Chapter 4 – Real equilibrium exchange rates for Norway

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This article presents and employs the theories of purchasing power parity (PPP), behaviour equilibrium real exchange rate (BEER) and the fundamental equilibrium real exchange rate (FEER) to estimate the equilibrium real exchange rate for Norway. It also discusses whether the real exchange rate was overvalued in 2002 relative to the implied estimates of the equilibrium real exchange rate and whether Norway's substantial petroleum wealth imply a permanently strong equilibrium real exchange rate. It appears that both the PPP and the BEER approaches imply a constant equilibrium exchange rate for Norway. Estimates of the equilibrium real exchange rate imply that the real exchange rate was overvalued in 2002. On the other hand, the FEER approach implies an estimate of the equilibrium real exchange rate on a par with the actual exchange rate in this period. However, the equilibrium exchange rate can not remain at a strengthened rate. Calculations of FEER suggest that it weakens over time and converge towards the rate that balances foreign trade with traditional goods and services. This is because the share of import that can be financed by petroleum revenues becomes insignificant in the long run as import of goods and services is assumed to grow with growth in income.

1. Introduction

The Norwegian real exchange rate strengthened considerably in the course of 2002. A pertinent question would be whether this represented an adjustment to a stronger equilibrium real exchange rate (hereafter equilibrium rate) or simply a temporary deviation from the existing equilibrium rate. In particular, it has been argued that the real exchange rate strengthened permanently because of a permanent increase in government spending, financed by revenues from the Norwegian Petroleum Fund, see e.g. Svensson, Houg, Solheim and Steigum (2002) Moreover, a strong equilibrium real exchange for Norway is often justified on the grounds that Norway has substantial net foreign assets in the form of petroleum wealth and the Norwegian Petroleum Fund which reduce the need for exporting traditional goods and services to pay for imports.

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This article presents and applies three different approaches to determine the equilibrium exchange rate for Norway. These approaches are: the theory of purchasing power parity (PPP), the behavioural equilibrium real exchange rate (BEER) approach and the fundamental equilibrium real exchange rate (FEER) approach, see MacDonald and Stein (1999), Akram, Brunvatne and Lokshall (2003) and the references therein. The FEER-approach is particularly suitable for discussing whether, to what extent and for how long revenues from petroleum wealth imply a strong equilibrium real exchange rate for Norway.

The three approaches focus on different aspects of the economy and therefore identify several factors that are important to movements in the Norwegian real exchange rate over different time horizons. Use of different methods to calculate the level of the equilibrium exchange rate also gives several benchmark values when assessing whether and to what extent the real exchange rate is over or undervalued.

The article is organised as follows: Section 2 considers the theory of purchasing power parity and points out that it enables us to characterise the behaviour of the Norwegian real exchange rate over time. The section also discusses how rapidly the real exchange rate can return to its equilibrium level when a deviation occurs. The presentation of the PPP approach is relatively brief, as we have already analysed the Norwegian nominal and real exchange rates using this approach in Akram (2000a, 2002).

Section 3 employs the BEER approach and derives an empirical model of the Norwegian real exchange rate that is used to calculate the equilibrium exchange rate in the medium and long term. A dynamic model of the real exchange rate is also derived. A number of factors that have short run effects on the exchange rate are included in this model, including growth in public spending, which may help to explain transitory or quite persistent deviations from the equilibrium level.

Section 4 presents the FEER approach, where the equilibrium exchange rate is determined on the basis of a model of Norwegian import and export of traditional goods and services, i.e. non-petroleum products including services. Given the lack of studies adapting the FEER approach to the Norwegian context, this section starts out by developing a theoretical model that can be used to derive FEER. This model can be used to examine the importance of petroleum revenues to the equilibrium exchange rate over time. Thereafter, we employ an empirical version of this model to derive a path for the Norwegian equilibrium real exchange rate far into the future: until 2070. It emerges that, as Norway has substantial net foreign assets in the form of petroleum wealth, the equilibrium exchange rate may be stronger than the level that balances external trade with traditional goods and services. This section also derives alternative paths for the equilibrium exchange rate, conditional on different assumptions regarding, for example, the size

of oil revenues and the rate of economic growth in Norway and abroad. This helps us to discuss whether relatively large revenues from petroleum wealth can justify a permanent appreciation of the equilibrium exchange rate. Section 5 presents a summary of the key results.

2. Equilibrium exchange rate based on PPP

According to the theory of (relative) purchasing power parity (PPP), the real exchange rate would be constant in equilibrium. This is expressed in equation (1):

$$R^* = \alpha, \tag{1}$$

where R^* is the real exchange rate in equilibrium and α is a constant parameter. The real exchange rate is defined as $R \equiv EP^f/P$, where E is the nominal exchange rate, which expresses the price of foreign currency in the home country's currency, and P^f/P is the ratio between the general price level abroad and the general price level at home. When the real exchange rate is at its equilibrium level, the rate of inflation in the home country will equal that abroad once we account for changes in the nominal exchange rate.

When the economy is in a state of internal and external balance, the real exchange rate will be at its equilibrium level. Any deviation from the equilibrium level may give rise to internal and external imbalances. Such imbalances will, however, bring the real exchange rate back to its equilibrium level. For example, if the actual exchange rate R is weaker than R^*, ($R > R^*$), competitiveness will improve and may result in trade surplus. This will be accompanied by a rise in the activity level and contribute to a tighter labour market. The trade surplus may result in an appreciation of the nominal exchange rate (lower E), while the high activity in the economy will serve to push up wage and price inflation (raise P^f/P). As a result, the real exchange rate will appreciate (R falls) and return to the equilibrium level, though this can occur in cycles around the equilibrium level until imbalances are eliminated, see Akram et al. (2003) (Chapter 3 of this Occasional Paper) for a more detailed explanation.

Movements in the Norwegian real exchange rate over the past thirty years comply well with predictions based on the theory of purchasing power parity. Figure 1 shows quarterly movements in the Norwegian effective real exchange rate in the period 1971:1–2002:4. The straight line at 0.975 represents an estimate of the equilibrium real exchange rate (R^*). This is calculated as the average of the real exchange rate over the sample period. The figure shows that the real exchange rate fluctuated around the estimated equilibrium level throughout the sample period, where positive deviations from the equilibrium level ($R > R^*$) were followed by negative deviations ($R < R^*$) sooner or later. There appears to be no sustained trend in one direction or the other,

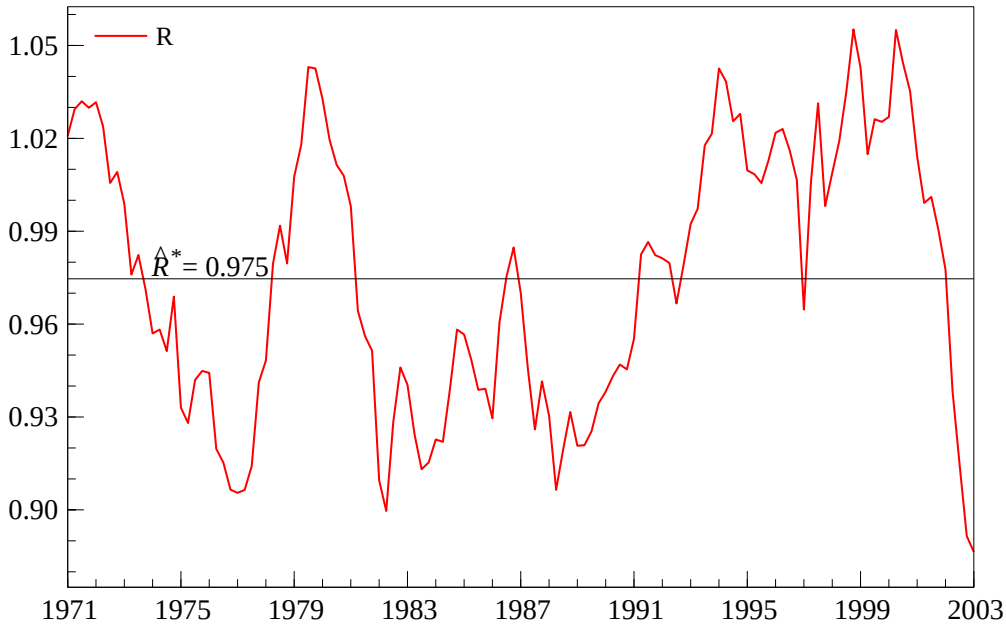

Figure 1: *Trade-weighted real exchange rate in period 1971:1–2002:4. The real exchange rate is constructed by dividing the product of the trade-weighted nominal exchange rate index and foreign consumer price index with the consumer price index in Norway. All indices have a value equal to 1 in 1997. An increase in the real exchange rate indicates a real depreciation.*

nor in the fluctuation margin. This impression is confirmed by several formal tests, see Akram (2000a, 2002). Some of these tests are presented in Table 1. Several more recent studies of other countries also find that real exchange rates generally converge towards a given level in line with the theory of purchasing power parity, see for example Sarno and Taylor (2002), Cheung and Lai (2000) and references therein.

Empirical evidences suggests that the Norwegian real exchange rate has a tendency to converge relatively rapidly towards the equilibrium level. Figure 2 shows the time path of a deviation from the equilibrium level, $(R - R^*)$. We see that one unit's deviation from the equilibrium level is halved in the course of five quarters, whereas 3/4 of the deviation is eliminated in the course of ten quarters, all else being equal. This figure is based on the time series model for the real exchange rate in Table 1. Similar studies for other industrial countries report half-lives of three to five years, see Rogoff (1996). The Norwegian real exchange rate's rapid adjustment speed (low half-life), on the other hand, is comparable with that found in studies for developing countries: one to two years, see Cheung and Lai (2000).

Table 1: Tests of PPP, speed of adjustment and contribution to adjustment

I. A time series model of the effective real exchange rate

$$\Delta\widehat{R}_t = \underset{(3.673)}{0.161} - \underset{(-3.681)}{0.167}\, R_{t-1} + \underset{(2.133)}{0.212}\, \Delta R_{t-1} + \underset{(1.491)}{0.156}\, \Delta R_{t-3} + \underset{(1.417)}{0.156}\, \Delta R_{t-5} + \underset{(1.845)}{0.202}\, \Delta R_{t-7}$$

$t-ADF = -3.681$, DF-critical values: 5 % $= -2.887$, 1 % $= -3.489$

Sample period: 1972:2–1997:4; Method: OLS

II. Adjustment towards equilibrium rate under different exch. rate regimes

Regime:	Stable and floating	Stable	Floating
Period:	1972:2–2001:4	1972:2–1992:4	1993:1–2001:4
$\Delta\widehat{R}_t$:	-0.118	-0.214	-0.398
	(0.037)	(0.052)	(0.132)
$t-ADF$	-3.16	-4.16	-3.01
Half-life	5.5 quarters	3 quarters	1.4 quarter

III. Contrib. from nominal exch. rate and price level to stabilise the real exch. rate

$$\Delta\widehat{e}_t = \underset{(0.042)}{-0.161}[e-(cpi-cpi^f)]_{t-1} + \text{short-run effects}$$

$$\Delta\widehat{cpi}_t = \underset{(0.018)}{0.032}\,[e-(cpi-cpi^f)]_{t-1} + \text{short-run effects}$$

Sample period: 1972:2–1997:4; Estimation method: FIML

IV. Contrib. from nominal exch. rate and domestic prices under different regimes

Regime:	Stable and floating	Stable	Floating
Period:	1972:2–2001:4	1972:2–1992:4	1993:1–2001:4
$\Delta\widehat{e}_t$:	-0.139	-0.149	-0.287
	(0.037)	(0.045)	(0.131)
$\Delta\widehat{cpi}_t$:	0.028	0.033	0.056
	(0.016)	(0.020)	(0.031)

Note: The results in panel II were achieved by re-estimating the time series model in panel I with data for different periods. We only report coefficient estimates (and associated t-values) for the coefficient for R_{t-1}. The half-life is calculated by using the standard formula: $ln(1/2)/ln(1-\alpha)$, where α denotes the estimated absolute value of the coefficient of R_{t-1}. The division between stable and floating regimes is approximate. Panel III reports the results from a simultaneous model of relative changes in the nominal exchange rate, inflation in Norway and in trading partner countries. The coefficient estimates in front of the terms that show differences between the logarithm of the nominal exchange rate and price ratio, indicate the degree of adjustment towards a constant real exchange rate through changes in the nominal exchange rate and domestic inflation, respectively. Due to lack of space, the short-run effects of the different variables on each other are not shown, nor is the equation for inflation in trading partner countries, see Akram (2002).

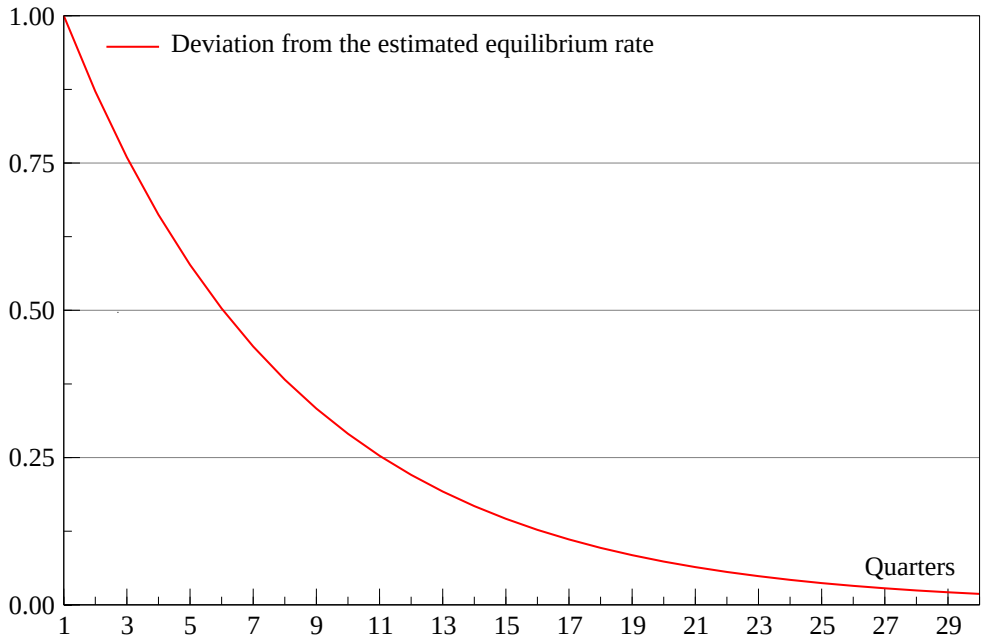

Figure 2: *Evolution of a deviation from the estimated equilibrium exchange rate, all else being equal. The shock that creates the deviation occurs in Q1.*

This type of analysis may, however, give an excessively optimistic impression of how rapidly the real exchange rate actually returns to the equilibrium level, as everything else is assumed to remain unchanged whilst the exchange rate adjusts towards the equilibrium level. Exchange rates are constantly exposed to shocks and this may contribute to deviations from the equilibrium level over longer periods of time than those implied by such partial analyses, cf. Figure 1.

The tendency of the Norwegian real exchange rate to converge more rapidly towards the equilibrium level than real exchange rates in many other industrial countries may be because the Norwegian economy is more open. Changes in the real exchange rate/competitiveness may therefore swiftly result in internal and external imbalances, which on the other hand may have a stronger and more rapid effect on the real exchange rate. While the averages for import and export comprise a share of less than 1/4 of GDP in a typical industrial country, the corresponding average value for Norway is less than 1/3, see Cheung and Lai (2000). This is also the case if one looks at Norwegian foreign trade in traditional goods and services relative to mainland-GDP, cf. Figure 8 in section 4.2. Furthermore, Norwegian export contains a relatively large share of commodities and semi-manufactures that face greater competition on the world market than finished goods, cf. the rapid adjustment speed for developing countries. The relative openness and composition of export may serve to strengthen the relationship between the real exchange rate,

foreign trade and the activity level more than can be expected in many other industrial countries. It is therefore no coincidence that considerations for competitiveness have played an important role in the formulation of Norwegian monetary and fiscal policies, particularly in the past thirty years. For example, in the period to mid-1986, the Norwegian krone was devalued on several occasions to offset a deterioration in competitiveness and reduce foreign trade deficits.

Another cause for the rapid adjustment towards equilibrium could be that wages and prices react more strongly to imbalances in the labour and product markets in Norway than in most other industrial countries. For example, Layard, Nickell and Jackman (1991, ch. 9) report that the wage and price response to imbalances in the labour and product markets in Norway is the second highest of 19 industrial countries. The high wage and price response may be due to centralised and coordinated wage bargaining, which contributes to internalising the overall costs of a strong real exchange rate, for example in the form of high unemployment. This in itself contributes to restraining wage demands and thereby to lower price inflation in the face of low competitiveness. In a system with centralised and coordinated wage bargaining it is also easier for the authorities to influence wage and price formation through incomes policies.

Empirical studies show that both the nominal exchange rate and domestic prices react when the real exchange rate deviates from the equilibrium level and contribute to its convergence towards the equilibrium level, see Table 1 and Akram (2002). The contribution from the nominal exchange rate, however, appears to be 4–5 times greater than the contribution from (wage and) price inflation. There is little to indicate that the contributions from the nominal exchange rate and prices have diminished in the past decade relative to their sizes in the 1970s and 1980s, rather to the contrary. The evidence in Table 1 indicates that the nominal exchange rate and prices reacted more sharply to deviations from the equilibrium level in the 1990s than previously. This may be ascribed to greater capital mobility and the abandonment of a fixed exchange rate policy, which contributed to rigidity in the nominal exchange rate. But the possibilities of convergence towards the equilibrium level being reversed also increase when the exchange rate is floating. Deviations from equilibrium may therefore persist over longer periods, despite a possibly stronger (partial) response of the nominal exchange rate to a misalignment.

3. The behavioural equilibrium exchange rate (BEER)

The PPP approach in the above section does not identify factors that have given rise to fluctuations in the Norwegian real exchange rate over time. Nor is it given that only trade costs and other conditions compatible with PPP can imply a stable equilibrium exchange rate. In this section, we seek to explain fluctuations in the real exchange rate and identify variables that may

determine the level of the equilibrium exchange rate in the medium and long term. We adopt the behavioural equilibrium exchange rate (BEER) approach that implies the following model for the real exchange rate, see MacDonald and Stein (1999) or Akram et al. (2003) for a derivation:

$$r = \alpha_0 + \beta z - (ir - ir^f) + \varepsilon \tag{2}$$

where r symbolises the logarithm of the real exchange rate (R); z represents a vector of macroeconomic variables and $ir - ir^f$ denotes the real interest rate differential between the home country and abroad. α_0 is a constant term, β represents the partial effects of z on the real exchange rate and ε is a stochastic residual that represents the effect of all variables that individually or collectively have short-run effects on the real exchange rate.

The equilibrium exchange rate in the "medium run" can be determined by the actual values of z, and the actual interest rate differential, if this has a tendency to be positive or negative over longer periods. More specifically, it can be equated to the "fitted values" of r over the sample period if one has an estimated version of the model (2). Hence, the equilibrium exchange rate in the medium term is also referred to as the "current" equilibrium exchange rate.

The long run behavioural equilibrium exchange rate (BEER, r^*) is implied by model (2), when βz is at its equilibrium level/path βz^* and $ir - ir^f = 0$, if we assume real interest rate parity in the long run:

$$r^* = \alpha_0 + \beta z^*. \tag{3}$$

It follows that BEER will be constant if βz^* is also a constant term. BEER can be equal to the PPP-level of the equilibrium exchange rate if βz^* is zero, cf. equation (1). This can occur if a linear combination of the variables in vector z^* that is defined by vector β becomes equal to zero, even though z^* and β individually are different from zero.

In the following, we first present an empirical variant of model (2) that is used to derive the equilibrium exchange rate in the medium and long term. When deriving this model, we specified the vector z in the light of previous empirical studies of real exchange rates based on the BEER approach. Commonly, vector z consists of indicators for the differences in productivity growth between the home country and abroad; terms of trade; differences in public debt and or government spending between the home country and abroad; and domestic net foreign assets, see MacDonald and Stein (1999) for an overview. [2]

[2] The BEER-approach is commonly adopted to explain the behaviour of real exchange rates when it displays long swings and persistent movements in one or the other direction, displaying weak if any signs of convergence towards a certain level, i.e. when there is not any or sufficient evidence in support of purchasing power parity. The behaviour of the explanatory variables that are included in z, therefore ususally display similar characteristics as the real exchange rate over time. However, it suffices that the behaviour of the linear combination of the variables in z, i.e. βz, is able to match that of the real exchange rate.

Second, we present a model that contains several variables that are important to the real exchange rate in the short run. We also demonstrate that continuous demand impulses in the form of e.g. growth in public spending over several years, can contribute to relatively long-term deviations from the real exchange rate, despite a strong partial equilibrium correcting response of the real exchange rate to deviations from its equilibrium rate.

The empirical results in the following sections are based on quarterly data for the period 1972:1–2001:4 and the models that are presented are estimated by the OLS method.

3.1. Equilibrium exchange rate in the medium run

Actual movements in the real exchange rate can be broadly explained with the help of the following static empirical model, cf. (2):

$$\begin{aligned} r &= 0.09 - \underset{(-8.52)}{0.23}[(p_s - p_c) - (p_s - p_c)^f] - \underset{(-2.05)}{0.012}\, roilp - \underset{(-2.78)}{0.19}\, I.Y \\ &\quad - \underset{(-8.98)}{1.05}\,(i - i^f). \end{aligned} \tag{4}$$

The model suggests that the real exchange rate is determined by the difference between relative prices for sheltered (s) goods and services and those exposed to international competition (c) in Norway and trading partner countries ($(p_s - p_c) - (p_s - p_c)^f$), the real oil price in USD (*roilp*) and investment-GDP ratio ($I.Y$). The nominal interest rate differential between Norway and its trading partners is also included ($i - i^f$). All the variables in the equation are in logarithmic form, with the exception of the interest rate differential and the investment share ($I.Y$). A minus sign in front of a variable indicates that an increase in the variable's value has an appreciating effect on the real exchange rate; the figures in brackets show (standard) t-values.[3] The explanatory variables in model (4), probably with the exception of the investment share, have also been used in previous studies of the Norwegian real exchange rate, see e.g. Chaudhury and Daniel (1998), Alexius (2001) and Bjørnland and Hungnes (2002).

The difference in relative prices for s and c-goods (and services) may reflect differences in productivity between the exposed and sheltered sectors ($q_c - q_s$). It is implied, for example by the Scandinavian model of inflation, that the ratio between prices for n and c-goods can be set equal to the ratio between productivity in the sheltered and exposed sectors, i.e. $p_s - p_c = q_c - q_s$, see Aukrust (1977). Accordingly, an increase in the productivity differential results in higher prices for s-goods relative to c-goods. This is because wage growth in the sheltered sector, which is determined by productivity growth in the exposed sector for a given rate of

[3] Use of standard *t*-values presuppose that variables are stationary, which we are not confident about. Formal tests, however, do not suggest that the empirical model represents a spurious relationship between the real exchange rate and the right hand side variables, cf. equation (5).

imported inflation, rises relative to productivity growth in the sheltered sector. An increase in the productivity differential between the exposed and sheltered sectors therefore contributes to higher inflation and a real appreciation. A corresponding increase in the productivity differential between the exposed and sheltered sectors in trading partner countries contributes to higher foreign inflation and a real depreciation. The extent to which the real exchange rate appreciates or depreciates will therefore depend on the relative productivity differential between the exposed and sheltered sectors in Norway and abroad, here represented by the relative price differential between n and c-goods.[4]

The relative price differential between n and c-goods can also capture the effects of different demand impulses in Norway and abroad as a result of, for example, differences in fiscal policies. Public expenditures are largely directed towards the production of sheltered goods and services. An increase in public spending may therefore result in higher price inflation in the sheltered sector than in the exposed sector, thereby pushing up inflation and contributing to a real appreciation. Similarly, growth in public spending abroad may have a depreciating effect on the real exchange rate. The effect on the real exchange rate will thus be determined by the difference in growth of public spending between Norway and abroad. We found no direct effect of public spending when deriving the empirical model (4), though. This does not, however, preclude effects of public spending through the relative price differential.

We use the real oil price to represent the terms of trade between Norway and other countries. An improvement in the terms of trade (increase in the oil price) contributes positively to the trade surplus vis-à-vis other countries and raises the value of the petroleum wealth in the seabed. This increases net foreign assets, which provides the basis for capital revenues from other countries. This in turn gives rise to a real appreciation as a larger trade deficit can be financed by revenues from abroad, see section 4 for a more detailed discussion. Moreover, the actual trade surplus may raise demand for Norwegian krone, which may engender a nominal and thereby real appreciation. However, in statistical terms, it is doubtful whether the real oil price affects the real exchange rate in the long run, as the *t*-value is relatively low (in absolute terms). It should also be mentioned that we found no significant effects of alternative indicators for the terms of trade between Norway and other countries, for example, the ratio between export and import prices.

The investment share correlates, among other things, with the saving share and the economy's growth potential. A part of saving takes the form of an increase in net foreign assets. This provides the basis for higher capital revenues from abroad and thereby for a larger trade deficit, which entails a stronger real exchange rate. An increase in the investment share as a result of

[4] It is not obvious whether this effect, which is known as the Balassa-Samuelson effect, should be considered as short run or long run in this context, see Balassa (1964) and Samuelson (1964). One may argue that cross-country productivity differentials between sectors may not persist between countries that have a fairly similar economic structure and are at comparable levels of income, e.g. Norway and its main trading partners.

higher saving can therefore coincide with a real appreciation. Expectations of higher income in the future as a result of a higher investment share may also justify a larger trade deficit and an immediate real appreciation. The reason for this is that economic growth increases opportunities for a trade surplus and higher net foreign assets in the future.

Our use of the nominal interest rate differential, instead of the real interest rate differential, also begs an explanation. The nominal interest rate differential, here defined as the differential between six-year bond yields in Norway and trading partners countries, just turned out to have a far greater explanatory power than the corresponding real interest rate differential. The latter was defined by adjusting the nominal interest rate differential for differences in consumer price inflation. This may be because changes in real exchange rates in the short run are largely due to movements in the nominal exchange rate that are influenced quite considerably by nominal interest rate differentials, see Mark (1990). Note also that the coefficient estimates of 1.05 can be considered as 1, both numerically and statistically, see equation 2.

Figure 3 shows that the actual exchange rate has fluctuated around the medium-term or current equilibrium exchange rate. There is no sign of a persistent over or under valuation of the actual real exchange rate relative to the equilibrium exchange rate in the period 1972:1–2001:4. This is more apparent in Figure 4, which shows misalignment (over- or undervaluation) in relation to the medium-term equilibrium exchange rate at different points in time.

We note that over and under valuation (measured as a negative or positive deviation) is not persistent, but has a tendency to be (partially) corrected in the following period. Equation (5) shows that around 1/4 of a given deviation is (normally) eliminated in the following period. In the absence of more shocks, the deviation will be more or less eliminated in the course of two years. The equilibrium level in the medium term can therefore be reached within two years, given that there are no new shocks.

$$\Delta(R-\widehat{R})_t = \underset{(-4.72)}{-0.30}\,(R-\widehat{R})_{t-1} \tag{5}$$

The fact that deviations are not persistent indicates that they are caused by factors that have temporary effects on the real exchange rate.

3.2. Equilibrium exchange rate in the long run (BEER)

The long-run equilibrium exchange rate (BEER) can be estimated by making assumptions about the values of the right-hand variables in model (4) in the state of internal and external balance. Internal balance is characterised by equilibrium in the product and labour markets at home and abroad. When this is the case, domestic and foreign inflation will also be at a stable rate, which

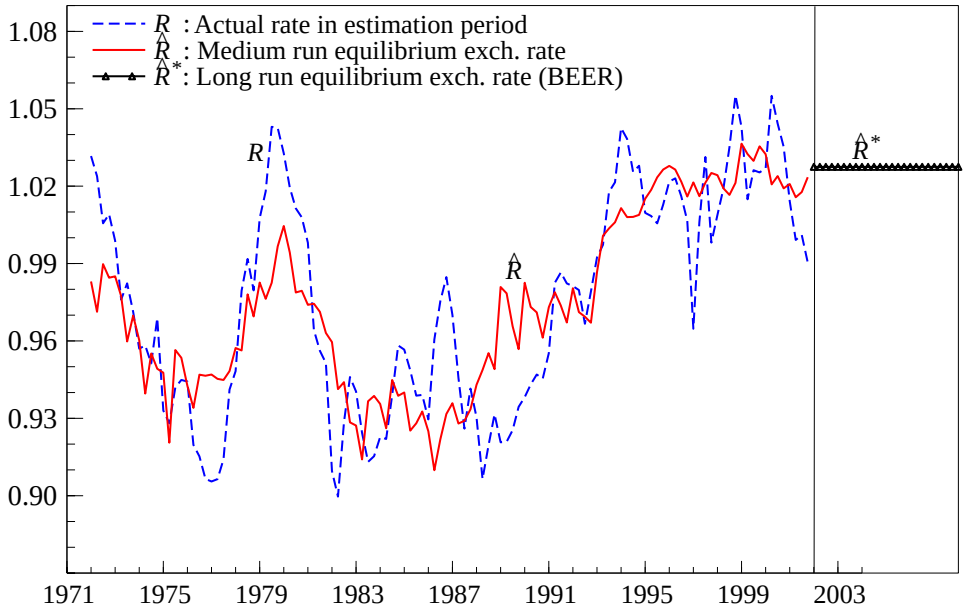

Figure 3: *Actual values of the real exchange rate (R) and estimates of the medium-term equilibrium exchange rate in the period 1972:1–2001:4. Estimates are based on model (3) for actual values of explanatory variables over the same period. The figure also shows estimates for the long-term equilibrium exchange rate, conditional on our assumptions about the equilibrium values/paths of the explanatory variables.*

can be assumed to be equal to the inflation targets at home and abroad. External balance is characterised by stable net foreign assets. That is when the current account surplus is equal to zero and (physical) investment is equal to total saving. Real interest rate parity implies that the real interest rate differential between the home country and other countries is equal to zero in the long run, so that the nominal interest rate differential reflects the difference in inflation targets between the home country and abroad.

We have specified the state of internal and external balance as follows. The nominal interest rate differential is set at 0.5 percentage point, which corresponds to an assumed difference in the inflation target between Norway and (several of) its trading partners. The investment share $I.Y$ is assumed to be equal to 0.24, which is the historical average value for the period 1966–2001. This level is also equal to the saving share in this period. The relative price differential between the n and c-sectors is assumed to be constant and equal to the value at end-2001:–0.086. The real oil price is assumed to equal 17 dollars, as assumed in the National Budget for 2003.

The equilibrium exchange rate (BEER) was estimated at 1.03 for the assumed equilibrium values

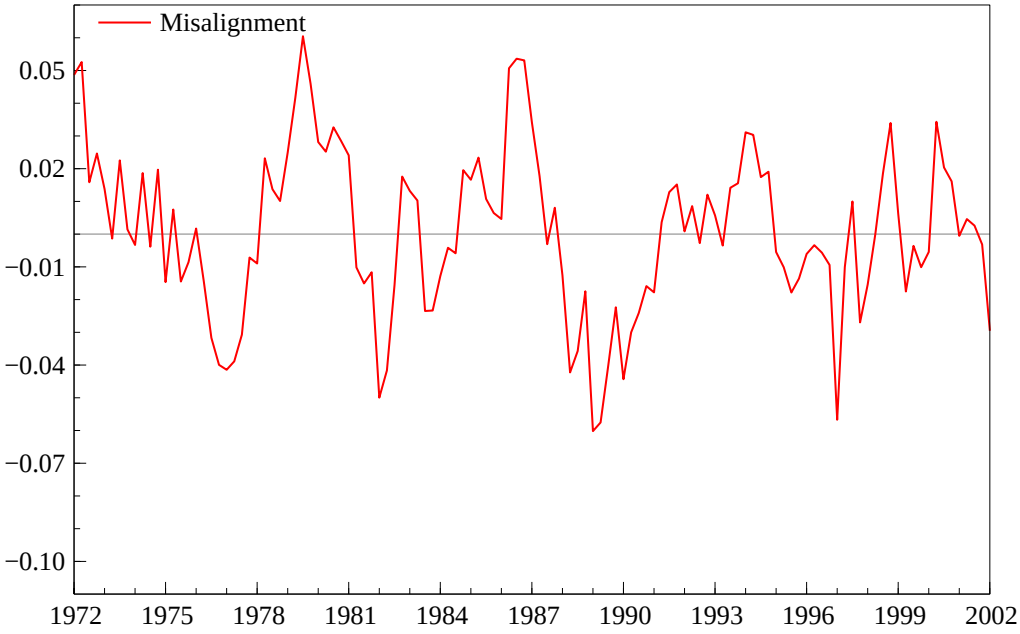

Figure 4: *Deviations (misalignment) from medium-term equilibrium exchange rate in the period 1972:1–2001:4. Deviations are the difference between actual values of the real exchange rate and estimates of the medium-term equilibrium exchange rate in Figure 3.*

of explanatory variables. Reasonable changes in the assumptions regarding the values of the right-hand side variables in the state with internal and external balance did not lead to any substantial changes in the estimate for the equilibrium exchange rate. The lower and upper limits for a 95 per cent confidence interval were estimated at 0.97 and 1.08, respectively. [5]

The lower limit of the confidence interval for the estimate for BEER is close to the PPP estimate of the equilibrium exchange rate (0.975), see Figure 1. The difference between the PPP and BEER estimates can be ascribed to the fact that the PPP estimate is equal to the average value of the real exchange rate in the period 1971:1– 2001:4, whereas the BEER estimate is based on values other than the average values of explanatory variables in the period 1971:1–2001:4. The estimated value of BEER becomes equal to the PPP estimate for the equilibrium exchange rate, if we use average values for explanatory variables as estimates for their equilibrium values. [6]

[5] Such confidence intervals may underestimate the uncertainty associated with the estimate of the equilibrium exchange rate, given that one assumes that the model is correctly specified and the true parameter values are equal to their estimates.

[6] This applies generally, as the average of the actual values of the left hand side variable is generally equal to estimated values of the left-hand side variable. For example, OLS implies that $1/T\sum_{t=1}^{T}(r_t - \widehat{r}_t) = 0$, where $\widehat{\ }$ symbolises an estimated value and T denotes number of observations. Then it follows that: $1/T\sum_{t=1}^{T} r_t = 1/T\sum_{t=1}^{T}\widehat{r}_t = \widehat{\alpha_0} + \widehat{\beta}(1/T\sum_{t=1}^{T} z_t) - 1/T\sum_{t=1}^{T}(ir_t - ir_t^f)$.

3.3. The short run

Even though actual movements in the real exchange rate can be broadly explained with the help of model (4), there is still a considerable part of the variation that is left unexplained. However, it seems that the unexplained part is caused by variables that only have short-run effects on the real exchange rate, see equation (5). A number of these affect the real exchange rate regularly, whereas others only have sporadic effects. Equation (6) shows the variables that regularly influence the real exchange rate. In the equation, we have decomposed a change in the real exchange rate into partial contributions of a number of explanatory variables in explaining a change in the real exchange rate.

$$\begin{aligned}\Delta r_t = &\underset{(-2.08)}{-0.004} - \underset{(-3.07)}{1.63}\,\Delta\left(\frac{ir - ir^f}{4}\right)_t - \underset{(-2.27)}{0.05}\,\Delta(q_c - q_s)_{t-1} + \underset{(1.62)}{0.34}\,\Delta y^f_{t-1} \\ &- \underset{(-2.91)}{0.12}\,\Delta_4(g-y)_t - \underset{(-3.83)}{0.10}\,\Delta oilp_t \times F(14) + \underset{(4.15)}{0.31}\,\Delta r_{t-1} \\ &- \underset{(-4.94)}{0.23}\,[r - (r^e - (i - i^f))]_{t-1} - \underset{(-3.86)}{0.04}\,cid97q1 + \widehat{\varepsilon}. \end{aligned} \tag{6}$$

A change in the real exchange rate may be ascribed to changes in the real exchange rate differential ($\Delta(\frac{ir-ir^f}{4})_t)$), the productivity differential between the sheltered and exposed sectors ($\Delta(q_c - q_s)$), economic growth in trading partner countries (Δy^f_t), annual growth in public spending relative to GDP ($\Delta_4(g-y)$) and changes in the real oil price when the nominal oil price is at a relatively low level (under 14/15 dollars), see Akram (2000b) for details. A part of the change in the real exchange rate can also be ascribed to adjustments for deviations from the equilibrium level in the preceding period, see equation (5). It also appears that a real appreciation/depreciation in one period contributes to a continued real appreciation/depreciation in the following period. This may be due to lags in the behaviour of participants in the foreign exchange market, so that the exchange rate does not change at the same pace as changes in macroeconomic variables, or due to persistence in price inflation as a result of unsynchronised and gradual price adjustments on different goods at home and abroad, or due to other factors that have a systematic effect on the exchange rate, but that are not included explicitly in the model. $\widehat{\varepsilon}_t$ represents unidentified factors that combined appear to have transitory effects on the real exchange rate. The variable $cid97q1$, which is 1 in 1997:1 and – 1 1997:2, represents factors underlying the relatively sharp nominal and real appreciation in 1996/1997 and subsequent depreciation. The other variables in the model could not fully explain these sharp movements in the real exchange rate.

In this model we have included explicitly productivity growth in Norwegian manufacturing industry and private services production as indicators for productivity growth in the exposed and sheltered sectors. The growth rate for foreign GDP Δy^f_t can be interpreted as an indicator

for trading partners' productivity growth. Growth in public spending relative to growth in GDP is also explicitly included. It follows that an increase in public spending can contribute directly to a real appreciation in the short run, in addition to the possibly indirect effect via an increase in prices for s-goods. It has also been possible to establish a relationship between changes in the real exchange rate and the real interest rate differential (instead of the nominal interest rate differential) in the short term. Annual interest rates are quarterlised by dividing them by four, for simplicity.

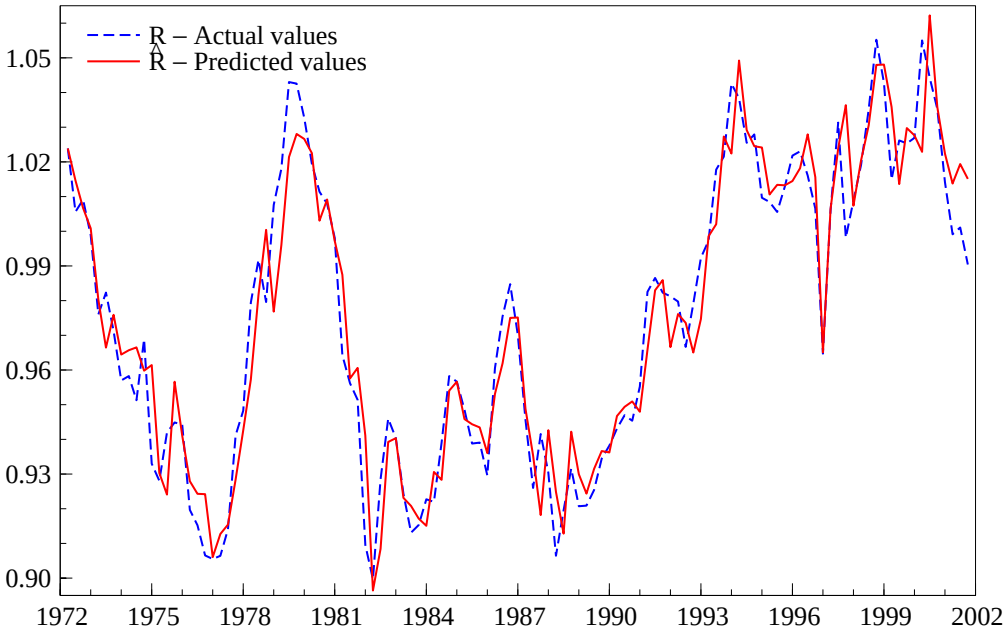

Figure 5: *The dynamic model's explanatory capacity over the estimation period 1972:3–2001:4. The predicted values are represented by the continuous curve.*

Figure 5 shows that the model's explanatory power is relatively good over the estimation period. The figure displays actual movements in the real exchange rate, the predictions from model (6) at historical values of the explanatory variables. We note that the model does not lead to systematic over or under prediction of the actual values.

Statistical tests suggest that the dynamic model gives a quite satisfactory description of actual movements in the real exchange rate, see Table 2.

The dynamic model can be used to study deviations from equilibrium as a result of continual changes in the different explanatory variables. As an illustration, we look at the (direct) effect on the real exchange rate of growth in public spending over the next thirty years. We assume

Table 2: Statistical evaluation of the dynamic model of the real exchange rate

Properties	
R^2	0.46
$\widehat{\sigma}$	1.2 %
RESET $F(1,\ 108)$	0.03 [0.87]
ARCH 4: $F_{arch,1-4}(4,\ 101)$	0.17 [0.95]
AR 1-5: $F_{ar,1-5}(5,\ 104)$	0.67 [0.65]
Normality: $\chi^2_{nd}(2)$	3.83 [0.15]
Heterosc.: $F_{\mathrm{Xi}^2}(16,\ 92)$	0.65 [0.83]
Heterosc.: $F_{\mathrm{XiXj}},(37,\ 71)$	0.79 [0.78]

Note: See Doornik and Hendry (2001) and references therein for a more detailed description of the different tests.

that public spending relative to GDP grows at the same rate as the structural budget deficit in relation to mainland GDP, see National Budget for 2003. Growth in public spending relative to GDP is specified in Figure 6. As we assume that the budget deficit in its entirety is due to the growth in public spending, public spending as a share of GDP increases by around 6 per cent over the course of the next thirty years.

Figure 7 shows the partial effect on the real exchange rate of the growth in public spending outlined above. It appears that the immediate real appreciation is 0.3 per cent and that after four years, the real appreciation is 0.4 per cent. The real appreciation then slows gradually to zero in the long run.

This may be less than the total effect of growth in public spending. In order to calculate the total effect of growth in public spending, the indirect effect of the growth through e.g. higher prices on s-goods relative to c-goods must also be taken into account.

4. The fundamental equilibrium exch. rate (FEER)

An equilibrium exchange rate that is consistent with internal and external balance can also be derived with the help of a simple model of export and import of traditional goods and services. The implied equilibrium exchange rate can be termed FEER in this case, see e.g. Akram et al. (2003) for a discussion of the FEER approach. The model presented in section 4.1 takes into account the fact that positive net foreign assets generate revenues that can finance a part of import expenditures. It appears that FEER generally is a variable equilibrium exchange rate, but that it can be constant or converge towards a constant level in the long run under some not unreasonable conditions, cf. PPP and BEER approaches. The underlying assumption and empirical results are presented in section 4.2. In this section, we particularly investigate whether

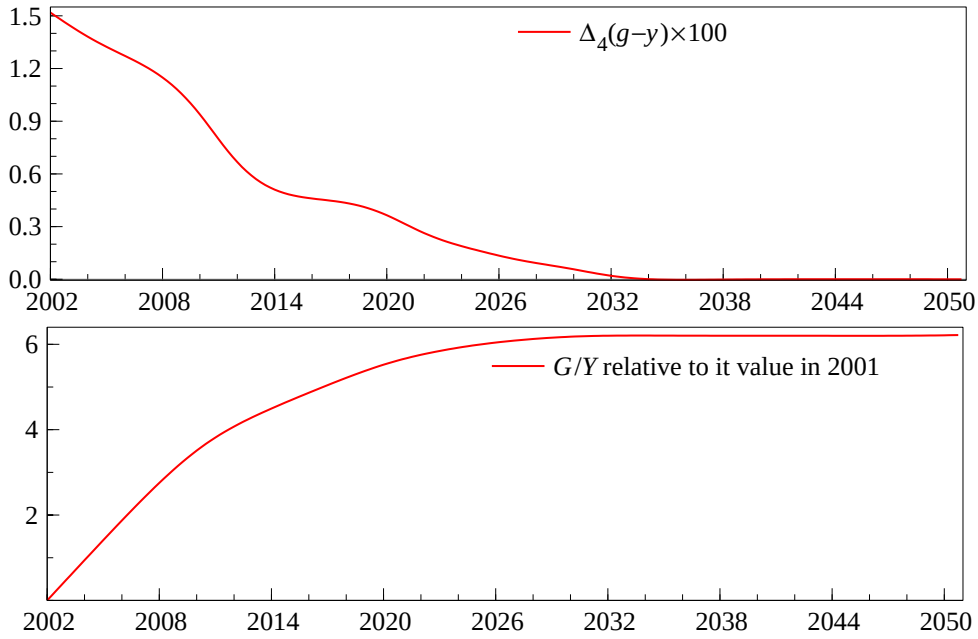

Figure 6: *Changes in public expenditure (public consumption and gross public investment) relative to GDP in the period 2002:1–2050:4. Top: annual growth in public expenditure relative to GDP. Bottom: public expenditure as a share of GDP, measured in relation to the level in 2001.*

Norway's relatively large petroleum wealth justifies a permanently strong real exchange rate.

4.1. Theoretical derivation

Let us assume that the import volume (B) measured in terms of domestic product units increases with the income level in the home country (Y) and the strength of the real exchange rate (R; low values of R indicate a strong real exchange rate). Such an import function can be expressed by equation (7):

$$B = Y^{\beta_1} R^{-\alpha_1}, \tag{7}$$

where the Greek letters are constant parameters with positive values. β_1 represents the income elasticity of import and $-\alpha_1$ denotes the price elasticity of import, i.e. sensitivity to changes in the real exchange rate.

Similarly, the home country's export volume (A) in terms of domestic product units is assumed to increase with the income level abroad Y_f but fall with the strength of the real exchange rate,

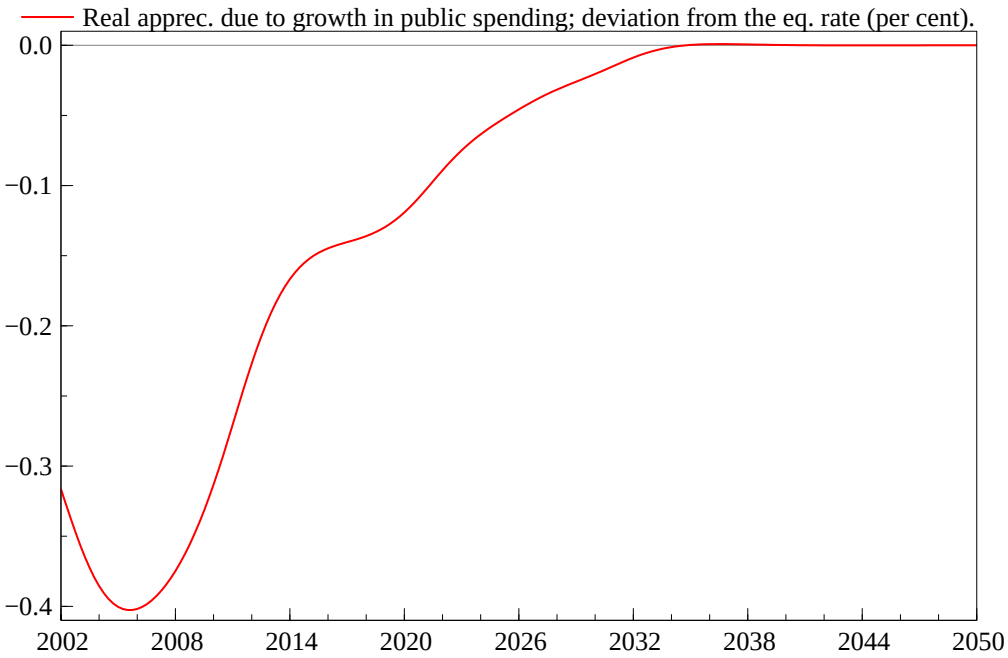

Figure 7: *Real appreciation in per cent as a result of growth in public expenditure, as specified in Chart 6. Real appreciation: percentage difference in relation to equilibrium exchange rate.*

as expressed by the export function (8):

$$A = Y_f^{\beta_2} R^{\alpha_2}. \tag{8}$$

Here, β_2 and α_2 denote the income elasticity and price elasticity of export, respectively.

The trade deficit (TD) can then be expressed as a function of domestic and foreign income and the real exchange rate. By inserting the import and export functions in the definition of the trade deficit, we get:

$$TD \equiv B - A = Y^{\beta_1} R^{-\alpha_1} - Y_f^{\beta_2} R^{\alpha_2}. \tag{9}$$

The import and export functions entails that the trade deficit increases with the domestic income level, but falls when the real exchange rate weakens and income level abroad rises.

Equation (9) implies a unique negative relationship between the trade deficit and the real exchange rate for given values of domestic and foreign income. It can therefore be used to find the real exchange rate that is compatible with a given level of the trade deficit (for given values of domestic and foreign income).

This possibility can be expressed more explicitly by inverting equation (9) and solving it with respect to R:

$$R = \left[\frac{Y^{\beta_1}}{Y_f^{\beta_2}} \left(1 - \frac{TD}{B} \right) \right]^{1/(\alpha_1 + \alpha_2)} . \tag{10}$$

This relationship indicates that the real exchange rate must depreciate when domestic income rises in order to offset the increase in the trade deficit caused by higher import, see equations (9) and (7). Similarly, the real exchange rate must appreciate when foreign income increases, so that the trade deficit does not fall as a result of higher export, see equations (9) and (8). The net effect on the real exchange rate will depend on the evolution of income-determined import demand Y^{β_1} relative to income-determined export demand $Y_f^{\beta_2}$, i.e. the evolution of $Y^{\beta_1}/Y_f^{\beta_2}$. This ratio can be interpreted as the income-determined trade deficit. The term for the real exchange rate also implies that the real exchange rate is stronger in the case of trade deficit ($TD > 0$), than in the case of trade balance ($TD = 0$), or trade surplus ($TD < 0$).

The fundamental equilibrium exchange rate (FEER) can be defined as the real exchange rate level that results when there is internal and external balance, i.e. trade deficit and domestic and foreign income levels are at their equilibrium levels, PI, $\overline{Y}$ and $\overline{Y}_f$ respectively. In other words,

$$FEER = \left[\frac{\overline{Y}^{\beta_1}}{\overline{Y}_f^{\beta_2}} \left(1 - \frac{PI}{B} \right) \right]^{1/(\alpha_1 + \alpha_2)} . \tag{11}$$

$\overline{Y}$ and $\overline{Y}_f$ can be assumed to be equal to potential GDP in the home country and abroad, while the trade deficit can be said to be at its equilibrium level (PI) when it can be financed without accumulating foreign assets or debt (external balance). This would be the case if the trade deficit is financed by the return on net foreign assets, i.e. if PI equals the permanent income from net foreign assets. External balance requires that the trade deficit is equal to zero ($TD = 0$) if there is no income from net foreign assets, i.e. PI = 0. Import expenditures then would have to be covered solely by export income.

It is worth noting that it is not the level of permanent income from net foreign assets (PI) itself that is of importance to the real exchange rate, but the share of import that can be financed by the permanent income. When there is external balance, PI/B (which is equal to $(B-A)/B$) can be interpreted as the share of import that is financed by the permanent income, whereas $(1-PI/B)$ can be seen as the share of import that is financed by export. The greater PI/B is, the stronger the equilibrium exchange rate can be, see equation (11).

4.1.1. Is FEER a variable or constant equilibrium exchange rate?

FEER is generally a variable equilibrium exchange rate. This is because the income-determined trade deficit $\overline{Y}^{\beta_1}/\overline{Y}_f^{\beta_2}$ can change over time if trend growth in the home country and abroad differ, or import's income elasticity differs from export's income elasticity. Moreover, the permanent income (PI), and thereby also the sustainable level of the trade deficit, can be revised as a result of changes in net foreign assets or the rate of return on such. In addition, import and export can become more sensitive to changes in the real exchange rate, for example, as a result of increased globalisation. In this case, α_1 and α_2 can increase and thus influence the equilibrium exchange rate.

FEER can also weaken over time even though $\overline{Y}^{\beta_1}/\overline{Y}_f^{\beta_2}$ and PI remain unchanged. This is because import demand will increase over time as a result of economic growth at home. The import share that can be financed by permanent income (PI/B) will thus diminish steadily. In order to keep the trade deficit equal to permanent income, the real exchange rate has to depreciate steadily to slow import and boost export.

FEER can, however, be constant in the long run if $\overline{Y}^{\beta_1}/\overline{Y}_f^{\beta_2}$ remains unchanged over time. This is because PI/B may become insignificant in the long run, i.e. $PI/B \longrightarrow 0$, if import demand continues to grow. The bulk of import will then have to be financed by export. This could happen even if permanent income is revised upwards over time, as long as import increases at a higher rate than the permanent income. Thus the FEER level for $PI > 0$ will converge towards the FEER for PI = 0, which balances trade with other countries. It could also be said that in the long run, FEER is not dependent on the level of permanent income and hence on a given stock of net foreign assets. In summary:

$$FEER \longrightarrow \left[\frac{\overline{Y}^{\beta_1}}{\overline{Y}_f^{\beta_2}}\right]^{1/(\alpha_1+\alpha_2)} \quad \text{as } \frac{PI}{B} \longrightarrow 0 \text{ if } \Delta\overline{y}_t > 0.$$

This also implies that changes in permanent income are of more importance to FEER in the short run (when B is small) than in the long run (when B is large). The equilibrium exchange rate that balances foreign trade will depend positively on the equilibrium income-determined trade deficit: $\overline{Y}^{\beta_1}/\overline{Y_f}^{\beta_2}$. The higher the import level is relative to the export level, the weaker the equilibrium exchange rate will have to be in order to achieve trade balance.

FEER will equal 1, as in the theory of absolute purchasing power parity, if import and/or export are extremely sensitive to changes in the real exchange rate:

$$FEER \longrightarrow 1 \text{ if } (\alpha_1+\alpha_2) \longrightarrow \infty.$$

In such cases, the equilibrium exchange rate will neither depend on permanent income nor on income at home and abroad. This can be explained by the fact that an arbitrary trade deficit can be achieved and sustained with the help of minor changes in the real exchange rate when price elasticity is extreme. If, for example, the domestic income level becomes much higher than in other countries, the real exchange rate only needs to depreciate marginally in order to offset the income effect on import so that the trade deficit does not exceed *PI*.

4.2. FEER and foreign trade in equilibrium

This section presents paths for the equilibrium exchange rate, FEER, based on simulations to the year 2070. The simulations are based on empirical models of Norwegian import and export of traditional goods and services that have been derived for this purpose. The empirical models are documented and evaluated in more detail in Akram (2003). Here we will therefore just specify variables that have been used to derive these models, briefly discuss their behaviour over the sample period and present our estimates of key parameters. Internal and external balance is then specified and we derive the equilibrium exchange rate that is consistent with this specification. In addition, the equilibrium exchange rate that balances trade of traditional goods and services with other countries is also derived. A path for FEER depends on the permanent income from Norway's net foreign assets, which are assumed to only constitute Norway's petroleum wealth in the form of oil reserves in seabed and the Norwegian Petroleum Fund. In addition, paths for FEER depend on the economic growth rate at home and abroad. We illustrate this dependency by deriving several paths for FEER by changing our assumptions regarding the size of permanent income and the growth rate.

4.2.1. Assumptions

Import (B) and export (A) here mean the import and export of traditional goods and services measured in NOK billion at fixed 1999 prices. These are explained by the trade-weighted real exchange rate (R) that was defined above, mainland GDP (Y) and trading partners' GDP Y_f. We have used quarterly data for the period 1979:1–2001:4 to estimate dynamic econometric models of import and export in line with the functions (7) and (8). The time series of import, export and the trade deficit over the estimation period are presented in Figure 8 while that of the real exchange rate is presented in Figure 1.

Figure 8 suggests that the import and export volumes (of traditional goods and services) grew more or less continuously in the period 1979–2001. Measured as a share of mainland GDP, import and export have also generally expanded over time. However, import has grown at a swifter pace than export, thus increasing the trade deficit (TD) over time.

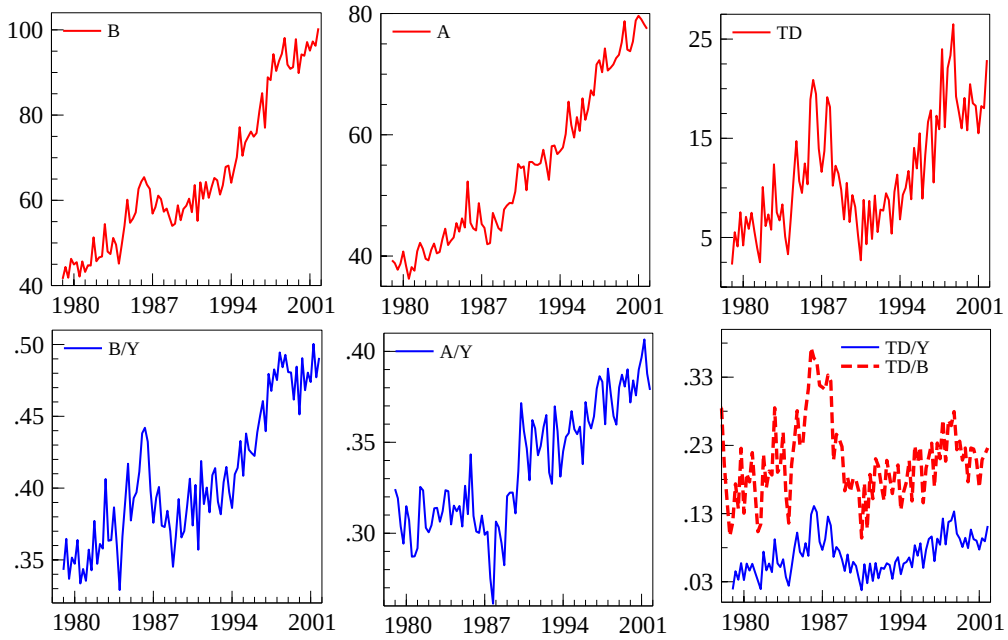

Figure 8: *Import (B) and export (A) of traditional goods and services in the period 1979:1–2001:4. Top row: quarterly data for import, export and the trade deficit (TD) measured in NOK billions at fixed 1999 prices. Bottom row: import, export and the trade deficit measured as a share of Norwegian mainland GDP (Y). The trade deficit is also measured as a share of import, TD/B. The time series of TD/B characterises the evolution over time of the import share that is not financed by (current) export.*

Table 3.A presents our estimates of the income and price elasticities, 1.5 and 0.7 (in absolute values), respectively, which are comparable with estimates from other Norwegian and international studies, see Hinkle and Montiel (1999, p. 355, 475, and 489), Goldstein and Khan (1985), Marquez (1990) and Clarida (1996) for an overview of estimates based on a large number of extensive studies. We also note that our estimates indicate symmetry in income and price elasticities: $\beta_1 = \beta_2$ and $\alpha_1 = \alpha_2$, which is supported by formal tests. It is also interesting to note that this property as well as both the size of income and price elasticities are the same as those presented in Houthakker and Magee (1969) for Norway, who used annual data from the period 1951–1966. This indicates that income and price elasticities of foreign trade have been fairly stable over time.

However, income elasticities that are greater than 1 imply increasing GDP shares for import and export over time, if the real exchange rate is constant or the price elasticities are sufficiently low. Such increases in GDP shares of import and export over time seem to be in line with actual developments in Norway, at least over the past 50 years, cf. Figure 8 and the results in Houthakker

and Magee (1969). One explanation could be that import and export both contain factor inputs in contrast to the income measures, mainland GDP in Norway and trading partners' GDP, which measure value added. Hence, an increasing GDP share does not necessarily imply that the GDP share of import adjusted for inputs will also increase. Beside this, when making simulations far into the future, we experienced that the variability of the (equilibrium) real exchange rate and the size of our estimates of price (and income) elasticities prevent GDP shares for import and export from becoming unreasonably large, at least in the short and medium term, i.e. over a time period of about forty years, see next section. Given that we are primarily interested in the near future, we found it unnecessary to adjust our estimates of the income and or price elasticities.

Table 3: Assumptions underlying the basic FEER path

A. Estimates of income and price elasticities				
Parameters:	β_1	β_2	α_2	α_2
Estimates:	1.5	1.5	0.7	0.7
Sample period:	1979:1–2001:4			

B. Equilibrium correction models of foreign trade

$$\Delta\widehat{b}_t = \underset{(-2.68)}{-1.14} - \underset{(-2.69)}{0.17}\,[b-(1.5y-0.7r)]_{t-1} + \text{short run effects}$$

$$\Delta\widehat{a}_t = \underset{(3.23)}{2.81} - \underset{(-3.22)}{0.25}\,[a-(1.5y_f+0.7r)]_{t-1} + \text{short run effects}$$

Estimation method: FIML

C. Internal and external balance

Trend growth: $\Delta_4\overline{y} = \Delta_4\overline{y}^f = 2$ %; 0.5 % per quarter

Trade deficit: $\overline{TD} = PI = 105$ Bill. NOK/year; 105/4 = 26.25 Bill. NOK/quarters

Note: Trend growth rates for Norway and abroad are approximately equal to the corresponding sample averages. The estimate of NOK 105 billion for permanent income is based on the National Budget for 2003. This is equivalent to 4 per cent of the current value of petroleum wealth (government's share), which is NOK 2616 billion, of which NOK 619 billion is the market value of the Government Petroleum Fund at start-2002. The remainder (NOK 2000 billion) is the current value of the estimated value of the government's share of cash flow from oil and gas production to 2070, when all resources are assumed to be depleted/depreciated. The discount rate and real rate of return are assumed to be equal to 4 per cent per annum.

Table 3.B presents a simplified version of our estimated model of import and export of traditional goods and services which is in log-linear form. We employ this model to derive paths for FEER conditional on different specifications of the state of internal and external balance. This model has fairly good explanatory power over the sample period, despite the fact that it is based on a limited information set determined by the theoretical framework outlined in the previous section. The model has also satisfactory statistical properties, which suggests that it is not obviously misspecified, see Akram (2003) for a comprehensive documentation.

Table 3.C specifies the assumptions regarding internal and external balance. Internal balance is characterised by mainland GDP in Norway and GDP in trading partner countries growing at a trend growth rate of 0.5 per cent per quarter (2 per cent per year). External balance is specified by equating the (quarterly) trade deficit to the permanent income from Norway's net foreign assets at each point in time. Net foreign assets have been set equal to the estimated current net value of total petroleum wealth, which consists of the current net value of the estimated petroleum resources in the seabed and the market value of the Norwegian Petroleum Fund at the end of 2001. The implied permanent income (PI) is estimated at NOK 105 billion per annum, see National Budget 2003. We have chosen to disregard other net foreign assets, as total net foreign assets for Norway have largely comprised petroleum wealth, particularly from the mid-1990s, see Akram (2003) for further details.

4.2.2. FEER and foreign trade in the period 2002–2070

Figure 9 shows paths of the equilibrium exchange rate when trade deficit is financed by the permanent income from petroleum wealth and if we had required trade balance in absence of revenues from petroleum wealth and other net foreign assets. Figure 10 shows movements in import, export and the trade deficit that are consistent with the equilibrium exchange rate, in the former case. The paths of these variables are not only interesting in themselves, but they also cast light on the mechanisms underlying the behaviour of the equilibrium exchange rate over time.

The equilibrium exchange rate conditional on the permanent income is relatively strong in the first few years, but then weakens over time. It moves from values of around 0.90 to 0.95 in the period 2002–2010, but is 1.10 by end–2070. Most of the depreciation occurs in the course of the first 35 years, as the rate of depreciation is greater in the short run than in the long run. Interestingly, the figure suggests that the actual exchange rate in 2002 was at the same level as the estimated equilibrium exchange rate for this period, see Figure 1.

The depreciation of the equilibrium exchange rate over time reflects an increase in the import level relative to permanent income due to economic growth. Figure 10.b shows that permanent income can finance 25 per cent of import in 2002, but that this share declines in line with growth in import and moves towards zero in the long run. After 2035, permanent income can only finance under 10 per cent of import demand. As a share of mainland GDP, permanent income amounts to 13 per cent in 2002 but falls to less than 7 per cent after 2035. Steadily higher export has to compensate for the diminishing importance of permanent income as a (possible) financing source for import in order to ensure external balance. This is brought about via a depreciation in the equilibrium exchange rate as shown in Figure 9.

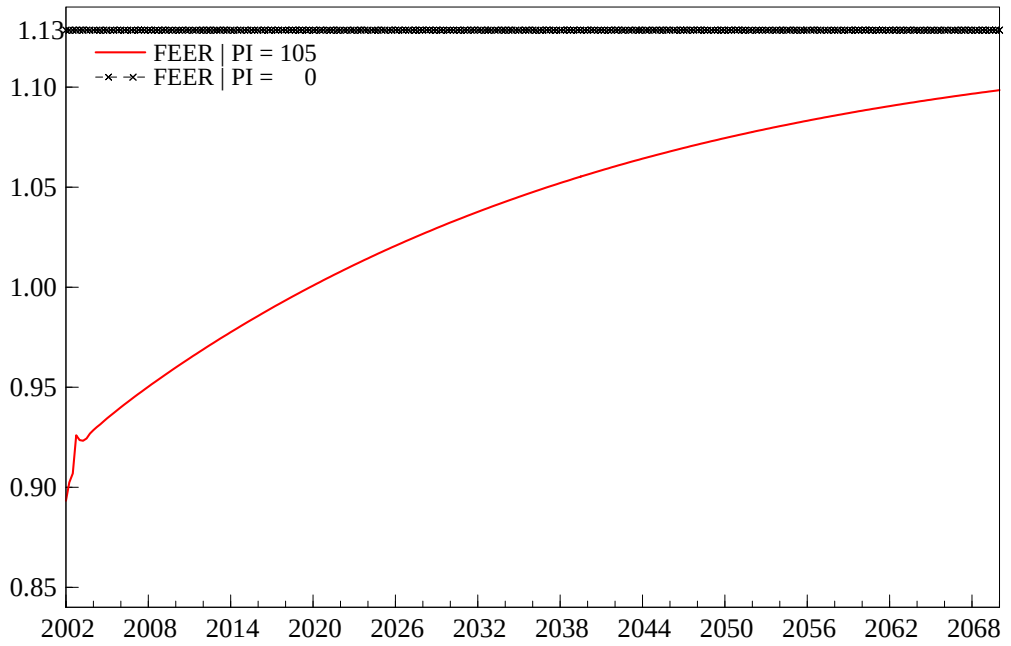

Figure 9: *Fundamental equilibrium exchange rate (FEER) in the period 2002:1– 2070:4. The continuous rising curve plots FEER when the trade deficit equals permanent income at NOK 105 billion, i.e. 26.25 (=105/4) billions per quarter. The straight curve represents FEER when external balance is defined as trade balance at each point in time, i.e. PI = 0.*

In the long run, the equilibrium exchange rate is more or less the same as the level that achieves trade balance where nearly all import is financed by export. Figure 9 shows that the equilibrium exchange rate for a permanent income level of NOK 105 billion per year converges toward the equilibrium exchange rate for trade balance, which is roughly 1.13.[7] This indicates that the Norwegian real exchange rate must depreciate considerably from the level at the start of 2002, for example, if import of traditional goods and services is to be financed solely by export of traditional goods and services.

Figure 10 also depicts the effects of changes in the equilibrium exchange rate on import and export. Figure 10.a shows the annual growth in import. Trend growth of 2 per cent per year contributes partially to import growth of 3 (= 1.5×2) per cent. The depreciation of the equilibrium exchange rate, however, implies that import growth remains under 3 per cent over the whole simulation period. Figure 10.c shows that export expands faster than import, which is a result of the depreciation in the equilibrium exchange rate. The growth differential is less than 1

[7]In general, the estimate of the equilibrium exchange rate depends on the level of the income-determined trade deficit. A number of simulations, however, suggested that reasonable changes in the income-determined trade deficit at the end of 2001, do not lead to numerically large deviations from 1,13, see Akram (2003).

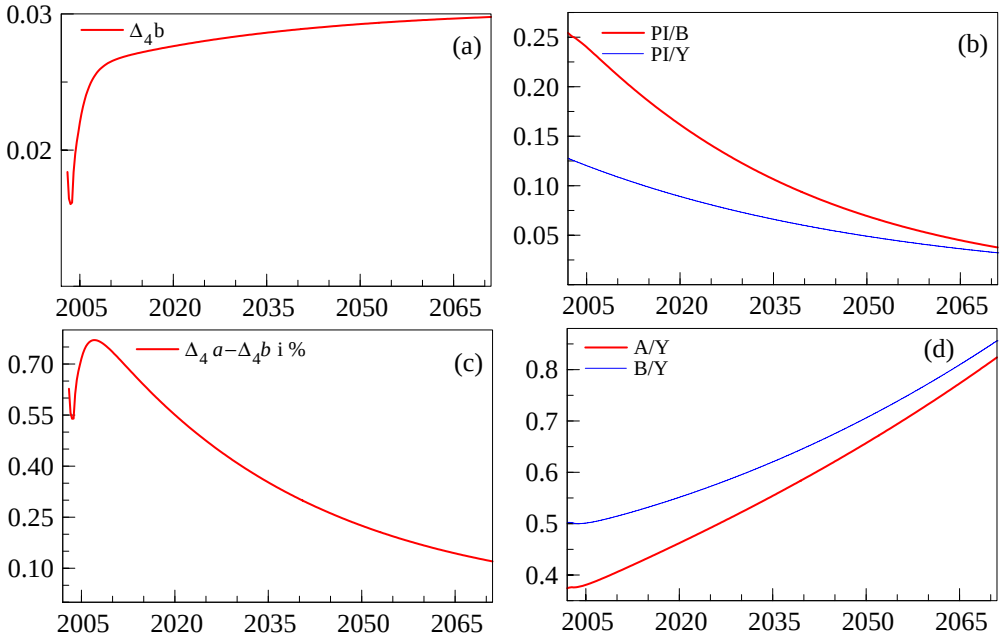

Figure 10: *Paths of import and export that are consistent with FEER|PI = 105 in the period 2002:1–2070:4. (a): annual growth in import $\Delta_4 b$; (b) import share financed by permanent income (PI/B) and trade deficit relative to mainland GDP (PI/Y); (c) percentage growth differential between import and export per year $\Delta_4 b - \Delta_4 a$ and (d) paths of import and export shares relative to mainland GDP, B/Y and A/Y, respectively.*

per cent per year over the whole simulation period and slows in line with the decline in the rate of depreciation. Equal trend growth in Norway and abroad means that export and import grow at same rate in the long term, when the rate of depreciation has become zero. Figure 10.d shows that export as a share of mainland GDP grows more rapidly than the corresponding import share. This means that the initial trade deficit of 13 per cent relative to mainland GDP, which is covered by permanent income, diminishes over time. We see that the export share converges towards the import share in the long run. These shares expand over time as a result of income elasticities that are greater than 1. Growth in the import share is, however, curbed by the depreciation in the equilibrium exchange rate, particularly at the start of the simulation period. This means that the import share only increases from 50 per cent to 55 per cent in the period 2002–2020 and in 2035 is still no higher than 60 per cent. The income effect has a full impact in the long run when the equilibrium exchange rate becomes constant.

4.2.3. Importance of petroleum revenues

Figure 11 shows alternative paths for FEER for the period 2002:1–2070:4. The paths are derived for a permanent income equal to NOK 120, 105 and 90 billion per year, based on oil prices of 20, 17 and 14 dollars, respectively, from 2005 to the end of 2070. It also shows the equilibrium exchange rate conditional on balanced trade, i.e. permanent income of zero. All paths are based on the assumption of annual trend growth of 2 per cent in Norway and abroad.

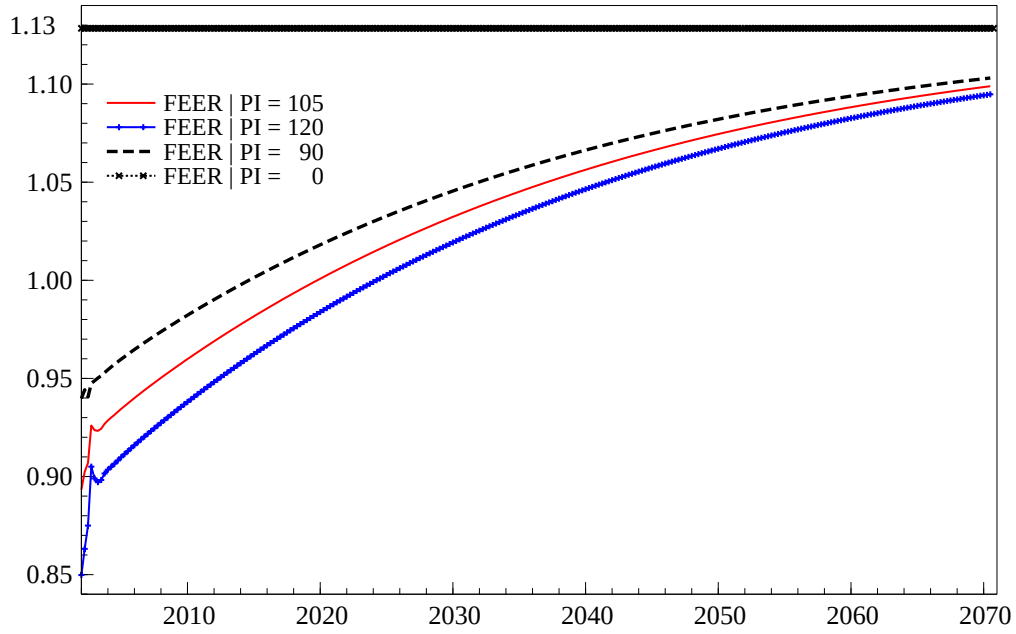

Figure 11: *FEER paths for different values of permanent income (PI), when trend growth in Norway and trading partner countries is assumed to equal 2 per cent per year. The continuous curve in the middle plots the path for FEER when PI equals 105 (NOK billion per year). The lower curve is FEER when PI = 120 and the upper curve is FEER when PI = 90. The straight curve at the top of the chart shows FEER when PI = 0, i.e. when trade balance is enforced.*

An increase in permanent income entails a stronger FEER than would otherwise have been the case over the whole simulation horizon. Higher permanent income is synonymous to a higher sustainable level for the trade deficit, so that FEER has to be stronger in order to bring the trade deficit to the sustainable level. All else being equal, the import share that can be financed with permanent income increases over the whole time horizon. We see that an increase of NOK 25 billion per in year in permanent income or NOK 6.25 billion per quarter serves to strengthen the equilibrium exchange rate immediately by around 5 per cent, from 0.89 to 0.85. A corresponding reduction in permanent income serves to weaken the equilibrium exchange rate by around the same amount, as FEER weakens from 0.89 to 0.94. This suggests an immediate appreciation

(depreciation) in the equilibrium exchange rate of 0.8 per cent per NOK billion increase (fall) in permanent income.

Changes in permanent income are of greater importance to FEER in the short run than in the long run, as the importance of permanent income diminishes over time due to growth in import demand. The figure shows that the difference between the various paths for FEER becomes increasingly smaller over time. Thus, in the long run, FEER does not depend on the level of permanent income. Figure 11 indicates that the different FEER paths converge towards the FEER level for permanent income equals zero. In the short and medium term, changes in the level of permanent income may, however, have a considerable effect on FEER.

4.2.4. Importance of economic growth

FEER is constant in the long run if trend growth in the home country and abroad is the same. This long-term level is not only independent of permanent income, but is also independent of the rate of trend growth. The speed with which FEER converges towards this level is, however, influenced by the growth rate as this determines how rapidly import expands relative to permanent income. Growth in import also depends on the income elasticity of import. The higher income growth and/or sensitivity to income is, the faster permanent income will become insignificant in relation to import demand and the faster FEER will fall in order to increase export and curb import growth, so that external balance can be maintained.

Figure 12 shows movements in FEER, conditional on four different trend growth rates that are assumed to be the same in Norway and abroad. This means that income-determined growth in import and export will be equal. Permanent income is assumed to be NOK 105 billion per year in all cases. The speed with which convergence towards long-term equilibrium occurs can be measured by calculating the half-life (H), which indicates how rapidly the difference between the initial value of FEER (here 0.89) and the long-term level of FEER (1.13) is halved, i.e. when the value of 1.01 is achieved. The half-life can be used as a measure of how swiftly Norway must balance its foreign trade without petroleum revenues.

The figure suggests a strongly negative relationship between the growth rate and the half-life. The half-life increase from 20 to 45 years if the growth rate becomes 1 per cent instead of 2 per cent per year. If the growth rate doubles from 2 to 4 per cent per year, the half-life becomes only 8 years. However, if the economy and import do not grow, a fixed import share can be financed indefinitely by permanent income. In this case, FEER remains at its 2002 level and the half-life is infinite. In other words, in order to achieve a permanent appreciation, we have to assume that import demand does not grow over time, so that the import share that is financed by petroleum revenues remains unchanged over time.

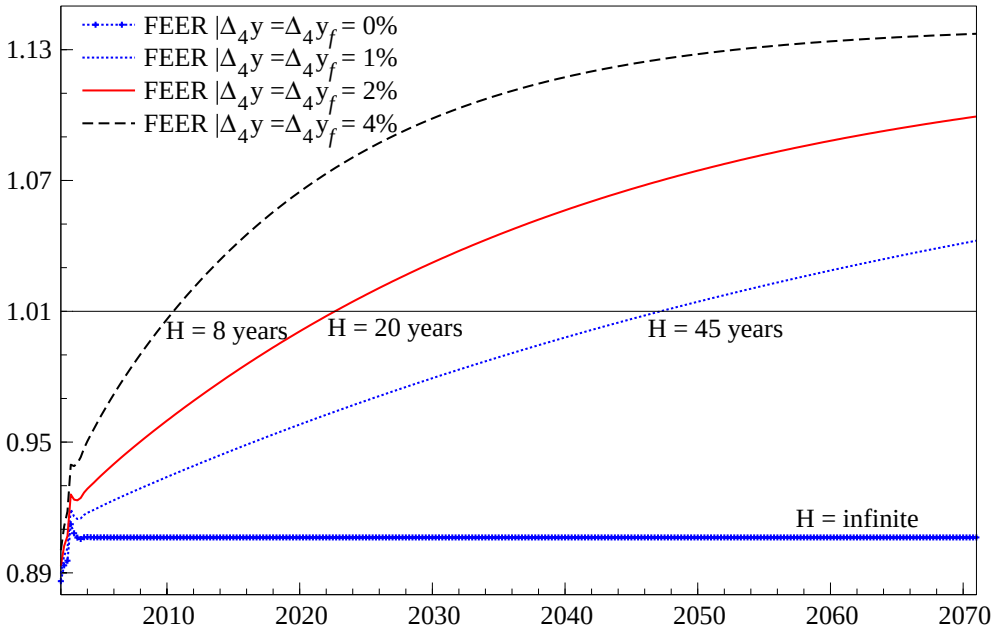

Figure 12: *FEER paths for different growth rates, when the trade deficit equals permanent income at NOK 105 billion per year. It is also assumed that trend growth in Norway and abroad is the same. H denotes the half-life, i.e. how rapidly FEER converges towards its long-term level, the level where the import share that can be financed by permanent income becomes insignificant.*

Changes in the income elasticity of import and export over time will have the same qualitative effect on the half-life as changes in growth rates. A decline in income elasticity will lengthen the half-life, whereas an increase will shorten the half-life, ceteris paribus.

5. Conclusions

We have used the PPP, BEER and FEER approaches to describe and explain movements in the Norwegian real exchange rate and to calculate its equilibrium value. A summary of our findings is given below.

Movements in the Norwegian real exchange rate comply well with predictions based on the theory of purchasing power parity (PPP). The real exchange rate has fluctuated around its estimated equilibrium level, which appears to have remained stable over time. The Norwegian real exchange rate has also shown a tendency to converge relatively rapidly towards the equilibrium

level. A given deviation from the equilibrium level is halved in the course of 5–6 quarters, all else being equal. Deviations from equilibrium are eliminated through changes in the nominal exchange rate and prices, where the contribution of nominal exchange rate dominates. There is little to indicate that the contributions of the nominal exchange rate and prices have changed relative to each other, or that either has diminished in the last decade relative to their sizes in the 1970s and 80s, in fact, rather to the contrary. Exchange rates are, however, constantly exposed to shocks so that a move towards the equilibrium level may be reversed. The real exchange rate may therefore deviate from its equilibrium level for a longer period of time than implied by purely partial analyses. By identifying which shocks/variables that are affecting the real exchange rate, it is possible to get a better indication of how persistent a deviation can be. It can also be argued that the equilibrium level of the real exchange rate can be constant for reasons other than those given by the theory of purchasing power parity. By identifying these, it is possible to gain insight into which conditions determine the actual level of the equilibrium exchange rate. The BEER approach allows one to take such considerations into account.

The behavioural equilibrium real exchange rate (BEER) approach explains movements in the Norwegian real exchange rate in the long run using the following variables: the difference between relative prices for n and t-products between Norway and its trading partners, the real oil price and the share of investment in GDP. The equilibrium real exchange rate in the long run has been estimated by making assumptions about the equilibrium levels of these variables. Implicitly, the real exchange rate may deviate from its equilibrium level partly because these variables may deviate from their equilibrium levels. As such deviations are assumed to be temporary, deviations from the equilibrium exchange rate will also be temporary. Other variables that influence the real exchange rate in the short and medium term include the interest rate differential between Norway and its trading partners and growth in public spending in Norway. We have demonstrated that the real exchange rate may be stronger than its equilibrium level for a long period as a result of planned growth in public expenditures in the period ahead. In the short run, we have also observed a tendency for the real exchange rate to continue moving in one direction or the other, even when the shock that caused the initial movement has dissipated.

As regards the fundamental equilibrium exchange rate (FEER) approach, we first derived the FEER with the help of a simple theoretical model for the import and export of traditional goods and services, where it was taken into account that a trade deficit can be sustained with revenues (permanent income) from positive net foreign assets. The empirical analysis was carried out on the basis of this model. Permanent income from net foreign assets was set equal to estimated revenues from Norway's total petroleum wealth in the form of petroleum reserves in the seabed and the Norwegian Petroleum Fund. The empirical analysis showed, among other things, that FEER generally is variable. It has a tendency to weaken over time, even when the income flow from net foreign assets, i.e. permanent income from total petroleum wealth, remains unchanged.

This is because import demand increases over time due to economic growth. Thus the import share that can be financed by permanent income declines steadily. In order to ensure that the trade deficit equals permanent income, the real exchange rate has to depreciate steadily to slow import and boost export. Sufficiently far into the future, the import share that can be financed by permanent income becomes insignificant. Import is then largely financed by export and the equilibrium exchange rate is the same as when permanent income equals zero, i.e. when trade balance is enforced. This equilibrium level will be constant if trend growth in the home country and abroad is constant. The path of FEER over time depends on the sustainable level of the trade deficit and the growth rate at home and abroad. An increase in permanent income, that is as a result of, for example, higher oil prices serves to strengthen FEER more than would otherwise be the case over the whole simulation horizon. Changes in permanent income are, however, of more importance to FEER in the short run than in the long run, as the importance of permanent income diminishes over time. The more rapidly the economy grows, the faster permanent income will become insignificant relative to the size of the growing import level and the sooner Norway will have to balance its foreign trade without petroleum revenues. It is also shown that a permanent appreciation would require that import does not grow over time, so that the import share that is financed by oil revenues remains unchanged over time.

Both the PPP and the BEER approaches suggest an equilibrium exchange rate that is weaker than the observed real exchange rate in 2002. The PPP approach implies an equilibrium exchange rate of 0.975, whereas the BEER approach implies 1.03 conditional on our specification of internal and external balance. The FEER level in 2002 is, however, on a par with the actual exchange rate that year, but depreciates over time and converges towards 1.13 which balances foreign trade with traditional goods and services. However, the different point estimates should be interpreted as being indicative as there is considerable uncertainty attached to the model specifications, parameter estimates and the assumed equilibrium values of the explanatory variables.

References

Akram Q.F. (2000a) “PPP despite real shocks: An empirical analysis of the Norwegian real exchange rate”. Working Paper 2000/7, Norges Bank.

Akram Q.F. (2000b) “When does the oil price affect the Norwegian exchange rate?” Working Paper 2000/8, Norges Bank.

Akram Q.F. (2002) “PPP in the medium run despite oil shocks: The case of Norway”. Working Paper 2002/4, Norges Bank.

Akram Q.F. (2003) "Effisient konsum av petroleumsinntekter". Unpublished manuscript (in Norwegian), Norges Bank.

Akram Q.F., Brunvatne K.M. and Lokshall R. (2003) "Real equilibrium exchange rates". Chapter 3 in this issue of Norges Bank Occasional Papers.

Alexius A. (2001) "Sources of real exchange rate fluctuations in the Nordic countries". *Scandinavian Journal of Economics* 103, 317–331.

Aukrust O. (1977) "Inflation in the open economy: Norwegian model". In L.B. Krause and W.S. Sâlant (eds.) "World Wide Inflation. Theory and Recent Experience", Brookings, Washington D. C.

Balassa B. (1964) "The purchasing power doctrine: A reappraisal". *Journal of Political Economy* 72, 584–596.

Bjørnland H.C. and Hungnes H. (2002) "Fundamental determinants of the long run real exchange rate: The case of Norway". Discussion Paper 326, Statistics Norway.

Chaudhury K. and Daniel B.C. (1998) "Long-run equilibrium real exchange rates and oil prices". *Economic Letters* 58, 231–238.

Cheung Y.W. and Lai K.S. (2000) "On cross-country differences in the persistence of real exchange rates". *Journal of International Economics* 50, 375–397.

Clarida R.H. (1996) "Consumption, importprices, and the demand for imported consumer durables: A structural econometric investigation". *The Review of Economics and Statistics* 78, 369–374.

Doornik J.A. and Hendry D.F. (2001) *Modelling Dynamic Systems using PcGive 10, Volume II*. Timberlake Consultants LTD., London.

Goldstein M. and Khan M. (1985) "Income and price elasticities in foreign trade". In R. Jones and P. Kennen (eds.) "Handbook of International Economics", bd. II, ch. 23, 1042–1099. Amsterdam: North Holland.

Hinkle L.E. and Montiel P.J. (1999) *Exchange Rate Misalignment: Concepts and Measurement for Developing Countries*. Oxford University Press for the World Bank, Oxford.

Houthakker H.S. and Magee S.P. (1969) "Income and price elasticities in world trade". *The Review of Economics and Statistics* 51, 111–125.

Layard R., Nickell S. and Jackman R. (1991) *Unemployment*. Oxford University Press, Oxford.

MacDonald R. and Stein J.L. (1999) *Equilibrium Exchange Rates*. Kluwer Academic Publishers, Massachusetts.

Mark N.C. (1990) “Real and nominal exchange rates in the long run: An empirical investigation”. *Journal of International Economics* 28, 115–136.

Marquez J. (1990) “Bilateral trade elasticities”. *The Review of Economics and Statistics* 72, 70–77.

Rogoff K. (1996) “The purchasing power parity puzzle”. *Journal of Economic Literature* 34, 647–668.

Samuelson P. (1964) “Theoretical notes on trade problems”. *Review of Economics and Statistics* 46, 145–154.

Sarno L. and Taylor M.P. (2002) “Purchasing power parity and the real exchange rate”. *IMF Staff Papers* 49, 1, 65–105.

Svensson L., Houg K., Solheim H.O.A. and Steigum E. (2002) “Norges Bank Watch 2002. an independent review of monetary policy and institutions in Norway”. Techn. rap., Centre for Monetary Economics at the Norwegian School of Management, BI.