice of fundamentals is based on various theories as mentioned above; nevertheless some fundamentals are added to a list of potential explanatory variables in an ad hoc way. We list the major approaches below and describe it shortly. It is noteworthy that some approaches are quite similar to each other.

3.1 Various approaches for estimating medium-term REER

BEER

BEER stands for behavioral exchange rate and has been developed by MacDonald (1997) and Clark and MacDonald (1998). The approach is based on the standard UIP condition. Expected inflation differential is subtracted from this condition. As a result, real exchange rate is linked to the expected real exchange rate, real interest rate differential and risk premium. Further, it is assumed that risk premium depends on domestic and foreign government debt. Expected real exchange rate is a function of fundamentals in the long run. Typically, it is assumed that the list of fundamentals that affect real exchange rate is the following: Terms of trade, Balassa-Samuelson effect (ratio of non-tradable to tradable prices) and net foreign assets. To

[6] Or in its relative version, that prices and exchange rate should move in a direction that the absolute PPP will hold over the longer-term.

summarize the BEER approach, real exchange rate depends on real interest rate, ratio of domestic to foreign government debt, terms of trade, Balassa-Samuelson effect and net foreign assets.

Obviously, BEER is rather a statistical approach, which is meant to link the real exchange rate to a set of macroeconomic variables through a single equation setting. The choice of the fundamentals is ad hoc, to a certain extent, as the underlying theory gives a relatively large room in terms of which fundamentals will be included into the model. The fitted value of the estimated equation, which may be derived either on the basis of observed series or using long-term values of the fundamentals, represents the estimated equilibrium exchange rate.

Babetskii and Egert (2005) or Komarek and Melecky (2005) are examples of current applications of BEER to the Czech koruna.

CHEER

CHEER stands for Capital enhanced equilibrium exchange rates and build on PPP condition. This approach states that exchange rate is determined by the nominal interest rate differential (UIP condition) and relative prices (PPP condition) in the medium-term. As Driver and Westaway (2005) note, the implicit assumption of CHEER is that interest rate differential vanishes in the long-run and exchange rate is determined in line with PPP.

DEER

DEER stands for Desired equilibrium exchange rate. DEER is an alternative to FEER, to a certain extent. This approach conditions REER on optimal fiscal policy instead of focusing on current account sustainability.

FEER

FEER is an abbreviation of the fundamental equilibrium exchange rate. The approach focuses on finding out which real exchange rate would likely emerge, if the economy simultaneously were in its internal and external equilibrium.

In its simplest version, it is assumed that the current account is influenced by the domestic and foreign potential output and real effective exchange rate. The model is then solved for the real effective exchange rate, which is a function of domestic and foreign potential output and sustainable current account. Current account is modeled by export and import equations. The approach also hinges on the judgment about sustainable net external debt. Typically, the

FEER estimates are usually derived from large scale macroeconometric models or partial trade blocks of a given economy.

A recent example of FEER applied to the Czech economy is Šmídková, Barrell and Holland (2002). Bulíř and Šmídková (2005) enrich the FEER approach by assigning a special role for foreign direct investment, e.g. one of determining factor behind the real exchange rate appreciation in new EU member states. Bulíř and Šmídková label their approach as SRER – sustainable real exchange rates.

ITMEER

ITMEER is an abbreviation of Intermediate-term model-based equilibrium exchange rate. This approach has been put forward by Wadhwani (1999). As opposed to CHEER, this approach also models risk premium in nominal UIP. Risk premium is assumed to be influenced by two factors: return on other assets (such as stocks and bonds) and deviation from equilibrium. The latter is assumed to be affected by the relative current accounts (normalized by GDP), relative unemployment, relative net foreign assets to GDP and relative ratio of producer to consumer prices. As a result, exchange rate is linked to relative interest rates, asset return, current account, unemployment, net foreign assets and producer to consumer price ratio.

Macroeconomic balance

Macroeconomic balance approach is a variant of FEER. To circumvent normativity of FEER, this approach, which has been sharpened and widely used by the IMF, estimates directly the sustainable level of current account deficits (surpluses) based on the saving and investment balance (see MacDonald, 2000, p.41).

Monetary model

Monetary model focuses on the short-term or medium-term determination of exchange rate. It states that the exchange rate is influenced both by goods as well as asset markets. The model assumes the standard money demand function (in both countries, as the model typically comprises of two countries), e.g. the ratio of money to prices is function of output and interest rates. Further, it is assumed that money demand and money supply equals for both countries at any period of time. Exchange rate is linked to domestic and foreign price level and fully reflects the purchasing power parity (PPP) condition. Combining these assumptions, it is

simple to show that exchange rate is determined by the ratio (or difference, if the data are in the logarithms) of domestic and foreign money supply, output and interest rates.

Certainly, the assumption of PPP is often too restrictive. Therefore, the literature typically introduces Balassa-Samuelson effect. Namely, it is assumed that overall price level is as weighted average of tradable and non-tradable prices and PPP holds only in the tradable sector. Combining this decomposition of price level and tradable-based PPP in the original monetary model, it is easy to show that exchange rate is now determined by the difference of domestic and foreign money supply, output and interest rates and by the difference between domestic and foreign "Balassa-Samuelson effect". This effect is defined in a standard way, as the difference between non-tradable and tradable prices.

The study of Crespo-Cuaresma, Fidrmuc and MacDonald (2005) is an example of recent application of the monetary model to the CZK and several other currencies in the NMSs.

NATREX

NATREX is in short Natural real exchange rate. NATREX, as proposed by Stein and Allen (1995), builds on a relation among investment, savings and current account. The approach assumes that while savings are largely influenced by the rate of time preference and net foreign assets, investments depend on Tobin's 'q'. The latter is a function of capital stock, productivity and the real exchange rate. The model is then solved for the real exchange rate.

Frait and Komarek (2001) study is an example of NATREX approach applied to an analysis of REER in the Czech Republic.

PEER

PEER is a shortcut for Permanent equilibrium exchange rates. PEER is similar to BEER approach, but disentangles between permanent and transitory components of fundamentals. Thus, when calculating misalignment it imposes that all fundamentals are at their steady-state, which is achieved by statistical technique of Gonzalo and Granger (1995).

Typically, the aforementioned models are relatively simple to estimate, but there are some pitfalls associated with their theoretical underpinnings. The models are primarily of macroeconomic nature and lack sound microeconomic foundations (as opposed to recent stochastic dynamic general equilibrium models) and also do not identify the nature of shocks (as in structural vector autoregressive – SVAR – model[7]). These models also assume that

[7] See Clarida and Gali (1994) or Detken et al. (2002).

exchange rate is endogenous to fundamentals; but in fact exchange rate affects fundamentals as well. Indeed, there is some evidence that exchange rate may be rather shock-generator rather than shock-absorber, as these models typically assume. In this respect, Borghijs and Kuijs (2004) find that all exchange rates in Central Europe have served rather as propagator of financial and monetary shocks rather as absorber of the shocks.

3.2 Fundamentals Affecting Real Exchange Rates

In this section, we present the list of main fundamentals that influence the fluctuations of the real exchange rates over medium term/monetary policy target horizon. Researchers estimating the REER typically consider the following fundamentals and/or effects: Balassa-Samuelson effect, current account deficit, government indebtness, net foreign assets, level of oil prices, openness/external liberalization, productivity differential, real interest rate differential, the dynamics of regulated prices and the terms of trade.

Current Account

When current account is in the deficit, it is likely to be accompanied with the depreciation of exchange rate other things equal. The effect is typically a result of various factors such as country risk or money demand. Current account reflects rather current supply and demand of foreign goods, as opposed to capital account, which is much-more forward looking.

External Liberalization

Greater opening up may initially worsen trade balance resulting in depreciation. However, greater external liberalization leads to appreciation in medium-term, as the country risk typically decreases and supply capacities increase. As the index of external liberalization is available only on a yearly basis, researchers use openness as proxy for the extent of trade liberalization. Openness is likely to be strongly correlated with the external liberalization in the NMSs. Nevertheless, generally, openness (greater volume of international trade) should not have any systematic effect on the exchange rate movements.

Indebtness

Larger government indebtness should result in depreciation due to greater interest payments on debt and increased country risk. If public spending is oriented especially at non-tradable sector (such as infrastructure), greater spending may eventually result in exchange rate

appreciation. This argument hinges on an assumption that this spending would improve the productivity.

Net foreign assets

Net foreign assets (NFA) increase is likely to lead to appreciation in the long term, but the effect is not clear-cut when NFA move towards the desired level. For a catching-up country, the desired level of NFA may actually be negative. As a result, initial decrease in the NFA may be associated with the appreciation (mainly due to FDI inflow). Later on, as the country starts paying the interest on their net foreign liabilities, the RER may depreciate.

Productivity

Typically, greater productivity in the domestic economy compared to the foreign economy (for example, via foreign direct investment) is likely to lead to a higher domestic inflation and consequently in a real exchange rate appreciation. This is accomplished for example as a result of goods quality improvement, which in turn shifts preferences.

Regulated prices

Price deregulation is likely to be associated with price increases and this should result in real exchange rate appreciation. However, price deregulation is likely to improve market conditions and consequently increase supply capacities. As a result, this may weaken or eliminate initial appreciation.

Terms of trade

The effect of the terms of trade depends on the price elasticity of exports and imports. If the price sensitivity is not particularly high, increase in terms of trade likely results in appreciation. Often, oil prices have a great influence on the terms of trade.

Interest rate

According to the UIP condition, the interest rate differential is an optimal predictor of expected exchange rate movements, providing the condition of rational expectations and risk neutrality holds. Positive interest rate differential increases demand for domestic money and therefore lead to the current appreciation of exchange rate, but it also implies depreciation expectations in the future. Additionally, MacDonald and Ricci (2003) emphasize that interest rate differential has a real effects, namely on aggregate demand, productivity and monetary

policy. Under the condition of less than perfect capital mobility, greater interest rate differential induces greater demand for domestic goods (if savings do not increase to offset the effect) and real exchange rate appreciates accordingly (relative price increases in domestic non-tradable goods).

4. Empirical Methods to Estimating the Equilibrium Exchange Rate

In this section we briefly discuss the empirical methods to estimating the equilibrium exchange rate. Namely, we discuss the econometric techniques applied and what are the pros and cons of these techniques for the EER estimation.

4.1 Methodology[8]

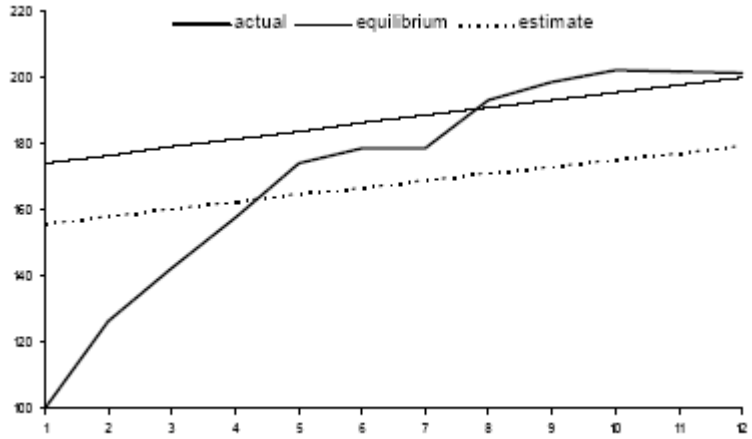
First, there is an important expert-based judgment about the length of sample[9] and number of countries to be included for the estimation. Basically, these may be classified into several groups (as described in Maeso-Fernandez *et al.*, 2004): country-by-country analysis, cross section analysis and panel data analysis. Panel data analysis may be further classified into so-called in-sample and out-of-sample approach. We discuss each classification successively.

The advantage of country-by-country analysis is that it may fully take into account the country specificity. Nevertheless, time series is rather short in this case, which may substantially influence the power of statistical tests. Additional problem arises from the possibility that the exchange rate was largely undervalued at the outset of transition (Halpern and Wyplosz, 1997). This undervaluation was associated with the lack of market forces at work, namely with the widespread price regulation. When not accounting properly for the initial undervaluation, the constant term will be biased in the estimated reduced-form equation linking fundamentals to the exchange rate. As a result, the estimate of exchange rate misalignment will be biased, as depicted in Chart 1. In case of the trend appreciation of the RER, the overvaluation of the currency would seem larger than it actually is.

[8] This section (4.1) draws heavily on Maeso-Fernandez et al. (2004).

[9] On the one hand, greater length of sample increases the number of observations and improves inference, but on the other hand, it also increases the probability of structural break in the data sample. Ignoring structural breaks is likely to lead to a bias in misalignment estimation. Sometimes, data quality may also affect the choice of sample.

Chart 1 – Illustration of Estimating the EER without Considering Initial Undervaluation



Source: Maeso-Fernandez *et al.* (2004).

Next, several authors apply cross-sectional analysis. The benefit of cross-sectional analysis is that it simply eliminates the likely presence of the structural breaks in time series of a transition economy. Typically, the authors estimate the exchange rate misalignment as the difference between PPP exchange rate and actual exchange rate (eventually accounting for other factors such as the role of regulated prices, terms of trade or non-tradables prices, see Čihák and Holub, 2003). The PPP exchange rate is defined in a standard way, e.g. as the number of units of domestic currency that are needed in order to buy the same basket in the "numeraire country".

The short times series in transition countries encourage researchers to estimate the REER by employing the panel data analysis. As a result of forming a panel of countries, the power of the statistical tests applied may substantially increase. Basically, there are two approaches to estimating the determinants of exchange rate fluctuations. The "in-sample" approach makes use of only transition countries (or eventually of subset of these countries). The advantage of "in-sample" approach lies in the fact that transition countries form relatively homogenous group, as compared to an analysis where both transition and non-transition countries would be included.

However, if the countries experience substantial structural changes in the economy, "out-of-sample" approach is a plausible alternative.[10] This approach estimates the equilibrium relationship between the fundamentals and exchange rate for (a subset of) developed

[10] This approach has been applied for example by Halpern and Wyplosz (1997).

economies, as it is believed that largely similar structural relationships will prevail in the transition economies in future as well. Moreover, "out-of-sample" approach overcomes the weaknesses in data quality and structural breaks in time series. Next, the estimated equilibrium relation is used and the corresponding values of fundamentals for transition countries are imputed. The resulting difference between the fitted value of exchange rate and actual value is interpreted again as misalignment. The apparent drawback of this approach is that even after transition countries possibly catch-up in future; the equilibrium relations among fundamentals and exchange rate may still differ significantly from those of developed countries. In other words, the sample of countries is not homogenous and common estimated parameters are likely to be too restrictive in this reason. In addition, there is no constant term for transition country is available. The constant has to be chosen on a rather ad hoc way. Maeso-Fernandez *et al.* (2004, p. 29) discuss the possible strategies for the choice of the constant term.

4.2 Econometric Estimation Method

As the uncertainty of EER estimates tends to be rather large, more econometric techniques applied is one of possible ways to address the robustness of the results. Typically, the studies either calibrate structural model or estimate cointegrating relationship among the relevant variables in a single equation setting. In some cases, simple filtering of data is used as well.

Most simply, one may filter the actual real exchange rate to obtain certain trend. These filters typically are: Hodrick-Prescott (HP) filter, Kalman filter or band-pass filter. While relatively easy to apply, the obvious disadvantage of these methods is that they alone do not have any underlying economic theory and thus it is very difficult to interpret the filtered path of the exchange rate as the equilibrium one. Additional drawback of these methods is that they suffer from so-called end-point bias (e.g. series has an exaggerated influence on a trend at the beginning and end of sample) and thus they cannot be used for determining the current exchange rate misalignment.[11] Nevertheless, the statistical approaches are simple to use and may serve as some additional consistency checks of the results of more advanced models based on economic theory.

[11] The option is to widen the sample by an inclusion of forecasted values. However, the success of this approach crucially depends on an accuracy of a forecast. The alternative for H-P filter is proposed by Bruchez (2003). Bruchez proposes to give an extra weight to a smoothing parameter at the end of sample. As a result, this reduces (but not eliminates) end-point bias.

In general, end-point bias tends to be smaller for Kalman and band-pass filter, as compared to H-P filter.

More plausible way to estimate EER is to apply cointegration analysis. Several cointegration techniques has been recently developed and widely applied in estimating the EER. The cointegration techniques are particularly suited for single equation models such as BEER or PEER. Babetskii and Egert, 2005 or Komarek and Melecky, 2005 are recent examples of the application of cointegration in examining EER for the Czech economy. Typically, the authors use several cointegration methods such as autoregressive distributed lag (ARDL), dynamic ordinary least squares (DOLS), fully modified ordinary least squares (FM-OLS), Engle-Granger technique or Johansen technique.[12] It is beyond the scope of this paper to discuss the pros and cons among these techniques. Generally, more techniques should be applied to identical sample to assess the robustness of results. Importantly, Egert and Halpern (2005) using meta-regression analysis find that econometric method may actually affect the estimated size of misalignment. In addition, the cointegration model should be parsimonious, as it is very likely the results will not be robust with a large number (say about 6-8) of explanatory variables.

Another option to calculate the EER is to calibrate multi-equation structural model (see e.g. Bulíř and Šmídková, 2005, for an application to the Czech data). The advantage of calibration is that it overcomes certain drawbacks inherent in time series analysis (such as short length of sample). Besides, the models typically have better theoretical underpinnings as compared to single equation cointegration models. This is especially the case for the models that build on the proper microeconomic foundations. In addition, structural model are forward-looking and provide the likely path of the RER in the future. The advantage of structural models is also that it identifies the sources of the shocks. On the other hand, it seems that there is a great uncertainty about the particular parameters used for calibration, which may substantially influence the estimate of misalignment. The possible option is to re-estimate the original (estimated or expert judgment) parameters by the use of Bayesian econometrics.

5. Are REER Estimates Useful for Setting the Central Parity?

In this section, we discuss which properties REER estimates should ideally have in order to provide some clues about the "optimal-strategy" central parity in future ERM II participation.13 To a certain extent, we also summarize some of the arguments mentioned earlier in this note.14

[12] See Harris and Sollis (2003) for an accessible introduction to cointegration techniques.

[13] Central parity does not have to be set at the level of EER. The choice of parity depends not only on the equilibrium exchange rate, but also on the pace of real equilibrium rate appreciation. In case of positive

Given the aforementioned uncertainty surrounding the estimate of REER and the non-existence of some superior estimation method, it is necessary to provide substantial sensitivity analysis of the results. This includes both the theoretical model and econometric technique. Thus, the comprehensive report about the estimates of REER in connection to setting the central parity should discuss the results based on various models such as BEER, PEER or FEER. Regarding the latter, the single equation models should be estimated with up to date data with the use of various cointegration techniques such as ARDL, DOLS, FM-OLS, Engle-Granger and Johansen technique. In addition to this, one may also alternate/rotate the explanatory variables and estimate the identical model applying the same technique, but with the different set of explanatory variables. Consequently, it is possible to construct the confidence interval for the mean exchange rate misalignment estimated for each model. Alternatively, in case of structural model it is possible to calibrate the model. This all together provides substantial checks about the sensitivity of results.

A comparison of the results based on various specifications provides additional insights. Namely, to what extent the confidence interval coincide to each other or alternatively, why they differ. In the next step, the results for the RER misalignment could be recalculated for the NER misalignment, as the central parity is obviously set in nominal terms.15 The recalculation should be carried out either with the equilibrium/targeted or than actual domestic and foreign inflation rates. Targeted inflation might be preferable on theoretical basis, but actual inflation is definitively plausible alternative for a short-run.

Additional robustness analysis is to be provided by estimating both actual and total misalignment. There are both pros and cons associated with either method as aforementioned. Total misalignment is theoretically more plausible, but is subject of end-point bias, because typically certain filter is used to estimate the trend in the fundamentals.

Next, it is self-evident that the chosen theoretical models should be medium term orientated. The fluctuations of exchange rate are largely unpredictable in the short term and models such as standard PPP are oriented on the horizon that is beyond the monetary policy target horizon. Besides, the definition of REER in theoretical models should be general; defined as the rate fulfilling internal and external equilibrium in the economy rather than in terms of some

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equilibrium appreciation, parity might be set at the "depreciated" level to cushion potential appreciation during the ERM II participation. However, it is anyway useful to have the best possible estimate of EER regardless the parity is set on equilibrium level or not.

[14] In addition, it is important to note that we analyze different issue than Bulíř and Šmídková (2005). Bulíř and Šmídková focus on a rather more general question, i.e. the ability to fulfill jointly inflation and exchange rate criterion under equilibrium real exchange rate appreciation.

[15] One may neglect this adjustment, if the inflation differential is low.

specific aspect such as optimal indebtness. The models also should imply that the exchange rate reverts back to its equilibrium value. The estimated equations arising from these models should be parsimonious and ideally stable over time, to a large extent.

Additional property of the results is that the equilibrium exchange rate should be less volatile than the actual corresponding exchange rate (under the floating exchange rate regime). This is so, because actual exchange rate volatility is influenced by heterogeneous beliefs and different information set of the market participants.

Generally, as the result of large uncertainty associated with the equilibrium value of exchange rate, there are concerns about the applicability of the REER models, when setting the central parity.16 This idea holds in more general to support eventually any monetary policy decision-making, too. The REER models seem to be more informative in terms of sign rather than the size of misalignment. Consequently, this leads us to a belief that the resulting misalignments based on the aforementioned REER models should be largely "ignored" if they suggest the magnitude of exchange rate misalignment is less than 10%. Obviously, the choice of this 10% "ignorance band" reflects rather expert judgment considering various types of uncertainties inherent in the REER estimation. In our opinion, certain part of the parameter uncertainty is not quantifiable and thus it is very difficult to come up with any sophisticated method to derive the size of "ignorance band". This uncertainty is especially associated with weak theoretical foundations of REER models.

Despite the aforementioned uncertainties, one may claim that if the majority of the results suggest substantial misalignment of the exchange rate (say more than 10%); it should be cautiously considered by the policy makers anyway. Consequently, this would lead to certain concerns about timing of ERM II entry. In our opinion, both options, e.g. entering the ERM II with misaligned exchange rate or setting the central parity at the level largely different from the market level, are too risky, as they lack credibility.

In addition, the Maastricht exchange rate criterion is in fact somewhat asymmetric (-2.25% - +15% fluctuation band).17 There is also tendency for the EER to appreciate. These issues have an implication for the 'ignorance' band, which is in turn asymmetric, too. Indeed, overvaluation of the exchange rate is a greater concern in this case.18

[16] Definitively, uncertainty is even more amplified, if one uses theoretical model, which focuses on the different time horizon than is the policy question to be analyzed.

[17] See Čech, Horváth and Komárek (2003) for greater details.

[18] See Bulíř and Šmídková (2005).

Conclusions

This short paper provides a description of the methodological, operational, empirical and theoretical aspects of the REER models. Next, it discusses the applicability of the estimates of REER in connection to setting the central parity for the ERM II.

In general, there is a relatively large uncertainty about the estimates of the exchange rate misalignment and thus substantial sensitivity analysis has to be undertaken. This requires both the application of various theoretical models, econometric techniques and different empirical specifications.

All in all, REER estimates resemble to a certain extent, throwing a basketball into a golf hole, as the confidence intervals of the estimates might become large. This leads us to a belief that the estimates are informative in terms of sign rather than size of the misalignment.[19] Consequently, as a rule of thumb, the equilibrium exchange rate estimates should be considered in the decision about setting the central parity for the ERM II only if the majority of estimates suggest that the exchange rate is misaligned more than roughly 10% (despite, overvaluation may get special treatment due to perceived EER appreciation). In such case, the ERM II entry in our opinion too risky, as entering the ERM II with misaligned exchange rate or setting the central parity at the level largely different from the market level invite speculative attacks.

Literature

Babetskii, I. and B. Egert (2005): Equilibrium Exchange Rate in the Czech Republic: How Good in Czech BEER?, *Czech Journal of Economics and Finance,* 5-6, pp. 232-252.

Borghuis, A. and L. Kuijs (2004): Exchange Rates in Central Europe: Blessing or Curse? *International Monetary Fund Working Paper No. 2*.

Bruchez, P-A. (2003), A Modification of the HP Filter Aiming at Reducing the End Point Bias, Working Paper 2003/3 of the Group of Economic Advisors to the Federal Finance Administration.

Bulíř, A. and K. Šmídková (2004): Exchange Rates in the New Accession Countries: What Have We Learned From the Frontrunners?, *IMF WP 05/27*.

Čech, Z., Horváth, R. and L. Komárek (2003): ERM II – The View of Accession Countries, *Czech National Bank Working Paper No. 11*.

Čihak, M. and T. Holub (2003): Price Convergence to the EU: What do the 1999 ICP Data Tell Us?, *Czech National Bank Working Paper No. 2*.

Cincibuch, M. and J. Podpiera (2004): Beyond Balassa – Samuelson: Real Appreciation in Tradables in Transition Countries, *Czech National Bank No. 9*.

[19] Despite this, REER models remain useful in understanding what drives RER developments.

Clarida, R. and J. Gali (1994): Sources of Real Exchange Rate Fluctuations: How Important Are Nominal Shocks?, *Carnegie-Rochester Conference Series on Public Policy*, Vol. 41, pp. 1-56.

Crespo-Cuaresma, J. and J. Hlouskova (2005): Beating the Random Walk in the Central and Eastern Europe, *Journal of Forecasting*, pp. 189-201.

Crespo-Cuaresma, J., Fidrmuc, J. and R. MacDonald (2005): The Monetary Approach to Exchange Rates in the CEECs, *Economics of Transition*, pp. 395-416.

Derviz, A. (2004): Exchange Rate Risks and Asset Prices in a Small Open Economy, *European Central Bank Working Paper No. 314*.

Detken, C.; Dieppe, A.; Henry, J.; Marin, C. and F. Smets (2002): Model Uncertainty and the Equilibrium Value of the Real Effective Euro Exchange Rate, *Australian Economic Papers*, pp.342-365.

Driver, R. and P. Westaway (2005): Concepts of Equilibrium Exchange Rates, *Bank of England Working Paper*, No. 248.

Egert, B. (2003): Assessing Equilibrium Exchange Rates in CEE Acceding Countries: Can We Have DEER with BEER without FEER? A Critical Survey of the Literature, *Focus on Transition 2/2003*, pp. 38-106.

Egert, B. and L. Halpern (2005): Equilibrium Exchange Rate in Central and Eastern Europe on the Eve of the Euro: Meta-Regression Analysis, *CEPR Discussion Paper No. 4869*.

Egert, B. and K. Lommatzsch (2004): Equilibrium Exchange Rate in the Transition: Tradable Price-Based Real Appreciation and Estimation Uncertainty, *Williams Davidson Institute Working Paper No. 676*.

European Central Bank (2003): Policy Positions of the Governing Council of the European Central Bank on Exchange Rate Issues Relating to the Acceding Countries.

Frait, J. and L. Komárek (2001): Real Exchange Rate Trends in Transitional Countries, *Warwick Economic Research Papers* No. 596.

Gonzalo J. and Granger, C. (1995): Estimation of Common Long-Memory Components in Cointegrated Systems, *Journal of Business and Economic Statistics*, pp. 27-35.

Halpern, L. and Ch. Wyplosz (1997): Equilibrium Exchange Rates in Transition Economies, *IMF Staff Papers*, 44, pp.430-461.

Harris R. and R. Sollis (2003): Applied Time Series Modeling and Forecasting, John Wiley & Sons, Chicester, Great Britain.

Komárek, L. and M. Melecký (2005): The Behavioral Approach and the Equilibrium Exchange Rate of the Czech Koruna, forthcoming in *Czech National Bank Working Paper Series*.

Kilian, L. and M. Taylor (2003): Why It Is So Difficult to Beat the Random Walk Forecast of Exchange Rates?, *Journal of International Economics*, pp. 85-107.

Lipschitz, L. and D. MacDonald (1991): Real Exchange Rates and Competitiveness: A Clarification of Concepts and Some Measurements for Europe, *IMF Working Paper No. 91/25.*

Lyons, R. K. (2001): Microstructure Approach to Exchange Rates, Cambridge University Press.

MacDonald, R. (1997): What determines real exchange rate? The long and short of it. IMF Working Paper, No. WP/97/21, January 1997.

MacDonald, R. (2000): Concepts to Calculate Equilibrium Exchange Rates: An Overview, Discussion paper, Economic Research Group of the Deutsche Bundesbank.

MacDonald, R. and L. Ricci (2004): Estimation of the Equilibrium Real Exchange Rate for South Africa. *South African Journal of Economics*, pp. 282-304.

Maeso-Fernandez, F., Osbat, Ch. and B. Schnatz (2004): Towards Estimation of Equilibrium Exchange Rates For CEE Acceding Countries: Methodological Issues and a Panel Cointegration Perspective, *European Central Bank Working Paper No. 353*.

Sarno, L. and M. P. Taylor (2002): Exchange Rate Economics, Cambridge University Press, London.

Sarno, L. and I. Chowdhury (2003): The Behavior of the Real Exchange Rate: Evidence From an Alternative Price Index, *Economic Notes by Banca Monte dei Paschi di Siena SpA*, pp. 295-333.

Šmídková, K., Barrell, R. and D. Holland (2002): Estimates of FRERs for the Five EU Accession Countries, *Czech National Bank Working Paper*, No. 3.

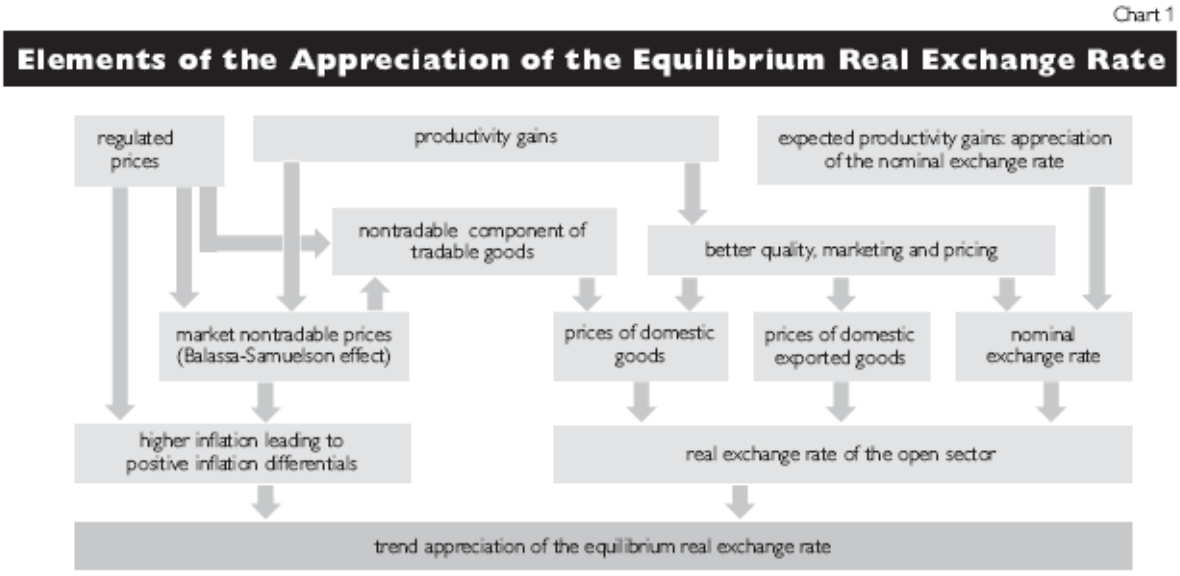
Stein, J. and Allen P.R. (1995): Fundamental Determinants of Exchange Rates, Oxford: Oxford University Press.

Wadhwani, S.B. (1999): Currency Puzzles, Speech delivered at the London School of Economics, 16th September 1999.

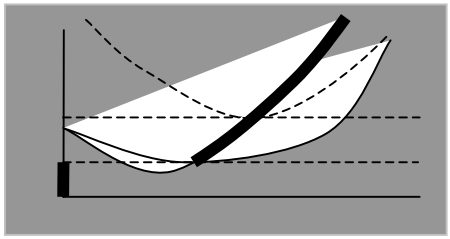
Williamson, J. (1983): The Exchange Rate System, Institute of International Economics, Washington DC: Policy Analyses in International Economics, No. 54.

Appendix

Chart 2 – Trend Appreciation of Real Exchange Rates in Transition Economy



Source: Egert (2003).



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