Do Fundamentals Explain the Behaviour of the Real Effective Exchange Rate?

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Abstract

In this study, we make use of time series analysis to calculate a real effective equilibrium exchange rate for Sweden. The results indicate that the krona was severely overvalued in late 1992, when the fixed exchange rate regime finally was abandoned. Furthermore, the results indicate that the real effective equilibrium exchange rate has depreciated substantially since the mid-1990s, primarily due to deteriorating terms of trade. The results indicate that the krona was undervalued by some 4 to 5 percent at the end of 2000, given the prevailing economic conditions. We also provide some arithmetical examples of SEK/EUR conversion rates, under various assumptions, to provide some guideline if Sweden is to adopt the common currency in the near future.

Key words: BEER, conversion rate, equilibrium exchange rate, real exchange rates.

JEL classification: F31, F32, F41

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Contents

1. Introduction 4

2. Alternative Concepts of Equilibrium Exchange Rates 5

3. The BEER Approach 7

4. Econometric Methodology 8

5. Data 10

6. Empirical Models and Results 15

7. Calculating Real Effective Equilibrium Exchange Rates 21

8. Arithmetical Examples of Conversion Rates 26

9. Summary 28

10. References 30

11. Appendix 32

1. Introduction

When the Swedish krona was left to float freely in late 1992, it depreciated by roughly 30 percent in nominal effective (multilateral) terms within a year. Many observers have regarded the krona as being undervalued ever since. Furthermore, between late 1993 and late 2001 the krona weakened some additional 10 percent in nominal effective terms.[1]

From an economic policy point of view the issue of an appropriate exchange rate of the krona vis-à-vis the euro is becoming increasingly more relevant, as a Swedish decision whether to adopt the common currency or not is getting closer.[2] If the euro is to be adopted, this necessarily requires the fixing of a conversion rate between the krona and the euro. It is desirable that this conversion rate is set such that unnecessary adjustment costs are avoided. An assessment of a suitable conversion rate thus requires some estimate of an equilibrium exchange rate.

The purpose of this study is twofold. First, the so-called BEER (Behavioral Equilibrium Exchange Rate) approach of Clark and MacDonald (1999, 2000) is applied in order to calculate a real effective equilibrium exchange rate for the krona. Quarterly data for 1982q1 to 2000q4 are used. A weighted average of 14 OECD countries serves as an approximation of the foreign economy. By comparing the observed real effective exchange rate with the equilibrium rate, periods of misalignment are exposed. Second, we derive arithmetical examples of suitable conversion rates if Sweden is to adopt the euro. These arithmetical examples are based on various assumptions concerning future inflation rates, bilateral nominal exchange rates, etc.

The outline of the paper is as follows. In section two we briefly discuss alternative concepts of equilibrium exchange rates. In the following section the BEER approach is outlined more thoroughly. Section four presents the econometric methodology, while section five presents the data. Section six presents alternative model specifications and estimation results, while equilibrium exchange rates of the various models are presented in section seven. Based on the equilibrium exchange rate estimates, section eight provides some arithmetical examples of a suitable conversion rate if Sweden is to adopt the euro in the future. Finally, section nine summarises the main findings of the paper.

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[1] The nominal effective exchange rate we refer to is geometrically weighted using the so-called Total Competitiveness Weights as calculated by the IMF. This weight-system covers 20 countries apart from Sweden. For a description of the weight-system, see e.g. Sveriges Riksbank (1995), p. 16.

[2] As yet, no specific date has been set for this decision, although the government has declared that it prefers a referendum some time after the next general election in the fall 2002.

2. Alternative Concepts of Equilibrium Exchange Rates

The traditional approach to the equilibrium exchange rate departs from the theory of Purchasing Power Parity (PPP). The cornerstone of PPP is the law of one price, which states that homogeneous goods should cost the same in all countries when expressed in a common numeraire. The absolute version of the PPP generalises the law of one price. It relates to the overall price level and postulates that the same basket of goods should cost the same in all countries when expressed in a common numeraire. The absolute form of PPP thus assumes that the equilibrium value of the real exchange rate, defined as the relative price of equivalent basket of goods expressed in a common numeraire, is unity. Although intuitively appealing, the theory of absolute PPP is undermined by trade costs and other impediments to international trade. A weaker, and perhaps more realistic, version is the relative PPP, which states that the rate of change in the nominal exchange rate should equal the difference between the domestic and foreign rates of inflation for equivalent baskets of goods. Relative PPP thus maintains that the real exchange rate remains constant over time, but does not impose any restrictions on the absolute price levels.

The mechanism behind PPP is that international (free) trade should tend to equate goods prices expressed in a common numeraire across countries (inflation rates in the case of relative PPP). Hence, the theory of PPP is essentially a theory for internationally traded goods. High transportation costs and other trade impediments may, however, prevent goods from being traded internationally. Moreover, most services are not traded on the international market. For such non-tradables there may be little tendency for arbitrage to equate prices across countries.[3]

From a theoretical standpoint the “sticky-price” model of exchange rates provides one explanation why PPP may fail temporarily.[4] This model suggests that prices of goods react sluggishly in the short run to unanticipated changes in monetary conditions, while nominal exchange rates react much more rapidly. As a consequence, unanticipated changes in monetary conditions may cause fluctuations in real exchange rates.

Even though “sticky-prices” explain why the real exchange rate may deviate from its PPP value temporarily, it does not invalidate PPP as a theory of the equilibrium real exchange rate. A less strict interpretation of PPP is that the real exchange rate is mean-reverting towards its constant

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[3] However, under the assumptions of identical production functions across countries, internationally perfectly mobile capital and perfectly mobile labour within economies (but not necessarily between them), free international trade will tend to equate factor prices across countries. In turn, factor price equalisation will tend to equate the price of non-tradables across countries. Hence, from a theoretical standpoint, PPP may hold under certain assumptions even when allowing for non-tradables. For a model along these lines, see e.g. Obstfeld and Rogoff (1996), Chapter 4.

[4] See Dornbusch (1976).

equilibrium value, but may differ in the short run due to temporary shocks.

A large number of empirical studies have analysed the validity of PPP. Various testing procedures have been applied and the results are quite mixed.[5] More recent studies quite often confirm the mean reversion of real exchange rates, although the half-year life of shocks typically is found to be around 4 years or longer. This high persistence of real exchange rates was labelled the “PPP puzzle” by Rogoff (1997), since the very slow rate of mean reversion questions the relevance of PPP.

An explanation for the puzzle stems from the recognition that there in fact may be real determinants of the real exchange rate. As these real determinants, or *fundamentals*, change, the real exchange rate and its equilibrium value may change as well.

One fundamental variable are the terms of trade, i.e. the ratio of export to import prices. With imperfect substitutability among traded goods, relative prices of various traded goods may be subject to changes as their supply and demand change. Shifts in supply and demand may occur for a number of reasons, such as changes in taste, differences in export and import elasticities with respect to income, and differences in growth rates. Since countries do not export and import identical bundles of goods, such changes will affect export and import prices differently across countries, thereby causing changes in the terms of trade, which, in turn, may alter the real exchange rate and its equilibrium value.[6]

Another reason why the equilibrium real exchange rate may change over time arises when the real exchange rate covers also internationally non-traded goods and services. Differences in total factor productivity (TFP) growth rates between the tradables and non-tradables sectors, and across countries, may then cause the equilibrium real exchange rate to change. This is the so-called Balassa-Samuelson effect.[7] The usual explanation assumes a small country, constant returns to scale in production of both tradables and non-tradables, and that the law of one price prevails on the market for tradables and in the capital market. If TFP increases (faster) in the tradables sector, the marginal productivity of labour will tend to increase (faster) in this sector as well. This will be matched by a (faster) rise in wages so that, with perfect labour mobility across sectors, the price of non-tradables will increase accordingly. In turn, this will lead to an appreciation of the real exchange rate and its equilibrium value.

A number of other fundamentals have been suggested in the literature. These include net foreign debt, tariffs and trade restrictions, the level and

[5] For surveys on empirical evidence, see e.g. Boucher Breuer (1994), Froot and Rogoff (1995), and MacDonald and Stein (1999).

[6] The effects of changes in the terms of trade on the real exchange rate and its equilibrium value depend among other things on whether the changes are temporary or permanent and whether non-tradables are included in the analysis or not. See e.g. Ostry (1988) and Edwards (1989).

[7] See Balassa (1964) and Samuelson (1964).

composition of government expenditure, and the level and composition of investments.[8]

The weak support for PPP and the recognition that there are real determinants of real exchange rates have led to the development of alternative approaches to calculating equilibrium exchange rates. One direction of research has focused on the so-called internal-external balance approach. This approach was developed by Williamson (1983, 1994), who labelled the associated equilibrium the Fundamental Equilibrium Exchange Rate (FEER).[9] Internal balance is typically taken to be a level of output consistent with full employment and stable inflation (potential output). External balance requires that net savings generated at this output level corresponds to a sustainable current account balance. The sustainable current account balance need not, however, equal zero for external balance to prevail. Rather, the net flow of resources between countries may be calibrated to what is subjectively considered to be a sustainable level. This calibration highlights the normative nature of the FEER approach. It also reveals that the FEER approach is merely a way of calculating a real exchange rate consistent with what is subjectively considered to be a medium-term macroeconomic equilibrium. It follows that the FEER approach does not answer questions concerning the dynamics of the real exchange rate in its adjustment towards equilibrium. Hence, it is not a method for exchange rate determination.

In the more recent Behavioral Equilibrium Exchange Rate (BEER) approach (Clark and MacDonald 1999, 2000) such dynamic aspects are considered explicitly. The BEER approach attempts to explain the actual behaviour of the real exchange rate in terms of the relevant economic variables. The next section briefly outlines the BEER approach.

3. The BEER Approach

The BEER approach departs from the familiar risk-adjusted uncovered interest rate parity condition:

$$E_t\left[\Delta s_{t+k}\right] = (i_t - i_t^*) - c \qquad (1)$$

where s_t is the price of a unit of foreign currency, i_t is the nominal interest rate, and c is a (constant) risk premium. $E_t\left[\cdot\right]$ is the rational expectations operator conditional on the information set at time t, Δ is

[8] See e.g. Alberola, Cervero, Lopez and Ubide (1999), Clark and MacDonald (1999), Edwards (1989), Faruqee (1995), MacDonald (1999), Stein, Allen and associates (1995), and Williamson (1994).

[9] The so-called Desired Equilibrium Exchange Rate (DEER) approach (see e.g. Bayoumi et al., 1994) and the Natural Real Exchange Rate (NATREX) approach (Stein et al., 1995) are other applications of the internal-external balance approach.

the first difference operator, $t+k$ is the maturity horizon of the bonds, and * is an indicator for foreign variables.

By subtracting the *expected* inflation differential, $E_t\left[\Delta p_{t+k} - \Delta p^*_{t+k}\right]$, from both sides of equation (1), it is converted into a real relationship which may be written as:

$$q_t = E_t[q_{t+k}] - (r_t - r_t^*) + c \tag{2}$$

where $r_t = i_t - E_t\left[\Delta p_{t+k}\right]$ is the real interest rate and q_t is the real effective exchange rate. Equation (2) is thus the condition for risk-adjusted uncovered real interest rate parity. The real effective exchange rate is explained by the *expected* future real effective exchange rate, the real interest rate differential and the risk premium. The real interest rate differential enters with a negative sign, indicating that an increase in the differential will cause an appreciation of the real effective exchange rate. Likewise, a decrease in the risk premium will cause the real effective exchange rate to appreciate.

As for the unobservable expected future real effective exchange rate, $E_t[q_{t+k}]$, it is assumed to be determined by a set of long-run determinants, the so-called fundamentals.

The relevant set of fundamentals is discussed thoroughly in e.g. Faruqee (1995), Clark and MacDonald (1999) and Alberola, Cervero, Lopez and Ubide (1999).[10] The stock-flow consistent model by Faruqee departs from the balance of payments equation, which equates the current account and the capital account. The current account balance is a function of the real effective exchange rate, the interest payments on the net foreign debt, and exogenous variables that affect the relative demand and supply of domestic and foreign goods. The capital account is a function of the real interest rate differential and the "desired" rate of net foreign debt accumulation (or de-accumulation). By equating the current account and the capital account equations and solving the model with the additional assumption of uncovered interest rate parity, Faruqee shows that the long-run equilibrium real effective exchange rate depends on the long-run equilibrium stock of net foreign debt and exogenous variables. The stylized model developed by Faruqee, however, considers only tradables. In the empirical model Faruqee makes use of a real exchange rate based on consumer prices, thus covering also non-tradables. With this broader definition of the real exchange rate, Faruqee argues that the most relevant fundamentals are the stock of net foreign debt (as a share of GDP), the terms of trade and the relative price of tradables to non-tradables, the latter as a proxy variable for productivity differentials.[11] A lower net foreign debt is expected to contribute to a more appreciated real effective exchange rate, as are improved terms of trade. An increase in the relative price of tradables to non-tradables is, however, expected to contribute to a more

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[10] See also MacDonald (1999) and Stein (1999).

[11] As an alternative, more direct measure of productivity differentials, Faruqee makes use of an index of relative labour productivity.

depreciated real effective exchange rate. Alberola, Cervero, Lopez and Ubide (1999) extend the stylized model by Faruqee by explicitly including a non-tradables sector. They derive the same set of fundamentals as suggested by Faruqee, with the relative price of tradables to non-tradables acting as a proxy variable for productivity differentials and potential exogenous demand factors such as e.g. public expenditure.

4. Econometric Methodology

When analysing the relationships between the real effective exchange rate and the fundamental variables, Johansen's Maximum Likelihood method of cointegration provides a tractable framework. With this approach it is possible to test for the number of long-run relationships (cointegrating vectors) between the variables in the model and to identify which variables should enter the various relationships.

The starting point for the analysis is a vector autoregressive model (VAR) as of equation (3). $\mathbf{x_t}$ is a $(n \times 1)$ vector containing the n endogenous variables; $\mathbf{k}$ is a $(n \times 1)$ vector containing the intercepts; $\mathbf{A_i}$ are $(n \times n)$ matrices containing parameters to be estimated; $\mathbf{D_t}$ is a vector of deterministic and exogenous variables with corresponding parameters in the $\boldsymbol{\psi}$ matrix; $\boldsymbol{\varepsilon}_\mathbf{t}$ is a $(n \times 1)$ vector containing Gaussian disturbance terms; and p is the lag length of the VAR.

$$\mathbf{x_t} = \mathbf{k} + \sum_{i=1}^{p} \mathbf{A_i x_{t-i}} + \boldsymbol{\Psi}\mathbf{D_t} + \boldsymbol{\varepsilon}_\mathbf{t} \tag{3}$$

All variables in $\mathbf{x_t}$ are assumed to be at most I(1). If cointegration exists, it is, following the so-called Granger representation theorem,[12] appropriate to re-parameterise equation (3) as a vector error correction model (VECM):

$$\Delta\mathbf{x_t} = \mathbf{k} + \sum_{i=1}^{p-1} \boldsymbol{\Gamma}_\mathbf{i} \Delta\mathbf{x_{t-i}} + \boldsymbol{\Pi}\mathbf{x_{t-1}} + \boldsymbol{\Psi}\mathbf{D_t} + \boldsymbol{\varepsilon}_\mathbf{t} \tag{4}$$

where Δ is the first difference operator, $\boldsymbol{\Gamma}_\mathbf{i}$ are $(n \times n)$ matrices containing short-run parameters and $\boldsymbol{\Pi}$ is a $(n \times n)$ matrix of long-run parameters. The number of cointegrating vectors is determined by the rank of the matrix $\boldsymbol{\Pi}$. If this matrix is of full rank, all variables in the system are stationary and the model may be estimated with the variables in levels as in equation (3). If the matrix $\boldsymbol{\Pi}$ is of zero rank, there exist no cointegrating relationships between the variables in the system. In this case the model should be estimated in first differences as in equation (4), however, without the error correction mechanism since there exist no long-run relationships

[12] See Engle and Granger (1987).

between the variables in the system. When the matrix $\mathbf{\Pi}$ is of reduced rank, i.e. $0 < r < n$, there exist r (linearly independent) cointegrating vectors. The matrix $\mathbf{\Pi}$ may then be written as $\mathbf{\Pi} = \boldsymbol{\alpha}\boldsymbol{\beta}'$, where $\boldsymbol{\beta}$ is a ($n \times r$) matrix containing the parameters of the cointegrating vectors and $\boldsymbol{\beta}'\mathbf{x}_{t-1}$ are the error-correction terms. $\boldsymbol{\alpha}$ is a ($n \times r$) matrix containing the adjustment coefficients, so-called loadings, which determine the system's speed of adjustment towards the long-run solution as implied by the error correction terms.

The estimation involves solving an eigenvalue problem, where the rank of $\mathbf{\Pi}$ is determined by the number of non-zero eigenvalues. With n endogenous variables in the system there are n eigenvalues. If there are r non-zero eigenvalues, the rank of $\mathbf{\Pi}$ is r. Two standard tests for testing the rank of $\mathbf{\Pi}$ have been developed: the maximum eigenvalue test and the trace test. In the maximum eigenvalue test, the hypothesis that there are at most r cointegrating vectors is tested against the alternative hypothesis that there are $r+1$ cointegrating vectors. The eigenvalues are ordered from the largest to the smallest. Sequential testing if the eigenvalues differ from zero reveals the number of cointegrating vectors. The trace test differs in that it tests the hypothesis that there are at most r cointegrating vectors against the alternative hypothesis of more than r cointegrating vectors.

Once the number of cointegrating vectors has been determined, restrictions on $\boldsymbol{\beta}$ may be tested in order to identify which variables belong to the various cointegrating vectors. Restrictions on $\boldsymbol{\alpha}$ may also be tested in order to identify which variables are weakly exogenous for the various cointegrating vectors. For a thorough discussion of the procedures of testing and identification, see e.g. Johansen (1995).

Below, we apply Johansen's method to the BEER model briefly outlined in section 3. Five endogenous variables are accordingly considered in the VAR model. These are the real effective exchange rate, the three fundamentals, i.e. the net foreign debt as a share of GDP, the terms of trade and the relative price of tradables to non-tradables, and the real interest rate differential. The latter variable is presumably stationary, and is intended to capture only cyclical variations in the real effective exchange rate. The real effective exchange rate and the three fundamentals are, however, presumably all I(1). These variables are expected to form at least one long-run relationship.[13]

[13] Faruqee (1995) and Clark and MacDonald (1999) generally find one long-run relationship between the fundamentals and the real effective exchange rate. The extended theoretical model by Alberola, Cervero, Lopez and Ubide (1999) suggests that there may be two long-run relationships: one between the real effective exchange rate, the relative price of tradables to non-tradables and the net foreign debt, the other between the terms of trade and the net foreign debt. Alberola, Cervero, Lopez and Ubide (1999) do, however, not model the terms of trade in their empirical analysis and thus focus on the role of the former long-run relationship alone.

5. Data

The study makes use of quarterly data. Data availability constrains the sample period to 1982q1 to 2000q4. Apart from data on Sweden, the study makes use of data on 14 OECD countries.[14] Weighted together with the Total Competitiveness Weights (TCW),[15] data on these 14 countries serve as an approximation of the foreign economy. Since the study does not cover all 20 countries in the TCW scheme, due to lack of data, the weights of the 14 countries have been re-scaled so that they sum to one. Definitions of the five variables of the model and the sources of data are as follows:[16]

Real effective exchange rate: q
The real effective exchange rate is a geometrically weighted index of nominal bilateral exchange rates and relative consumer price indices for Sweden vis-à-vis the 14 partner countries. The formula is:

$$\ln q = \sum_{i=1}^{m} w_i \cdot \ln(e_i \cdot cpi_i / cpi_{dom}) \qquad (5)$$

where w_i is the (re-scaled) weight attached to country *i*, e_i is the bilateral nominal exchange rate vis-à-vis country *i*, expressed as SEK per foreign currency, cpi_i is the consumer price index of country *i* and cpi_{dom} is the consumer price index for Sweden. The consumer price indices and the bilateral nominal exchange rates are all re-based so that they equal 100 in 1990q1. The variable is used in its natural log-form in the analysis.

The data on consumer price indices and bilateral nominal exchange rates were obtained from the IMF International Financial Statistics (rows 64 and 1..rf respectively).

Relative effective terms of trade: tot
A country's terms of trade are defined as the ratio of export unit value to import unit value (for some countries export prices and import prices are used). The relative effective terms-of-trade index is computed as the ratio of the Swedish terms of trade to the effective foreign terms of trade, where the latter is obtained by geometrically weighting the 14 partner countries' terms of trade with the re-scaled weights. All unit value series and price indices are re-based so that they equal 100 in 1990q1. The variable is used in its natural log-form in the analysis.

Export and import unit values are used for nine countries and were obtained from IMF International Financial Statistics (rows 74 and 75).[17]

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[14] The countries are: Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Spain, United Kingdom and United States.

[15] The TCW scheme is described e.g. in Sveriges Riksbank (1995), p. 16.

[16] All data from IMF, OECD and national sources were obtained via Thomson Financial Data.

[17] The countries are Canada, Denmark, Germany, Italy, Japan, Norway, Sweden, UK and the US. For Germany rows 76 and 76.x in the IFS are used. For Denmark and Norway data are

For the remaining countries OECD data on export and import prices are used.[18]

Relative effective price ratio of tradables to non-tradables: tnt
A country's price ratio of tradables to non-tradables is defined as the ratio of wholesale price index (wpi) or producer price index (ppi) to consumer price index. A relative effective index is computed as the ratio of the Swedish relative price of tradables to non-tradables to the effective foreign relative price of tradables to non-tradables, where the latter is obtained by geometrically weighting the 14 partner countries' relative price of tradables to non-tradables with the re-scaled weights. All price indices are re-based so that they equal 100 in 1990q1. The variable is used in its natural log-form in the analysis.

All data were obtained from IMF International Financial Statistics (rows 63 and 64), with the exception of the producer price index for France which is from a national source (I.N.S.E.E.).

Net foreign debt as a share of GDP: nfd
The variable for the Swedish net foreign debt as a share of GDP is defined as the negative of the nominal Swedish net foreign assets as a share of nominal GDP. Data on net foreign assets were obtained from the Swedish central bank (*Riksbanken*). Quarterly data have been intrapolated from annual data when necessary. Data on nominal GDP were obtained from the IMF International Financial Statistics (row 99).

Real interest rate differential: rdiff
The real interest rate is defined as the annual interest rate in percent on nominal long-term bonds (10-years for most countries), minus the percentage change in the consumer price index over four quarters. Hence, we are implicitly assuming that inflation expectations are adaptive. This rather restrictive, simplifying assumption is, however, difficult to avoid. The reasons are that data on inflation expectations are not available and that an assumption of perfect foresight cannot be made since it would restrict the sample severely.

The real interest rate differential is defined as the Swedish real interest rate minus the foreign real interest rate. The latter is computed by arithmetically weighting the 14 partner countries' real interest rates with the re-scaled weights.

The data on consumer price indices were obtained from IMF International Financial Statistics (row 64), while the data on nominal long-term interest rates were obtained from the NiGEM database, provided by the National Institute of Economic and Social Research, London.

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extrapolated for 2000q2-q4 and 2000q3-q4, respectively. For Sweden, growth rates of OECD data on export and import prices are used to extrapolate data for 2000q3-q4.

[18] For Austria and Belgium, growth rates of NIER data on manufactured export and import prices are used to extrapolate data for 1982q1-1987q4 and 1982q1-1985q1, respectively.

Figure 1. Real effective exchange rate (q), natural logaritm

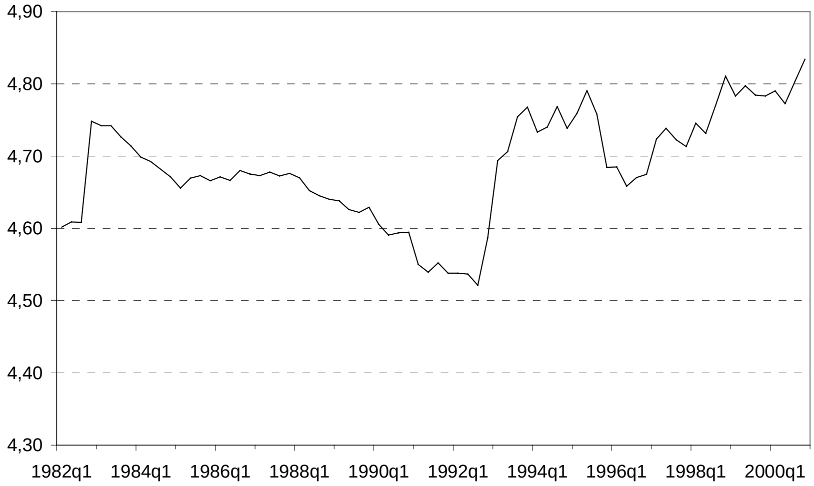


Figure 2. Relative effective terms of trade (tot), natural logaritm

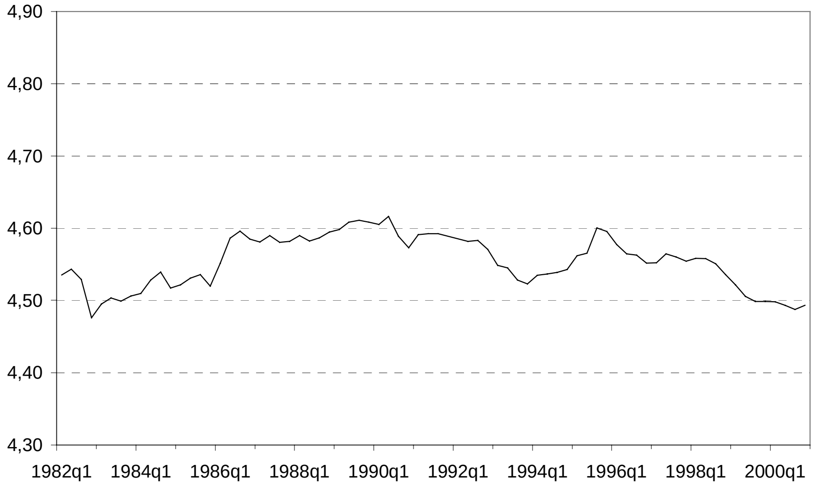


Figure 3. Relative effective price ratio of tradables to non-tradables (tnt), natural logaritm

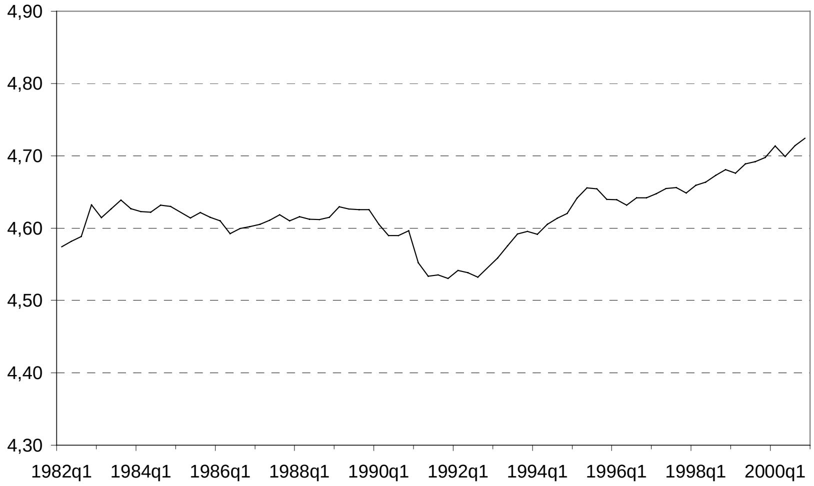


Figure 4. Net foreign debt as a share of GDP (nfd)

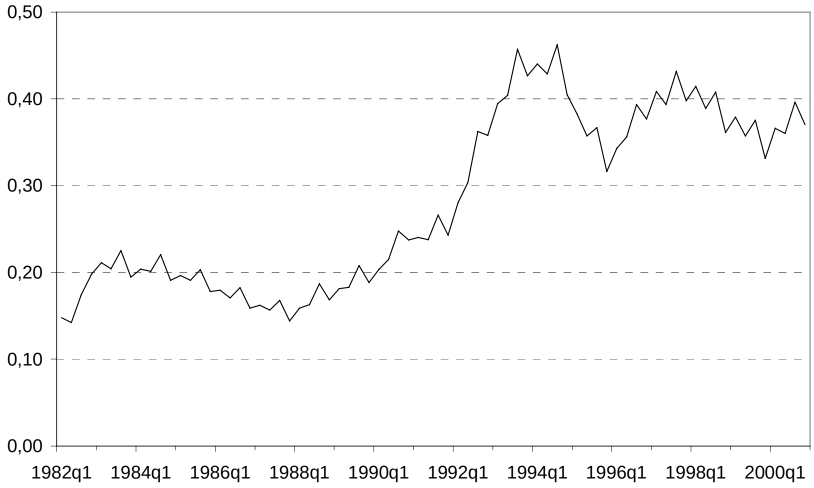
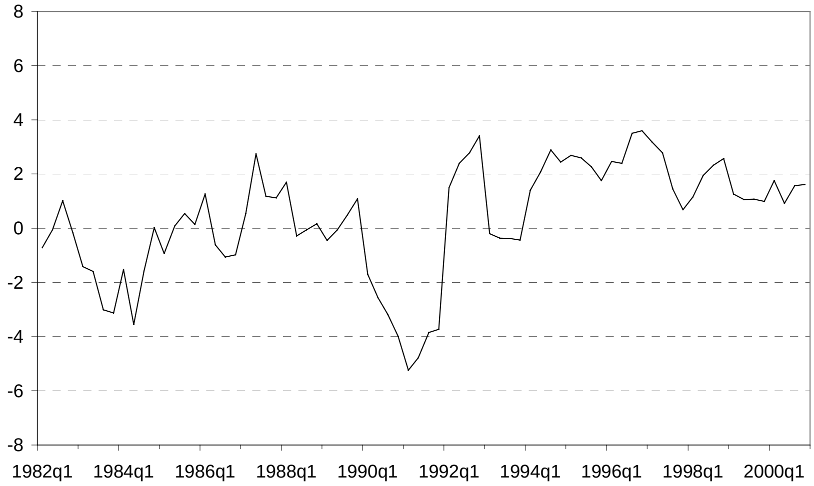


Figure 5. Real interest rate differential (rdiff), percent



6. Empirical Models and Results

Before estimating the VAR model, augmented Dickey-Fuller (ADF) tests are calculated to give a first indication of the order of integration of each of the time series. The results of these unit root tests are reported in Table 1. For all series but the real interest rate differential the ADF tests indicate that the series are integrated of order one. For the real interest rate differential, however, the ADF-test rejects the hypothesis of non-stationarity at the 5 percent level.

Table 1 Augmented Dickey-Fuller tests, 1982q1-2000q4.

	ln q [a]	*Δ ln q* [b]	*ln tot* [a]	*Δ ln tot* [b]	*ln tnt* [a]	*Δ ln tnt* [b]	*nfd* [a]	*Δnfd* [b]	*rdiff* [a]
ADF test statistic	0.880	-7.502 [c]	-0.347	-6.943 [c]	1.446	-7.856 [c]	0.840	-3.053 [d]	-1.975 [d]
F_{ar1}, *p-value*	0.3217	0.9080	0.1577	0.2986	0.5262	0.5552	0.3307	0.1778	0.4164
F_{ar1-4}, *p-value*	0.5128	0.7035	0.3022	0.3068	0.6166	0.5944	0.5014	0.5612	0.7170

The ADF tests allowed for the possible trend or drift in accordance with tthe procedure outlined in Enders (1995), pp. 256-258. [a] refers to ADF models including neither intercept nor deterministic trend, while [b] refers to ADF-models including an (insignificant) intercept. The number of lags included in the ADF tests are chosen as to rid problems with serial correlation when present. Seasonal dummy variables are included when significant.
[c] Rejects null hypothesis of non-stationarity at the 1 percent significance level.
[d] Rejects null hypothesis of non-stationarity at the 5 percent significance level.

In the above discussion of the BEER model, it was argued that the real interest rate differential should not be expected to enter in any long-run relationship between the real effective exchange rate and the fundamentals. Rather, the real interest rate differential should be expected to be a stationary variable that explains cyclical variation in the real effective exchange rate. The fact that the ADF test indicates that the real interest rate differential is stationary is thus in line with the BEER approach.

From a theoretical standpoint the real interest rate differential may well be expected to be endogenous with respect to the real effective exchange rate and the fundamental variables. There is, however, little support for this in the data. Granger causality tests indicate that neither the real effective exchange rate nor the fundamentals Granger-cause the real interest rate differential.[19] Furthermore, even when increasing the number of lags, these OLS regressions suffer from serial correlation. The real interest rate differential is thus poorly modelled by lagged values of itself and the other variables. We therefore choose to treat the real interest rate differential as an exogenous variable.[20]

[19] The Granger-causality tests were carried out both with the real effective exchange rate and the fundamental variables in levels and as first differences.

[20] If the real interest differential is treated as an endogenous variable in the subsequent VECM analyses, it is weakly exogenous with respect to the cointegrating vectors containing the real effective exchange rate and the fundamentals. Moreover, apart from lagged values of the real interest rate differential, short-run dynamics are in general insignificant in the equation of the real interest rate differential. Although these results should be interpreted cautiously due to poor residual diagnostics, they further warrant the treatment of the real interest rate differential as an exogenous variable.

The estimation of the VAR model is constrained to include at most 6 lags due to the limited number of observations. The real effective exchange rate and the three fundamentals are all endogenous variables, while the real interest rate differential is treated as exogenous. An intercept and centred seasonal dummies are also included in the model. Using information criteria and F-tests, the VAR model can be paired down to a lag length of one. Model evaluation diagnostics of the VAR(1) model are presented in Table 2.

Table 2 Model evaluation diagnostics of the VAR(1) model. P-values

Test-statistic / Equation	*ln q*	*ln tot*	*ln tnt*	*nfd*
$F_{ar1}(1,64)$	0.7820	0.1479	0.3811	0.3399
$F_{ar1-4}(4,60)$	0.5110	0.3296	0.5669	0.0751
$F_{arch}(4,57)$	0.6045	0.7696	0.9241	0.4852
$F_{heterosc.}(15,49)$	0.3267	0.5574	0.3484	0.9256
$\chi^2_{normal}(2)$	0.0001	0.0035	0.008	0.1031

Multivariate tests: $F_{ar1}(16,177) = 0.8039$; $F_{ar1-4}(64,182) = 0.7186$; $F_{heterosc.}(150,353) = 0.8804$; $\chi^2_{normal}(8) = 0.3613$

The hypothesis of no serial correlation cannot be rejected for any of the residual series at conventional levels. The multivariate test does not either indicate any problems with serial correlation. There are no signs of heteroscedasticity or ARCH-effects. However, all residual series but the one from the net foreign debt ratio equation are non-normal. This is primarily a consequence of excess kurtosis. The non-normal residuals imply that test statistics may be biased and that hypothesis tests need to be interpreted with caution. Sequential one-step ahead Chow-tests and one-step ahead residuals indicate that there may be outliers in the data and/or structural breaks in the model, particularly around 1992q4/1993q1 when the fixed exchange rate regime was abandoned. We will return to this issue below.

Cointegration and economic interpretation

The methods used to test for cointegration are those of Johansen (1995) as presented in section 4.[21] As was argued in section 3, one may expect to find one or more cointegrating relationships between the real effective exchange rate and the three fundamental variables. To enable tests of whether the model contains a drift term or not, exogenous variables must not add a drift term to the model. Therefore, the mean is subtracted from the exogenous real interest rate variable.

Whether the intercept may be restricted to act only as an intercept in the cointegrating vector(s) and not as a drift term, is determined by the so-called Pantula principle. This principle implies that when the cointegration tests indicate the same number of cointegrating vectors in the model with

[21] The estimations are carried out in the PcFiml software package.

the intercept restricted to the cointegrating space as in the model with an unrestricted intercept, preference is given to the more restrictive model.[22]

Table 3 presents the results of the cointegration tests based on the VAR(1) model. The maximum eigenvalue test tests the hypothesis of less than or equal to *r* cointegrating vectors against the hypothesis of exactly $r+1$ cointegrating vectors. The trace test differs in that the alternative hypothesis is equal to *or more* than $r+1$ cointegrating vectors. As is clear from Table 3, the maximum eigenvalue test and the trace test both indicate that there is one cointegration vector when the intercept is restricted to the cointegrating space. Also when the intercept is unrestricted, both tests indicate that there is one cointegrating vector.[23] Following the Pantula principle the appropriate model thus contains one cointegrating vector with the intercept restricted to the cointegrating space. Furthermore, all eigenvalues of the companion matrix are inside the unit circle, thereby indicating that the I(1) framework we rely on is appropriate.

Table 3 Results of cointegration tests of the VAR(1) model

Rank H_0	Max. eigenvalue test	Max. eigenvalue test, small sample correction	Critical value 95%	Trace test	Trace test, small sample correction	Critical value 95%
Intercept restricted to the cointegrating space						
r=0	52.04 [a]	49.26 [a]	28.14	76.80 [a]	72.70 [a]	53.12
r<=1	18.62	17.62	22.00	24.76	23.44	34.91
r<=2	5.008	4.740	15.67	6.141	5.814	19.96
r<=3	1.134	1.073	9.24	1.134	1.073	9.24
Intercept unrestricted						
r=0	51.02 [a]	48.30 [a]	27.07	70.21 [a]	66.46 [a]	47.21
r<=1	15.78	14.94	20.97	19.18	18.16	29.68
r<=2	2.367	2.241	14.07	3.400	3.219	15.41
r<=3	1.033	0.9781	3.76	1.033	0.9781	3.76

[a] Rejects the null hypothesis at the 1 percent level.

Table 4 reports the estimated parameters of the cointegrating vector and the adjustment coefficients. All parameters of the cointegrating vector carry the expected sign and are significant at conventional levels.[24] The cointegrating vector is normalised on the real effective exchange rate so that this parameter is unity.[25] The parameter estimate of the relative

[22] For a more comprehensive description of the Pantula principle, see e.g. Harris (1995), p. 97.

[23] When adding a deterministic trend to the model (restricted to the cointegrating space; Pantula's model 4), the cointegration tests still indicate that there is one cointegrating vector. Following the Pantula principle, the deterministic trend should then not be included in the model. These tests are not reported.

[24] The fact that we find only one cointegrating vector containing the real effective exchange rate and the three fundamentals, suggests that there is a more complex relationship between these variables in our data than implied by the stylized theoretical model by Alberola, Cervero, Lopez and Ubide (1999).

[25] Tests for stationarity of the variables in the cointegrating vector, carried out by placing restrictions on the parameters in the $\boldsymbol{\beta}$ vector, support the results of the ADF tests that the real effective exchange rate and the fundamentals all are non-stationary variables.

effective terms of trade is positive and of reasonable magnitude. Starting from an equilibrium (a steady-state of the model), a one percent improvement in the relative effective terms of trade requires a 0.76 percent appreciation (decrease) of the real effective exchange rate to restore equilibrium. As for the relative effective price of tradables to non-tradables we have that the parameter estimate is negative as expected, once again of plausible magnitude. Consider a rise in this price ratio. In terms of the Balassa-Samuelson effect this reflects a relatively smaller productivity growth rate differential between the tradables and the non-tradables sector in Sweden, compared to the rest of the world. A one percent rise in this price ratio requires a 0.37 percent depreciation of the real effective exchange rate to restore the equilibrium. The estimated parameter of the net foreign debt ratio is –0.14. Hence, an increase of the net foreign debt by one percent of GDP requires a 0.14 percent depreciation of the real effective exchange rate to restore equilibrium.[26]

Table 4 Estimated Parameters in the Cointegrating Vector and Adjustment Coefficients of the VAR(1) model

Variable / Equation	*ln q / Δln q*	*ln tot / Δln tot*	*ln tnt / Δln tnt*	*nfd / Δnfd*	*intercept*
Parameters of the cointegrating vector	1.000	0.7557 (0.1674)	-0.3720 (0.1490)	-0.1366 (0.06086)	-6.376 (1.247)
Adjustment coefficients	-0.3066 (0.07544)	0.07104 (0.03583)	-0.01273 (0.03180)	-0.2191 (0.03459)	-

Standard errors reported within parentheses.

The adjustment coefficients shed light on the dynamics of the adjustment process towards an equilibrium.[27] Consider a situation where the error correction term is positive. This corresponds to a situation where the real effective exchange rate is undervalued. With an adjustment coefficient of -0.31 in the real effective exchange rate equation, the error-correction term in this equation contributes to reduce the undervaluation by 31 percent per quarter. The real effective exchange rate thus tends to stabilise itself. For the relative effective terms of trade the situation is quite different. In combination with a positive parameter of the relative effective terms of trade in the cointegrating vector, the positive adjustment

[26] To clarify whether this parameter estimate is of plausible magnitude or not, we may turn to a simple numerical example. Assume that the interest rate on the net foreign debt is 5 percent. A one percent increase in the net foreign debt ratio then causes an extra capital outflow, due to the additional interest payments, corresponding to 0.05 percent of GDP. To restore equilibrium, this capital outflow will have to be matched by an improvement of the current account. Swedish exports and imports both roughly equal 50 percent of GDP. To generate an improvment of the current account corresponding to 0.05 percent of GDP, it follows that: (i) Swedish exports will have to increase by some 0.10 percent; (ii) Swedish imports will have to decrease by some 0.10 percent; (iii) a combination of the two. With a parameter estimate of the net foreign debt ratio in the cointegrating vector of –0.14, the model suggest that the required improvement of the current account will be achieved by a depreciation of the real effective exchange rate with 0.14 percent. The parameter estimate thus seems to be of a reasonable magnitude.

[27] It is, however, important to bear in mind that the adjustment process generally is affected both by the adjustment coefficients and the error-correction terms and by the short run dynamics of the VECM (absent in the VAR(1) case).

coefficient in the relative effective terms of trade equation implies that this equation is destabilising to the system. In other words, an undervalued real effective exchange rate will improve the relative effective terms of trade, which in turn will increase the undervaluation of the real effective exchange rate further. This is a quite reasonable property. It merely suggests that the pass-through of an undervaluation of the real effective exchange rate will be greater to export prices than to import prices. The adjustment coefficient in the equation of the relative effective price ratio of tradables to non-tradables is by and large insignificant, whereas the adjustment coefficient in the net foreign debt ratio equation is negative and significant. Since the parameter of the net foreign debt ratio in the cointegrating vector is negative as well, also this equation is destabilising to the system. Once again, this is a reasonable property. An undervalued real effective exchange rate tends to contribute to a decreasing net foreign debt ratio, thereby causing the real effective exchange rate to become increasingly undervalued. Even though two of the equations are destabilising, the overall system is stable due to the relatively high speed of adjustment of the real effective exchange rate.

An alternative VAR specification

The VAR(1) model presented above is arguably parsimoniously specified in terms of dynamics. As a sensitivity analysis, we therefore report results based on a VAR(3) model as well.[28] In all four equations taken together, only five of the extra lags are significant at conventional levels. In the system as a whole none of them are significant. Adding the extra two lags does not either remedy the general problem of non-normality of the VAR(1). In fact, autocorrelation tests indicate that some residuals now are serially correlated. The model evaluation diagnostics are displayed in the Appendix, table A1.

The evidence of cointegration is somewhat weak for the VAR(3), see table A2 in the Appendix. Neither the trace test nor the maximum eigenvalue test indicates any cointegrating relationship when the small sample correction is applied. However, without the correction both tests indicate that there exists one cointegrating vector at the 10 percent level. The weak evidence on cointegration thus partly seems to depend on the loss of degrees of freedom as more lags are added to the model. The resulting cointegrating relationship is highly similar to the one of the VAR(1) model. The parameters carry the expected sign and are of plausible magnitude (see table A3 in the Appendix), although the parameter for the net foreign debt ratio now is insignificant at conventional levels. The adjustment coefficients are similar to those of the VAR(1) as well, with the exception that the adjustment coefficient in the terms of trade equation is insignificant.

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[28] In the VAR(3) model, only the contemporaneous exogenous real interest rate differential is included since all lags are insignificant.

Outliers and structural breaks

So far we have not considered statistical outliers in the data and/or structural breaks of estimated parameters, following e.g. the large depreciations of the real effective exchange rate in 1982q4 and 1992q4/1993q1. The former was due to a devalution of the Swedish krona, while the latter took place as the fixed exchange rate regime was abandoned and the krona was left to float freely.

One-step ahead residuals and one-step ahead Chow-tests indicate that the 1993q1 observation may be an outlier and/or associated with structural shifts in parameters. This observation may be one source behind the observed non-normality of the residuals of the VAR(1) model. Although not testable by recursive estimation, the 1982q4 observation is likely to be associated with the same kind of problems. To account for these problems dummy variables for 1982q4 and 1993q1 are introduced in the VAR(1) model.[29] The two dummy variables are highly significant and it turns out that they more or less remedy the problem of non-normality. However, auto-correlation tests now indicate that there may be some problem with serial correlation at longer lag-lengths in the net foreign debt equation. The model evaluation diagnostics of the VAR(1) model with dummy variables are displayed in the Appendix, table A4. The results of the cointegration tests are reported in table A5. One should bear in mind that the critical values of these cointegration tests may suffer from bias due to the inclusion of the dummy variables. Regardless of whether the intercept is restricted to the cointegrating space or not, the tests tentatively indicate that there is one cointegrating relationship. The resulting cointegrating vector (see table A6 in the Appendix) comes close to the one from the VAR(1) model without dummy variables. All parameters have the expected sign and are of reasonable magnitude. The adjustment coefficients, however, differ more substantially. In the VAR(1) model with dummy variables both the adjustment coefficient in the relative effective price of tradables to non-tradables equation and the adjustment coefficient in the relative effective terms of trade equation are insignificant. The adjustment coefficient in the net foreign debt ratio equation is almost unaffected by the inclusion of the dummy variables, while the adjustment coefficient in the real effective exchange rate equation is approximately halved. Hence, in the VAR(1) model including dummy variables the reversion of the real effective exchange rate towards it long-run equilibrium value is only half as fast as in the VAR(1) model without dummy variables.

The shift to a floating exchange rate regime in late 1992 may well have caused shifts in some of the parameters of the model. With a floating *nominal* exchange rate one may expect the *real* effective exchange rate to adjust more rapidly towards its long-run equilibrium value. There is, however, less reason why the long-run equilibrium value and the corresponding long-run parameters in the cointegrating relationship should have been affected by the change in exchange rate regime. Hence,

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[29] Lags of the dummy variables are not included since they are insignificant. Moreover, only the contemporaneous exogenous real interest rate differential is included since the lag is insignificant.

in terms of the VECM as of equation (4), it is primarily the short-run parameters and the adjustment coefficients that may be expected to have shifted.[30]

To account for the effects of the change in exchange rate regime on the dynamics of the model, the VAR(1) model with dummy variables is re-estimated allowing for structural shifts in the short-run parameters and the adjustment coefficients. Allowing for shifts in the adjustment coefficients complicates formal testing of cointegration and it is therefore merely assumed that there exists one cointegrating relationship.[31] The resulting cointegrating vector and the adjustment coefficients are reported in the Appendix, table A8. As is clear from the model evaluation diagnostics in table A7, the residuals of the net foreign debt ratio equation are generally not well behaved. In particular they suffer from severe serial correlation. Hence, the parameter estimates may not be reliable. Adding an extra lag to the model does not remedy the problem and one may consequently question the model specification. Even so, it is interesting to note that the estimated cointegrating vector comes close to the vectors of the other VAR(1) models. Furthermore, the supposition that the adjustment coefficient in the real effective exchange rate equation should be larger (in absolute terms) from 1993q1 to 2000q4 is seemingly confirmed. The parameter estimate is –0.50 for the period 1993q1-2000q4, and –0.07 for the period 1982q2-1992q4. In the net foreign debt equation the adjustment coefficient carry the expected negative sign with the speed of adjustment being approximately twice as high in the 1993q1-2000q4 period when it equals –0.27. The adjustment coefficients in the relative effective price of tradables to non-tradables equation and the relative effective terms of trade equation are rather small and insignificant. Although question-marks surround the model's specification, the results thus seem plausible from an economic point of view.

7. Calculating Real Effective Equilibrium Exchange Rates

The perhaps most important feature of the BEER approach is that it recognises that the real equilibrium exchange rate may change over time as its underlying determinants change. A straightforward way to derive a real effective equilibrium exchange rate is to compute it directly from the long-

[30] If the long-run parameters have shifted as well, there is no point in estimating the model using the full sample. Rather, the sample should be split in pre- and post- periods of the change in exchange rate regime. The resulting samples would, however, cover quite short periods of time and may therefore be unsuitable for cointegration analyses.

[31] The model was estimated in its VECM-form using the Full Information Maximun Likelihood estimator. Dummy variables for the independent variables of the model, taking on the observed value for 1982q1 to 1992q4 and zero for 1993q1 and on, were added to the model (except for the seasonal dummy variables). By placing restrictions on the long-run parameters, the cointegrating vector of dummy long-run variables was equated to the cointegrating vector containg the full span long-run variables.

run parameters of the model. The real effective exchange rate is in equilibrium when the error correction term in the VECM equals zero and the system is in a steady-state. A real effective exchange rate can thus be computed as the real effective exchange rate required for the error correction term to equal zero, given values of the fundamental variables in the long-run relationship. Hence, by using actual, *current* values of the fundamental variables, one obtains the *current* real effective equilibrium exchange rate. By doing so for every time period covered by the model, a time series of the current real effective equilibrium exchange rate is obtained.

Although easy to calculate, the current real effective equilibrium exchange rate merely reflects the real effective exchange rate that is required for equilibrium to prevail, given the current values of the fundamentals. It does not account for the fact that the (endogenous) fundamental variables may change in the adjustment process towards equilibrium.

By decomposing the real effective exchange rate into a permanent and a transitory component, one can derive a *permanent* real effective equilibrium exchange rate. Various decomposition techniques exist. Since our models contain no drift term – the intercept is restricted to the cointegrating space – a straightforward way to make the decomposition is to generate forecasts with the VECM.[32] Given actual starting values of all variables, the VECM is iterated forward until the real effective exchange rate and the fundamental variables reaches a steady-state.[33] Hence, the decomposition allows not only the real effective exchange rate but also the fundamental variables to change in the adjustment process towards equilibrium. By repeating this procedure for every time period covered by the model, a time series of the permanent real effective equilibrium exchange rate is obtained.[34]

Figures 6 to 11 present current and permanent real effective equilibrium exchange rates based on the four models that were reported in section 6. Figure 6 reports the real effective exchange rate (REER), the *current* real effective equilibrium exchange rate (CEER) and the *permanent* real effective equilibrium exchange rate (PEER) based on the VAR(1) model. Figures 7 to 9 do likewise for the VAR(3) model, the VAR(1) model with dummy variables and the VAR(1) model with dummy variables and structural shifts in adjustment coefficients, respectively. Figure 10 compares the various current real effective equilibrium exchange rates while figure 11 compares the various permanent real effective equilibrium exchange rates.

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[32] This corresponds to the so-called Beveridge-Nelson decomposition.

[33] Since seasonal dummy variables are included, the steady-state values are calculated as the mean of the final four values in each iteration.

[34] Obviously, permanent components of the fundamental variables are obtained as well.

Figure 6. Equilibrium exchange rates of the VAR(1), natural logaritm

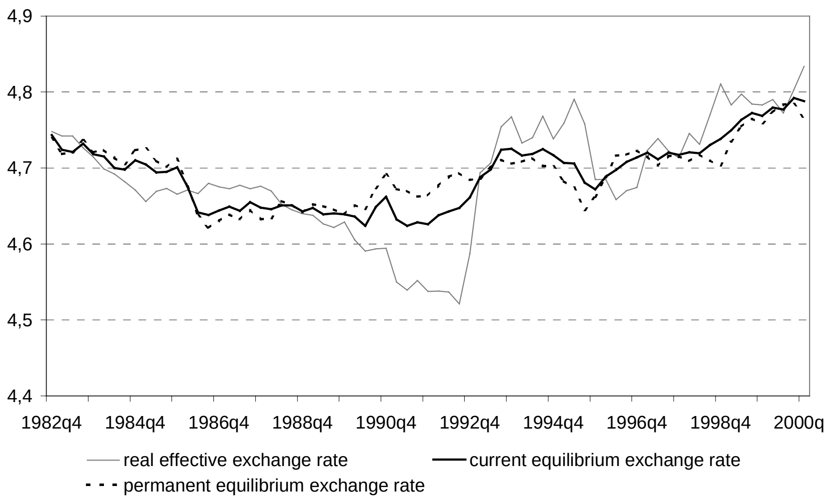


Figure 7. Equilibrium exchange rates of the VAR(3), natural logaritm

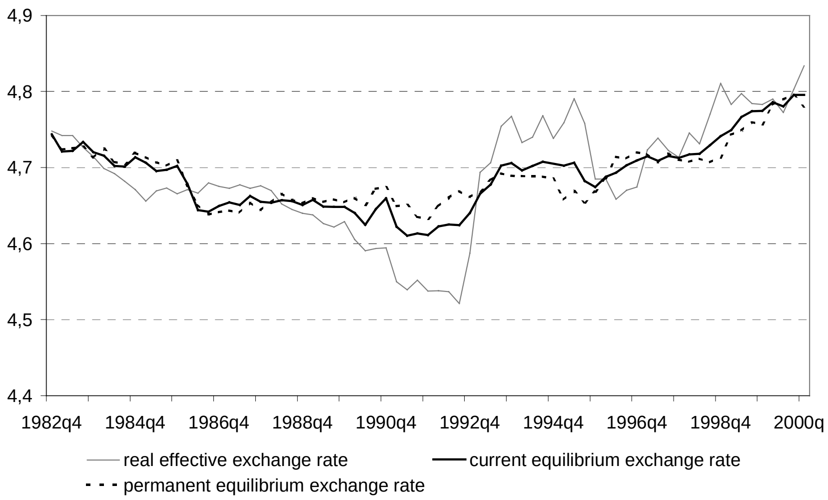


Figure 8. Equilibrium exchange rates of the VAR(1) with dummy variables, natural logaritm

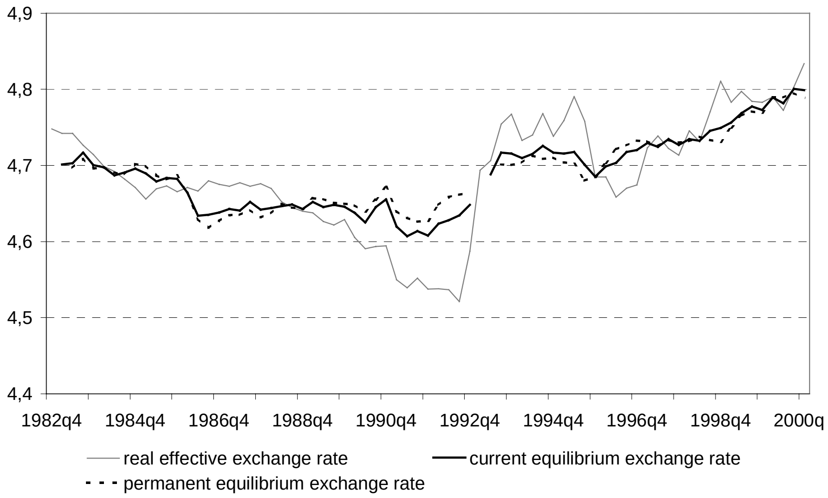


Figure 9. Equilibrium exchange rates of the VAR(1) with dummy variables and structural break, natural logaritm

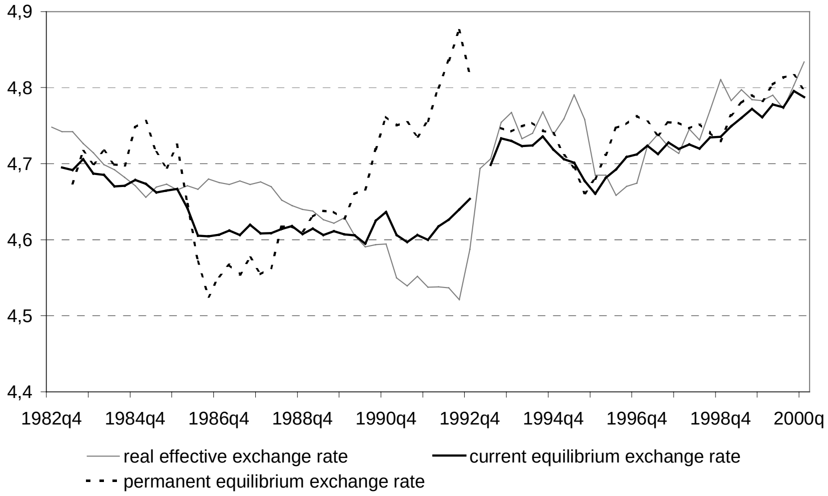


Figure 10. Current equilibrium exchange rates (CEERs), natural logaritm

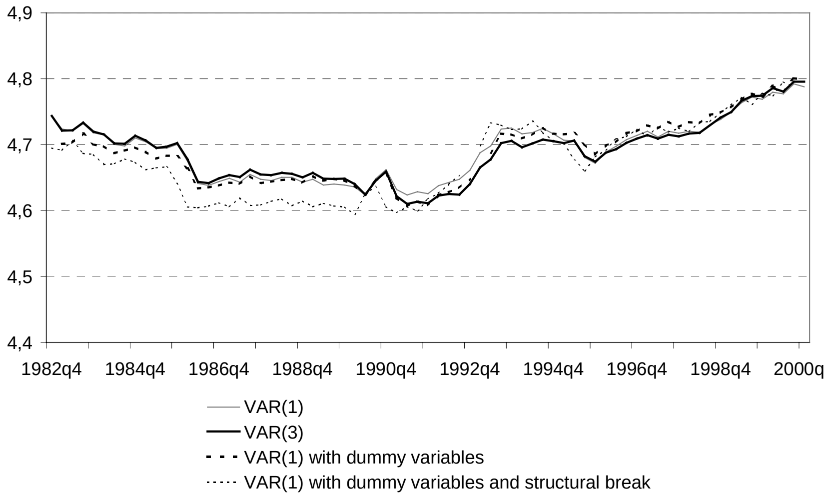
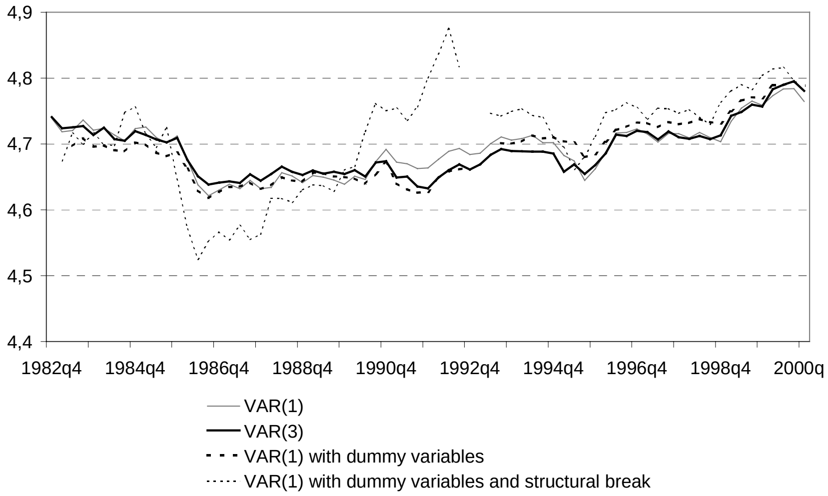


Figure 11. Permanent equilibrium exchange rates (PEERs), natural logaritm



As is clear from the figure 10, the various current real effective equilibrium exchange rates come close to each other. This is not surprising since, there is only little difference between the cointegrating vectors of the alternative models. From e.g. figure 6, it is evident that the real effective exchange rate stayed fairly close to the current real effective equilibrium exchange rate until the beginning of the 1990s, when the appreciation of the real effective exchange rate became more accelerated. During the same period, the current real effective equilibrium exchange rate was fairly stable and the real effective exchange rate became increasingly overvalued. In 1992q3, the real effective exchange rate was more than 10 percent overvalued compared to what was warranted by the actual values of the fundamentals. As the fixed exchange rate regime was abandoned in 1992q4, the real effective exchange rate depreciated sharply. In fact, it soon overshot the current real effective equilibrium exchange rate and became undervalued. This period of undervaluation continued until late 1995, when the real effective exchange rate became more or less aligned with the current real effective equilibrium exchange rate.

Since then the current real effective equilibrium exchange rate has depreciated steadily, all in all by more than 10 percent. The real effective exchange rate has stayed broadly in line with the current real effective equilibrium exchange rate, although it apparently became undervalued during the so-called Asian crisis in 1998 to 1999. In 2000q4, the real effective exchange rate appears to have been undervalued by some 4 to 5 percent compared with the current real effective equilibrium exchange rate.

The steady depreciation of the current real effective equilibrium exchange rate since late 1995 is primarily a consequence of deteriorating relative effective terms of trade. Between 1995q4 and 2000q4, the relative effective terms of trade fell by over 10 percent. The steady increase in the relative effective price of tradables to non-tradables has also contributed. Between 1995q4 and 2000q4, this price ratio increased with approximately 8 percent. In terms of the Balassa-Samuelson effect, this suggests that the productivity growth rate differential between the tradables and the non-tradables sector was smaller in Sweden than in the “rest of the world” during these years. It may, however, also reflect shrinking profit margins in the Swedish non-tradables sector as a consequence of the ongoing deregulation in this sector.

The permanent real effective equilibrium exchange rates generally indicate larger misalignments than the corresponding current real effective equilibrium exchange rates do. This should come as no surprise. Consider, for example, the situation where the real effective exchange rate is overvalued compared to the current real effective equilibrium exchange rate. The current account will then tend to be in deficit so that the net foreign debt is increasing. This will in turn depreciate the real effective equilibrium exchange rate further. Hence, as the real effective exchange rate depreciates towards equilibrium, the equilibrium itself is depreciating further. The process continues until the real effective exchange rate finally reaches its permanent equilibrium value.

It should be clear that the speed of convergence here plays a crucial role. The higher the speed of convergence of the real effective exchange rate, the closer will the permanent real effective equilibrium exchange rate track the current real effective equilibrium exchange rate. This becomes quite clear from the case with the VAR(1) model with dummy variables and structural shifts in the adjustment coefficients, see figure 9. During the fixed exchange rate regime era, the permanent real effective equilibrium exchange rate often differed markedly from the current real effective equilibrium exchange rate. For example, in 1992q3 the latter indicate an overvaluation by some 10 percent while the former indicate an overvaluation by more than 30 percent. This is primarily a consequence of the relatively slow speed of adjustment of the real effective exchange rate during this period, see table A8 in the Appendix. During the floating exchange rate regime era, starting in 1993q1, the speed of convergence has been much higher. Accordingly, the permanent real effective equilibrium exchange rate has moved much closer to the current real effective equilibrium exchange rate during this period.

The large swings in the permanent real effective equilibrium exchange rate of the VAR(1) model with dummy variables and structural shifts in the adjustment coefficients during the fixed exchange rate regime era, is not matched by the other permanent real effective equilibrium exchange rates. However, as is clear from figure 11, all four permanent real effective equilibrium exchange rates move relatively closely together during the floating exchange rate regime era. In 2000q4, the real effective exchange rate appears to have been undervalued by some 4 to 7 percent, compared to the permanent real effective equilibrium exchange rates.

All in all, the resulting real effective equilibrium exchange rates of the various model specifications are quite similar. The various current real effective equilibrium exchange rates move closely together. This lends some credibility to the robustness of the results. Regardless of model specification, the various real effective equilibrium exchange rates all indicate that the Swedish krona was severely overvalued in late 1992, when the fixed exchange rate regime was abandoned. Moreover, they also indicate that the Swedish krona was undervalued by 4 to 5 percent in 2000q4, given the values of the fundamentals at the time. In 2000q4 the TCW-index, a measure of the *nominal* effective exchange rate, equalled 128.4. In terms of the TCW-index, the results thus imply that the current equilibrium exchange rate was in the range of 122 to 124 in 2000q4, depending on the model.

8. Arithmetical examples of conversion rates

If Sweden is to replace the krona with the euro, this will be associated with number of so-called convergence criteria, concerning e.g. exchange rate stability. This criterion will most likely require that the krona is joined to the European exchange rate mechanism ERM2 up to two years before the euro is adopted. The SEK/EUR central rate that is to prevail during the ERM2 phase will most likely serve as the conversion rate when the euro finally is adopted. An important question thus concerns how to choose an appropriate central rate. As implied by the BEER approach, the equilibrium exchange rate may change over time as the underlying macroeconomic factors of relevance changes. Hence, it is in general not possible to find an optimal exchange rate that will prevail forever. Rather, the question of finding an appropriate central rate should focus on minimising the adjustment costs in the Swedish economy during a transition period. In a longer perspective, the economy will have to adapt to exchange rate misalignments through other adjustment mechanisms.

A reasonable point of departure is to choose a SEK/EUR central rate so that the real effective exchange rate is in line with its *current* equilibrium value during the transition period. Such a calculation will necessarily be based on a number of assumptions.

The first assumption concerns the transition period. Here we will assume that this period takes place during 2004 to 2005. Second, we need to forecast values of the fundamentals for the chosen transition period. A straightforward way to do this is to make use of one of the above VEC models to generate such future values. Here we make use of the VEC model based on the VAR(1) model with additional dummy variables for 1982q4 and 1993q1.[35] An average value of the current real effective equilibrium exchange rate for the transition period may then be calculated by making use of the average values of the forecasted values of the fundamental variables for 2004 to 2005. To translate this current real effective equilibrium exchange rate into its *nominal* counterpart, assumptions must be made concerning the inflation rates of consumer prices. Since most countries included in the analysis employ inflation rate targeting with targets around two percent, we make the simplifying assumption that inflation rates will be equal in all countries during 2001 to 2005. With this assumption, adjustments in the real effective exchange rate are directly transferred to the nominal effective exchange rate, and vice versa. The current real effective equilibrium exchange rate then corresponds to a TCW-index of roughly 123 during the transition period in 2004 to 2005. This implies an appreciation of the TCW-index by over 9 percent from its value of 135.7 in February 2002. To translate the TCW-index to an appropriate SEK/EUR central rate, additional assumptions

[35] The motivation for using this model is that: (i) the dummy variables are significant and have a reasonable economic interpretation. Hence the model may seem as more relevant than the VAR(1) without dummy variables; (ii) the VAR(3) model adds little to the VAR(1) model; (iii) the VAR(1) model with dummy variables and structural shifts in adjustment coefficients is surrounded by specification problems.

must be made concerning the non-euro countries' bilateral exchange rates vis-à-vis the euro for 2004 and 2005.

Below, we provide some arithmetical examples. As a benchmark, we make use of the bilateral exchange rates that prevailed in February 2002, see table 5, and assume that these rates will be relevant also for 2004 to 2005. With this assumption, the required appreciation of the TCW-index can be directly translated to the bilateral SEK/EUR rate. Hence, for the TCW-index to reach 123, the krona needs to be strengthened by more than 9 percent from its value of 9.19 SEK/EUR in February 2002 to approximately 8.35 SEK/EUR.

As a second example, we make use of consensus exchange rate forecasts. Table 5 summarises the consensus exchange rate forecasts for March 2004.[36] Assuming that the forecasted bilateral exchange rates for March 2004 prevail throughout 2004 and 2005, a TCW-index of 123 corresponds to approximately 8.55 SEK/EUR.[37]

There has, however, for a long time been a concern about the present weakness of the euro, particularly vis-à-vis the US dollar. A large number of studies have reported medium to long-run bilateral equilibrium US$/EUR rates well above parity.[38] An example with a further weakening of the US dollar may therefore be relevant. Assume that the US dollar weakens an additional 15 percent vis-à-vis the euro compared to the consensus forecasts so that it equals 1.10 US$/euro during 2004 to 2005. Furthermore, assume that the Australian dollar, the New Zealand dollar, the Canadian dollar and the Japanese yen do likewise and track the US dollar. Under these circumstances a TCW-index of 123 corresponds to approximately 8.80 SEK/EUR.

Table 5 Exchange rate assumptions

	USA US$/EUR	Canada C$/EUR	Australia A$/EUR	New Zea. NZ$/EUR	Japan yen/EUR	UK £/EUR	Switzerl. SFr/EUR	Norway NKr/EUR
Actual values 2002m2	0.870	1.39	1.70	2.08	116	0.612	1.48	7.79
Consensus forecasts for 2004m3	0.953	1.44	1.61	1.96	123	0.654	1.51	8.02
Additional weakening of the US$	1.10	1.66	1.86	2.26	142	0.654	1.51	8.02

9. Summary

In this paper we have analysed the relationship between fundamental variables and the behaviour of the Swedish real effective exchange rate,

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36 See Foreign Exchange Consensus Forecasts, March 11th, 2002.

37 The Danish krona is assumed to track the euro.

38 For a survey of recent studies, see Koen et. al. (2001).

using the so-called BEER approach. The relative terms of trade, the relative price ratio of tradables to non-tradables, and the net foreign debt as a share of GDP all proved to be important long-run determinants of the Swedish real effective exchange rate. In the estimated long-run relationship, they are all statistically significant with plausible parameter estimates. The results are quite robust in the sense that alternative specifications of the VAR model produce similar results of the long-run parameters.

The results suggest that the Swedish krona was severely overvalued in late 1992 when the fixed exchange rate regime was abandoned. As the krona was put on a floating basis, it depreciated sharply and became somewhat undervalued relative to the equilibrium value implied by the fundamental variables. After a brief recovery, the krona depreciated steadily from the mid 1990s. This weakening of the krona may largely be explained by changes in the fundamental variables and a subsequent depreciation of the real effective equilibrium exchange rate. The prime force behind this development has been deteriorating terms-of-trade. The results, however, indicate that the krona was undervalued by some 4 to 5 percent in 2000q4 relative to what was warranted by the fundamental variables at the time.

The resulting BEER models are used to provide arithmetical examples of suitable conversion rates for the case Sweden is to adopt the euro. These arithmetical examples are, however, highly sensitive to the various assumptions they are based on. The very idea of the BEER approach is that the equilibrium exchange rate may change over time. Hence, there exist no optimal conversion rate that will prevail forever. Rather, the conversion rate should be chosen so as to minimise the adjustment costs of the Swedish economy during a transition phase after the SEK/EUR rate is fixed. A number of assumptions must here be made. The first concerns when Sweden will join the ERM2 so that the krona is tied to the euro. Assumptions must also be made concerning future inflation rates, future values of the fundamental variables, and future values of non-euro countries' bilateral exchange rates vis-à-vis the euro. This highlights the problem of assessing a suitable conversion rate. Apart from the statistical uncertainty of the model, such assessments by necessity rely on a number of additional assumptions.

In the arithmetical examples we provide, it is assumed that Sweden will be joining the ERM2 in 2004, and that 2004 to 2005 is the relevant transition period. Furthermore, we assume that the Swedish inflation rate will be equal to the inflation rate of all the other countries covered by the model until the end of the transition period. The values of the fundamental variables for the transition period are derived as forecasts of our BEER model. Under these assumptions, our results indicate that the exchange rate will be in equilibrium during 2004 to 2005 at a TCW-index of approximately 123. Under the additional assumption that consensus forecasts of non-euro countries' bilateral exchange rates vis-à-vis the euro for March 2004 will prevail throughout 2004 and 2005, a TCW-index of 123 corresponds to approximately 8.55 SEK/EUR.

References

Alberola, E., S. Cervero, H. Lopez and A. Ubide, 1999, " Global Equilibrium Exchange Rates: Euro, Dollar, "Ins", "Outs" and other Major Currencies in a Panel Cointegrating Framework", IMF Working Paper WP/99/175, International Monetary Fund, Washington.

Balassa, B., 1964, "The Purchasing Power Parity Doctrine: A Reappraisal", *Journal of Political Economy*, Vol. 72, pp. 584-596.

Bayoumi, T., P. Clark, S. Symansky and M. Taylor, 1994, "The Robustness of Equilibrium Exchange Rate Calculations to Alternative Assumptions and Methodologies" in Williamson, J., ed., *Estimating Equilibrium Exchange Rates*. Institute for International Economics, Washington D.C.

Boucher Breuer, J., 1994, "An Assessment on the Evidence on Purchasing Power Parity" in Williamson, J., ed., *Estimating Equilibrium Exchange Rates*. Institute for International Economics, Washington D.C.

Clark, P. B. and R. MacDonald, 1999, "Exchange Rates and Economic Fundamentals: A Methodological Comparison of BEERs and FEERs" in MacDonald, R and J. Stein, eds., *Equilibrium Exchange Rates*. Kluwer Academic Publishers, Dordrecht.

Clark, P. B. and R. MacDonald, 2000, "Filtering the BEER: A Permanent and Transitory Decomposition", IMF Working Paper WP/00/144, International Monetary Fund, Washington.

Dornbusch, R., 1976, "Expectations and Exchange Rate Dynamics", *Journal of Political Economy*, Vol. 84, pp. 1161-1176.

Edwards, S., 1989, *Real Exchange Rate, Devaluation and Adjustment*, The MIT Press, Cambridge, MA.

Enders, W., 1995, *Applied Econometric Time Series*, John Wiley & Sons, Inc.

Engle, R. and C. Granger, 1987, "Cointegration and Error Correction: Representation, Estimation and Testing", *Econometrica*¸ Vol. 55, pp. 251-276.

Faruqee, H., 1995, "Long-Run Determinants of the Real Exchange Rate: A Stock Flow Perspective", *Staff Papers*, International Monetary Fund, Vol. 42, No. 1, pp. 80-107.

Foreign Exchange Consensus Forecasts, 2002, March 11th, Consensus Economics Inc., London.

Froot, K. A. and K. Rogoff, 1995, “Perspectives on PPP and Long-Run Real Exchange Rates”. In G. Grossman and K. Rogoff, eds., *Handbook in international economics*, vol. 3. Amsterdam, North Holland.

Harris, R., 1995, *Cointegration Analysis in Econometric Modelling*, Prentice Hall.

Johansen, S., 1988, “Statistical Analysis of Cointegration Vectors”, *Journal of Economic Dynamics and Control*, Vol. 12, pp. 231-254.

Johansen, S., 1995, *Likelihood-Based Inference in Cointegrated Vector Autoregressive Models,* Oxford University Press, Oxford.

Koen, V. *et. al.*, 2001, “Tracking the Euro”, Economics Department Working Papers No. 298, OECD, Paris.

MacDonald, R., 1999, “What Determines Real Exchange Rates? The Long and Short of it” in MacDonald, R and J. Stein, eds., *Equilibrium Exchange Rates*. Kluwer Academic Publishers, Dordrecht.

Obstfeld, M. and K. Rogoff, 1996, *Foundations of International Macroeconomics*. The MIT Press, Cambridge, MA.

Ostry, J., 1988, “The Balance of Trade, Terms of Trade, and Real Exchange Rate: An Intertemporal Otimizing Framework”, *Staff Papers*, International Monetary Fund, Vol. 35, pp. 451-73.

Rogoff, K., 1997, “The Purchasing Power Parity Puzzle”, *Journal of Economic Literature*, Vol. 34, pp. 647-68.

Samuelson, P., 1964, “Theoretical Problems on Trade Problems”, *Review of Economics and Statistics* Vol. 46, pp. 145-54.

Sveriges Riksbank, 1995, *Inflation och Inflationsförväntningar i Sverige*, November 1995, Sveriges Riksbank.

Stein, J., P. Allen and Associates, 1995, *Fundamental Determinants of Exchange Rates.* Oxford University Press.

Stein, J., 1999, “The Evolution of the Real Value of the US Dollar Relative to the G7 Currencies” in MacDonald, R and J. Stein (eds.) *Equilibrium Exchange Rates*. Kluwer Academic Publishers, Dordrecht.

Williamson, J., 1994, *Estimating Equilibrium Exchange Rates*. Institute for International Economics, Washington D.C.

Appendix

Results of the VAR(3) model

Table A1 Model evaluation diagnostics of the VAR(3) model. P-values

Test-statistic / Equation	*ln q*	*ln tot*	*ln tnt*	*nfd*
$F_{ar1}(1,55)$	0.5509	0.0037	0.9038	0.1621
$F_{ar1-4}(4,52)$	0.4388	0.0146	0.9977	0.6890
$F_{arch}(4,48)$	0.0001	0.5959	0.5416	0.8814
$F_{heterosc.}(24,31)$	0.4956	0.9347	0.6680	0.8207
$\chi^2_{normal}(2)$	0.0003	0.0016	0.0034	0.0001

Multivariate tests: $F_{ar1}(16,150)$ = 0.0004; $F_{ar1-4}(64,147)$ = 0.0083;
$F_{heterosc.}(240,228)$ = 0.9998; $\chi^2_{normal}(8)$ = 0.0487

Table A2 Results of cointegration tests of the VAR(3) model

Rank H_0	Max. eigenvalue test	Max. eigenvalue test, small sample correction	Critical value 90%	Trace test	Trace test, small sample correction	Critical value 90%
Intercept restricted to the cointegrating space						
r=0	26.49 [b]	22.13	25.56	52.85 [b]	44.17	49.65
r<=1	19.93	16.65	19.77	26.37	22.03	32.00
r<=2	5.483	4.582	13.75	6.438	5.379	17.85
r<=3	0.9545	0.7976	7.52	0.9545	0.7976	7.52
Intercept unrestricted						
r=0	26.46 [b]	22.11	24.73	48.73 [a]	40.72	43.95
r<=1	17.65	14.75	18.60	22.27	18.61	26.79
r<=2	4.463	3.729	12.07	4.622	3.862	13.33
r<=3	0.1589	0.1328	2.69	0.1589	0.1328	2.69

[a] Rejects the null hypothesis at the 5 percent level.
[b] Rejects the null hypothesis at the 10 percent level.

Table A3 Estimated Parameters in the Cointegrating Vector and Adjustment Coefficients of the VAR(3) model

Variable / Equation	ln q / Δln q	ln tot / Δln tot	ln tnt / Δln tnt	nfd / Δnfd	constant
Parameters in the cointegrating vector	1.000	0.6839 (0.1825)	-0.5683 (0.1684)	-0.06697 (0.06377)	-5.159 (1.353)
Adjustment coefficients	-0.3467 (0.1317)	0.01049 (0.06112)	-0.006810 (0.05365)	-0.1765 (0.05470)	-

Standard errors reported within parentheses.

Results of the VAR(1) model with dummy variables

Table A4 Model evaluation diagnostics of the VAR(1) model with dummy variables. P-values

Test-statistic / Equation	*ln q*	*ln tot*	*ln tnt*	*nfd*
$F_{ar1}(1,63)$	0.9851	0.1503	0.6574	0.2088
$F_{ar1\text{-}4}(4,60)$	0.2477	0.3203	0.1992	0.0081
$F_{arch}(4,56)$	0.2724	0.4930	0.6679	0.5584
$F_{heterosc.}(15,48)$	0.0894	0.3195	0.2565	0.6024
$\chi^2_{normal}(2)$	0.1473	0.0365	0.2474	0.3012

Multivariate tests: $F_{ar1}(16,174)$ = 0.9244; $F_{ar1\text{-}4}(64,178)$ = 0.5527; $F_{heterosc.}(150,345)$ = 0.8818; $\chi^2_{normal}(8)$ = 0.0692

Table A5 Results of cointegration tests of the VAR(1) model with dummy variables

Rank H_0	Max. eigenvalue test	Max. eigenvalue test, small sample correction	Critical value 95%	Trace test	Trace test, small sample correction	Critical value 95%
Intercept restricted to the cointegrating space						
r=0	39.87 [a]	37.75 [a]	28.14	68.05 [a]	64.42 [a]	53.12
r<=1	19.22	18.20	22.00	28.18	26.68	34.91
r<=2	6.365	6.025	15.67	8.954	8.476	19.96
r<=3	2.589	2.451	9.24	2.589	2.451	9.24
Intercept unrestricted						
r=0	39.75 [a]	37.63 [a]	27.07	61.98 [a]	58.67 [a]	47.21
r<=1	15.43	14.61	20.97	22.23	21.04	29.68
r<=2	4.269	4.041	14.07	6.797	6.434	15.41
r<=3	2.528	2.393	3.76	2.528	2.393	3.76

[a] Rejects the null hypothesis at the 1 percent level.

Table A6 Estimated Parameters in the Cointegrating Vector and Adjustment Coefficients of the VAR(1) model with dummy variables

Variable / Equation	ln q / Δln q	ln tot / Δln tot	ln tnt / Δln tnt	nfd / Δnfd	constant
Parameters in the cointegrating vector	1.000	0.5113	-0.6094	-0.1872	-4.148
		(0.1825)	(0.1599)	(0.06737)	(1.342)
Adjustment coefficients	-0.1517	0.04349	0.03480	-0.1968	-
	(0.06431)	(0.03577)	(0.03050)	(0.03607)	

Standard errors reported within parentheses.

Results of the VAR(1) model with dummy variables and structural shift in adjustment coefficients

Table A7 Model evaluation diagnostics of the VECM with dummy variables and structural shift in adjustment coefficients. P-values

Test-statistic / Equation	*ln q*	*ln tot*	*ln tnt*	*nfd*
$F_{ar1}(1,65)$	0.7747	0.1009	0.7719	0.0003
$F_{ar1-4}(4,62)$	0.3906	0.3677	0.8350	0.0001
$F_{arch}(4,58)$	0.0228	0.0960	0.6388	0.0001
$F_{heterosc.}(13,52)$	0.0095	0.3015	0.1124	0.0001
$\chi^2_{normal}(2)$	0.2223	0.0993	0.4837	0.2349

Multivariate tests: $F_{ar1}(16,180) = 0.7227$; $F_{ar1-4}(64,186) = 0.0001$;
$F_{heterosc.}(130,360) = 0.0008$; $\chi^2_{normal}(8) = 0.1224$

Table A8 Estimated Parameters in the Cointegrating Vector and Adjustment Coefficients of the VECM with dummy variables shift in adjustment coefficients

Variable / Equation	ln q / ∆ln q	ln tot / ∆ln tot	ln tnt / ∆ln tnt	nfd / ∆nfd	constant
Parameters in the cointegrating vector	1.000	0.7547 (0.2403)	-0.4061 (0.1919)	-0.2947 (0.1195)	-6.172 (1.857)
Adjustment coefficients 93q1-00q4	-0.4996 (0.1215)	0.07573 (0.07282)	-0.07180 (0.06171)	-0.2726 (0.07152)	-
Adjustment coefficients 82q2-92q4	-0.07179	0.02075	0.02840	-0.1444	-

Standard errors reported within parentheses.

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