Oil wealth and real exchange rates: The FEER for Norway

Q. Farooq Akram*

Abstract

It is often argued that Norway's sizeable net foreign assets based on its petroleum wealth imply an appreciation of its real exchange rate to a permanently strong level. We investigate this issue within the framework of the fundamental equilibrium real exchange rate (FEER) approach. It is shown that the strength of the FEER depends on the share of imports that can be financed by petroleum (based) revenues. Projections of the FEER over a long horizon suggest that the petroleum wealth implies a stronger equilibrium exchange rate than the rate that would have balanced (non-petroleum) foreign trade in each period. However, the FEER depreciates steadily over time with growth in imports relative to petroleum revenues and converges towards the rate that balances foreign trade. A permanently strong FEER presupposes that e.g. imports stay constant over time. Our results are in accord with the behaviour of the real exchange before and after the discovery of Norway's petroleum resources.

Key words: *Equilibrium real exchange rate, FEER, econometric analysis.*

JEL classification: *C32, C53, F31, F41.*

*I would like to thank participants at seminars in Norges Bank for valuable comments. The author is affiliated with the Research Department of Norges Bank, but is solely responsible for the contents of this paper. E-mail: qaisar-farooq.akram@norges-bank.no. Tel. +47 22316692; Fax. +47 22424062.

1 Introduction

Norway has considerable net foreign assets in the form of petroleum resources and the Government Petroleum Fund; their current value is more than twice the size of Norwegian GDP. Permanent income from these assets can finance a sizeable share of present-day Norwegian imports.

A pertinent question is whether the Norwegian real exchange rate can rightly appreciate to a permanently stronger rate. If there is a negative relationship between the strength of the real exchange rate and the size of the non-oil exposed sector, the answer to this question has a bearing on the issue of whether Norway can permanently do away with a sizeable share of its (non-petroleum) export sector, see e.g. Corden (1984). Thus, the answer may also shed light on the expected or desired direction, from a policy view, of resource flows between exposed and sheltered sectors.[1] Such issues are commonly faced by countries endowed with exportable natural resources. Furthermore, countries that have been exposed to adverse economic shocks, including natural disasters, may face similar issues, analytically. Our analysis and conclusions may therefore be of broader interest.

We apply the fundamental equilibrium real exchange rate (FEER) approach to calculate the equilibrium real exchange rate for Norway and to discuss whether, to what extent, and for how long Norway's net foreign assets imply a strong equilibrium real exchange rate. The FEER approach is a well recognised approach for calculating equilibrium real exchange rates, see e.g. Williamson (1994), Faruqee et al. (1999), MacDonald and Stein (1999), Wren-Lewis (2003) and the references therein. It provides a convenient framework for discussing effects of net foreign assets on a country's real exchange rate. Yet, it seems that the FEER approach has previously

[1] A number of studies have explained or justified appreciations of the Norwegian real exchange rate and the transfer of resources from exposed sectors to sheltered sectors by pointing to Norway's substantial net foreign assets, see e.g. Alexander et al. (1997), Haldane (1997), and Svensson et al. (2002).

not been employed to discuss the relationship between Norway's petroleum wealth and its real exchange rate.

The paper is organised as follows: Section 2 presents a simple theoretical model that can be used to derive a FEER. This model can be used to examine the importance of petroleum wealth to the equilibrium exchange rate over time. Thereafter, Section 3 develops and evaluates an empirical version of this model. Section 4 employs this model to simulate a path of the FEER for Norway until 2070. It emerges that Norway's substantial net foreign assets imply a stronger equilibrium exchange rate than the rate that would balance its foreign trade with non-petroleum products over the simulation horizon. This section also derives several paths of the FEER conditional on alternative assumptions about the size of petroleum wealth 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 permanently strong equilibrium exchange rate. Furthermore, we discuss our findings in the light of the actual behaviour of the Norwegian real exchange rate before and after the discovery of Norwegian petroleum resources in 1969. Section 5 concludes.

2 Fundamental Equilibrium Exchange rate (FEER)

The FEER is considered a real exchange rate that is consistent with internal and external balance of an economy. Section 2.1 presents a simple model of exports and imports of non-petroleum products that can be used to derive a FEER.[2] It takes into account that positive net foreign assets generate revenues that can finance a share of import expenditures. It appears that a FEER is generally a variable equilibrium

[2] We employ a so-called partial equilibrium approach to derive the FEER. Alternatively, one can employ a general equilibrium approach where all relevant variables are endogenously determined. The partial approach is more convenient and transparent relative to the general equilibrium approach. A possible drawback with the partial approach is that it neglects potential interdependencies between the endogenous and presumedly exogenous variables. However, some studies suggest that such interdependencies tend to have quantitatively negligible effects on results, see e.g. Driver et al. (2001).

exchange rate, but that it can be constant or converge towards a constant level in the long run under reasonable conditions.

2.1 Theoretical framework

We assume a small open economy whose 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 (1):

$$B = Y^{\beta_1} R^{-\alpha_1}, \tag{1}$$

where the Greek letters are constant parameters with positive values. β_1 represents the income elasticity of imports and $-\alpha_1$ denotes the price elasticity of imports, 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, as expressed by the export function (2):

$$A = Y_f^{\beta_2} R^{\alpha_2}. \tag{2}$$

Here, β_2 and α_2 denote the income elasticity and price elasticity of exports, 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:

$$TD \equiv B - A = Y^{\beta_1} R^{-\alpha_1} - Y_f^{\beta_2} R^{\alpha_2}. \tag{3}$$

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

Equation (3) 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 (3) and solving it with respect to R:

$$R = \left[\frac{Y^{\beta_1}}{Y_f^{\beta_2}} \left(1 - \frac{TD}{B} \right) \right]^{1/(\alpha_1 + \alpha_2)} . \tag{4}$$

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 imports, see equations (3) and (1). Similarly, the real exchange rate must appreciate when foreign income increases, so that the trade deficit does not fall as a result of higher exports, see equations (3) and (2). 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. on the evolution of $Y^{\beta_1}/Y_f^{\beta_2}$. This ratio can be interpreted as the income-determined trade deficit.

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

$$FEER = \left[\frac{\overline{Y}^{\beta_1}}{\overline{Y}_f^{\beta_2}} \left(1 - \frac{PI}{B} \right) \right]^{1/(\alpha_1 + \alpha_2)} . \tag{5}$$

$\overline{Y}$ 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 net 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 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 imports that can be financed by permanent income. When there is external balance, PI/B (which is equal to $(B - A)/B$) can be interpreted as the share of imports that is financed by permanent income, whereas ($1-$ PI/B) can be seen as the share of imports that is financed by exports. The greater PI/B is, the stronger the equilibrium exchange rate can be, see equation (5).

The 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 differs, or the income elasticity of imports differs from the income elasticity of exports. Moreover, 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 these assets.

The FEER can also weaken over time even though $\overline{Y}^{\beta_1}/\overline{Y}_f^{\beta_2}$ and PI remain constant over time. 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 subdue imports and boost exports.

The FEER can, however, be constant in the long run if $\overline{Y}^{\beta_1}/\overline{Y}_f^{\beta_2}$ stays constant over time.[3] 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 imports will then have to be financed by exports. This could happen even if permanent income is revised upwards over time, as long as imports increase at a higher rate than permanent income. Thus the FEER for $PI > 0$ will converge towards the FEER for PI = 0, which balances trade with other countries. In other words, the FEER does not depend on the level of permanent income, and hence on a given stock of net foreign assets, in the long run. In summary:

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

This expression also implies that changes in permanent income are of more importance to the 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.

3 Empirical analysis

This section develops an econometric model of Norwegian imports and exports of non-petroleum goods and services within the theoretical framework outlined above. Section 4 employs this model to derive paths for the FEER under different conditions. In the following, we specify variables that are used to develop the model and

[3] The FEER will equal 1, as in the theory of absolute purchasing power parity, if imports and/or exports are extremely sensitive to changes in the real exchange rate, that is if $(\alpha_1 + \alpha_2) \longrightarrow \infty$. In such cases, the FEER will neither depend on revenues from abroad nor on income at home and abroad. Intuitively, an arbitrary trade deficit can be achieved and sustained through minor changes in the real exchange rate when price elasticity is extremely high. 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 imports so that the trade deficit does not exceed *PI*.

discuss their behaviour over the sample period. The model and its properties are presented in Section 3.2.

3.1 Data

In the empirical analysis, imports (B) and exports (A) refer to Norwegian imports and exports of non-petroleum goods and services measured in NOK billion at constant 1999 prices. These are explained by Norwegian mainland GDP (Y), trading partners' GDP (Y_f) and the trade-weighted real exchange rate (R). The real exchange rate is defined as $R \equiv EP^f/P$, where E is the trade-weighted nominal exchange rate index, and P^f/P is the ratio of the trading partners' consumer price index to the consumer price index in Norway. Use of consumer price indices eases the construction and updating of the foreign general price index, which covers 25 of Norway's main trading partners.

We use quarterly data for the period 1978q1–2001q4 to estimate dynamic econometric models of imports and exports in line with the functions (1) and (2). The data for Norwegian trade and mainland GDP are from the current Norwegian Quarterly National Accounts (QNA), which has recently been revised back to 1978. The trade-weighted measures of GDP, consumer prices and the nominal exchange rate are readily available from Norges Bank's database (TROLL8), which draws on QNA, IMF-IFS and OECD-MEI databases when constructing these series.

Figure 1 presents the time series of imports, exports and the implied trade deficit over the sample period. It suggests that the import and export volumes grew more or less continuously in the sample period. However, imports have grown at a swifter pace than exports, thus increasing the trade deficit (TD) over time. Measured as shares of mainland GDP, imports and exports have also generally expanded over time.

Figure 2 displays the behaviour of the explanatory variables (in logs) over the

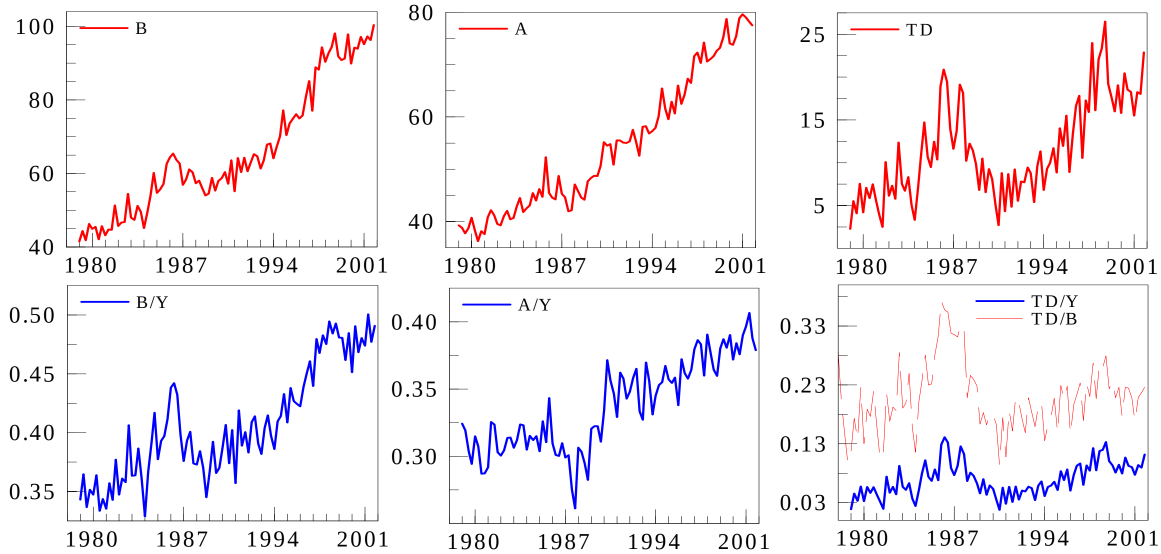

Figure 1: *Imports (B) and exports (A) of traditional goods and services in the period 1979q1–2001q4. Top row: quarterly data for imports, exports and the trade deficit (TD) measured in NOK billions at constant 1999 prices. Bottom row: imports, exports and the trade deficit measured as a share of Norwegian mainland GDP (Y). The trade deficit is also measured as a share of imports, TD/B. The time series of TD/B characterises the evolution over time of the import share that is not financed by (contemporary) exports.*

sample period. We treat these variables, as well as imports and exports, as non-stationary variables that are integrated of order one in our econometric analysis. This assumption can be supported by formal augmented Dickey-Fuller (ADF) tests for unit roots.

3.2 Econometric model of non-petroleum foreign trade

Table 1.A presents our preferred estimates of the income and price elasticities, 1.5 and 0.7 (in absolute values), respectively. They are close to unrestricted estimates obtained by estimating static log-linear models of imports and exports and to those from (unrestricted) equilibrium correction models of imports and exports, cf. Ericsson and MacKinnon (1990). The symmetry restrictions ($\beta_1 = \beta_2$ and $\alpha_1 = \alpha_2$) were imposed for simplicity in the light of the unrestricted parameter estimates and were

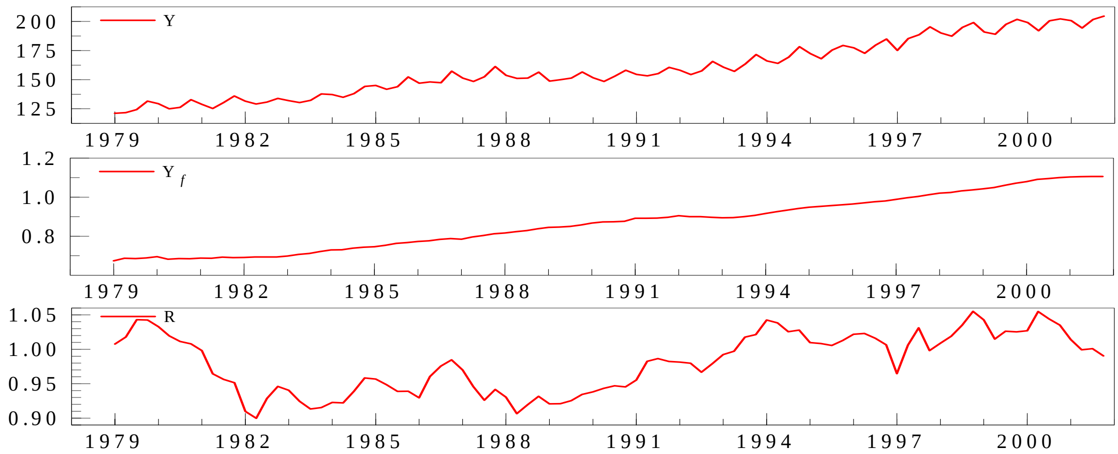

Figure 2: *Mainland GDP (Y), GDP in trading partner countries (Y_f) and the real exchange rate (R) in the period 1979q1–2001q4.*

not rejected. For example, panel B of the table suggests that our preferred estimates of income and price elasticities are able to characterise the long-run behaviour of imports and exports. Specifically, null hypotheses of non-cointegration are clearly rejected by the ADF tests at the 5per cent level. They can also be rejected if we take into account that the income and price elasticities have been estimated and employ critical values from the response surface offered by MacKinnon (1991).

Our estimates of income and price elasticities are comparable with those from other Norwegian and international studies, see Hinkle and Montiel (1999, p. 355, 475, and 489), Goldstein and Khan (1985) and Marquez (1990) for an overview of estimates based on a large number of extensive studies. It is also interesting to note that they 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 one imply increasing GDP shares for imports and exports over time, if the real exchange rate is constant or the price elasticities are sufficiently low. Such increases in GDP shares of imports and exports over time seem to be in line with actual developments in Norway over the

Table 1: 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
Estimation period:	1979q1–2001q4; $T = 92$ observations			

B. Tests for cointegration		
Variable/Term:	t-ADF	DF-model with intercept is augmented by:
$b - (1.5y - 0.7r)$:	-4.13	Δb_{t-4}.
$a - (1.5y_f + 0.7r)$:	-4.60	Δa_{t-4} and Δa_{t-5}.
ADF-critical values: 5%: -2.89; 1%: -3.50.		
MacKinnon (1991)'s-critical values: 5%: -3.84; 1%: -4.36.		

C. Model of non-oil foreign trade in equilibrium correction form

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

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

Estimation method: FIML

Note: The estimates have been obtained by using PcGive , see Doornik and Hendry (2001).

past 50 years, cf. Figure 1 and the results in Houthakker and Magee (1969).[4] One explanation could be that our measures of imports and exports both contain factor inputs in contrast to our measures of income: mainland GDP and trading partners' GDP. Hence, an increasing GDP share does not necessarily imply that the GDP share of imports adjusted for inputs will also increase.

Besides 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 the price (and income) elasticities prevent the GDP shares of imports and exports from becoming unreasonably large, at least over a time period of about forty years, see next section. Given that we are primarily interested in the near future, we do not adjust our estimates of the income and price elasticities.

Table 1.C presents a parsimonious version of our estimated equilibrium correction

[4] Estimates of income elasticities greater than one are very common in the empirical trade literature. A number of explanations have been offered to solve this puzzle, see e.g. Krugman (1989) and chapter 3 in Marquez (2002).

model of imports and exports. This model was obtained by imposing the preferred estimates of the income and price elasticities on a fairly general vector equilibrium correction model with four lags and seasonal dummies, but thereafter numerically and statistically insignificant short-run dynamics and seasonal effects were left out.

3.2.1 Model evaluation

The model has fairly good explanatory power over the estimation period, even though it is based on a limited information set determined by the theoretical framework outlined in Section 2.1. Figure 3 displays the fitted values of the levels of imports, exports and trade deficit implied by the model against their actual values over the estimation period. We note that the fit is relatively good in all cases.

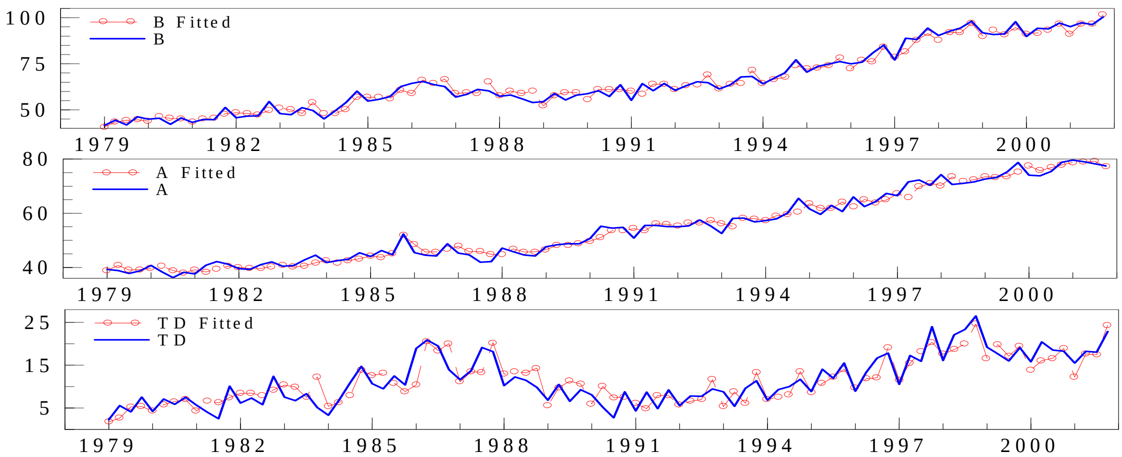

Figure 3: *The model's in-sample explanatory power. From above: actual and predicted values of the levels of imports, exports and trade deficit in NOK billion. The predicted values in levels have been obtained from the model in Table 1 (after transforming predicted values in logs).*

The model has also satisfactory statistical properties, which suggest that it is able to characterise the behaviour of imports and exports over the sample fairly well, see Table 2. Moreover, outcomes of the tests for parameter constancy depicted in Figure 4 do not indicate changes in parameters over the sample.

Table 2: Model diagnostics

Test statistics	Equation Δb_t	Equation Δa_t	As a system
R^2	0.54	0.39	
$\widehat{\sigma}$	4.5%	3.9%	
RESET $F(1,\ df_2)$	0.13[0.72]	0.60[0.44]	
ARCH 4: $F_{ARCH,\,1-4}(4,\ df_2)$	1.64[0.17]	0.33[0.86]	
Hetero: $F_{XiXj},(df_1,\ df_2)$	1.27[0.22]	0.84[0.71]	1.23[0.12]
AR 1-5: $F_{AR,1-5}(5,\ df_2)$	1.75[0.13]	2.98[0.02]*	1.62[0.06]
Normality: $\chi^2_{nd}(2)$	0.26[0.88]	0.87[0.65]	0.66[0.96]

Note: The square brackets include p-values. RESET F(df1, df2) tests the null hypothesis of correct model specification against the alternative hypothesis of misspecification by using the square of the fitted value; df1 and df2 denote degrees of freedom. In addition, we test the following null hypotheses for each of the two equations in the system: Absence of ARCH effects up to order 4; no heteroscedasticity; no autocorrelation in the residuals up to order 5 and normally distributed errors. In the fourth column, we test three of the latter hypotheses at the system level. See e.g. Doornik and Hendry (2001) and the references therein for details about the tests.

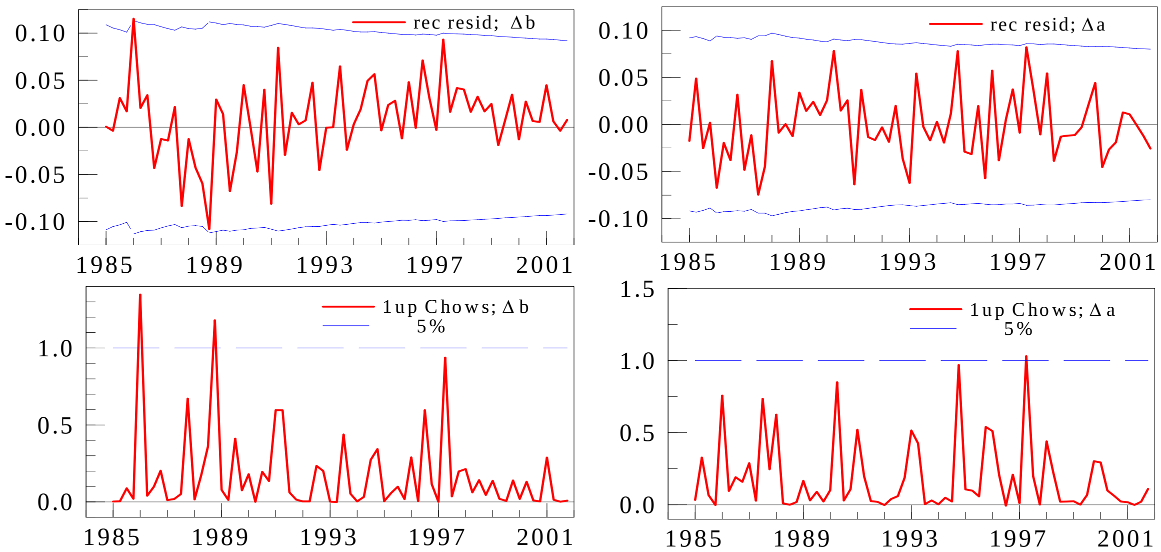

Figure 4: *Tests of parameter stability undertaken by recursive estimation; initial estimation period is 1979q1–1984q4. Upper row displays 1-step ahead residuals* ± 2 $\times$*estimated standard errors for the import and export equations, respectively. Bottom row depicts 1-step ahead Chow test-statistics for both equations. The test statistics have been scaled by their critical values at the 5% level.*

4 Simulations of the FEER and foreign trade

This section employs the model in Table 1.C to project paths of the equilibrium exchange rate (FEER) over the period 2002–2070, with or without petroleum wealth (net foreign assets). It also shows developments in imports and exports, which are jointly determined with the FEER, in order to explain the behaviour of the FEER over time. Finally, Sections 4.2.1 and 4.2.2 calculate paths of the FEER under alternative assumptions about the size of petroleum wealth and economic growth. This sensitivity analysis sheds more light on the relationship between petroleum wealth and the (equilibrium) real exchange rate.

4.1 Assumptions

Table 3 specifies our assumptions regarding internal and external balance, from the viewpoint of a small home economy. 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). Both the level of and equality between the growth rates at home and abroad are supported by empirical evidence from the last decades, see Table 3. Furthermore, the observed equality between the growth rates is consistent with our evidence of symmetry between the income elasticities of trade ($\beta_1 = \beta_2$). A number of studies have observed a tendency of relative growth rates to be inversely related to the ratio between income elasticities: $\Delta\overline{y}/\Delta\overline{y}_f = \beta_2/\beta_1$, see Krugman (1989) who refers to this widely observed relationship as the 45-degree rule.

Nevertheless, the assumption of constant rates of trend growth is clearly made for simplification in the light of empirical evidence of stochastic trends in the GDP of industrialised countries. Moreover, the assumed exogeneity of trend growth rates leads to neglect of potential interdependencies between the real exchange rate and the growth rates. The results of Driver et al. (2001) are to some extent comforting as they show that, when present, such interdependencies tend to have negligible effects on FEER-estimates.

Table 3: Assumptions underlying the (reference) path of the FEER

Internal and external balance			
Trend growth: $\Delta_4\overline{y} = \Delta_4\overline{y}^f = 2\%$; 0.5% per quarter			
Historically:			
	1979q1–2001q4	1980q1–1989q4	1990q1–2001q4
$\Delta_4\overline{y} =$	2.2%	2.0%	2.3%
$\Delta_4\overline{y}_f =$	2.2%	2.2%	2.2%
Trade deficit: $\overline{TD} = PI = 105$ billion per year; $105/4 = 26.25$ billion per quarter			

Note: 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. NOK 619 billion of this sum 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. The discount rate and the real rate of return are assumed to be equal to 4 per cent per annum.

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 Government Petroleum Fund at the end of 2001. The implied permanent income (PI) is estimated at NOK 105 billion per annum, see National Budget 2003 (St. meld. no. 1) for more details.

We have chosen to disregard other net foreign assets, as total net foreign assets for Norway have largely comprised petroleum wealth, particularly from the late 1990s, cf. Figure 5. It shows that Norway's net financial assets abroad since the late 1990s are mainly those of the central government, which are almost totally accounted for by the Government Petroleum Fund. The private sector's net financial assets abroad were on average close to zero in the 1990s.

The central government's net financial assets abroad are expected to grow substantially over time as petroleum resources are extracted from the seabed and their value is deposited in the Petroleum Fund.[5] Our measure of permanent income is, however, unaffected by this transformation of petroleum resources into financial wealth, i.e. portfolio shift, over time.

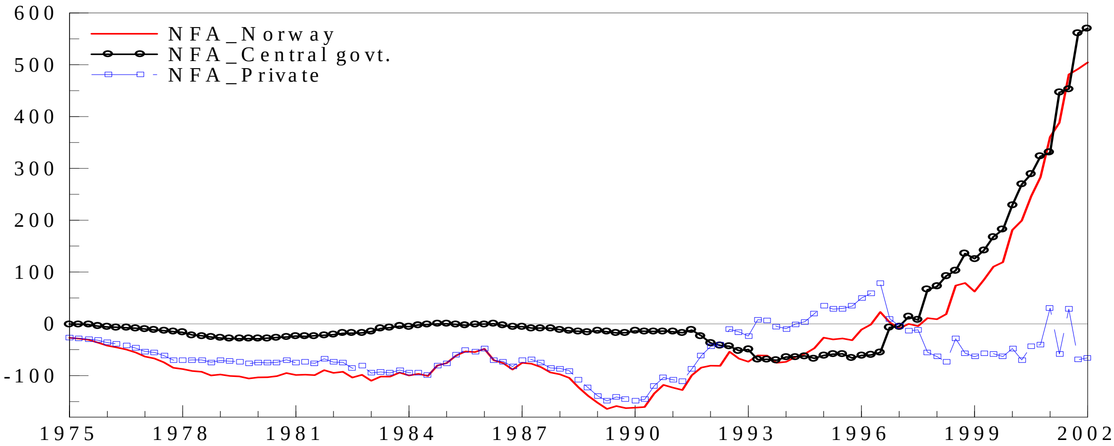

Figure 5: *Norwegian net financial assets abroad (in NOK billion) during 1975q1 to 2001q4. NFA_Norway denotes public (i.e. central and local government) and private sector's net financial assets abroad. NFA_Central govt. and NFA_Private denote central government's and private sector's net financial assets abroad, respectively. Source: Norges Bank.*

4.2 The FEER and foreign trade in the period 2002–2070

Figure 6 shows paths of the equilibrium exchange rate when the trade deficit is financed by permanent income from petroleum wealth and if we had required trade balance in the absence of revenues from petroleum wealth and other net foreign assets. Figure 7 shows movements in imports, exports and the trade deficit that are consistent with the equilibrium exchange rate in the former case.

[5] A fiscal policy rule of March 29, 2001 restricts annual consumption of petroleum revenues to permanent income from the Government Petroleum Fund, which is specified as 4% of the market value of the Petroleum Fund at the beginning of a year. However, this rule does not take into account the substantial petroleum wealth in the seabed, whose current value in 2002 amounted to ca. 4 times the value of the Petroleum Fund. The fiscal rule may therefore underestimate the sustainable level of Norwegian trade deficits as long as the value of petroleum resources are not fully deposited in the Fund.

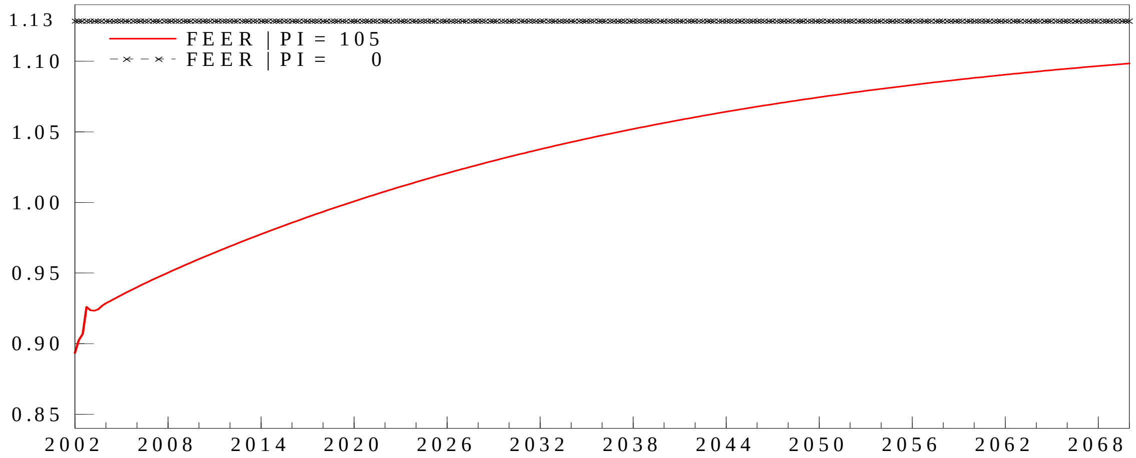

Figure 6: *The continuous rising curve plots FEER when the trade deficit equals permanent income at NOK 105 billion, i.e. 26.25 (= 105/4) billions per quarter. The straight curve represents the FEER when external balance is defined as trade balance at each point in time, i.e. PI = 0.*

The equilibrium exchange rate that ensures external balance by way of balancing the trade, i.e. FEER|PI = 0, is constant over time. This is because the ratio of income-determined imports to exports ($Y^{\beta_1}/Y_f^{\beta_2}$) stays constant over time, as their income elasticities and growth rates at home and abroad are equal. The estimate of FEER|PI = 0 is about 1.13.[6]

The equilibrium exchange rate conditional on permanent income (FEER|PI = 150) is initially about 20 per cent stronger than FEER|PI = 0, which presupposes zero income from petroleum wealth. However, FEER|PI = 150 weakens over time. The figure shows that it converges towards FEER|PI = 0 by depreciating continuously over time. 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.

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

[6] In general, the estimate of FEER|PI = 0 depends on the initial level of the income-determined trade deficit ($Y^{\beta_1}/Y_f^{\beta_2}$). 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.

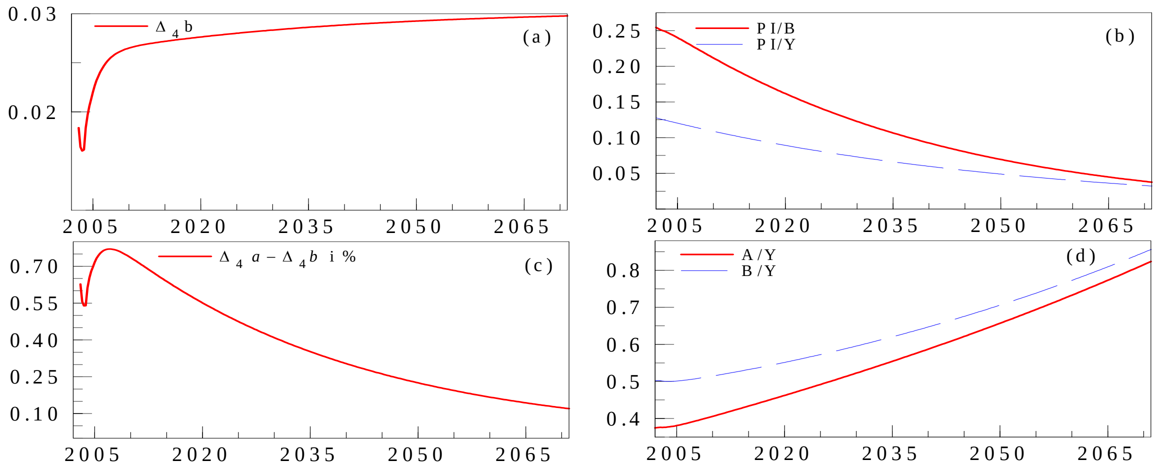

Figure 7: *Paths of imports and exports that are consistent with FEER|PI = 105 in the period 2002q1–2070q4. (a): annual growth in imports* $\Delta_4 b$*; (b) import share financed by permanent income (PI/B) and trade deficit relative to mainland GDP (PI/Y); (c) percentage growth differential between imports and exports 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.*

7.b shows that permanent income can finance 25 per cent of imports in 2002, but that this share declines in line with growth in imports 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 exports have to compensate for the diminishing importance of permanent income as a (possible) financing source for imports in order to ensure external balance. This is brought about via a depreciation of the equilibrium exchange rate as shown in Figure 6.

Figure 7 also indicates effects of changes in the equilibrium exchange rate on imports and exports. Figure 7.a presents the (implied) annual growth of imports over time. 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 7.c suggests that exports expands faster than imports, which is a result of the exchange rate depreciation. The growth differential is less than 1 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 exports and imports grow at the same rate in the long term, when the rate of depreciation has become zero.

Figure 7.d shows that exports as a share of mainland GDP grow 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 of 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, that is when $FEER|PI = 150$ becomes equal to $FEER|PI = 0$.

4.2.1 Importance of petroleum wealth

Figure 8 presents alternative paths for the FEER over the simulation horizon. The paths are derived for permanent income equal to NOK 120, 105 and 90 billion per year. In also shows the equilibrium exchange rate conditional on zero permanent income, that is balanced trade. All paths are based on the assumption of annual trend growth of 2 per cent in Norway and abroad.

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 with a higher sustainable level for the trade deficit, so that the FEER

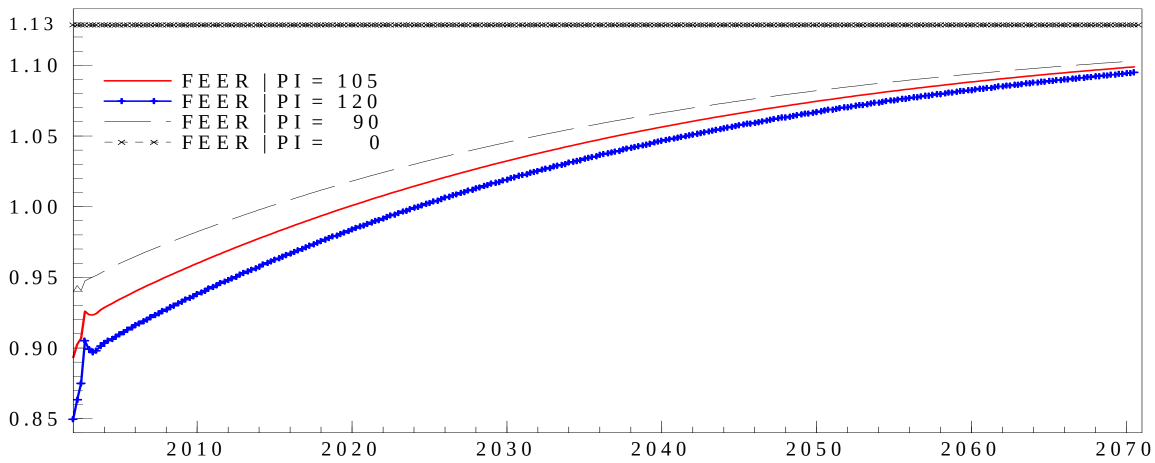

Figure 8: *FEER paths for different values of permanent income (PI), when trend growth in Norway and trading partner countries is assumed to equal 2 per cent per year. The curve in the middle plots the path for the FEER when PI equals 105 (NOK billion per year). The lower curve is the FEER when PI = 120 and the upper curve is the FEER when PI = 90. The straight curve at the top of the chart shows the FEER when PI = 0.*

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 by permanent income increases over the whole time horizon.

The figure suggests that the equilibrium exchange rate appreciates (depreciates) immediately by nearly 1 per cent when permanent income increases (decreases) by a billion NOK per annum. Note that an increase of NOK 25 billion per year in permanent income, i.e. 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 similar reduction in permanent income serves to weaken the equilibrium exchange rate by about the same rate, as the FEER weakens from 0.89 to 0.94.

Changes in permanent income are of greater importance to the 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 the FEER becomes increasingly smaller over time. In the long run, the FEER does not depend on the level of permanent income. Figure 8 indicates that the different FEER paths converge towards the FEER level for zero permanent income. In the short and medium term, changes in the level of permanent income may, however, have a considerable effect on the FEER.

4.2.2 Importance of economic growth

The FEER is constant in the long run if trend growth in the home country and abroad is the same, see Section 2.1.[7] 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 the FEER converges towards this level is, however, influenced by the growth rate as this determines how rapidly imports expands relative to permanent income. Growth in imports also depends on the income elasticity of imports. The higher income growth and/or income elasticity of imports, the faster permanent income will become insignificant in relation to import demand and the faster the FEER will fall in order to boost exports and suppress imports, so that external balance can be maintained.

Figure 9 shows movements in the FEER, conditional on three different trend growth rates that are assumed to be the same in Norway and abroad. 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 the FEER (here 0.89) and the long-term level of the 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

[7] Differences in growth rates between Norway and its trading partners can lead to paths of FEER that are ever appreciating or depreciating, ceteris paribus. Such outcomes may seem implausible, however. This is partly because persistent differences in growth rates between countries that trade with each other, particularly at largely similar income levels per capita, does not seem likely, e.g. in the light of convergence in growth rates across trading partners. Another argument is the above mentioned 45-degree rule, which implies that income elasticities of trade may change such that effects of possible differences in growth rates on real exchange rates are counteracted in the long run, see Krugman (1989).

swiftly Norway must balance its foreign trade without petroleum revenues.

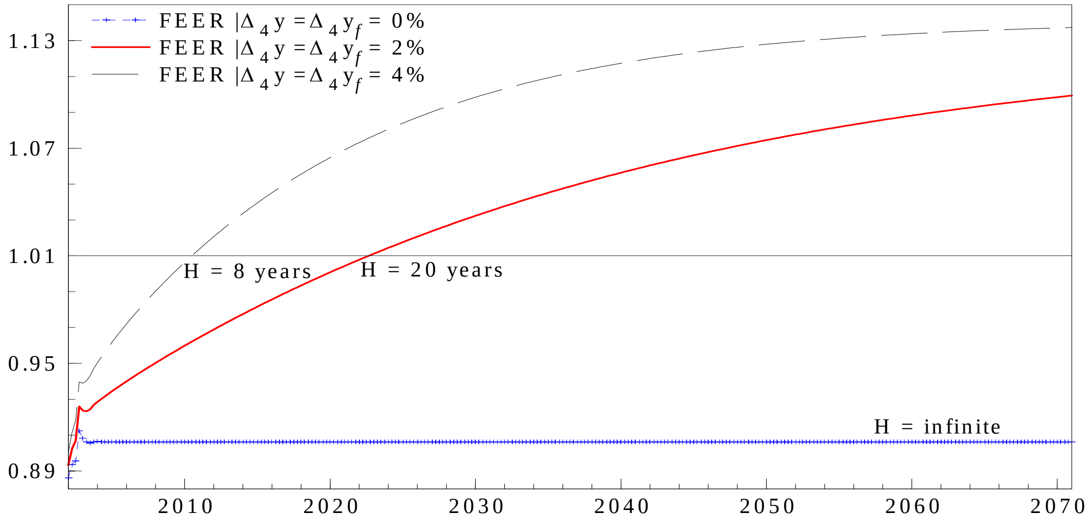

Figure 9: *FEER paths for different growth rates, when the trade deficit equals permanent income at NOK 105 billion per year. It is also assumed that trend growth in Norway and abroad is the same. H denotes the half-life, i.e. how rapidly the FEER converges towards its long-term level, the level where the import share that can be financed by permanent income becomes insignificant.*

The figure suggests a strongly negative relationship between the growth rate and the half-life. The half-life falls from 20 to 8 years, if growth rates double from 2 to 4 per cent per year. However, if the economy and imports do not grow, a fixed import share can be financed indefinitely by permanent income. In this case, the FEER remains at its (initial) 2002 level and the half-life is infinite. In other words, a permanent appreciation is possible if import demand does not grow over time, so that the import share that is financed by petroleum revenues remains unchanged over time.

Changes in the income elasticity of imports and exports 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.

4.3 Behaviour of the FEER before and after the oil-discovery

The above sections have demonstrated a positive relationship between petroleum wealth and the strength of the FEER, theoretically and empirically. However, this relationship tends to weaken over time in a growing economy. A higher growth rate diminishes the importance of petroleum wealth at a faster rate than a lower rate. Accordingly, the FEER becomes effectively independent of petroleum wealth at some point in time, which depends on the growth rate of the economy. In particular, the long-run level of the FEER conditional on vast petroleum wealth converges to the level of the FEER in the (counterfactual) case of no petroleum wealth.

Interestingly, the implications of the theoretical and empirical models fit well with the behaviour of the Norwegian real exchange rate in the period before and after the discovery of petroleum in 1969 and its upward revision over time, mainly due to oil price shocks and additional discoveries of petroleum reserves. Figure 10 displays the actual behaviour of the Norwegian real exchange rate from 1966q1 to 2002q4 together with the estimated paths of the FEER displayed above in Figure 8. Some characteristics of the real exchange rate and paths of the FEER are worth pointing out.

First, the real exchange rate in the pre-petroleum era is almost at the same level as our estimate of the FEER in the absence of petroleum wealth (i.e. $\text{FEER}|\text{PI} = 0$). Its estimated level (1.13) also indicates that the real exchange rate must depreciate considerably from the level at the start of e.g. 2002, if imports of traditional goods and services are to be financed solely by exports of traditional goods and services.

Second, the real exchange rate appreciates steadily into the 1970s with the increasing importance of petroleum wealth. Thus the behaviour of the real exchange rate into the 1970s is opposite to the behaviour of the FEER into the future when importance of petroleum wealth diminishes over time.

Third, fluctuations of the real exchange rate at largely the same level in the

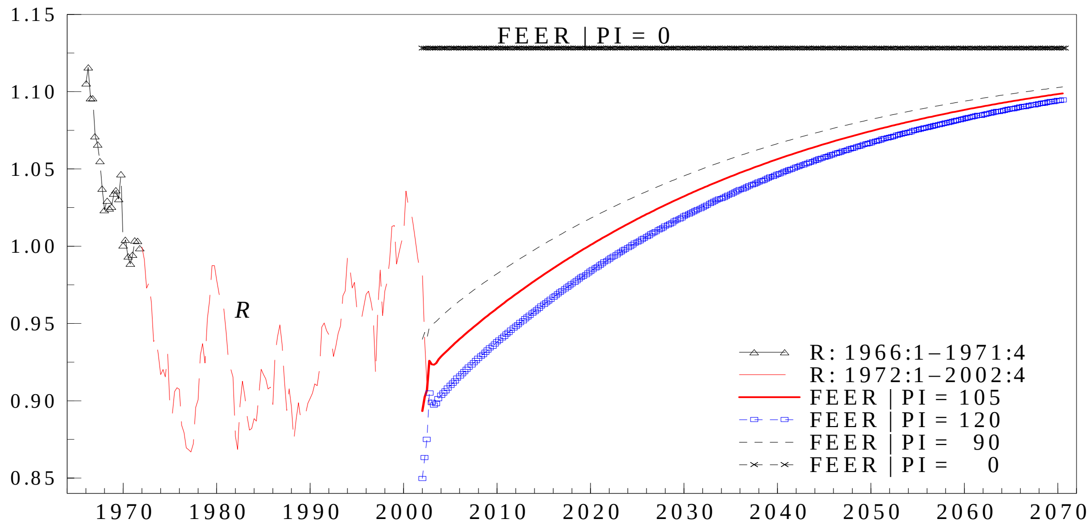

Figure 10: *Petroleum wealth and the real exchange rate. Actual observations of the real exchange rate in the period 1966q1–2002q4 together with the simulated paths of the FEER in the period 2002q1–2070q4, see Figure 8 for more details. Given that data for a trade-weighted real exchange rate were not publicly available, observations of the real exchange rate in the period 1966q1–1971q4 are based on import weights while those afterwards are based on trade weights. Source: Norges Bank.*

period 1972–2002 seem to suggest a rather constant FEER in this period, despite the evidence of growth in GDP and the level of imports, see Figure 1. One interpretation of this rather stable FEER could be that upward revisions of petroleum wealth over time may have counteracted the depreciation effect of economic growth (i.e. growth in imports) on the FEER. Thus evidence of a rather stable equilibrium rate in the past 30 years is not necessarily at odds with the framework outlined above, though a closer investigation is warranted using data on reassessments of petroleum wealth over time.

Finally, large fluctuations of the real exchange rate in the past underscore the strong likelihood that actual paths of the real exchange rate will be quite erratic in contrast to the smooth paths of the FEER. An explanation of such fluctuations in real exchange rates around their presumed equilibrium rates is also left to future studies.

5 Conclusions

We have used the FEER approach to calculate the equilibrium path of the Norwegian real exchange rate and to discuss the issue of whether Norway's petroleum wealth justifies a permanently strong real exchange rate.

The FEER was derived with the help of a simple theoretical model for imports and exports of non-petroleum 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 an econometric version of this model that was developed for this purpose. 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 Government Petroleum Fund.

The empirical analysis showed inter alia that the 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 subdue imports and boost exports. Sufficiently far into the future, the import share that can be financed by permanent income becomes insignificant. Imports are then largely financed by exports 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 the 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, as a result of for example higher oil prices, serves to strengthen the FEER more than would otherwise be the case over the whole simulation horizon. Changes in permanent income are, however, of more importance to the 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 imports do not grow over time, so that the import share that is financed by petroleum revenues remains unchanged over time.

Our analysis demonstrates that the importance of large real shocks may diminish over time in a growing economy. The faster the growth rate, the faster a shock becomes negligible. We have analysed the impact of a windfall on the equilibrium real exchange rate, but the analysis can also be applied to discuss the effects of adverse shocks.

References

Alexander, E. W., J. H. Green, and B. Arnason (1997). A monetary policy framework for Norway: The options. In A. B. Christiansen and J. F. Qvigstad (Eds.), *Choosing a Monetary Policy Target for Norway.* Scandinavian University Press, Oslo.

Corden, W. M. (1984). Booming sector and Dutch Disease economics: Survey and consolidations. *Oxford Economic Papers 36*, 359–380.

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

Driver, R. L., J. Power, and G. Ramsay (2001). Fundamental equilibrium exchange rates: an empirical investigation. Working Paper Forthcoming, Bank of England.

Faruqee, H., P. Isard, and P. R. Masson (1999). A macroeconomic balance framework for estimating equilibrium exchange rates. In R. MacDonald and J. L. Stein (Eds.), *Equilibrium Exchange Rates*. Massachusetts: Kluwer Academic Publishers.

Goldstein, M. and M. Khan (1985). Income and price elasticities in foreign trade. In R. Jones and P. Kennen (Eds.), *Handbook of International Economics*, Volume II, Chapter 23, pp. 1042–1099. Amsterdam: North Holland.

Haldane, A. G. (1997). The monetary framework in Norway. In A. B. Christiansen and J. F. Qvigstad (Eds.), *Choosing a Monetary Policy Target for Norway*. Oslo: Scandinavian University Press.

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

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

Krugman, P. (1989). Differences in income elasticities and trends in real exchange rates. *European Economic Review 33*, 1055–1085.

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

MacKinnon, J. G. (1991). Critical values for cointegration tests. In R. F. Engle and C. W. J. Granger (Eds.), *Long-Run Economic Relationships*. Oxford: Oxford University Press.

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

Marquez, J. (2002). *Estimating Trade Elasticities*. Boston: Kluwer Academic Publishers.

Svensson, L., K. Houg, H. Solheim, and E. Steigum (2002). An independent review of monetary policy and institutions in Norway. Norges Bank Watch 2002, Center for Monetary Economics, Oslo.

Williamson, J. (1994). Estimates of FEERs. In J. Williamson (Ed.), *Estimating Equilibrium Exchange Rates*, pp. 177–243. Institute for International Economics, Washington.

Wren-Lewis, S. (2003). Estimates of equilibrium exchange rates for sterling against the euro. EMU study, HM Treasury, UK.