EQUILIBRIUM EXCHANGE RATE OF THE ESTONIAN KROON, ITS DYNAMICS AND IMPACTS OF DEVIATIONS

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The aim of the analysis presented here is to examine the behaviour of the real exchange rate of the Estonian kroon, to estimate its equilibrium value and investigate its impact on the competitiveness of Estonian economy.

A brief account on possible measures of the real exchange rate (RER) is given, and then the real effective exchange rate (REER) weighted with domestic and foreign consumer price indices (CPI) is chosen for the estimation.

A model for the equilibrium real exchange rate (ERER) determination suitable for a small open economy as Estonia is outlined and provides a theoretical basis for understanding what kind of fundamentals can affect real exchange rate behaviour.

Given the short sample considered here, a single equation estimation method is used. The choice of fundamentals is determined both by particular features of the Estonian economy and data constraint. The fundamentals finally adopted are productivity differential between tradeables and nontradeables sectors, investment share, resource balance and nominal effective exchange rate. Having detected the existence of one cointegration vector between RER and fundamentals, it is possible to estimate the long-run relationship linking them and an error correction mechanism in order to have some information on short-run behaviour of the real exchange rate.

Estimation results are then used to construct both ERER series and misalignment measures. To do this, some hypotheses on equilibrium/sustainable levels of fundamentals are set and discussed. Our simulation hence brings us to conclude that an appreciation of RER in the sample period occurred together with an appreciation of its equilibrium level. The latter appreciated slower, hence the initial undervaluation was corrected and the difference between RER and its equilibrium level shrank, leading to a slight overvaluation after the Russian crisis.

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Introduction

Since the fall of the Soviet Union, Estonia was, among the Eastern European countries, one of the most active in pursuing the reforms needed to transform the economic environment and lead it to a market economy structure. One of the cornerstones of the stabilisation path was set in 1992 with the choice of currency board arrangement and, consequently, of a peg for the newly born Estonian kroon to the German mark[1]. Since then this set-up, and in particular the nominal peg, has been held unchanged. The aim of this study is to explain the behaviour of the real exchange rate of Estonian currency unit and understand its impacts on Estonian economy[2].

The paper is organised as follows: in Section 1 different definitions of real effective exchange rate are stated and analysed in order to find out which one can be more appropriate for the following analysis. In Section 2 attention will be paid to the model. In particular, a brief overview of models used in literature to explain equilibrium level of real exchange rate will be given[3]. Then attention will be focused on one particular model suitable for our case and it will be used to give a theoretical explanation of effects of some fundamental variables on real exchange rate. The last Section will be devoted to the empirical analysis and quantification of misalignment of real exchange rate of the Estonian kroon.

SECTION 1

1.1 REER measures

The real exchange rate is defined as follows:

$$e = \frac{Np^*}{p} \qquad (1)$$

where N is the nominal exchange rate, p^* and p the foreign and domestic price indices, respectively. This is a bilateral definition, but in the empirical part a multilateral definition of real exchange rate will be used. The REER is defined as follows:

$$REER = \prod_{i=1}^{n} \frac{\left(N_i p_i^*\right)^{\omega i}}{p} \qquad (2)$$

where the subscript i denotes different foreign countries and ω is the weight assigned to each trade partner. The problem of choosing the right weight to be attached has been long

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[1] During the last decade currency board arrangement (CBA) has undergone a revival. This system has been adopted in Estonia, Bulgaria, Lithuania and Argentina (in Hong Kong it was reintroduced in 1983). For some recent studies on CBA see Gulde et al 2000, Nenovsky-Hristov 99, Korhonen 99.

[2] This is particularly important if related to accession to EU and EMU. On this subject some useful analysis can be found in Kopits 99, Masson 99, Weber-Taube 99.

[3] For a survey on real exchange-related issues in emerging economies see Edwards-Savastano 99.

debated, and it is beyond the scope of this study. It is useful to point out here that there are many factors to be taken into account, the most important ones being the choice between total direct trade weights (containing export and import trade weights counted together) and export/import trade weights, the choice of the number of countries included in the calculation, the choice between bilateral trade weights or trade weights including also third country competition and so on.

The choice of price indices is even more challenging. Converting nominal exchange rates into real exchange rates basically aims to exploit the most important feature of this variable: the index of the ability of the domestic economy to compete in the international markets. The step from a nominal variable to a real one implies the 'cleaning' of the variable through an index of the nominal factor. In the case of the exchange rate we need a pair of prices (domestic and foreign), which should have three main features:

(1) They should be *comparable*, in the sense that they should be as 'equal' as possible among the countries considered.

(2) They should be strongly *linked to the external sector* (tradeable goods), because of course it is in this sector that the competitiveness concept is meaningful.

(3) They should be easy to obtain. Often the *data constraint* is crucial in the choice of the price index to be used.

But unfortunately there does not exist an ideal way for transforming nominal exchange rates into real exchange rates, any tool used has its advantages and disadvantages, briefly touched upon below[4].

The first natural choice is the **CPI** (consumer price index), because it is considered the broadest measure of prices, and is usually in the focus of public opinion. From the point of view of the comparability property, this is a good tool for measuring REER if the basket of goods utilised in any country is similar, and if there are no price controls or other distortions in price setting (commonly CPI includes taxes on goods, which can be very different in different countries). The presence of nontradeable goods in the basket of CPI, however, can affect the second desirable feature stated above (link to the external sector). From this point of view, the CPI can be seen as an 'expenditure' or 'demand side' index, accounting for the prices of goods consumed in the domestic market. Therefore, it does not take into account the prices of goods produced inside the country and then exported (obviously an important component of tradeable goods) and instead takes into account the goods imported and consumed domestically. This can be seen as an important and relevant drawback of the CPI in measuring the RER. The important advantage of the CPI is surely given by the data problem: CPI is calculated for a large number of countries and it is quite quickly available. Therefore, despite the drawbacks, it has often been used in empirical applications.

PPI (producer price index) or **WPI** (wholesale price index) offer other alternatives. These indices can be viewed as 'supply side' indices, and in this sense they are more

[4] For a methodological overview on nominal and real exchange rate calculation see Zanello-Desruelle 97. An example of empirical application can be found in Lafrance et al 98. They analyse the importance of both price indices and weighting schemes in constructing REER for Canada.

closely linked to the tradeables sector (satisfying therefore better than CPI the second feature stated above), partly also including nontradeable goods. The problem here is comparability, because the PPI and WPI indices are often calculated in different ways for different countries.

Recently many empirical works have focused on the **ULC** (unit labour cost) index. This can be viewed as an attempt to improve the second feature of the measures used. The unit labour cost is an important element of the production costs that is linked to a production factor quite similar across countries (hence comparable), it is not subject to international competition directly, but it is related to production of tradeable goods. In this sense it is a good indicator of how and to which extent a country is able to use internal resources to produce goods that then compete in the international market. The main problem is that it is not calculated (or calculated only for some years) in many countries (the IMF produces the calculation of the REER based on ULC for only 21 industrial countries). Other problems affecting the REER calculated using labour market variables could arise from the fact that the ratio of capital/labour intensity in the production is different across countries[5], and also the labour productivity is different. These problems do not play any important role in comparing countries with a similar degree of development, but considering developing countries (as Estonia) with relevant trades compared to industrial countries, the distortion can affect strongly the REER measure.

An alternative measure linked to the labour market is the **dollar wage.** It is not used to calculate the real effective exchange rate, but simply as an indicator of relative competitiveness of an economy. This methodology is often used in studies regarding developing countries[6]. Given the nominal exchange rate against the dollar and wages in domestic currency terms, for each country the wage in dollar terms is calculated. The country with a lower dollar wage is then more competitive.

It is also possible to consider a different definition of real exchange rate, usually denoted as 'internal real exchange rate'. In this case p^* and p in (1) refer to domestic measures, the first being the tradeables and the second the nontradeables price index. This is a measure of competitiveness for small open economies because the prices of tradeable goods are set by international markets' conditions and hence, if the law of one price holds[7], they are equal for every country. Therefore, the ability of a country to be competitive is given by its ability to limit domestic (nontradeable goods) price dynamics/costs. In empirical applications domestic WPI is used as a proxy for p^* (WPI, as said before, is more closely linked to tradeable goods than CPI) and domestic CPI for p (for the opposite reason, because it is more closely linked to nontradeables prices)[8].

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[5] In a country with low labour intensity variations the ULC can give distorted signals of variation in competitiveness of the domestic economy. In fact they represent only a small part of the unit costs.

[6] See Halpern-Wyplosz 96, Mongardini 98, Krajnyák-Zettelmeyer 97.

[7] The law of one price states that if the international market for any homogeneous tradeable good is efficient, the price of such good is equal across countries. Often the validity of this law has been tested and in some cases rejected (as an example, see Canzonieri-Cumby-Diba 99). Engle-Rogers 99 find that tradeable goods violate the law of one price more easily than nontradeable goods. This should be brought about by the relatively higher volatility of nominal prices for tradeable goods.

[8] Later a similar measure will be presented where the PPI of foreign countries is used instead of the WPI.

Given the possible definitions of real exchange rate, both in internal and external terms, the behaviour of the REER for the Estonian kroon is now analysed quantitatively. The effects of both different definitions of REER and some relevant episodes in the recent history of the Estonian kroon will be pointed out.

The starting point is the analysis of the dynamics of the REER calculated with the CPIs. Nine foreign countries, the most important trade partners[9], are examined and the REER is calculated in domestic terms. Figure 1 shows an initial strong fall of the value of REER in 1992, a sort of rebound in 1993 and then since the beginning of the 1994 a constant appreciation of the kroon.

Given the appreciating trend, three main episodes can be seen as deviations, and are therefore interesting to be analysed, at least from a qualitative point of view. The first one is the year 1993, during which the value of REER increased, thus going in the opposite direction to the trend. The second one refers to the following year, when there was a rapid appreciation, which can be seen as a correction of the behaviour of the previous period. Finally, it is worthwhile to say some words also about the crisis of the second half of 1998, driven by the Russian economic distress[10]. In the following part of this section a decomposition of the REER in different manners is presented, in order to understand its behaviour better, looking more closely to these three episodes[11].

The first decomposition (Figure 2) is in terms of bilateral real exchange rates of the Estonian kroon against nine major trade partners. This should help us find out if one or more currencies are responsible for the behaviour of the REER. The bilateral RERs are plotted starting form the first month of 1993, setting at this date all the values equal to 1. The first thing to be noticed is the different conduct of bilateral RERs with western countries and with eastern partners (Russia, Latvia and Lithuania). The second group of countries explains the increase of REER in 1993, and the subsequent sharp fall of the following year, while the behaviour of the bilateral RERs against the first group is quite stable as compared to the trend. Given the importance of Russia as a trade partner during that period (the weight in export and import is 20%, but considering just the nine countries, its normalised weight reaches 25%), the behaviour of the REER seems to be heavily affected by the problems of Russian economy. This is much more true for the third episode investigated: during the second part of 1998 the bilateral RER against the rouble falls abruptly, instead the behaviour against all the other currencies (Latvia and Lithuania too) is almost unaffected[12]. After this event, there was (and still is) a slow reallocation of the trade from Russia towards other partners (especially Nordic countries),

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[9] The partners considered are Russia, Latvia, Lithuania, Finland, Sweden, Denmark, Germany, the Netherlands and USA.

[10] For an analysis of this episode, see De Broeck-Koen 2000.

[11] There are several different ways in which real effective exchange rate can be decomposed. In our analysis only some of them are considered. Other decompositions can be found in Hinkle-Nsengiyumva 99(a).

[12] After the second half of 1998 bilateral RERs against western partners currencies are flat, except for US dollar, which appreciates against the kroon.

therefore the future episodes due to the instability of the Russian economy should be less important and less consequential.

Another useful exercise can be the decomposition of the REER in the following way:

$$REER = NEER \frac{\prod_{i=1}^{9} (p_i^*)^{\omega_i}}{p} \qquad (3)$$

This shows how much of the real appreciation can be explained by NEER (nominal effective exchange rate) and how much by the price differential. This decomposition is depicted in Figure 5.

In 1993, the REER behaviour is similar to that of the relative price index. This means that what drives the real kroon depreciation of this year is the price differential with the trading partners. In particular during this year the inflation in Russia and Lithuania is much higher than the domestic inflation. Therefore, in spite of a nominal appreciation, the REER increases. In 1994, instead, the relative price index was stable: the inflation in Russia was still higher, but the difference was smaller, and it was compensated by the slower price dynamics in the western countries, therefore both the NEER and the REER values dropped. From 1995 NEER and relative price index went in different directions (but remained close). The latter decreased, given the inflation differential with other countries, especially the western countries, and the NEER increased, given the bilateral nominal depreciation against Nordic countries' currencies and the US dollar (bilateral NERs with continental Europe were stable, and NER against the Russian rouble continued to appreciate). With the Russian crisis in 1998, the reaction of the three variables was different: there was a drop in both REER and NEER, and it was, instead, the relative price index that went in the opposite direction (making the REER drop lower than NEER drop).

An interesting exercise is to see how much the fluctuation against the Russian rouble affected the behaviour of the kroon (see Figure 3).

It seems that without Russia the behaviour is exactly what is predicted by the theories supporting the choice of a fixed exchange rate regime. The choice of the currency board is dictated by the desire to stabilise as fast as possible the economic environment. What happened is that the NEER remains quite stable, instead the REER increase is driven by the price differentials with other countries: a faster dynamics of prices undermines the competitiveness of the country through a real appreciation of the kroon. Figure 4 also shows the success of the convergence policy: during 1999 the three variables showed little movements, and high correlation.

To conclude this first part, we take a look at a couple of indicators often adopted in studies on developing countries. The first one derives directly from (2), where as foreign price index WPI or PPI is used instead of CPI. The reason is that PPI and WPI should represent better tradeables price, where instead domestic CPI (at denominator) is a better proxy for nontradeables prices. Figure 6 shows that in the case of Estonia this indicator is very similar to CPI-based REER.

The other measure, which, as stated above, is not an absolute measure of RER, but can be a useful relative index of competitiveness, and which was often used in comparing competitiveness of developing and transition countries, is the ratio of tradeables and nontradeables price indices[13]. Figure 6 shows that its behaviour is similar to the REER after 1994. In 1993 the ratio was considerably bigger. One of the possible explanations of this phenomenon can be the following. As we have seen before, the increase of REER in 1993 was driven mostly by the faster price dynamics in other eastern countries examined here (Russia above all). The tradeables/nontradeables measure shows that the tradeables prices were already driven by international competition with western countries, therefore the inflation in this sector was already much slower than in the nontradeables one.

In conclusion, the dynamics of the kroon fits the theory of currency behaviour for the transition economies: starting from an undervalued level it appreciates rapidly at the beginning and then slower, eroding the competitiveness of the domestic production. Some episodes can disturb this trend, as we have seen in case of 1993 and 1998.

The Russian economy, and particularly the rouble behaviour, seems to be the main cause of deviation from this trend towards appreciation. In 1993 the mechanism of currency board in Estonia slowed the price dynamics before other eastern trading partners, causing a real depreciation contemporaneously to a nominal appreciation. In 1994 there was a reversion effect, and the appreciation of the kroon was faster than the trend. In 1998 the Russian crisis was the main source of disturbance. The fall of economic activity in this country caused again an increase in the relative prices, but this time the nominal devaluation of the rouble completely compensated this effect, and finally brings about a real appreciation of the kroon. During this episode the bilateral RERs against other currencies remained in fact quite stable. Given the gradual shift from Russia to the Nordic/Western countries as trade partners, similar episodes of instability should have less impact in the future, but the shift will probably take time, and at current stage shocks in Russian economy can hit the real value of the kroon.

The behaviour of real effective exchange rate indicators examined here is qualitatively similar and also not differing too much quantitatively. Therefore, for the empirical part the REER calculated using CPI for domestic and foreign prices is used.

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[13] For a more detailed analysis on tradeables/nontradeables ratio as competitiveness indicator, see Hinkle-Nsengiyumva 99(b).

SECTION 2

2.1 Models of Equilibrium Real Exchange Rate

This section reviews the methods used in literature to estimate the equilibrium real exchange rate. The approach has the aim to present the evolution of the ERER literature both from a historical and technical point of view.

<u>PPP</u>

The first step in assessing the value of an equilibrium level for the real exchange rate is the PPP (purchasing power parity). In the long run the nominal exchange rate between two currencies should move in the opposite direction to the movement of relative price between the same goods in the two countries, in order to leave the purchasing power of the two currencies equivalent. The idea, attributed to Cassel (1922), has an older origin, back in the eighteenth century.

Many attempts have been made to assess empirically the validity of this rule. The simpler way to do this is to estimate the following equation:

$$n = \alpha + \beta(p - p*) + u \qquad (4)$$

where n is the logarithm of N in (1) and p and $p*$ are the logarithms of price indices. If the absolute version of the PPP holds, then the value of α should be 0 and the value of β should be 1. If instead the relative version of PPP is investigated, we should expect again β equal to 1, but α can have any value, where the value of α accounts for transaction and transport costs[14].

The econometric technique used at the beginning was ordinary least squares. In this case we could have the problem of a 'spurious regression' (if some of the regressors are non-stationary).

During the last decade there was a revival of empirical tests of PPP using new estimation methods. If the three variables involved in the regression are non-stationary, but have the same order of integration, it is possible to test if they are cointegrated. In other words, if they are cointegrated, there exists at least one linear combination of the three variables that is stationary, and the weights of this linear combination taken together form the 'cointegration vector'. A lot of tests have been performed, and some of them found that such a long-run relationship exists. If so, it is possible to test the relative or absolute PPP imposing some restrictions on the cointegration vector's parameters.

$$n = \beta p + \varphi p^* + \varepsilon \qquad (5)$$

[14] The absolute version of PPP states that in equilibrium e in (1) is equal to 1, whereas e is equal to a constant (possibly different from 1) if the relative version of PPP holds.

In particular, given the equation (5), imposing the symmetry means requiring the existence of at least one cointegration vector between these variables, whereas imposing also homogeneity means requiring $\beta = -\varphi$. If only the symmetry holds, then the relative version of the PPP can be accepted, if also the homogeneity holds, then the absolute version of PPP is valid.

Another kind of test is the unit root test of the RER. This series is modelled as an AR(p) process, and some tests are performed to see if it has a unit root. If this is the case, then the RER is non-stationary, and therefore the PPP does not hold[15].

The results from the literature are mixed. For the sake of brevity, no particular research is observed here, but in summary it can be said that a cointegration vector is generally found when two features match: the sample considered is very long (from thirty years to a century or more) and the countries considered are industrial countries[16]. This consideration is particularly important in our case. Given the recent history of the Estonian economy and the fact that our sample is entirely composed by a transition period, it is not possible to find a constant fixed value for RER.

Single equation specifications

Balassa and Samuelson gave the first explanation of the failure of PPP[17]. They started from the hypothesis that the price of the tradeable goods is equal in all the countries and also the growth of productivity of labour in the tradeable goods sector is higher than in the nontradeables sector. In addition in each country the labour market is such to equate the wages across sectors and in a richer country the relative productivity[18] is higher than in a poorer one.

Given these hypotheses, it is possible to state that the relative price of nontradeable goods will grow faster in a faster growing country than in a slower growing one, generating a structural appreciation of the RER.

This was the first model explaining the possible failures of PPP. It is important because it gives the essence of the whole follow-up literature on the equilibrium RER: the existence of structural differences across countries is the main determinant of variation of equilibrium exchange rate. From this starting point it is possible to think about all the components of this structural difference, and therefore to try to explain the (equilibrium) RER behaviour by means of fundamental variables. The importance of this contribution is also proved by the fact that productivity differentials are included in every upcoming attempt to use fundamentals to explain the ERER, and it is now known as the Balassa-Samuelson effect.

[15] For some unit root tests, see Sarno-Taylor 98 and Liang 98.
[16] For some other tests on PPP, again Liang 98, and for a survey on PPP literature Breuer 94.
[17] Examples of possible tests of Balassa-Samuelson effect can be found in Ito et al 99.
[18] The relative productivity is defined as the ratio of the productivity in the tradeables sector to that in the nontradeables sector.

Finally, it is important to say that this effect can be seen as a 'supply side effect'. In fact, it is the production side of the economy that produces the long-run appreciation (depreciation) of the RER. It has also been pointed out[19] that the long-run changes in RER given by differences in tradeable and nontradeable goods sectors can also come from a 'demand side' source. If in fact (as seems to be empirically proved) the demand elasticity to the income for the nontradeable goods is bigger than one, then a country growing faster will show an ever increasing demand for nontradeable goods. This implies dynamics of the prices for these goods faster than for tradeable goods (in this second sector the world market puts a limit to the price dynamics). If this is true, then the currencies of these countries will appreciate as compared to slower growing economies (as predicted by the Balassa-Samuelson model).

All the possible explanations and tests examined so far are based on a single equation specification. We have started from the most simple (PPP), and seen how the complications were treated. As stated above, after the first remark by Balassa and Samuelson, the attempts to explain the ERER have been in the direction of adding more explaining variables in the regression and finding a different specification for every particular case.

This approach has been applied both to industrial and developing countries[20]. Making a step further, the logical consequence in the attempt to explain the equilibrium RER has been to expand the analysis to a more general and exhaustive framework. This has been done building partial and then also general equilibrium models.

Partial equilibrium models

This kind of model tries to extend the approach to the determination of the equilibrium RER. They do not simply specify an equation for the RER, but they try to find the RER compatible with the internal and external equilibrium of the economy. Given that there is a broad consensus on the definition of internal equilibrium (always represented by the rate of growth compatible with NAIRU, Non-Accelerating-Inflation Rate of Unemployment), the most important issue is defining an equilibrium concept for the external sector of the economy.

The typical example of this approach is the macroeconomic balance approach. The common outline of this model is that the equilibrium RER must bring the external sector of the economy to equilibrium. The differences in defining the 'external equilibrium' lead to different models (and different determinants of the ERER).

One possible definition of the external balance is a CA (current account) always equal to zero. In this case, the ERER is the level of RER that clears out any possible flow with other economies (hence allowing the stock of foreign position claims to be constant).

[19] See, for example, MacDonald 97.
[20] For industrial countries, see for example MacDonald 97, Clark-MacDonald 98, Feyzioglu 97, and Chinn-Johnston 96. For developing countries, among others, Edwards 94, Elbadawi 94, Halpern-Wyplosz 96, Mongardini 98, Sundararajan et al 99, Wu 99.

This view is too restrictive, given that a CA different from zero can be sustainable, and also in some case desirable[21].

Another possibility is to differentiate between short-term and long-term capital flows. In this case the external balance is achieved when the short-term capital flows are zero. Also if theoretically this definition is reasonable, distinguishing between the two flows in practice is difficult.

Finally, it is possible to define the external balance as follows:

$$CA = S - I \qquad (6)$$

This states that the current account is in equilibrium when it equals the difference between the long-run levels of saving and investment in a country. In fact a country that has a structural level of saving higher than investment will achieve the external balance if it can transfer the excess resources abroad, running in this way a CA surplus. This approach is the method followed by the IMF in assessing the level of RER compatible with the internal and external balance[22]. Briefly, what the IMF does, is to regress CA on some fundamentals. Then, substituting equilibrium values of these fundamentals into the estimated equation, the medium-term equilibrium level of the CA[23] is calculated. The same procedure is applied to find the right-hand side of the equation (6), or the medium-term equilibrium S–I, using different explanatory variables.

The equilibrium is reached when these calculated values coincide (hence (6) holds). If this does not happen, given that S–I does not depend on RER (it depends on demographic factors, structure of the economy, government behaviour and so on), the adjustment must arise from the left-hand side of (6). The third step consists of assessing the degree of misalignment of the RER.

The virtues of this approach are primarily the possibility to see how a wide range of fundamental variables can affect the medium-term equilibrium RER through changes in both the left and right-hand side of (6). The estimation of the two sides of (6) separately can simplify the empirical work, and it also allows distinguishing between structural variables affecting only domestic economy (variables entering the right-hand side of (6)), and factors affecting directly the external sector (left-hand side). The main problem is that within a partial equilibrium framework, it is not possible to model the feedback from the RER to the other components of the model.

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[21] A rapidly growing country can run a CA deficit due to a high rate of return. This position can be optimal if the main part of the CA deficit is run to build up the necessary capital stock, and can be run for quite a long period.

[22] This section is based on Isard-Faruquee 98. They examine the internal and external balance separately, and in this sense the approach is a partial equilibrium approach. The same model can be specified through a simultaneous internal and external equilibrium. In this second case the model can be considered a general equilibrium model. Clark et al 94 describe the same framework of analysis.

[23] See Isard-Faruquee 98. This approach is a normative one: in order to find the equilibrium RER, equilibrium values of the fundamentals must be specified, and in some cases they are ‘desired levels’. Given that some equilibrium values are taken from forecasts, they do not necessarily hold for a period longer than three to five years. In this sense the equilibrium RER is a ‘medium-term equilibrium RER’.

For the case of Estonia, this framework (designed for industrial countries) can be of interest but it also presents some problems. First of all, the assessment of an equilibrium level of the right-hand side of (6) is problematic for developing and transition countries, because of their limited access to international capital markets[24]. Presumably for Estonia this is not a problem at the moment, but it probably was both in the first part of the sample period considered here and during the Russian crisis. Secondly, 'underlying current account estimates' can also be a source of bias[25]. As will be seen below, the approach we use is also subject to biases and depends heavily on the range of hypotheses taken. Nevertheless, a single equation approach helps us in minimising the level of uncertainty of the results (here only one equation must be estimated, whereas with a partial equilibrium framework at least two estimations must be run).

General equilibrium models

The main difference between these models and those of the previous section lies in the theoretical background. In this section we will see that the starting point of the analysis is a model for the whole economy (internal and external sectors are considered simultaneously). After that the equilibrium conditions of the model are found, and are generally represented by two (or more) equations explaining the behaviour of the economy.

The principal possible distinction is between normative and positive models. Constituents of the first category are the FEER (fundamental equilibrium exchange rate) and the DEER (desirable equilibrium exchange rate) models, whereas the NATREX (natural real exchange rate) and BEER (behavioural equilibrium exchange rate) are examples of the second type[26].

The FEER and DEER models specify the structure of the economy and hence a link between the RER and other relevant macroeconomic variables[27]. Given the behaviour of the economy, an equilibrium RER compatible both with internal equilibrium (output growth compatible with NAIRU) and external equilibrium is found. This second aspect is particularly important in setting the difference between normative and positive approach. The external balance is in fact defined as a 'desirable' level of current account, a concept particularly difficult to define and quantify[28].

The NATREX has already been used in some studies on small open economies. It has a positive approach in the sense that it does not try to give a priori values of CA or output

[24] See Isard-Faruquee 98 p 19.

[25] Isard-Faruquee 98, p 18: *'…Uncertainty about the appropriate specifications for trade equations and the estimated values of elasticity parameters implies imprecision both in the underlying current account estimates…'*

[26] For BEER model, see for example Clark-MacDonald 98. Examples of applications of NATREX model can be found in Stein 94 and Lim-Stein 95. A short clear summary of the NATREX model can also be found in Montiel 99(a), pp 250 to 254.

[27] Both these specifications as a matter of fact use the macroeconomic balance approach considered in the previous section. The difference here is that the right and the left side of equation (6) are considered simultaneously.

[28] Both the MULTIMOD (the model used by IMF, consistent with the DEER defined above) and the FEER model have never been applied to developing countries.

that is optimal or desirable to reach. Instead it tries to use past observations to decompose the RER in three main components:

$$e = (e - e_m) + (e_m - \bar{e}) + \bar{e} \qquad (7)$$

where e is the actual RER, e_m the medium run RER and $\bar{e}$ the long-run RER. From equation (7) we have a long-run component, given by the RER compatible with stationary values of the fundamentals (productivity, social thrift at home and abroad, with the level of foreign debt and capital stock fixed). Second, a medium-run component, given by the difference between long-run RER and a RER compatible with equilibrium of productivity and social thrift, but that allows foreign debt and capital to vary. Finally, a short-run part determined residually by the first term of (7). It also has the advantage to implement a smaller model.

From an econometric point of view, two ways can be pursued: first of all it is possible to reduce the model to a single equation and estimate it with OLS (or similar approaches as non-linear least squares estimation). This makes the approach similar to the one explained above, leaving to the model a theoretical role. An alternative is represented by the estimation of a complete VAR. In this case all the interconnections between RER and fundamentals are taken into account (in particular the feedback from RER to fundamentals). In the case of Estonia, given the short sample, this possibility is precluded. Therefore, a model will be used as theoretical background, and the estimation will be restricted to a single equation approach.

2.2 Montiel's Model

The model presented in detail in Appendix 1 gives us a theoretical basis to understand which fundamentals are important in explaining the behaviour of equilibrium real exchange rate (and compare these later with the results of the estimation). This model is a slightly simplified version of the model presented by Montiel[29]. This is a macroeconomic balance model (taken from Dornbusch model[30]) and it is a general equilibrium model in the sense that internal and external equilibrium are considered simultaneously, and the ERER assures that both sectors are in equilibrium. It will be shown that the solution of the model is taken for a particular level of current account, and in this sense this model belongs to the DEER stream of approaches. We will also see that the solution is found implicitly in the form of a single equation. This is a convenient basis for the empirical part also if the price to pay is that we lose the feedback part of the model, from ERER to the fundamentals. The main differences with Montiel's model are that here transaction costs in consumption are not considered (no relevant information for our purpose is lost), and also a fixed nominal exchange rate agreement is considered instead of a crawling peg as in the original version of the model. The general framework used is suitable for

[29] See Montiel 99(b), pp 266 to 278.

[30] Dornbusch R, *Real Interest Rates, Home Goods, and Optimal External Borrowing*, Journal of Political Economy 91(1)/1983.

Estonian situation because a small, financially open economy with two sectors (tradeable and nontradeable goods) is assumed[31].

The equilibrium level of real exchange rate assures that both internal and external balances are attained. Internal balance is reached when the nontradeables market is in equilibrium, or households and government consume the whole production. This is given by the following equation (Equation (25) in Appendix 1):

$$y_N(e) = c_N + g_N \qquad (8)$$

where y_N is total production in nontradeables, c_N and g_N are total consumption in nontradeables of households and government and e is the real exchange rate. From this the short-term equilibrium value of e is easily derived (equation (26) in Appendix 1):

$$e = e(c, g_N) \qquad (9)$$

where c is total consumption of households. We now need a condition for the equilibrium in the nontradeables sector. In this model it is reached when the country's net international creditor position is constant, hence its rate of change must be equal to zero. Following Montiel, it is here supposed that in equilibrium real account balance is equal to the inflationary erosion of real claims of country on the rest of the world[32]. This condition is expressed by the following equation (equation (28) in Appendix 1):

$$\pi_W f = y_T(e, \alpha) + (\rho + \pi_W) f - \theta c - g_T \qquad (10)$$

where π_W is the world inflation, f the net foreign asset position, α the productivity difference between tradeables and nontradeables sectors, ρ the time preference parameter of the households, θc consumption in tradeables of households and g_T consumption of tradeables of public sector. Equation (9) and (10) are the two equilibrium conditions for nontradeables and tradeables markets. They implicitly define the equilibrium level of the real exchange rate e (equation (29) in Appendix 1):

$$e = e(g_N, g_T, c, \alpha, \rho, \pi_W, \theta, f) \qquad (11)$$

As explained below, all the variables used in the estimation of the long-run value of the real exchange rate can find a theoretical background in the model sketched above, in particular in equation (11). In the next paragraph a short summary of the effects of fundamentals on ERER is presented.

[31] The main divergence of the model from the Estonian case is the hypothesis of a fully implemented market economy (for example perfect competition in goods market, full employment in labour market). At the beginning of the transition, agents probably behave as during centrally planned economy period, and also goods markets are far from the perfect competition case. A possible improvement of the model could be the consideration of an adaptation period during the first period of transition both of agents' behaviour and structure of the economic environment.

[32] See Montiel 99(b), p 277.

2.3 Effects of fundamentals on ERER

The representation of the equilibrium is depicted in Figure 7, where IB is the locus of internal equilibrium points and EB fixes the external equilibrium; *e* and *c* are the real exchange rate and the consumption level.

It is then possible to analyse, using the model specified above, the effects of the long-run determinants on the equilibrium RER.

Balassa-Samuelson and demand side: the Balassa-Samuelson effect is captured in this model in the labour market, where increase in productivity in the tradeable goods sector shift labour (and production) away from the nontradeable goods sector. The internal balance is affected because a decrease in output of nontradeable goods requires a decrease in demand of these goods (*c* decreases). To re-establish the internal equilibrium the IB must shift downwards to IB'. Also the external balance is affected through production: the excess supply in the tradeable goods sector generates a CA surplus that requires a real appreciation (decrease in *e*) of the RER. This shifts the EB curve downward to EB'. In conclusion, with this graph it is possible to capture both the Balassa-Samuelson effect (related to the production/supply, and affecting the EB) and the demand side effect (emerging from the consumption/demand, and affecting the IB). The combination of these two effects is the result of the productivity differentials between the two sectors of the economy. The equilibrium is now at point A.

In empirical applications this effect has been captured through different proxies. For example Edwards 94 uses simply the growth rate of GDP (supposing that faster growing countries have a higher productivity in the tradeable goods sector), Feyzioglu 97, instead, uses the differential productivity in manufacturing sector with trading partners (these data are generally not available for developing countries).

Fiscal policy: two cases are considered, a change in composition of government spending at constant fiscal deficit, or a change in the amount of fiscal deficit.

The first case has different effects on the final equilibrium RER depending on the sector involved in this change. If the government increases the consumption of tradeable goods, then only the EB is affected (it shifts upwards to EB'' because the excess demand of tradeable goods tends to create a trade deficit that must be corrected through a real depreciation). The equilibrium is then at C. If the public sector instead increases the consumption of nontradeable goods, the IB shifts downwards to IB' because an excess demand of nontradeable goods requires an increase in their prices. This causes an appreciation of the equilibrium RER (the equilibrium is at point B). Both cases lead to a reduction of consumption by the private sector, but the final effect on equilibrium RER differs.

The second case is given by a change in the deficit through changes in taxes. In this model the effects on RER are given by changes in transaction costs associated with consumption[33]. For example a decrease in taxes causes an increase in real output (of tradeables or nontradeables) shifting one of the two curves (or both) to the right. Some authors do not consider the fiscal policy a determinant of equilibrium RER either because it has no effect on the equilibrium RER[34] or because, as noted above, the government spending in different sectors can cause opposite effects on the equilibrium RER, and data on government spending decomposition are often not available (see Mongardini 98). Or others simply take the ratio of total government spending to GDP assuming that it refers to the nontradeable goods sector (see Edwards 94). For developing countries it seems reasonable to include the fiscal policy among the determinants of the equilibrium RER, as most of the researchers do. This stems from the fact that an important variable in assessing the competitiveness of such countries is the ratio of the prices of tradeable and nontradeable goods. Given that often the consumption of the government in nontradeables is relevant, a permanent shift of government behaviour can affect structurally the competitiveness of the country.

International economic environment: the most important component analysed with the model regards financial conditions. These are represented by the world interest rate. Here it has lasting effects because a (temporary) deviation of the real interest rate affects (temporarily) the capital flows. This in turn changes the position of the country as net debtor or creditor in the international markets, producing a (permanent) higher service of the debt (or revenue from the credit). For example, a decrease in the world real interest rate can cause a higher rate of capital inflow, which can create a future obligation to repay not only a higher debt, but its service too. This causes a shift of the EB upwards to EB'' (hence a depreciation of the equilibrium RER to point C).

Also the terms of trade, here not explicitly considered, is an important element of international economic conditions. Hence it can be useful to see how this variable affects ERER, using Figure 7. If we define the terms of trade as the ratio of price of exportables to the price of importables, an increase in this variable implies a convenience for the country to shift production from the nontradeables to the tradeables sector. This shifts the IB curve downwards to IB' (the excess demand of nontradeable goods brings about an increase in the prices of these goods, and hence an appreciation of the equilibrium RER). Again, the terms of trade improvement cause a trade balance surplus and thus an appreciation of the equilibrium RER is required (EB shifts downwards to EB'). The two effects combined cause an appreciation of the equilibrium RER and the new equilibrium is at point A. From an empirical point of view, almost all studies include this factor, both for its importance and because it is easily available. In Estonian case the series for import price indicator is available only starting from 1997, hence the terms of trade are not considered in the empirical part.

[33] Without transaction costs, the change in government amount of expenditure depends again on the composition of expenditure. If the composition does not change, then the government behaviour is counterbalanced by private sector, hence equilibrium remains at E (see Figure 7).

[34] *"...composition and level of government consumption. I have always doubted the empirical significance of the former..."* Williamson 94, pp 13 to 14. About the latter, he argues that the level of fiscal expenditure, if sustainable, will not affect the equilibrium RER (in the equilibrium it should offset the private consumption).

Commercial policy: the change in commercial policy towards liberalisation should affect both EB and IB. In particular liberalisation (through diminished export subsidies or lower tariffs on imported goods) makes the imported (exported) goods more (less) competitive, hence causes an incipient trade deficit. This requires a depreciation of the RER, thus shifting the EB upward to EB''. In the internal market the pressure on tradeable goods shifts the production from tradeables to nontradeables. This brings about an excess supply in the nontradeable goods sector, hence requires a depreciation of the equilibrium RER. This shifts IB upward to IB''. The final effect is a depreciation of the equilibrium RER to point D.

Generally it is rather difficult to find a satisfactory proxy for the commercial policy shifts (one example is the ratio of tariffs revenues to imports). If the change is once and for all (such as abolition of a tariff or of a limitation in currency convertibility), then it is possible to capture this effect with a dummy variable. In the case of Estonia, from the beginning of the transition period the economy was open to external competition, therefore no commercial policy variable is included to the explanatory fundamentals of the long-run RER.

SECTION 3

This section presents the empirical part of the research.

3.1 Estimation method

The estimation method is taken from Baffes et al 99. They use time series analysis in a single equation approach. In particular the starting point is equation (12).

$$\lg e_t^* = \beta \lg F_t + \varepsilon_t \qquad (12)$$

where $\lg F_t$ is the vector containing the logarithms of fundamentals. This equation is exactly (11) under the hypothesis that the long-run relationship between real exchange rate and fundamentals can be defined and estimated in a linear form. The time series approach is necessary because if some of the variables are non-stationary, we could have the problem of the spurious regression applying OLS to (12). This procedure would instead give meaningful results if all the variables have the same order of integration and if only one cointegration vector among them exists. An advantage of this approach is that it is possible to build an error correction mechanism specification, which can give additional information on the short-run dynamics of the real exchange rate. The ECM specification can be estimated in two versions:

$$\Delta \lg e_t = \eta \hat{\varepsilon}_{t-1} + \gamma \Delta \lg F_t + \tau \lg S_t + u_t \qquad (13)$$

$$\Delta \lg e_t = \eta (\lg e_{t-1} - \beta \lg F_{t-1}) + \gamma \Delta \lg F_t + \tau \lg S_t + u_t \qquad (14)$$

where *S* is the variables affecting *e* only in the short run. The difference between the two is the error correction term, which in the first specification is given simply by the residuals of equation (12). In principle they should give the same results, but we will see that in our case the short sample, hence the low number of observations, can heavily affect the quality of the results obtained estimating (15) because of the bigger number of parameters to estimate.

We will see below what kind of information this procedure reveals, and how it will be used to estimate the long-run level and degree of misalignment of the real exchange rate.

3.2 Variables

In this section the set of variables used in the empirical part is analysed closely. Detailed comments are given for those variables adopted in the final version (the specification later used to estimate the real exchange rate equilibrium value and misalignment).

LREER: this is the log of real effective exchange rate constructed using the official nominal exchange rate for the nine most important commercial partners of Estonia. The price index used is the CPI both for domestic and foreign prices. The weights used are derived from both import and export weights against each foreign country.

PRODDIF: the level of productivity is calculated separately for nontradeables and tradeables sector. As proxy of productivity in each sector the ratio of real output to the number of employees is taken. The difference between productivity in the two sectors is then calculated. Given that at the beginning of the period it is higher in the nontradeables sector, when the difference decreases we have a higher growth of productivity in the tradeables sector, hence an appreciation in the real exchange rate, if the Balassa-Samuelson effect works.

ISHARE: this is given by the ratio of level of investment to the sum of investment, consumption and public expenditure (all in real terms). It is not taken in log, but is seasonally adjusted.

RESB: this is given by the ratio of net export to GDP (again all in real terms), in log and seasonally adjusted.

LNEER: this is the log of the nominal effective exchange rate, constructed with the same weighting scheme used for REER.

DURUS: this is a dummy variable with values equal to 1 in the last three quarters of the sample, and it is included to capture the effect of the Russian crisis[35].

[35] The estimation was initially performed without this dummy variable, but it presented a low value of D-W statistics (=0.77). Some tests for parameter stability were performed and a break point was signalled in the third quarter of 1998 performing Chow forecast test, Recursive residuals and CUSUM.

A larger set of explanatory variables was initially employed to try to explain both the long and short-run dynamics of the real exchange rate. Some of them were discharged, and some not, considered in the list above, are inserted in Table 1 because, also if not used in the final version of the estimation, in previous estimations (reported in Table 3) they can help us in analysing some particular features of the Estonian economy.

The integration order of all the variables is detected using the adjusted Dickey Fuller test. The results are summarised in Table 1, where statistics including the trend (columns a and c) or only the constant (columns b and d) are reported. All the variables are I(1)[36,37].

3.3 Cointegration

The last thing needed before estimating equation (12) is to verify the order of cointegration of the variables involved. Therefore, the Johansen procedure is performed to test the number of cointegration vectors. A deterministic trend in the data is allowed, and in the cointegration equation no trend is assumed. The results are reported in Table 2.

There are two cointegration vectors, but correcting the small sample[38] we see that there is only one cointegration vector at 5% level. Therefore, it is possible to estimate the long-run relationship between real exchange rate and fundamentals using OLS.

3.4 Estimation results

Before analysing in details the results of the final specification, it is useful to comment in a few words the results reported in Table 3[39]. As also pointed out above, these estimations are performed for a smaller sample because some of the series used do not have available observations from the period before 1994.

The first thing to notice is that all the estimated specifications give similar results for both sign and absolute values of ECT (Error Correction Term), productivity, ISHARE, RESB. This group of results can be seen as a sensitivity analysis: using different exogenous variables and endogenous variables does not affect the effect of these main fundamentals on real exchange rate.

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[36] In this way the only hypothesis needed regards the number of lags used in the ADF test. A more detailed procedure is suggested by Doldado et al, where the significance of the trend and constant in the equation for the ADF is considered at each step. This procedure was tried and it confirmed the order of integration reported in Table 1.

[37] Results reported in Table 3 refer to a shorter period (1993 is excluded). In these cases an integration test was performed for each variable for the sample considered, and again the same order of integration was found as reported in Table 1.

[38] See Baffes et al 99 and Table 2.

[39] For all the estimations in Table 3 PROD is used instead of PRODDIF. This is a measure of overall productivity of the economy, measured by the log of the ratio of real GDP to the number of workers.

Something can also be said about G (total government expenditure in real term) and r_de (real yield of 10 year German Bund, here used as a proxy of international real interest rate). In the model permanent shifts in the value of these variables should affect the equilibrium real exchange rate (g_N, g_T and π_W in equation (11)[40]). In Table 3 it can be easily seen that for both, when included in the vector of fundamentals, the parameter estimated is often not significant, and the sign changes in different specifications. This can be explained with the particular situation of the Estonian economy. In the sample public expenditure remained more or less constant (fiscal policy was rigorous), therefore the outcome was expected. Hence in the final specification G is dropped, but in future it can be a source of equilibrium real exchange rate fluctuation if its amount (or composition) will change. The situation is more or less the same for r_de. In the sample the world interest rate does not show large changes, therefore the effect on ERER is not highly significant.

We can now turn the attention on the final specification used: the results are reported in Tables 5.1, 5.2, 5.3 and Figures 8.1, 8.2, 8.3.

The first equation is simply the relation between LREER and the other explanatory variables in levels, estimated with OLS, allowing the constant. The results are reported in Table 5.1 and Figure 8.1.

Comments: in this case the parameters have the expected signs. They are also all significant. Only ISHARE is not significant at 5% level (but significant at 10%). The possible cause is the presence of a certain degree of correlation between ISHARE and RESB. In fact in the Estonian case the level of investment has a high import content, hence an increase in the investment share is associated with an increase in the level of imports (and decrease in RESB). The correlation coefficient is in fact equal to –0.49 in level and –0.42 in first differences. The estimation of the same equation without one of the two variables was performed, and the amount of decrease of R-squared seems to suggest that the two factors have separately some explaining power on LREER movements. Therefore, this variable is kept in the long-run relationship.

The residuals are also well behaving, in the sense that they do not show autocorrelation (checked with autocorrelation, partial correlation graphs and Durbin Watson statistics) and are also normally distributed (Jarque-Bera test's p-value equals to 0.89).

The second equation is the ECM, with only one lag for first differences. The series of residuals from the previous estimation is used as error correction term. This two-step procedure is useful in this case to help overcome the short sample problem. The results are reported in Table 5.2 and Figure 8.2.

Comments: this gives a first confirmation of the goodness of the specification in the sample: R-squared is quite high and all the parameters are highly significant except the coefficient of the first difference of the productivity, constant and DURUS. This can suggest that PRODDIF plays no role in explaining the very short-run dynamics of real

[40] Given i^*, π_W determines also r^*, the level of world interest rate.

exchange rate. This result seems reasonable, given that ISHARE and RESB are linked to movements in current account balance, hence they have a direct impact on real exchange rate, and LNEER also has an immediate effect on LREER. Instead the productivity has only a structural, medium-run effect in the Balassa-Samuelson hypothesis (it works through wages and, therefore also through prices). Finally the error correction term's parameter is significant and with expected sign. The absolute value is slightly higher than the one found in past studies[41]. This can be due to the fact that the LNEER is also considered in the fundamentals, a nominal variable adjusting faster than the other fundamentals, hence pushing faster the value of LREER towards its equilibrium.

The residuals are in this case well behaving, showing no autocorrelation and again normally distributed (Jarque Bera test's p-value is equal to 0.82).

Then the estimation of the complete set of parameters of the error correction mechanism was tried. The results are reported in Table 5.3 and Figure 8.3.

Comments: The results confirm the positive (and negative) outcomes of the previous estimations: the R-squared is again high, and in this case also the residuals are well behaved (not autocorrelated and the Jarque Bera test's p-value is 0.11). The F-test also establishes that the whole set of parameters have jointly a high explanatory power of the behaviour of real exchange rate.

The problems are confirmed in the sense that PRODDIF is insignificant and with the wrong sign both in level and first difference, and ISHARE has the wrong sign in level and is not significant (but with expected sign) in first difference. Probably both the big number of parameters to be pinned down and the short sample amplify the problems considered above. Given that the results of the estimation as a whole are good and that the ECM parameter is significant and of the same magnitude as in the previous estimation, we can conclude that the long-run link between LREER and fundamentals here considered is confirmed.

3.5 Equilibrium

The equilibrium value of LREER can be calculated taking the fitted values of the equations estimated above, eliminating all the transitory components, and then using the long-run or equilibrium values of the fundamental variables.

This means that the parameters from the estimation of the long-run relationship (Table 5.1) are exactly the parameters of the equilibrium relationship:

$$ERER=-2.132+0.443\cdot PRODDIF^{*}+1.422\cdot RESB^{*}+0.778\cdot ISHARE^{*}+0.438\cdot LNEER^{*} \quad (15)$$

[41] See, for example, Baffes et al 99 p 437. The absolute value is almost the same as the one found here, but I use quarterly observations instead of yearly ones, hence the speed of adjustment of REER implied by this estimation is higher.

where stars beside every variable indicate their equilibrium/sustainable levels.

The next step consists of defining reasonable equilibrium values for the explanatory variables. Usually in the literature a 'time series approach' is used: the transitory part of each series is eliminated with some econometric technique, and the resulting series gives the dynamics of the permanent value of the variable[42]. The implicit hypothesis of this approach is that in the sample the variables were on average in equilibrium, or followed on average the equilibrium path of evolution. In a transition country as Estonia and with a small sample this is not necessarily true for all the variables under consideration. In this sense a 'counterfactual analysis' approach is more promising: the equilibrium value of each variable is assessed taking into account not (or not only) its time series properties, but also the economic aspect of its behaviour and evolution. This second approach is more sensitive to the hypotheses imposed by the researcher, but in our case the potential distortion is more than compensated by the power of the results.

In general, we can see from a graphical analysis of the whole set of variables that it is possible to isolate what from now on will be called an 'equilibrium period'. The meaning of equilibrium in this formulation deserves an explanation. As also pointed out above, the whole sample can be considered a disequilibrium period in the sense that the transition started after the fall of the 'Soviet Empire' is not yet completed. The transition implies a convergence/evolution of every component of the economic environment towards a 'normal situation' (namely, a fully implemented market economy). The path towards the final (normal) stage is not linear, but suffers continuously from shocks, abrupt stops and sudden restarts. The 'equilibrium period' here defined is a period during which this path towards the normal stage is sufficiently stable. A separate consideration of this period (here taken from the beginning of 1995 to the end of 1996) can help us to understand or infer some properties of the transition path of the variables used in our research. These two years are chosen as equilibrium period also looking at the output gap series. This has a stable behaviour close to zero in 1995–1996, whereas it is more volatile and far from zero in other periods of the sample considered.

Different hypotheses on the equilibrium value are presented here for every fundamental, from the more neutral (eg taking as equilibrium value the HP filtered series of the fundamental) to the strongest one.

PRODDIF: the productivity in both sectors shows a continuous increase in the sample, with a greater speed in the tradeables sector. The series displays therefore a constant decrease in the sample. In this sense the HP filtered series can be used as first approximation of equilibrium value. If instead we want to construct a 'counterfactual analysis' value of this variable, we have to conjecture an equilibrium path either for the two productivities separately or directly for their difference. In the 'equilibrium period' in both sectors the productivity grew less than in the entire sample. The crucial hypothesis lays in the assessment of an initial equilibrium level of productivity. We can suppose reasonably that at the beginning of the transition productivity is below potential in both sectors (both workers' skills and capital obsolescence can explain this assumption). We

[42] See for some applications to industrial countries Alberola et al 99, MacDonald-Nagayasu 99.

also suppose that this initial negative gap is larger in the tradeables sector[43]. The equilibrium series listed below with _PR# are constructed taking different hypotheses on initial productivity gap and productivity growth.

> PRODDIF_HP: series filtered with Hodrick-Prescott filter, with λ=1600
> PRODDIF_EQ: series constructed taking as starting point the value of HP filtered series in 1993:2 and utilising the rate of growth in 'equilibrium period' (for both the sectors slightly smaller than the rate of growth of the entire period)
> PRODDIF_PR1: in both sectors the rate of growth is the same as HP filtered series, but productivity is 20% below potential in tradeables sector and 10% in nontradeables sector in 1993:2
> PRODDIF_PR2: constructed as _PR1, but productivity is 50% below potential in tradeables sector and 30% in nontradeables sector
> PRODDIF_PR3: in both sectors the rate of growth of productivity is equal to the rate of growth of the 'equilibrium period' and productivity is 20% below potential in tradeables sector and 10% in nontradeables sector
> PRODDIF_PR4: in both sectors the rate of growth of productivity is equal to the rate of growth of the 'equilibrium period' and productivity is 50% below potential in tradeables sector and 30% in nontradeables sector.

ISHARE: this series depicts an initial value around 22 percent, a slight increase with a peak of 31 in 1997 third quarter, and a sharp fall in 1999 corresponding to the Russian crisis. In the 'equilibrium period' it is stable around 24 percent. This behaviour suggests two considerations. The first is that, as expected, investment share is linked to business cycle[44], hence the peak in 1997 and the fall in the following year are probably due to expectations of GDP growth behaviour. The second consideration regards the comparison with growth theories. Growth catch-up theories suggest that investment share should be higher when the capital accumulation required is higher. In our case we see an opposite behaviour. This can be explained in two ways. At the beginning of the transition period in former Soviet Union countries there is an increase in previously too low consumption demand (driven by GDP growth), and, secondly, investments in a small country as Estonia depend from foreign investors, and it took time to gain international investors' confidence. These factors are in the sample here considered probably more important than those pointed out by growth catch-up theories. Hence equilibrium values considered are:

> ISHARE_HP: series filtered with Hodrick-Prescott filter, with λ=1600
> ISHARE_CR: this attempts to capture the 'trust gain' hypothesis. From 1993 until the beginning of 1997 it is the same as ISHARE_HP (hence slowly increasing). From that point on its value does not change (the trust of foreign investors is finally gained)

[43] This is a 'stylised fact' in literature. See for example Richards-Tersman 96, p 128, Jakab-Kovacs 99, p 26, Halpern-Wyplosz 96, pp 15 to 16. This can be explained for example by the fact that the capital obsolescence problem is particularly serious in tradeables (more capital intensive) sector.

[44] GDP gap and investment share series show a very similar behaviour and a high correlation coefficient.

ISHARE_024: the equilibrium value for ISHARE is held fixed at 24%, that is more or less the average of investment share in the 'equilibrium period'
ISHARE_025: the equilibrium value for ISHARE is held fixed at 25%, the average of the whole sample.

RESB: the resource balance's sustainable level is a subject often debated in studies on developing countries[45]. The deficit can be considered sustainable if financed by long-term capital inflows, or if it is used to build up the capital stock. Therefore, there is no consensus on the most reliable way of measuring the sustainable part of the deficit.

Equilibrium values here considered are:
RESB_HP: series filtered with Hodrick-Prescott filter, with $\lambda=1600$
RESB_FDI: this is the part of resource balance deficit covered by inflows of foreign direct investments[46]. These are usually considered the less volatile part of financial inflows, hence not subject to sudden reverse. In Estonian case this measure is influenced by some events involving large flows, which are often reported in financial account as outflows of portfolio investments and inflows of direct investments, when in fact their nature was not really changed. These problems make this series not very reliable as equilibrium/sustainable level of resource balance deficit
RESB_095: in literature on currency crisis often a current account deficit of 5% is considered a no-currency-crisis rule of thumb level[47]. Therefore, a value always equal to 5% deficit is taken as sustainable level
RESB_090: in the 'equilibrium period' the resource balance deficit reached the highest point at 13% level, and was under 10% for more than one year. This could indicate that also a deficit around 10 percent can be sustainable (the average in 1995–96 was 10.1%).

LNEER: theoretically the nominal exchange rate should be fixed, or at least the fluctuations should be small and temporary, given the anchor to the German mark and the currency board arrangement. In the sample both the huge movements against the Eastern European currencies (in the first part of the sample) and the constant appreciation of the US dollar (in the second part) let the nominal exchange rate move significantly. Intuitively when the parity against the German mark was fixed an undervalued level of nominal exchange rate was chosen. Therefore, it is possible to construct an equilibrium series starting from a lower initial level than the actual, and let it appreciate less than the actual series.

[45] See for example Blöndal-Christiansen 99, pp 12 to 13.
[46] See Castello Branco 99 for a brief summary of capital inflows to the Baltic States in the first period of transition.
[47] For an overview of current account sustainability in transition economies see Roubini-Wachtel 98. For determinants of currency crisis in emerging markets see Frankel-Rose 96 and Flood-Marion 98. Applications to particular cases can be found in Warner 97 (Mexico) and Ho-Don Yan 99 (East Asia).

Given these considerations, the equilibrium values here considered are:

LNEER_HP: series filtered with Hodrick-Prescott filter, with $\lambda=1600$

LNEER_HP2: series filtered with Hodrick-Prescott filter, with $\lambda=50$[48]

LNEER_TR: series constructed detrending the actual series over a longer period (starting from the launch of the Estonian kroon)[49]

LNEER_TR2: this is obtained from the previous one, starting from the hypothesis that the initial value of nominal exchange rate was fixed at 20% undervalued.

In the first part of Table 4 the three main experiments used to calculate the equilibrium level of real exchange rate are reported. A brief description and analysis of these calculations follows:

HP: this represents the more neutral case, where the HP filtered series are used simply for all the fundamentals. It is here reported because it can be a first benchmark of the analysis, but the drawback is evident: the underlying assumption of equilibrium throughout the sample produces an estimated equilibrium series very similar to the actual one. With the exception of the first year of the sample, the maximum percentage misalignment is 10%, but on average the misalignment is around one percentage point. This can clearly give some information on short-run movements of LREER, but we reasonably expect a higher degree of misalignment. Except again in 1993, the real exchange rate is slightly overvalued.

EQ: this is the case linked to the 'equilibrium period': the value of fundamentals examined here can be considered compatible with the 'equilibrium period' (1995–1996) as described above. In particular, RESB and ISHARE are held fixed at the average level of 1995–96 , the trend is used for LNEER, and productivity in both the tradeables and nontradeables sector is supposed to start in equilibrium and then evolve in time with the average rate of growth in 1995–96. This exercise is useful to see how important the assumptions regarding the initial value of fundamentals are. Assuming that the initial value of the variables is not out of equilibrium brings us to results not particularly interesting. The LREER was on average in equilibrium (in Table 4 the average misalignment is 2%), given that (as for HP) the initial strong undervaluation is counterbalanced by a slight overvaluation from 1994 on, with a peak during the Russian crisis.

COUNT: in this case a counterfactual analysis is applied. PRODDIF_PR3 is taken because it satisfies two reasonable hypotheses. First of all it is assumed that at the beginning of the period in both sectors the productivity was under potential (20% in tradeables and 10% in nontradeables). Secondly, assigning the rate of growth of 1995–96 (lower than the rate of growth in the whole sample) to both sectors' productivity, it is supposed that the productivity gap is closing through time.

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[48] This is used because in this way a series closer to the original is obtained that is very similar to the 2 years moving average series, but using the HP filter observations at the extremes are not lost.

[49] The trend is obtained from the fitted values of the following estimation: LNEER=c(1)+c(2)/TIMEˆc(3).

Taking LNEER_TR2 it is assumed that nominal exchange rate was fixed at 20% undervalued at the beginning of transition, and, given the nominal anchor to the DEM (Euro from 1999) its adjustment happened just smoothly over time. Given the high inflation rate in Estonia when the peg for the Estonian kroon was fixed (in 1992), it is reasonable to assume that the value against the German mark was fixed undervalued, in order to avoid too huge losses of competitiveness in the following years, before the price dynamics was brought under control again.

ISHARE_025 is considered because investment share is a structural variable that changes quite slowly, and given the short sample, it seems to be prudent to fix it at its overall average.

Finally, sustainable resource balance is supposed to be RESB_90, because it is the average of both 'equilibrium period' and the whole sample. Again, it should capture a structural feature of the economy; hence the short sample suggests a constant value.

In Table 4 the results are reported in the third line (in bold type). From the table and from Figure 9.1 and Figure 9.2 it is possible to draw some conclusions about the behaviour of ERER. In particular, the findings are compatible with a 'stylised fact' presented for example by Halpern and Wyplosz[50]: at the beginning of the transition the real exchange rate is undervalued, and through time there is an appreciation of both actual and equilibrium exchange rate, with the latter appreciating less. This causes a decrease of undervaluation in the actual exchange rate. In our case, the gap is covered in 1998, and in the last three quarters of the sample LREER appears to be slightly overvalued.

The next step of the analysis is a sensitivity analysis in order to understand both how our conclusions are sensitive to the hypotheses made and how large is the effect of each fundamental on ERER behaviour.

The results are reported in the second part of Table 4. The procedure is the following: the last experiment above (COUNT) is taken as benchmark, and the calculation of ERER and percentage misalignment is rerun changing the equilibrium series for only one fundamental. The table reports the main statistics grouped by fundamental. It is then possible to interpret the results in the following way: the statistics can be compared both within the single group and with COUNT. If they are similar then different hypotheses on that fundamental are not going to influence heavily the final results.
Different hypotheses on ISHARE (Figure 10.1) and LNEER (Figure 10.2) do not seem to influence the final result of the misalignment estimation much. Using different equilibrium series for LNEER the average misalignment is smaller than in case of COUNT because with LNEER_HP, LNEER_HP2 and LNEER_TR the degree of initial nominal undervaluation is smaller, hence the ERER is less undervalued. In any case at the end of the sample all the measures converge to the same degree of overvaluation.

In case of RESB (Figure 10.4), it is interesting to see that using RESB_FDI and RESB_095 (both depicting a lower sustainable level of resource balance deficit), starting

[50] See Halpern-Wyplosz 96, pp 7 to 12.

from 96 LREER is more overvalued and the misalignment is around 10% in 1999. This means that assessing the sustainable level of resource balance (or current account) is a relevant task if the degree of misalignment of real exchange rate must be measured.

Finally also PRODDIF (Figure 10.3) can be a source of huge differences in ERER assessment. In particular, using PRODDIF_PR2 and PRODDIF_PR4, which use the hypothesis of a larger initial productivity gap, the LREER results not only more undervalued than using PRODDIF_PR3, but it results to be undervalued today (7–8%).

Summarising the above analysis, some main points emerge. Firstly, the consideration of the equilibrium level of fundamentals' values obtained simply through HP filter or moving average[51] does not give us any particular or interesting information on the behaviour of ERER, given the short sample we can study. Hence the counterfactual analysis is in our case the best approach.

Secondly, making different (reasonable) hypotheses on the equilibrium initial level and evolution through time of the fundamentals lead to the same qualitative conclusions: the LREER was highly undervalued at the beginning of the observed period, and its appreciation occurred with an appreciation of ERER. The rate of decline of the latter is lower; hence the undervaluation is corrected and then eliminated in 1998–99.

Thirdly, the sensitivity analysis shows that particular importance in assessing the degree of misalignment must be attributed to the initial level of productivity and resource balance behaviour. Hence it would be useful to do further analysis on productivity measures (more accurate than the measure used here) and understand the level of resource balance (and current account) that can be considered sustainable.

Fourthly, the drawbacks of this approach must always be kept in mind. There are variables that can have a relevant role in measuring competitiveness of an economy (as terms of trade) that are not considered here. Also some structural changes in the sample period are not considered, and they may have changed the competitiveness of the Estonian economy. One example can be the change of structure of trade partners: the share of Nordic and Western countries increased continuously, and these are countries with a higher price level. This means that in our analysis we are not taking into account an important competitive gain[52].

Another relevant element not considered here is the improvement in the quality of goods produced and exported by Estonian companies. This was one of the key factors of success in the penetration of Estonian products in western countries. This factor probably counterbalanced the negative impact of REER appreciation on external competitiveness.

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[51] ERER was also calculated using one year and two years moving average as equilibrium values of the fundamentals. The equilibrium series for real exchange rate obtained are similar to ERER_HP, hence they are here not reported.

[52] This structural change enters in our analysis through REER (weights attached to each trade partner change as time goes by), but other indirect effects of this trade rebalance (for example on stability, more synchronism of business cycle with western countries) can not be considered here.

Conclusion

The goal of the analysis presented above was to examine the behaviour of the real exchange rate of the Estonian kroon, to estimate its equilibrium value and investigate its impact on competitiveness of the Estonian economy.

The first step was to analyse the real exchange rate indicators, and we have seen that most of them display a similar behaviour in the sample examined here. Therefore, the real effective exchange rate weighted with foreign and domestic CPI was used.

The second step was to define a model that could help us theoretically explain the behaviour of the equilibrium real exchange rate, and could grant a conceptual foundation for its estimation. The first natural benchmark is the PPP theory. This was discharged because it was not appropriate to our case. Particularly in empirical applications, it is often rejected, or accepted if the observed period is very long (thirty years or more). We face a time constraint instead, in the sense that we can not analyse a period longer than six years. Moreover, PPP is always applied in studies on industrial countries, while a different approach is commonly used for developing countries. In the latter case, in fact, the structural changes in economic environment are relevant and can also cause permanent shifts in the real exchange rate level. This strand of research surely fitted better to our case, and therefore it was pursued. The theoretical model used hence was delineated in its main hypotheses and conclusions. In particular, the effects of fundamentals on ERER were analysed.

The next step was to choose fundamentals and estimation techniques. Regarding the first subject, both particular features of the Estonian economy and data constraint determined this choice. The fundamentals finally adopted were the productivity differential between tradeables and nontradeables sectors, investment share, resource balance and nominal effective exchange rate. With respect to the second subject, a cointegration analysis framework in a single equation specification was applied. This helped us estimate the long-run relationship between the real exchange rate and fundamentals and also explain something about short-run dynamics of RER through an error correction mechanism representation.

Estimation results are then used to construct both ERER series and misalignment measures. In order to estimate the equilibrium RER we need to make some hypotheses on medium-long run (or sustainable) values of the fundamentals. If, on the nature of fundamentals affecting the behaviour of real exchange rate, a broad consensus can be found, giving them medium-long run equilibrium values is particularly difficult in a transition country like Estonia. Different hypotheses can bring different estimates of misalignment. We chose equilibrium values compatible with the Estonian situation, hence a level of productivity higher than the actual one, particularly in tradeables sector, a fixed level of investment share, a resource balance deficit sustainable at 10% level, and an initially undervalued nominal exchange rate. Our simulation hence allows us conclude that an appreciation of RER in the sample happened in conjunction with an appreciation of its equilibrium level. The latter appreciated slower; hence, from an initial misalignment around 25–30% we arrived at a 7–8% level before the Russian crisis. This last event caused a sudden jump in REER, leading to 5% overvaluation of REER in the second quarter of 1999.

The last step was a sensitivity analysis, with which we tried to test the robustness of the results obtained by changing the equilibrium value of each fundamental in turn. The results suggest an important role in driving RER and equilibrium RER both for productivity and resource balance. This means that different hypotheses on these fundamentals can greatly affect the final result (for example a sustainable level of resource balance deficit of 5% instead of 10% gives an 8% misalignment instead of 5% in the last period observed here). In any case, the differences caused by different hypotheses do not change the general conclusion of the research as outlined in the previous paragraph.

Our analysis yields some notations on future developments and economic policy consequences. The real exchange rate overvaluation can be one important determinant and indicator of a currency crisis, but there are also other relevant elements including CA deficits, fiscal policies, external shocks (which can bring a crisis through contagion). In the first period of transition analysed here fiscal policy was under control, hence it was an important signal of stability for foreign investors. Current account deficit was deepening throughout the sample (in 1997 it peaked at –12%), but the continuous flow of foreign direct investments and the positive growth perspectives of Estonian economy (with the exception of 1998–1999 due to the Russian crisis) contributed to its perception as sustainable. If the fiscal policy remains rigorous and current account deficit does not deepen too much (in this sense, imports for consumption can be a source of worry), the nominal exchange rate at the actual value in a currency board arrangement frame can be sustained in future without undermining the external competitiveness too heavily. Also, the shift towards western countries as trade partners should help avoiding too huge fluctuations due to external shocks in the future. From Figure 4 it can be seen that REER without Russia has been already flat since 1998, suggesting that it should also remain stable in the future (if not affected by sudden external shocks).

The productivity growth remains high both in comparison with western countries and comparing tradeable to the nontradeable sector. This will probably also cause a real appreciation in the exchange rate in coming years, but this phenomenon is not something to be avoided, on the contrary, it is a positive sign for the Estonian economy. In this sense other relevant key factors, together with fiscal policies and current account deficits, are wage and price dynamics. If their growth can be held under control, the loss in competitiveness should be small.

Appendix 1: Model

In this Appendix the model is presented. At the end of this Appendix a list of all the variables used is given. As stated in the text, this is taken from Montiel 99(b). The differences with this model are that here transaction costs in consumption are not considered (no relevant information for our purpose is lost), and also a fixed nominal exchange rate agreement, instead of a crawling peg as in the original version of the model is considered. The structure of the model presents two main agents: households (who are also producers) and public sector.

Private consumption:

There is a representative agent maximising its utility function through the choice of optimal consumption path subject to a dynamic constraint. The optimisation problem is summarised in the following way:

$$
\begin{aligned}
&\underset{c}{MAX} \int_0^\infty U(c_T, c_N)\exp(-\rho t)dt \\
&U(c_T, c_N) = \frac{\left[c_T{}^{\theta} c_N{}^{(1-\theta)}\right]^{1-\sigma}}{1-\sigma} = \frac{\left[kce^{1-\theta}\right]^{1-\sigma}}{1-\sigma}
\end{aligned}
\qquad (16)
$$

where k is a constant, c_T consumption of tradeable goods, c_N consumption of nontradeable goods, c the total amount of consumption, θ the share of total consumption of tradeable goods and σ the relative risk aversion coefficient. The utility function has a CRRA (constant relative risk aversion) form and a Cobb-Douglas specification. The former gives a constant marginal intratemporal elasticity of substitution in consumption and the latter an intertemporal constant rate of substitution between consumption of tradeable and nontradeable goods. The optimisation is subject to a dynamic constraint, which defines the evolution of wealth over time:

$$
\begin{aligned}
&\dot{a} = y(e) - t - c + ra - im \\
&a = f_H + m
\end{aligned}
\qquad (17)
$$

where a is total wealth, y total production, f_H the net bond holdings of households, t taxes, r real interest rate and im is the opportunity cost of holding money (i being the nominal domestic interest rate and m the quantity of money). From these two equations and the transversality condition (which imposes that the value at the infinite limit of wealth is equal to or greater than 0) we can construct the Hamiltonian and derive the Euler equation:

$$
\frac{\dot{c}}{c} = \frac{1}{\sigma}\left(r + \varphi\frac{\dot{e}}{e} - \rho\right) \qquad (18)
$$

The optimal path of consumption depends hence on real interest rate, evolution of real exchange rate, time preference parameter and φ, a function of σ and θ.

Public sector:

The model specifies a consolidated public sector, ie government and central bank are considered as a unified institution. This means that government can finance public expenditures not only by collecting taxes or issuing bonds, but also by borrowing from the central bank at zero cost. The Estonian Currency Board Arrangement does not consider this possibility, but for simplicity the original hypothesis of the model is left unchanged. The budget constraint faced by the consolidated public sector is given by:

$$\dot{f}_c = t + rf_c - g_T - \frac{g_N}{e} + \dot{m} + \pi m \qquad (19)$$

where g_T and g_N are government production in tradeables and nontradeables and π is the domestic inflation rate. This equation states that the evolution over time of the stock of bonds held by the public sector depends on positive assets of each period (taxes, interest received/paid from stock of bonds held/issued, money growth and inflation tax) minus expenditures (in consumption of both tradeable and nontradeable goods).

Production:

Companies have labour as the only (variable) input; hence the optimal quantity of production is in both sectors obtained when the marginal product (derivative of output with respect to input) is equal to the real wage w:

$$\begin{aligned} y_T'(L_T) &= w \\ y_N'(L_N) &= we \end{aligned} \qquad (20)$$

Given the total quantity of labour, the labour market is cleared when all workers are employed:

$$L_T(w) + L_N(we) = L \qquad (21)$$

(20) determines, together with (21), also the optimal level of real wage, which is a function of differential in productivity growth between the two sectors (α)[53] and real exchange rate:

$$\begin{aligned} & w = w(e, \alpha) \\ & w_e' < 0, w_\alpha' > 0 \end{aligned} \qquad (22)$$

The total level of production can be expressed as:

$$y = y_T\left[L_T\left[w(e,\alpha),\alpha\right],\alpha\right] + y_N\left[L_N\left(w(e,\alpha)\right)\right]/e \qquad (23)$$

[53] The underlying assumption is that the Balassa-Samuelson effect works, or that productivity in tradeables sector is higher than in nontradeables sector. This explains also the presence of α among the determinant of y_T and not of y_N in equation (24).

This set of equations determines the equilibrium in the production sector. The total production is hence a function of productivity differential and real exchange rate.

The model is completed with the equilibrium condition on the supply of funds from abroad. This states that the nominal interest rate i is equal to the world interest rate i_w plus a risk premium *p(f)*, directly related to the total amount of foreign debt[54].

$$i = i_W + p(f) \qquad (24)$$

The equilibrium in nontradeables sector is attained by equality between production and consumption (this kind of goods can not be sold or acquired from abroad):

$$y_N(e) = c_N + g_N \qquad (25)$$

From this the short-term equilibrium value of e is implicitly derived:

$$e = e(c, g_N) \qquad (26)$$

In the nontradeables sector, instead, the long-run equilibrium is attained when the country's international net creditor position is constant, hence its rate of change must be equal to zero. Therefore, the flow budget constraint of the economy as a whole is taken (from (18) and (20)):

$$\dot{f} = y_T - \theta c - g_T + rf \qquad (27)$$

and set equal to zero. Adding and subtracting $\pi_w f$ (inflation adjustment) we obtain:

$$\pi_W f = y_T(e, \alpha) + (\rho + \pi_W) f - \theta c - g_T \qquad (28)$$

Equations (26) and (28) are the two equilibrium conditions for nontradeables and tradeables markets. They define implicitly the equilibrium level of the real exchange rate e:

$$e = e(g_N, g_T, c, \alpha, \rho, \pi_W, \theta, f) \qquad (29)$$

Variables:

e: Real exchange rate
c: Total consumption of households
c_T: Consumption of tradeable goods of households
c_N: Consumption of nontradeable goods of households
ρ: Time preference parameter

[54] If foreign debt stock increases, the risk of default also increases, leading to a higher premium required by foreign investors (f is equal to the sum of f_H and f_C).

k: Constant
θ: Share of total consumption in tradeable goods
σ: Relative risk aversion coefficient
a: Total wealth of households
y: Total production
t: Amount of taxes paid by households to government every period
r: Real domestic interest rate
i: Nominal domestic interest rate
m: Quantity of money
f_H: Net bonds holdings of households
$\varphi=(1-\theta)(1-\sigma)$
f_C: Net bonds holdings of public sector
f: Net bonds holdings of the economy, equal to f_H+f_C , it represents the net foreign asset position of the economy
g_T: Consumption of tradeable goods of the public sector
g_N: Consumption of nontradeable goods of the public sector
π: Domestic inflation rate
y_T: Production of tradeable goods
y_N: Production of nontradeable goods
L_T: Labour employed in tradeables sector
L_N: Labour employed in nontradeables sector
L: Total labour
w: Real wage
α: Productivity differential between tradeables and nontradeables sectors
i_W: World nominal interest rate
$p(f)$: Risk premium

Appendix 2: Data and Sources

REER: Real effective exchange rate. Eesti Pank
NEER: Nominal effective exchange rate. Eesti Pank
CPI: Consumer price index. Eesti Pank
PPI: Producer price index. OECD
REER without Russia. Author's calculations using the data of Eesti Pank
NEER without Russia. Author's calculations using the data of Eesti Pank
Relative prices without Russia. Author's calculations using the data of Eesti Pank
REERppi/cpi: REER calculated taking PPI as price indices of trade partners and domestic CPI for Estonia. OECD and Eesti Pank
RATIO Tr/NTr: Ratio between tradeables and nontradeables price indices. Eesti Pank
ERER: Equilibrium exchange rate. Author's calculations

LREER: Logarithm of real effective exchange rate. Eesti Pank
PROD: Logarithm of the ratio between real GDP (Eesti Pank) and total workers employed (Statistical Office of Estonia)

PRODDIF: Difference between the logarithm of the productivity in nontradeables and tradeables sector. In both sectors productivity is calculated as for PROD. Author's calculation, Eesti Pank and Statistical Office of Estonia
G: Logarithm of the total expenditure of government in real terms. Eesti Pank
r_de: Real rate of return of German 10 years Bund. IMF (International Financial Statistics)
RESB: The ratio of net export to GDP, all in real terms. Eesti Pank
ISHARE: The ratio of total fixed investment to the sum of total fixed investment, consumption and public expenditure (all in real terms). Eesti Pank
LNEER: Logarithm of nominal effective exchange rate. Eesti Pank

Appendix 3: Tables

Table 1. Integration Test

	Lags	ADF in levels		ADF in first differences		Integration order
		(a)	(b)	(c)	(d)	
		With trend	Without trend	With trend	Without trend	
LREER	2	-2.237	-1.666	-3.902	-3.682	1
Balassa-Samuelson						
PROD	2	-2.602	-0.373	-4.133	-4.204	1
PRODDIF	2	-1.129	-1.205	-3.597	-3.040	1
Fiscal policy						
G	2	-1.829	-1.418	-3.114	-3.175	1
Economic structure						
ISHARE	2	-1.922	-2.189	-4.236	-4.340	1
International environment						
r_de	2	-2.987	-3.194	-3.341	-2.712	1
Foreign position						
RESB	1	-0.673	-2.035	-4.036	-3.394	1
Other						
LNEER	1	-1.876	-1.130	-2.715	-2.686	1
NB: critical values are	1%	-4.417	-3.750	-4.442	-3.767	
	5%	-3.622	-2.997	-3.633	-3.004	
	10%	-2.247	-2.638	-3.253	-2.642	

Sample: quarterly observations, 1993:2-1999:2

Table 2. Cointegration Test

Date: 04/26/00 Time: 11:21
Sample: 1993:2 1999:2
Included observations: 23
Test assumption: Linear deterministic trend in the data
Series: LREER PRODDIF RESB ISHARE LNEER DURUS
Lags interval: 1 to 1

Original value	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Corrected values	
				5 Percent Critical Value	1 Percent Critical Value
0.872238	132.4219	94.15*	103.18*	127.38*	139.59
0.766232	85.09746	68.52*	76.07*	92.70	101.92
0.651223	51.66864	47.21*	54.46	63.87	73.68
0.498542	27.44226	29.68	35.65	40.15	48.23
0.253561	11.56684	15.41	20.04	20.85	27.11
0.189792	4.840683	3.76*	6.65	5.08	9.00

Correction of critical values obtained multiplying the original values by 1.3529=T/(T-nk), where T is the number of observations (23), n the number of variables in the cointegration vector (6) and k the number of lags used (1)

Table 3. Preliminary results

		Const	ect	PROD	G	r_de	ISHARE	RESB	LNEER	adjR2	DW	Notes
A	(12)	0.308 (0.80)		-0.948 ***	0.216 (0.26)		0.755 *		0.560 ***	0.956	1.438	Exogenous: LOAN, NFA
	(13)		-0.507 **							0.657	0.728	first diff: only LNEER is significant
	(14)		-0.408 **	-1.368 ***	0.274 ***		2.743 ***		-0.064 (0.72)	0.913	2.249	first diff: all significant but loan (0.11)
B	(12)	1.383 (0.40)		-1.246 ***	-0.014 (0.95)		2.263 ***	0.702 **		0.927	2.057	Exogenous: LNEER (if r_de added, results similar)
	(13)		-0.379 **							0.717	1.322	first diff: all significant but G
	(14)		-0.442 **	-1.309 ***	0.209 *		2.357 ***	0.424 (0.28)		0.844	2.290	first diff: ISHARE and LNEER significant
C	(12)	1.612 **		-1.304 ***		-0.017 (0.316)	2.100 ***	0.621 *		0.927	2.256	Exogenous: LNEER
	(13)		-0.373 **							0.707	1.222	first diff: all significant but r_de
	(14)		-0.409 ***	-0.951 ***		0.023 (0.12)	2.578 ***	0.977 ***		0.889	2.632	first diff: all significant but PROD
D	(12)	1.612 **		-1.304 ***		-0.017 (0.316)	2.100 ***	0.621 *		0.927	2.256	Exogenous: LNEER, G
	(13)		-0.373 *							0.692	1.308	first diff: all significant but r_de and G
	(14)		-0.409 ***	-0.950 ***		0.023 (0.14)	2.580 ***	0.973 ***		0.880	2.675	first diff: all significant but PROD, G
E	(12)	1.293 **		-1.255 ***			2.283 ***	0.704 **		0.926	2.050	Exogenous: LNEER, r_de, G
	(13)		-0.405 **							0.714	1.259	first diff: all significant but G, r_de
	(14)		-0.377 ***	-0.957 ***			2.439 ***	1.130 ***		0.863	2.321	first diff: all significant but PROD, G
F	(12)	1.293 **		-1.255 ***			2.283 ***	0.704 **		0.926	2.050	Exogenous: LNEER, EXCRE, G
	(13)		-0.251 *							0.775	1.161	first diff: all significant
	(14)		-0.318 ***	-1.087 ***			3.412 ***	1.267 ***		0.944	1.692	first diff: all significant
G	(12)	0.513 (0.10)		-0.695 ***			0.950 ***	0.801 ***	0.545 ***	0.979	1.627	Exogenous: EXCRE, G
	(13)		-0.491 **							0.820	1.183	first diff: all significant but G (0.14)
	(14)		-0.287 **	-1.175 ***			3.841 ***	1.281 ***	-0.119 (0.77)	0.939	1.725	first diff: all significant

***=1% , **=5% , *=10% , in parenthesis p-value

The first column reports the specification name. Different specifications have different fundamentals and/or different exogenous variables. ‘Const’ is the constant in the estimated equation, and ’ect’ represents the error correction term in equation (14) and (15). For every equation estimated there are also coefficient values reported with their significance test, adjusted R-square statistics and Durbin-Watson test on the residuals.

Table 4. Summary of statistics of ERER and Sensitivity Analysis

Case	VARIABLES				STATISTICS				
	PRODDIF	**ISHARE**	**RESB**	**LNEER**	**Mean**	**Median**	**Max**	**Min**	**Std.Dev**
HP	HP	HP	HP	HP	0.01266	0.01953	0.10612	-0.18437	0.06908
EQ	EQ	024	090	TR	0.02190	0.05797	0.16263	-0.23456	0.09904
COUNT	**PR3**	**025**	**090**	**TR2**	**-0.10382**	**-0.07119**	**0.05092**	**-0.35832**	**0.10660**
				ISHARE					
ZIS1	PR3	CR	090	TR2	-0.10314	-0.06774	0.05461	-0.36174	0.10922
ZIS2	PR3	HP	090	TR2	-0.10305	-0.06774	0.05459	-0.36174	0.10923
ZIS3	PR3	024	090	TR2	-0.11010	-0.07746	0.04423	-0.36347	0.10630
				LNEER					
ZNE1	PR3	025	090	HP	-0.06758	-0.03206	0.05457	-0.31215	0.09455
ZNE2	PR3	025	090	HP2	-0.06744	-0.03058	0.05855	-0.29653	0.09008
ZNE3	PR3	025	090	TR	-0.06728	-0.03424	0.05981	-0.30255	0.09067
				PRODDIF					
ZPD1	PR1	025	090	TR2	-0.11292	-0.08074	0.03246	-0.35939	0.10131
ZPD2	PR2	025	090	TR2	-0.17998	-0.14588	-0.05430	-0.40247	0.08942
ZPD3	PR4	025	090	TR2	-0.17011	-0.13935	-0.03451	-0.40128	0.09497
ZPD4	HP	025	090	TR2	-0.03563	-0.00845	0.13572	-0.30013	0.11163
ZPD5	TEQ	025	090	TR2	-0.01415	0.02148	0.16008	-0.29500	0.11857
				RESB					
ZRB1	PR3	025	FDI	TR2	-0.06247	-0.00613	0.10359	-0.40698	0.15151
ZRB2	PR3	025	095	TR2	-0.04203	-0.00861	0.11620	-0.30712	0.10917
ZRB3	PR3	025	HP	TR2	-0.10133	-0.07975	0.01863	-0.31123	0.07995

NB: the first column gives the name of the equilibrium real exchange rate calculated using equation (15). In every row the sustainable/equilibrium series of each fundamental used are reported. The STATISTICS refer to the percentage misalignment series, calculated as (LREER-ERER)/ERER, hence for example a Mean equal to 0.02 means that in the sample LREER was on the average 2% overvalued.

Table 5.1. Estimation 1 (12)

Dependent Variable: LREER
Method: Least Squares
Date: 04/19/00 Time: 13:21
Sample: 1993:2 1999:2
Included observations: 25

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.132117	0.421186	-5.062170	0.0001
PRODDIF	0.443357	0.157310	2.818357	0.0110
RESB	1.421650	0.320759	4.432140	0.0003
ISHARE	0.778075	0.396777	1.960990	0.0647
LNEER	0.438387	0.132265	3.314465	0.0036
DURUS	-0.115268	0.039643	-2.907649	0.0090
R-squared	0.961103	Mean dependent var		-0.994971
Adjusted R-squared	0.950867	S.D. dependent var		0.191496
S.E. of regression	0.042447	Akaike info criterion		-3.275557
Sum squared resid	0.034233	Schwarz criterion		-2.983027
Log likelihood	46.94447	F-statistic		93.89385
Durbin-Watson stat	1.559188	Prob(F-statistic)		0.000000

Table 5.2. Estimation 2 (13)

Dependent Variable: D(LREER)
Method: Least Squares
Date: 04/19/00 Time: 13:21
Sample(adjusted): 1993:3 1999:2
Included observations: 24 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.006057	0.005866	-1.032443	0.3163
RESID(-1)	-0.499510	0.169275	-2.950879	0.0089
D(PRODDIF)	0.103284	0.087246	1.183825	0.2528
D(RESB)	0.618299	0.190444	3.246618	0.0047
D(ISHARE)	0.707450	0.189853	3.726297	0.0017
D(LNEER)	0.442667	0.155898	2.839470	0.0113
D(DURUS)	-0.039387	0.041334	-0.952918	0.3540
R-squared	0.770578	Mean dependent var		-0.021418
Adjusted R-squared	0.689606	S.D. dependent var		0.043336
S.E. of regression	0.024144	Akaike info criterion		-4.371095
Sum squared resid	0.009910	Schwarz criterion		-4.027496
Log likelihood	59.45314	F-statistic		9.516554
Durbin-Watson stat	1.397348	Prob(F-statistic)		0.000116

Table 5.3. Estimation 3 (14)

Dependent Variable: D(LREER)
Method: Least Squares
Date: 04/19/00 Time: 12:48
Sample(adjusted): 1993:3 1999:2
Included observations: 24 after adjusting endpoints
Convergence achieved after 67 iterations
D(LREER) = C(12) + C(1)*(LREER(-1) + C(2)*PRODDIF(-1) + C(3)
*RESB(-1) + C(4)*ISHARE(-1) + C(5)*LNEER(-1) + C(6)*DURUS(
-1)) + C(7)*D(PRODDIF) + C(8)*D(RESB) +C(9)*D(ISHARE)
+C(10)*D(LNEER) + C(11)*D(DURUS)

	Coefficient	Std. Error	t-Statistic	Prob.
C(12)	-0.878156	0.423802	-2.072090	0.0605
C(1)	-0.452812	0.135530	-3.341054	0.0059
C(2)	0.266923	0.376107	0.709699	0.4915
C(3)	-2.181808	0.512503	-4.257163	0.0011
C(4)	0.454425	0.672028	0.676199	0.5117
C(5)	-0.885438	0.249280	-3.551979	0.0040
C(6)	0.056841	0.049964	1.137631	0.2775
C(7)	-0.061016	0.096021	-0.635447	0.5371
C(8)	0.756269	0.190695	3.965858	0.0019
C(9)	0.310373	0.199879	1.552809	0.1464
C(10)	0.438129	0.158423	2.765564	0.0171
C(11)	-0.040100	0.036928	-1.085900	0.2989
R-squared	0.908896	Mean dependent var		-0.021418
Adjusted R-squared	0.825383	S.D. dependent var		0.043336
S.E. of regression	0.018109	Akaike info criterion		-4.877986
Sum squared resid	0.003935	Schwarz criterion		-4.288959
Log likelihood	70.53583	F-statistic		10.88338
Durbin-Watson stat	1.971232	Prob(F-statistic)		0.000125

Appendix 4: Figures

Figure 1. Real Effective Exchange Rate

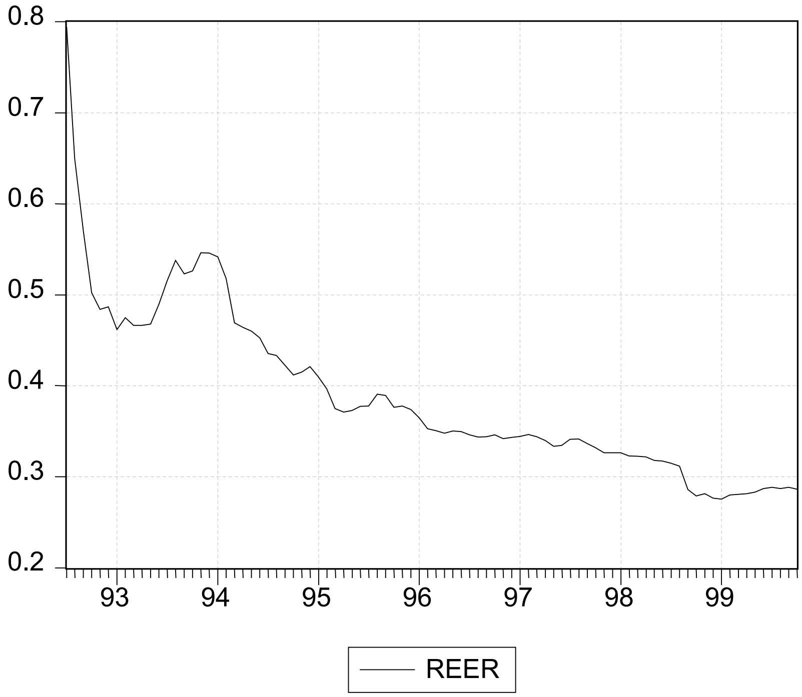


Figure 2. Bilateral Real Exchange Rates

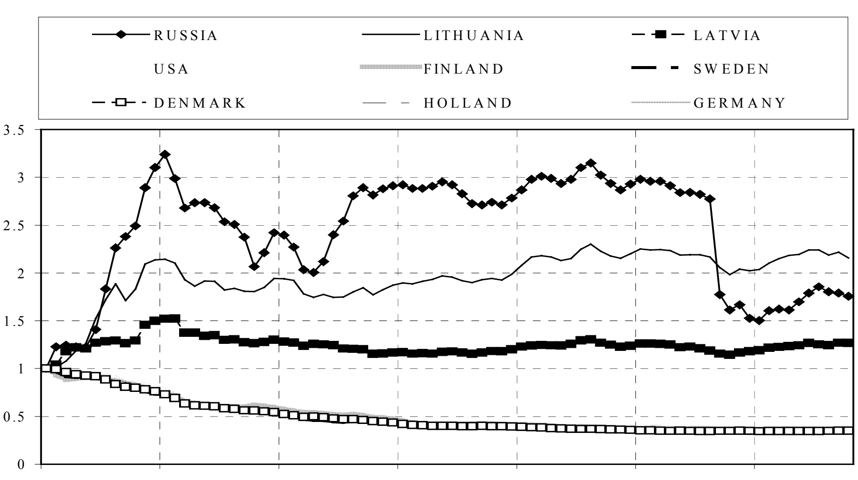


Figure 3. REER without Russia

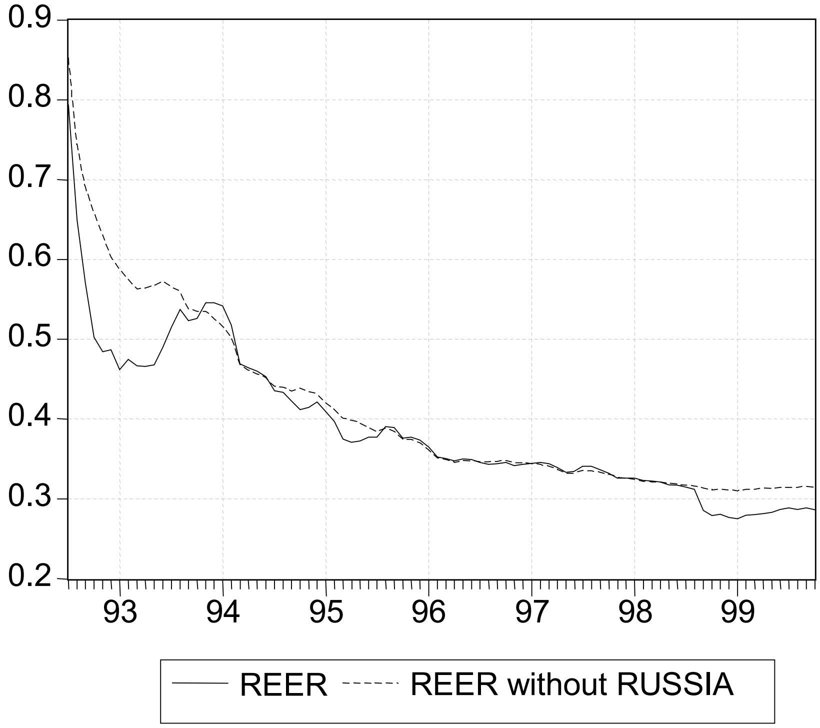


Figure 4. REER, NEER and Relative Prices without Russia

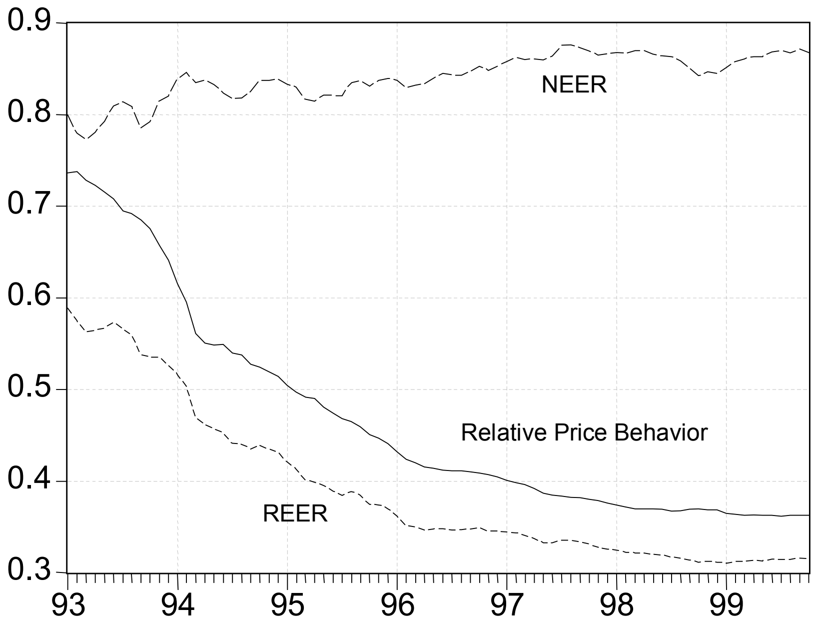


Figure 5. REER, NEER, Relative Prices

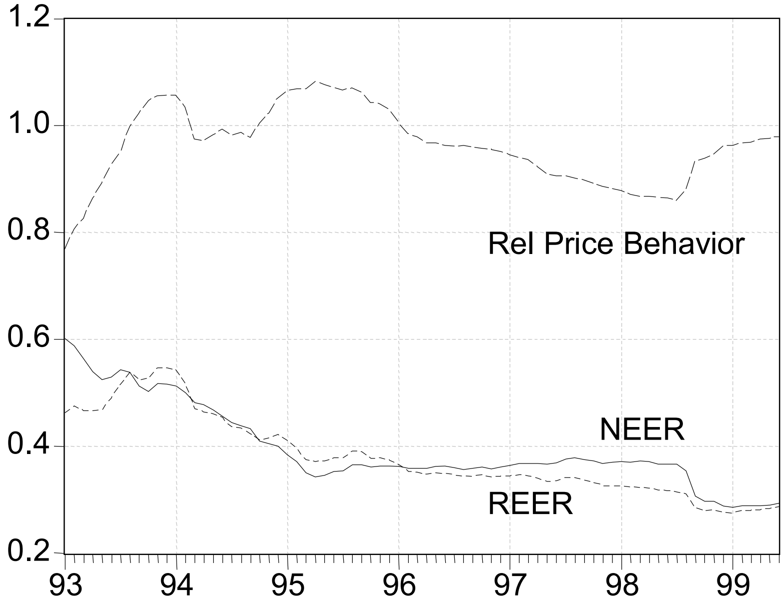


Figure 6. REERppi/cpi, Ratio Tr/NTr, REER

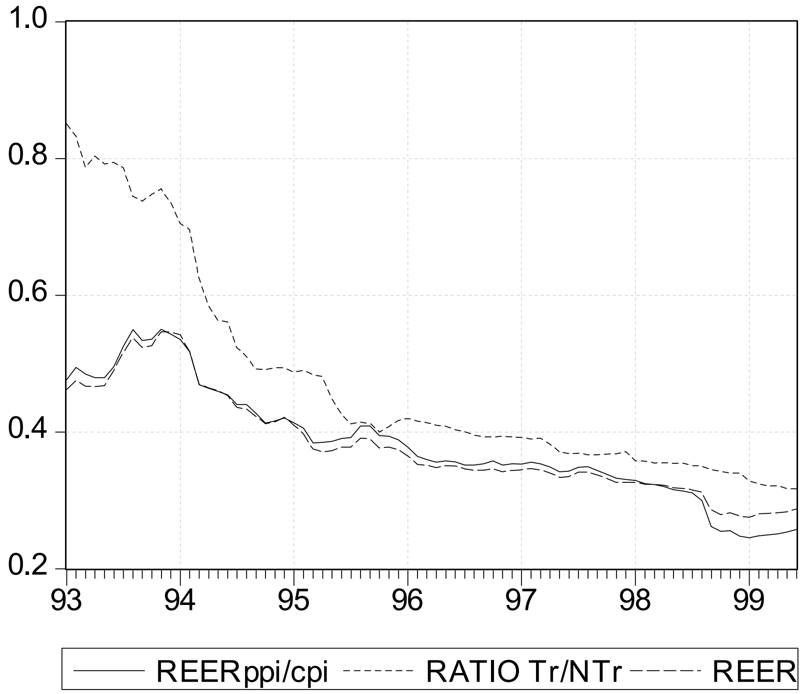


Figure 7. Internal and external balance

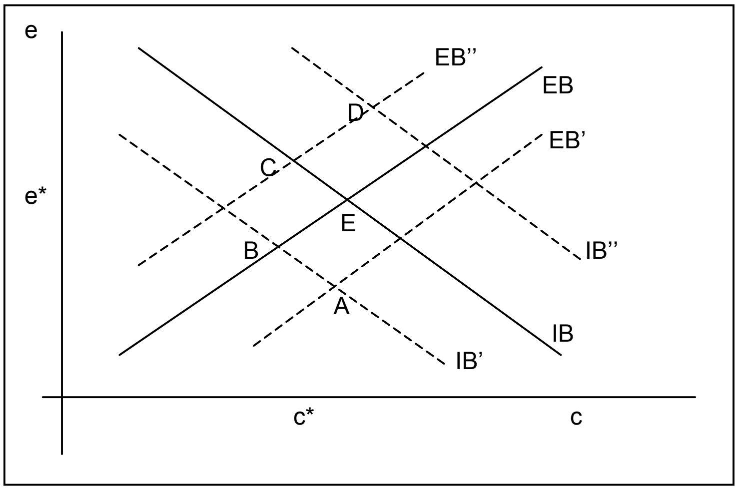
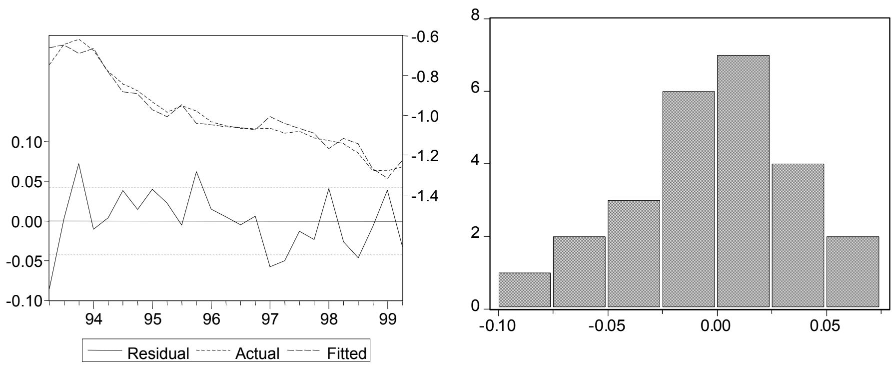
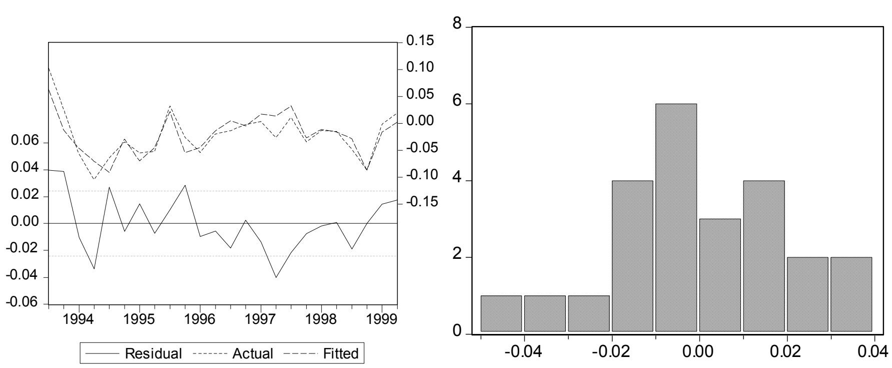


Figure 8.1. Estimation (12)



Series: Residuals	
Sample 1993:2 1999:2	
Observations 25	
Mean	3.13E-16
Median	0.003153
Maximum	0.071935
Minimum	-0.085627
Std. Dev.	0.037768
Skewness	-0.191268
Kurtosis	2.757509
Jarque-Bera	0.213684
Probability	0.898668

Figure 8.2. Estimation (13)



Series: Residuals	
Sample 1993:3 1999:2	
Observations 24	
Mean	-3.76E-18
Median	-0.003745
Maximum	0.039582
Minimum	-0.040125
Std. Dev.	0.020757
Skewness	0.219834
Kurtosis	2.559838
Jarque-Bera	0.387050
Probability	0.824049

Figure 8.3. Estimation (14)

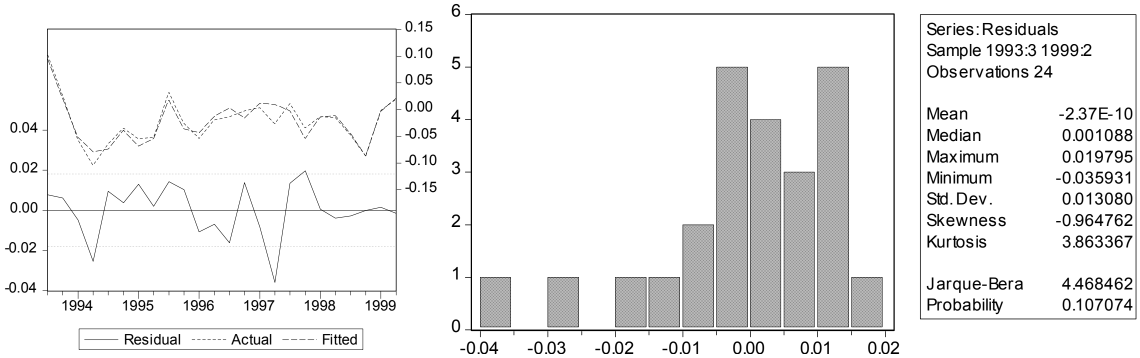


Figure 9.1. Equilibrium Real Exchange Rates

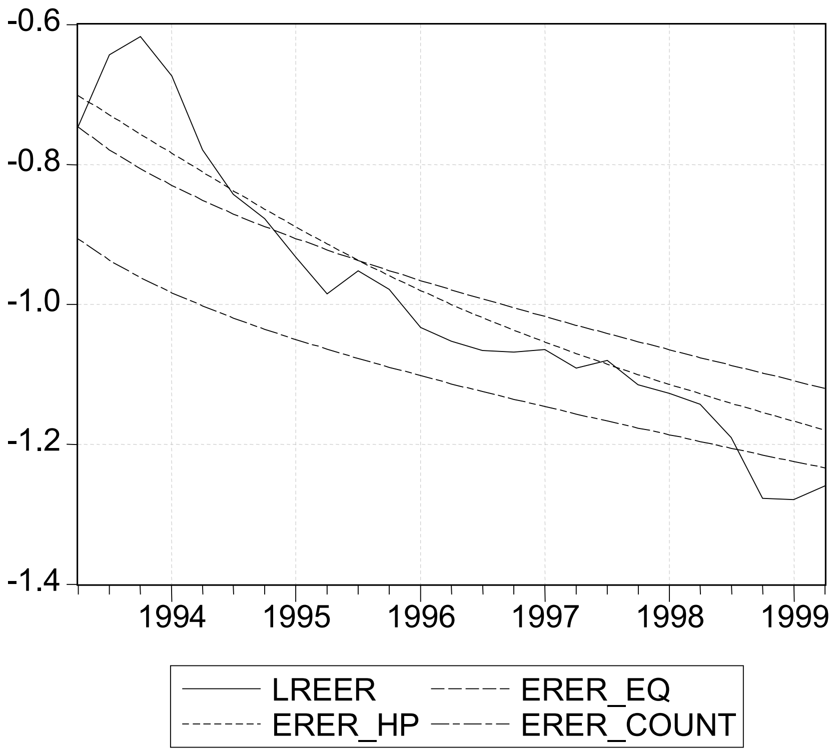


Figure 9.2. Percentage misalignment

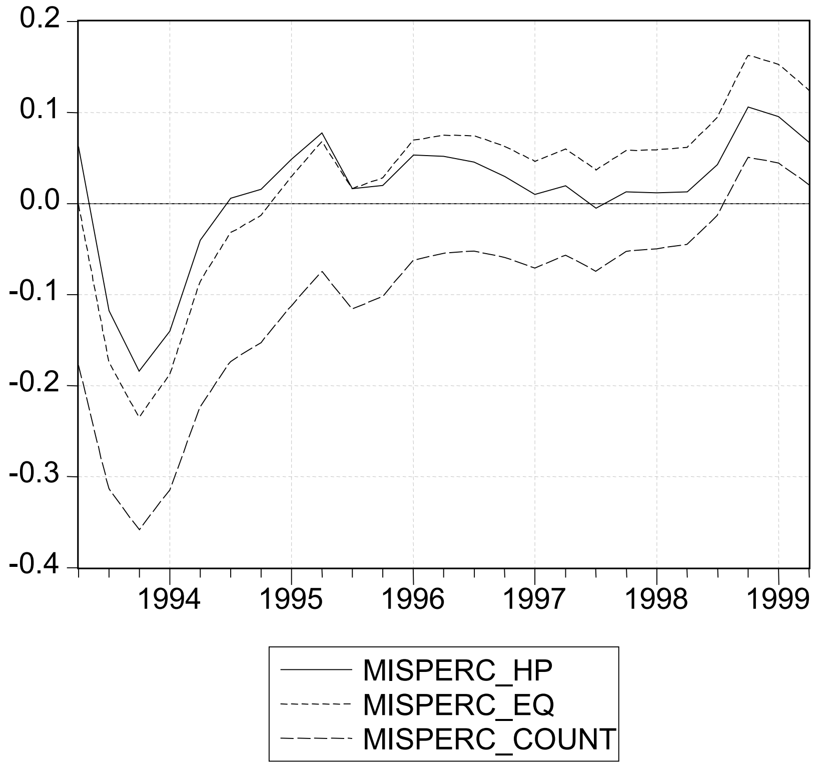


Figure 10. Sensitivity Analysis

Figure 10.1. ISHARE

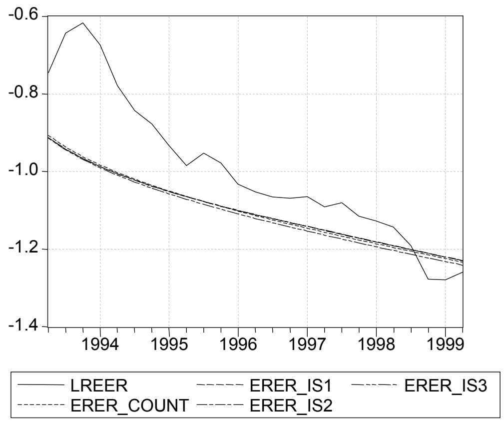


Figure 10.2. LNEER

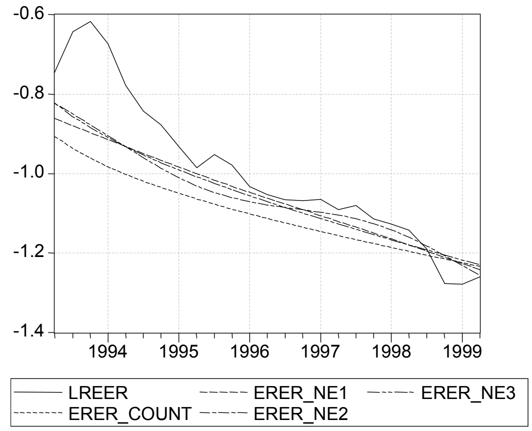


Figure 10.3. PRODDIF

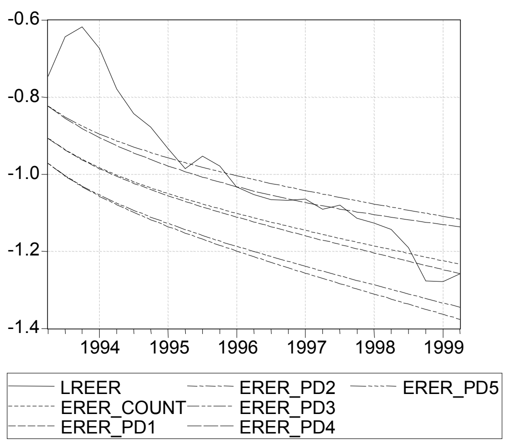
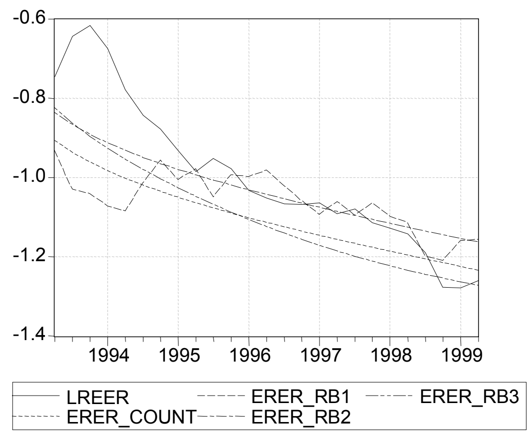


Figure 10.4. RESB



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