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The Role of the Exchange Rate as a Shock Absorber in a Small Open Economy

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Abstract

This paper analyses interactions between the real exchange rate and business cycles in a small open economy like Norway. Using a structural vector autoregression model, the role of different shocks are analysed, to investigate to what extent the real exchange rate is absorbing shocks, or a source of shocks itself. The results are ambiguous. Output and the real exchange rate are mainly explained by separate shocks, so that relinquishing exchange rate independence should come at little cost. However, the importance of nominal shocks in the business cycle emphasises that stabilisation is possible. Hence, remaining monetary independence may be attractive.

For a small open economy that is susceptible to (country specific) idiosyncratic shocks, an independent currency and exchange rate may provide the country with a potential means to stabilise against these idiosyncratic shocks. Norway, being a small, albeit important, oil producing country, has been hit by idiosyncratic shocks to a larger extent, than most other European countries. As a consequence, the business cycles in Norway have been asymmetric with respect to business cycles in Europe (c.f. Bjørnland, 2000).

Until now, Norway has chosen to remain outside the European Union (EU) and therefore also the European Monetary Union (EMU). A main economic argument against joining the EU and the EMU, is that Norway would have to adopt a common currency, and thereby lose the exchange rate as an instrument acting to stabilise the macroeconomy when facing asymmetric shocks. On the other hand, Norway would obviously gain from a reduction in transactions costs, as the other European countries have been doing. Which argument would be the most important, is clearly an empirical matter.

Although business cycles of the Norwegian economy have been asymmetric with respect to business cycles in Europe, very little has been said about the extent to which the Norwegian exchange rate has actually acted to absorb the different idiosyncratic shocks. Before one is able to assess whether Norway would gain by relinquishing its exchange rate and monetary independence as it would if it joined the EMU, a careful analysis should be conducted to assess to what extent the exchange rate has actually stabilised the macroeconomy in the face of different shocks. The relevant question to ask would then be to what extent is the exchange rate absorbing shocks to the economy or is a source of shocks itself.

This paper analyses the interactions between the real exchange rate and the business cycle in a small open economy like Norway. To do so, I specify a structural vector autoregression (VAR) model, and, without imposing strong economic beliefs, identify different demand and supply shocks through assumptions about the long run impacts of these shocks on the variables in the model (cf. Blanchard and Quah, 1989). As the direct measure of these shocks is difficult, it motivates the use of a VAR model, where, rather than specifying the impulses that correspond to the different policies, a set of equations are instead specified that characterise the different polices. The VAR model is also particularly useful, as it can be used to decompose the variation in the real exchange rate and the other variables into components attributable to different economic shocks (impulses).

In the (benchmark) VAR model estimated below, I will focus on four key endogenous variables: Real GDP, the unemployment rate, the real wage and the real exchange rate. These variables will be driven by four structural shocks: Two demand shocks (nominal and real demand shocks) and two supply shocks (productivity and labour supply shocks). To separate the different shocks from each other, I need to assume something about the effects they have on the variables in the model. The choice of variables and the restrictions imposed on the VAR model, should therefore be such that they capture the likely transmission mechanisms of the different shocks in the system.

First, the key (long run) identifying assumption used here to distinguish between demand and supply shocks, asserts that in the long run the level of real output will be determined by supply side factors only. However, in the short run, due to nominal and real rigidities, all four disturbances can influence production. Second, all shocks but the nominal shock can potentially have a long run effect on the real exchange rate (cf. Clarida and Gali, 1994). The long run restriction on the nominal shock is consistent with a model that explains short run exchange rate volatility with sticky prices and monetary disturbances (c.f. Dornbusch, 1976), but allows for a real exchange rate variation in the long run due to real shocks. Finally, to distinguish the two supply shocks from each other, I assume that only productivity shocks can affect the real wage in the long run. This is implied by a Solow growth model with a fixed savings rate and a constant-returns-to-scale production function (see Gamber and Joutz, 1993). In particular, a change in the labour supply will lead to an equal percentage change in the capital stock. The real wage will at first fall, but as the capital stock reaches its steady state level, the real wage increases back to the original level.

The VAR model specified here will be exposed to several robustness tests. First, I replace the rate of unemployment with the inflation rate, to (i) check whether the impulse responses remain invariant to this model specification, and (ii) test for overidentifying restrictions by investigating the implied effects of the different shocks on prices. Thereafter I introduce the real oil price into the model, to investigate whether oil price shocks have been important sources of business cycles in Norway.

The rest of the paper is organised as follows. In Section 2, I propose an open economy model that satisfies the identifying restrictions discussed above. Section 3 identifies the benchmark structural VAR, and in Section 4, I trace out the impulse response and the variance decomposition to the identified shocks. Section 5 assess in more detail the extent of the absorbing nature of the real exchange rate in response to the different shocks, by analysing the interactions between the real exchange rate and the business cycles. In Section 6, I test the robustness of the results, by performing model variations. Section 7 summarises and concludes.

1. An open economy model

The open economy (Keynesian) model presented here is a simple variant of a closed economy model put forward in Blanchard and Quah (1989), and consists of an aggregate demand function, a production function, an equation describing price setting behaviour, an equation describing wage setting behaviour, a labour supply schedule and a real exchange rate equation

$$y_t = m_t - p_t + d_t + \alpha\theta_t + \beta(e + p^* - p)_t \tag{1}$$
$$y_t = n_t + \theta_t \tag{2}$$
$$p_t = w_t - \theta_t \tag{3}$$
$$w_t = w \mid [E_{t-1}n_t = \bar{n}_{t-1}] \tag{4}$$
$$\bar{n}_t = \gamma(w_t - p_t) + \lambda_t \tag{5}$$
$$(e + p^* - p)_t = \Delta m_t + \pi d_t + \delta\theta_t + \sigma\lambda_t \tag{6}$$

where y_t is the log of real output, θ_t is the log of productivity, p_t is the log of the domestic price level, p_t^* is the log of the foreign price level, w_t is the log of the nominal wage, m_t is the log of nominal money supply, e_t is the log of the nominal exchange rate, d_t reflects real demand in the goods market, n_t is the log of employment, $\bar{n}_t$ implies the log of labour supply and λ_t is a labour supply factor. α, β, γ, π, δ and σ are coefficients. Δ is the difference operator, (1-L). The rate of unemployment is defined as

$$u_t = \bar{n}_t - n_t.$$

Equation (1) states that aggregate demand is a function of real balances, demand in the goods market, productivity and the real exchange rate. Both productivity and the real exchange rate are allowed to affect aggregate demand directly. I expect $\alpha > 0$, as a higher level of productivity may imply higher investment demand. The sign on β reflects the joint effect of the real exchange rate on the total economy. Typically, one would expect $\beta > 0$, as a depreciation (increase) of the real exchange rate induces a balance of trade improvement, via an expenditure switching.

The production function (2) relates output to employment and technology through a constant return Cobb-Douglas production function. The price setting behaviour (3) gives prices as a mark up on wages adjusted for productivity. As in Blanchard and Quah (1989), wages are chosen one period in advance to achieve full employment in (4). However contrary to that study, the labour supply is now allowed to vary. In (5), labour supply increases with the real wage and other supply factors.[1] I expect $\gamma > 0$, as labour supply increases with a higher real wage.

Equation (6) suggests a function for the real exchange rate that encompasses *both* short term volatility and long run deviations from purchasing power parity (PPP).[2] Persistent deviations from PPP has been found in many recent studies of exchange rate determination (see e.g. Rogoff, 1996 for a survey and Bjørnland and Hungnes (2002) for a recent application to Norwegian data). Instead, long-run deviations from PPP suggest the influence of real shocks with large permanent effects. Consistent with this, the real exchange rate is specified as a function of changes in money supply, real demand innovations and some fundamentals, represented here by productivity and labour supply factors.

As will be seen below, PPP is only preserved in the long run with respect to monetary changes, so that, leaving all other shocks aside, a monetary shock will increase the price and depreciate the exchange rate proportionally. This would leave the real exchange rate unchanged in the long run, as predicted by the Dornbusch overshooting model and the Mundell-Fleming model with flexible prices. The same models also predict that a real demand expansion appreciates the real exchange rate (via an increase in the interest rate, a capital inflow and a balance of payment surplus), hence I expect $\pi < 0$.

Productivity and labour supply are proxies for the fundamentals in the economy, as they will determine the path of real output in the long run. For a small oil producing country like Norway, the discovery of natural resources may have the same effects on the exchange rate as the introduction of a new technology, that changes relative prices and appreciates the real exchange rate in the long run, hence, $\delta < 0$.[3] The effect of a labour supply shock on the real exchange rate is more difficult to establish. A flexible price exchange rate model would typically predict that following a labour supply shock, the price level falls monotonically and the real exchange rate depreciates, hence $\sigma > 0$.

The model is closed by assuming that m, θ, λ and d evolve as random walks, driven by four serially uncorrelated orthogonal nominal shocks $(\varepsilon^{\mathrm{NOM}})$, productivity (or labour demand) shocks $(\varepsilon^{\mathrm{PR}})$, labour supply shocks $(\varepsilon^{\mathrm{LS}})$ and real demand shocks (ε^{RD})

$$m_t = m_{t-1} + \varepsilon_t^{\text{NOM}} \tag{7}$$
$$\theta_t = \theta_{t-1} + \varepsilon_t^{\text{PR}} \tag{8}$$
$$\lambda_t = \lambda_{t-1} + \varepsilon_t^{\text{LS}} \tag{9}$$
$$d_t = d_{t-1} + \varepsilon_t^{\text{RD}} \tag{10}$$

Solving for $\Delta y, u, \Delta(w - p)$ and $\Delta(e + p^* - p)$ yields:

$$\begin{aligned}\Delta y_t = {} & (1+\beta)\Delta\varepsilon_t^{\text{NOM}} + (1+\beta\pi)\Delta\varepsilon_t^{\text{RD}} + (1+\gamma)\varepsilon_t^{\text{PR}} \\ & + (\alpha - \gamma + \beta\delta)\Delta\varepsilon_t^{\text{PR}} + \varepsilon_{t-1}^{\text{LS}} + \beta\sigma\Delta\varepsilon_t^{\text{LS}}\end{aligned} \tag{11}$$
$$\begin{aligned}u_t = {} & -(1+\beta)\varepsilon_t^{\text{NOM}} - (1+\beta\pi)\varepsilon_t^{\text{RD}} - (\alpha - \gamma + \beta\delta)\varepsilon_t^{\text{PR}} \\ & + (1 - \beta\sigma)\varepsilon_t^{\text{LS}}\end{aligned} \tag{12}$$
$$\Delta(w - p)_t = \varepsilon_t^{\text{PR}} \tag{13}$$
$$\Delta(e + p^* - p)_t = \Delta\varepsilon_t^{\text{NOM}} + \pi\varepsilon_t^{\text{RD}} + \delta\varepsilon_t^{\text{PR}} + \sigma\varepsilon_t^{\text{LS}} \tag{14}$$

Equation (11) states that only productivity and labour supply shocks will affect the level of output, y_t, in the long run, as y_t will be given as accumulations of these two shocks. However, in the short run, due to nominal and real rigidities, all four disturbances can influence output. Neither of the shocks will have a long run effect on unemployment in (12). Only productivity shocks will affect the real wage in the long run in (13), whereas all shocks but the nominal shock can have a long run effect on the real exchange rate in (14).

Note that no specific policy variable like monetary policy is included in the model. Instead, a nominal shock is identified through the effect it has on a set of key macroeconomic variables. This seems appropriate for Norway, where it is difficult to identify a stable monetary policy instrument, as the interest rate has been almost fixed since 1985. After that, it has mainly been used to defend the many different exchange rate targets Norway has tried to pursue. It is also consistent with the main set up in Clarida and Gali (1994), which identifies the nominal shock through the effect it has on the exchange rate and real output.

In the next section, I show how the model can be specified and identified empirically. As the model above is rather static, I will allow for more dynamics by introducing lags. Further, I let Eqs. (7)–(10) evolve as random walks with drift, i.e., I allow for a constant in all the equations in the VAR. Note also that I will allow for some more flexibility in Eq. (13), by letting the real wage potentially be determined by all four shocks in the short run.

2. Identifying the structural VAR

The analysis above suggests that by estimating a VAR model containing real GDP, unemployment, the real wage and the real exchange rate, the four structural shocks; nominal demand, real demand, productivity and labour supply shocks, can be identified. In the model above, GDP, the real wage and the real exchange rate are nonstationary integrated, I(1), variables (where stationarity is obtained by taking first differences), whereas the unemployment rate is stationary I(0).[4] Denoting the real wage as $(rw = w - p)$ and the real exchange rate as $(s = e + p^{*} - p)$, and ordering the vector of stationary variables as: $z_t = (\Delta rw_t, \Delta y_t, \Delta s_t, u_t)'$, its moving average representation can be written as

$$z_t = C(L)e_t \tag{15}$$

where e_t is a vector of reduced form serially uncorrelated residuals with covariance matrix Ω. Assume that the orthogonal structural disturbances (ε_t) can be written as linear combinations of the innovations (e_t), i.e. $e_t = D_0\varepsilon_t$. A (restricted) form of the moving average containing the vector of original disturbances can then be found as

$$z_t = D(L)\varepsilon_t \tag{16}$$

where $C(L)D_0 = D(L)$. The ε_t's are normalized so they all have unit variance. If D_0 is identified, I can derive the MA representation in (16). However, the D_0 matrix contains sixteen elements, and to orthogonalise the different innovations sixteen restrictions are needed. First, from the normalisation of var(ε_t) it follows that $\Omega = D_0D_0'$. A four variable system imposes ten restrictions on the elements in D_0. Six more restrictions are then needed to identify D_0. These will come from restrictions on the long run multipliers of the $D(L)$ matrix. Ordering the four serially uncorrelated orthogonal structural shocks: $\varepsilon_t = (\varepsilon_t^{\mathrm{PR}}, \varepsilon_t^{\mathrm{LS}}, \varepsilon_t^{\mathrm{RD}}, \varepsilon_t^{\mathrm{NOM}})'$, the long run expression of (16) can then simply be written as

$$\begin{bmatrix} \Delta rw \\ \Delta y \\ \Delta s \\ u \end{bmatrix}_t = \begin{bmatrix} D_{11}(1) & D_{12}(1) & D_{13}(1) & D_{14}(1) \\ D_{21}(1) & D_{22}(1) & D_{23}(1) & D_{24}(1) \\ D_{31}(1) & D_{32}(1) & D_{33}(1) & D_{34}(1) \\ D_{41}(1) & D_{42}(1) & D_{43}(1) & D_{44}(1) \end{bmatrix} \begin{bmatrix} \varepsilon^{\mathrm{PR}} \\ \varepsilon^{\mathrm{LS}} \\ \varepsilon^{\mathrm{RD}} \\ \varepsilon^{\mathrm{NOM}} \end{bmatrix}_t \tag{17}$$

where $D(1) = \sum_{j=0}^{\infty} D_j$ indicate the long run matrix of $D(L)$. In Section 1 above, I found that only productivity shocks can affect the real wage in the long run, hence: $D_{12}(1) = D_{13}(1) = D_{14}(1) = 0$. Only productivity and labour supply shocks can affect output in the long run, hence: $D_{23}(1) = D_{24}(1) = 0$. All shocks except the nominal shock can affect the real exchange rate in the long run, hence: $D_{34}(1) = 0$. No restrictions are placed on unemployment. However, if the rate of unemployment is stationary, no shocks will permanently change the unemployment rate. With these six long run restrictions, the matrix $D(1)$ will be lower triangular, and I can use this to recover D_0. Combining the expression for Ω and the long run representation of (17) implies

$$C(1)\Omega C(1)' = D(1)D(1)'. \tag{18}$$

(18) can be computed from the estimate of Ω and $C(1)$. As $D(1)$ is lower triangular, expression (18) implies that $D(1)$ will be the unique lower triangular Choleski factor of $C(1)\Omega C(1)'$.

3. Empirical results

The data and their sources are described in Appendix A. Different unit root tests suggest that GDP, the real wage and the real exchange rate are appropriately described as I(1), whereas for the unemployment rate, I can reject the I(1) hypothesis in favour of the trend-break alternative for unemployment. The break was estimated to occur in 1988Q2 (c.f. Tables A.1–A.2 in Appendix A). The upward break in unemployment may suggest that the natural rate itself may have been increasing, due to for instance growing union power, or the introduction of policies that have obstructed the free workings of the labour market. In the remaining analysis I therefore de-trend the unemployment rate by removing the structural break prior to estimation.[5]

Lag reduction tests suggested that a model reduction to four lags could be accepted at the 5 pct. level. With four lags, I could reject the hypothesis of serial correlation and heteroscedasticity in each equation at the 5 pct. level. Non-normality tests are also satisfied for all variables except for the unemployment rate (see Table A.3).[6] Finally, tests for cointegration between the variables in the VAR model can also be rejected, in particular when adjusting for degrees of freedom since the sample is small (c.f. Table A.4).

3.1. Impulse responses and variance decompositions

The dynamic effects of nominal, real demand, productivity and labour supply shocks on GDP, unemployment, the real exchange rate and the real wage are reported in Figures 1–4. The figures presented give the cumulative response in (the level of) each endogenous variable to a unit (innovation) shock, with a one standard deviation band around the point estimate, reflecting uncertainty of estimated coefficients.[7]

The responses to the shocks are consistent with a conventional economic model such as that presented in Section 1. A nominal shock has a positive impact effect on the level of GDP. The response of GDP thereafter declines gradually as the long run restriction bites, and after two years, the standard error bands include zero. The effect on the rate of unemployment is a mirror response to that on GDP, and unemployment falls temporarily. Consistent with Dornbusch's overshooting model, a nominal shock depreciates the real exchange rate, before it appreciates (overshoots) back to the long run equilibrium. A nominal shock has a small effect on the real wage, indicating essentially an acyclical behaviour. An acyclical (or weakly countercyclical) behaviour of the real wage, is consistent with a traditional view of business cycles driven by aggregate demand where wages are sticky.

The real demand shock appreciates the real exchange rate, but has only a small positive effect on output the first half year. On the other hand, real demand shocks have a larger effect on the rate of unemployment, which falls the first half year. The rate of unemployment thereafter increases, before it reaches long run

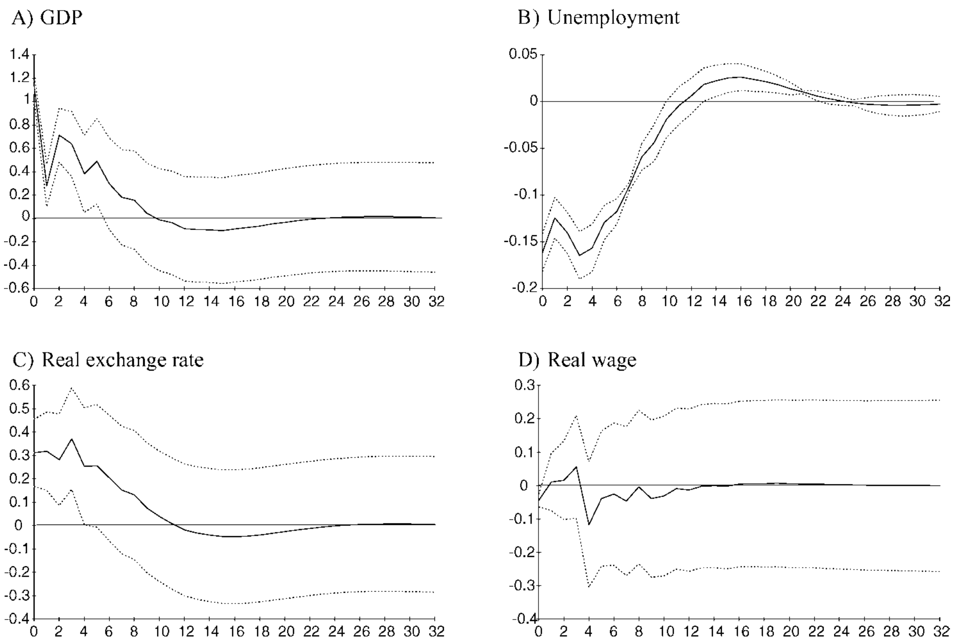

Figure 1. **Impulse responses: nominal shocks.**

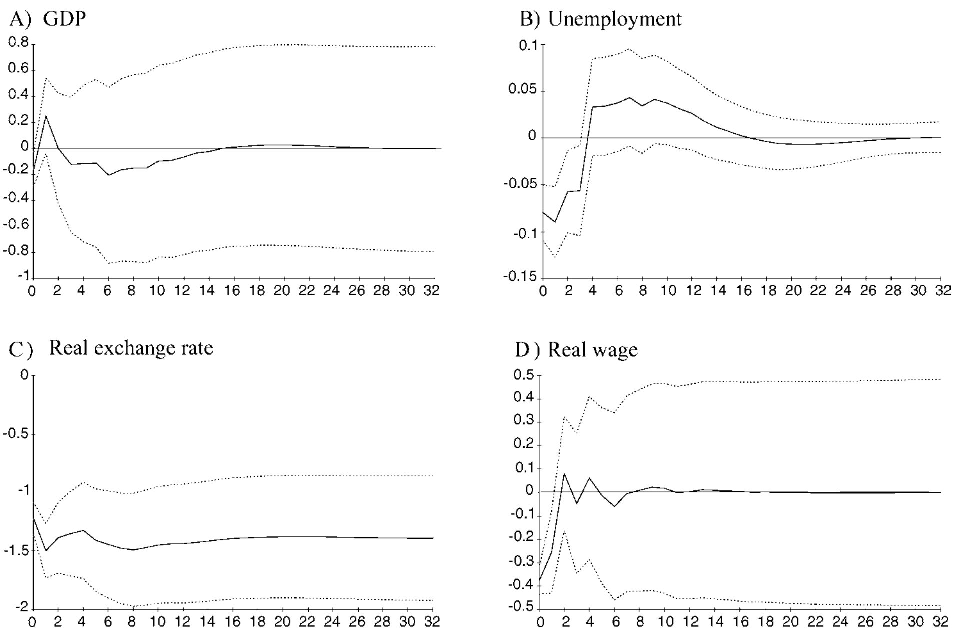

Figure 2. **Impulse responses: real demand shocks.**

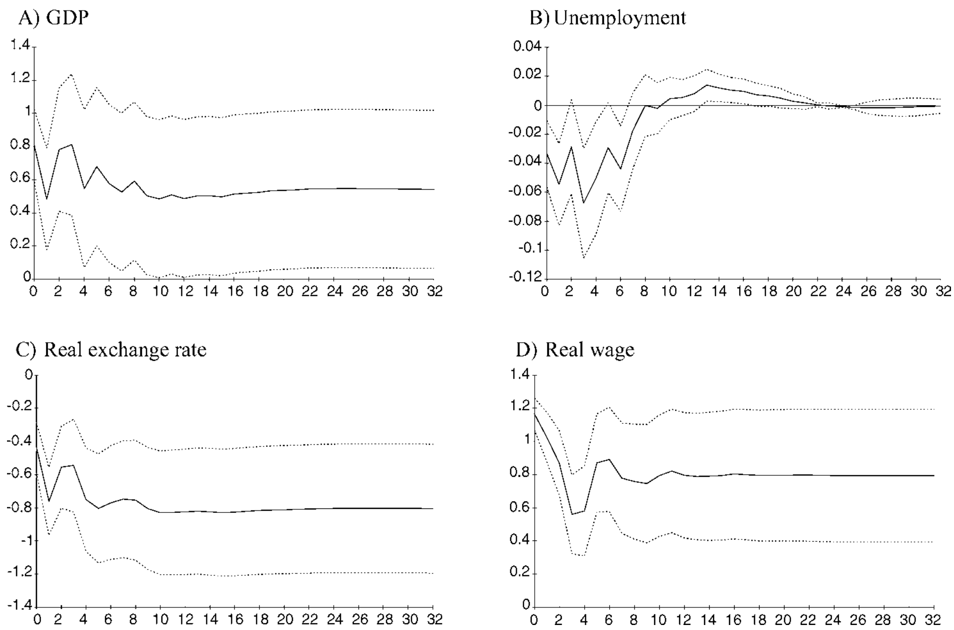

Figure 3. **Impulse responses: productivity shocks.**

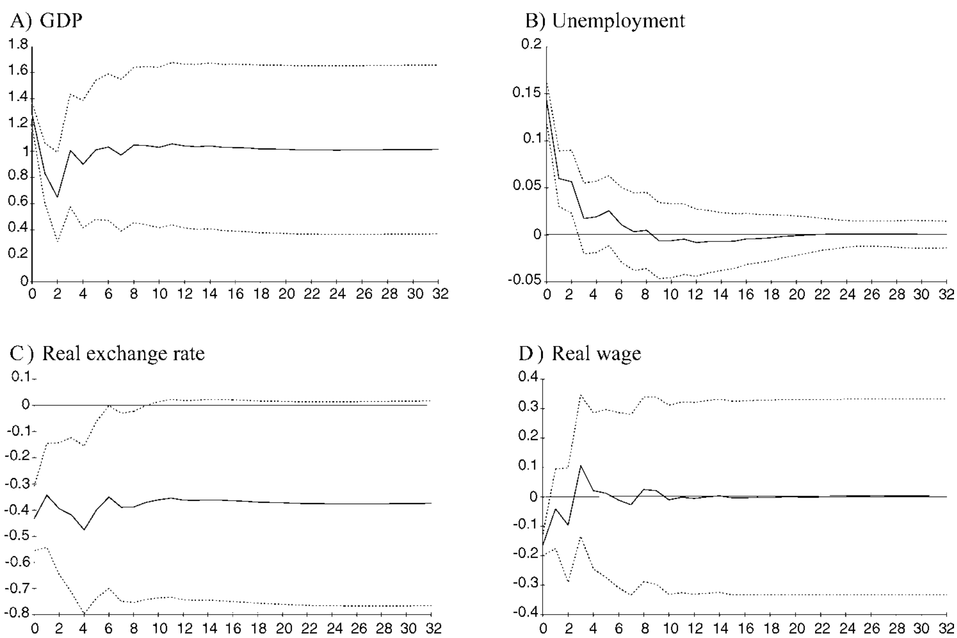

Figure 4. **Impulse responses: labour supply shocks.**

equilibrium after three years. These findings suggest that real demand shocks have little output effect as the exchange rate may have appreciated to such an extent that the trade balance deteriorates, leaving output unchanged in the long run. However, as will be discussed further below in Section 4, the fact that real demand shocks have a larger effect on unemployment may suggest that they capture the part of real demand policy (e.g. fiscal policy) that has been especially aimed towards achieving full employment. Finally, following a real demand shock, the real wage behaves countercyclically the first year, again consistent with an aggregate demand driven theory of business cycles where wages are sticky.

A productivity shock has a positive long run effect on output. The unemployment rate falls temporarily, but the effect is small. A productivity shock appreciates the real exchange rate. This is typical for a small open resource rich economy like Norway, where the rapid growth of the energy sector had labour demand effects that increased output and appreciated the real exchange rate. As expected, a productivity shock increases the real wage permanently and the effect is stabilised after two years.

A labour supply shock increases GDP. However, the rate of unemployment also increases the first year, as demand for employment fails to increase by enough to match the higher supply potential (see also Blanchard and Quah, 1989). A labour supply shock reduces the real wage temporarily. The real exchange rate appreciates temporarily, but thereafter depreciates back to equilibrium, when the effect is not significant different from zero after a year.

The variance decompositions for real output and unemployment are seen in Table 1, whereas the variance decomposition for the real exchange rate and the real wage are given in Table 2. In the short run, all shocks but the real demand shocks are important sources of the fluctuations in GDP, whereas (as expected) in the long run, labour supply and (to a lesser extent) productivity shocks dominate. Nominal and labour supply shocks are the most important factors behind unemployment variation at all horizons, although real

Table 1. Variance decompositions of GDP and unemployment[1].

	GDP				Unemployment			
Quarters	PR	LS	NOM	RD	PR	LS	NOM	RD
1	18.1	45.5	35.5	1.0	2.1	37.8	48.4	11.7
2	19.0	49.9	29.1	2.0	4.9	28.5	49.5	17.1
4	26.0	45.3	27.3	1.3	6.5	18.8	60.5	14.2
8	25.0	53.9	19.6	1.5	6.8	12.9	68.4	11.9
12	23.6	60.9	14.2	1.4	6.5	12.3	67.6	13.6
32	22.3	70.9	6.2	0.6	6.6	12.1	67.4	13.8

[1]PR: productivity shock, LS: labour supply shock, NOM: nominal shock and RD: real demand shock.

Table 2. Variance decompositions of real exchange rate and real wage[1].

	Real exchange rate				Real wage			
Quarters	PR	LS	NOM	RD	PR	LS	NOM	RD
1	9.8	9.6	5.0	75.6	88.7	1.7	0.1	9.4
2	15.5	6.1	4.0	74.5	89.9	1.1	0.1	8.0
4	13.9	6.4	4.2	75.4	92.7	1.3	0.2	5.8
8	17.7	6.2	2.9	73.2	95.2	0.8	0.4	3.6
12	19.3	5.6	2.0	73.2	96.5	0.6	0.3	2.6
32	22.3	5.2	0.7	71.7	98.6	0.2	0.1	1.1

[1] PR: productivity shock, LS: labour supply shock, NOM: nominal shock and RD: real demand shock.

demand shocks also play a non-negligible role in explaining unemployment fluctuations.

Real demand shocks explain most of the variation in the real exchange rate at all horizons, although eventually, productivity shocks also contribute significantly to the real exchange rate variation, emphasising the importance of "real" shocks in the long run. Productivity shocks are by far the most important shocks explaining the variation in the real wage at all horizons.

4. Is the exchange rate a shock absorber or a source of shocks?

As an important oil producing country that has chosen to remain outside the EU, Norway has been hit by idiosyncratic shocks to a larger extent than most other European countries. As a consequence, the business cycles in Norway have been asymmetric compared to the business cycles in Europe.

However, although the Norwegian economy may be facing asymmetric shocks, very little has been said about the extent to which the Norwegian exchange rate has actually succeeded in absorbing these shocks. Before one is able to assess whether Norway would gain by relinquishing its exchange rate and monetary independence by joining a monetary union, an analysis should be conducted to assess to what extent the exchange rate has actually stabilised the macroeconomy in the face of different shocks. Put simply, are the main shocks that determine output variation the same shocks as explain the exchange rate movements?

Previous studies by Canzoneri, Vallés, and Viñals (1996), Thomas (1997), Funke (2000) and Artis and Ehrmann (2000) set out to analyse the role of the exchange rate as a shock absorber for selected European countries (not including Norway). They find that, with the possible exception of UK and Canada, the exchange rate has had very little effect on economic fluctuations. Hence the cost of relinquishing exchange rate independence appears small. This study differs from earlier ones in many respects, but one difference is the fact that whereas many studies using VAR models lump all supply shocks together as one "aggregate supply shock", here supply shocks are separated into two independent shocks; Labour supply and productivity shocks. As was discussed above, this separation turned out to be particularly useful for Norway, since the shocks had very different effects on the economy.

From the variance decomposition reported above, we saw that the main shocks that determine output variation are not the same shocks as explain most of the real exchange rate variation. In particular, at the one- to two-year horizon (which is the most policy relevant), 50 pct. of GDP movements are explained by labour supply shocks, whereas the same shocks explain approximately 5 pct. of the exchange rate determination. Nominal shocks are also important for output movements in the short run, explaining 20–30 pct. of the GDP fluctuations, but less than 5 pct. of the real exchange rate variation. At the same time, real demand shocks contribute to 70 pct. of the real exchange rate variation, versus only 1.5 pct. of the output variations.

There is, however, one common shock to both output and real exchange rate variation, and that is the productivity shock. The shock becomes more important as the horizon is increased (and affects output before the real exchange rate), but after 3–4 years, it explains approximately 20 pct. of the variation in each of the variables.

To summarize. Three findings stand out in particular in the analysis, with conflicting implications. First, the exchange rate is very responsive to real demand shocks, but these shocks are not transmitted to the real economy to a large degree (although the effect on the unemployment rate is larger than on output). The importance of real demand shocks in explaining real exchange rate movements suggests instead that these shocks may have captured the exchange rate instruments that were used extensively in this period to devalue the exchange rate each time competitiveness was low (and unemployment high). In particular, the major currency devaluations in 1977Q3, 1978Q1, 1982Q3, 1982Q4 and 1984Q3 all followed periods of increasing unemployment. Hence, rather than absorbing shocks, the exchange rate market seems to be a source of shocks itself. To the extent that these are controllable policy shocks, Norway has little to lose by joining a monetary union.

Second, given that nominal shocks have an important short run effect on real output and unemployment, retaining an independent monetary policy seems clearly attractive as stabilisation is possible. On the other hand, the weak significance of nominal shocks on the exchange rate emphasises that no exchange rate adjustment is needed to restore equilibrium. Hence, the exchange rate plays no role in transmitting these shocks.

Third, productivity shocks seem to be common to both real output and real exchange rate variation, at least after two years. Relinquishing exchange rate independence will therefore imply that the transmission mechanisms will change, so that if the effect of a productivity shock on the real exchange rate comes through nominal exchange rate adjustments, it may now come via price movements. This will be examined further below, where we perform some sensitivity analysis, by analysing the responses of prices to the above identified shocks.

5. Extension of the model

Faust and Leeper (1997) have criticised the use of long run restrictions to identify structural shocks, and show that unless the economy satisfies some types of strong restrictions, the long run restrictions will be unreliable. In particular they argue that for the long run restrictions to give reliable results, the aggregation of shocks in small models should be checked for consistency using alternative models.[8] This is the approach taken here. First, as the model presented in Section 1 could have been solved for the growth rate of prices rather than for the unemployment rate, I replace the unemployment rate with inflation and re-estimate the model. This allows me to check whether the impulse responses remain invariant to this new model specification. In addition, I can test for overidentifying restrictions by investigating whether the implied price response is consistent with the theoretical model presented in Section 1. Second, I then introduce the real price of oil into the VAR model, to investigate whether oil price shocks are important sources behind the economic fluctuations in Norway. In particular, I want to check whether the rise in the oil price throughout the 1970s can account for the real exchange rate appreciation already captured by the productivity shocks. The answer to this question is no.[9]

5.1. A model containing prices

Solving the model described in Section 1 for prices (consumer price index; CPI) instead of unemployment, I can find the implied effect of each of the four shocks on prices. Clearly, the responses of the CPI are consistent with model predictions, and satisfy a set of overidentifying restrictions (see Appendix B). The price level increases gradually with both nominal and real demand shocks, stabilizing after 3–4 years at a permanent higher level. However, the effect of a real demand shock is small compared to the nominal shock, emphasising further that there are relatively few spill over effects of real demand shocks to prices, as well as the real economy. The effect of a productivity shock on prices is small and approaching zero the first year, before it increases and is just significantly different from zero in the long run. Hence, as suggested above, this emphasises that the non-negligible effect of a productivity shock on the real exchange rate comes via a nominal exchange rate adjustment rather than a price adjustment. Relinquishing the exchange rate will therefore imply that these transmission mechanisms may change. Finally, labour supply shocks reduce the price level monotonically as expected.

The responses of the three other variables (GDP, real wage and real exchange rate) to the identified shocks are also quite similar to what I got using the benchmark model, although now nominal shocks play a smaller (albeit still significant) role for output stabilisation than previously. Hence, the results presented so far point in the direction that by incorporating a set of key macroeconomic variables and thereby using more than one long run restriction to identify the different shocks, I have imposed enough information to side step some of the criticism of Faust and Leeper (1997). The results also strengthen the analysis above, and suggest that relinquishing exchange rate independence may come at little cost for the real economy and prices, if the transmission mechanisms following shocks do not change. This may not be the case following productivity shock, which now has large effects on both real output and the exchange rate.

5.2. The role of the oil price

Finally, I include the real oil price in the model specifically to investigate the effects of oil price shocks on the mainland economy. Previous studies of the effects of a real oil price shock on the Norwegian economy have emphasised that Norway has gained from a higher real oil price (by increasing net wealth and demand), see e.g. Bjørnland (2000) and the references stated there. The model specified here allows for a more complex set of possible channels of influence than Bjørnland (2000). In particular, I now control for the possibility that the exchange rate may be a "petrocurrency" that appreciates when the oil price is high and depreciates when the oil price is low. For instance, Haldane (1997) has argued that a rise in oil prices can explain a large part of an appreciation in the Norwegian currency.

In the VAR analysis, the oil price shock is identified as the only shock that can have a long run effect on the real oil price. This is plausible, given the small country assumption of Norway. However, no restrictions are placed on the response of the other variables to the oil price shocks. The results suggest that an oil price shock stimulates the real economy so that GDP increases temporarily, although in the long run, the effect is not significant. The price level is virtually unchanged the first year, but thereafter it is significantly positive. The real exchange rate depreciates the first two quarters following an oil price shock, but thereafter appreciates back towards equilibrium where the effect is no longer significant. The initial deprecation of the real exchange rate to an oil price shock is consistent with the fact that the domestic price level reacts slowly to an oil price increase, while foreign prices rise immediately to the same shock.

Finally, variance decompositions emphasise that a real oil price shock explains about 5–10 pct. of the output variation in the short run (when it is significant), whereas less than 5 pct. of the variation in the other variables are explained by an oil price shock. Hence, I have found no evidence to support Haldane's (1997) claim that the oil price increases explain a large part of the Norwegian real exchange rate appreciation. Similar conclusions have also been drawn in Bjørnland and Hungnes (2002), Aliber (1990) and the references cited there.

6. Conclusions and summary

This paper analyses the interactions between the real exchange rate and the business cycle in a small open economy like Norway, to examine to what extent the exchange rate is absorbing shocks to the economy or is a source of shocks itself. To do so I have specified a structural VAR model in GDP, the real wage, the real exchange rate and the rate of unemployment (or price) that is identified through long run restrictions on the dynamic multipliers in the model. The way the model is specified, I identify four structural shocks; nominal, real demand, productivity and labour supply shocks.

The results confirm the conventional view about the existence of significant shocks with impulse responses consistent with a standard open economy model of economic fluctuations. The results are also robust to alternative specifications of the model. The results emphasise that the main shocks that determine output variation (labour supply and nominal shocks) are not the same shocks as explain most of the real exchange rate variation (real demand shocks). Only productivity shocks seem to be common to both real output and real exchange rate variation, at least after two years.

The results presented here point in different directions, and one can therefore not conclude that Norway would have little to lose by joining the EMU and thereby relinquishing exchange rate and monetary independence. Clearly, the importance of real demand shocks in explaining real exchange rate movements suggests that to the extent that these are controllable policy shocks, Norway has little to lose by joining EMU. On the other hand, the importance of nominal shocks for GDP suggests that stabilisation is possible, hence giving up monetary independence will imply that Norway may no longer have the same possibility to tackle idiosyncratic shocks in the future.

Appendix A. Data and model specifications

The sample runs from 1972Q1–1994Q4. Using first differences and four lags in the VAR, the estimation sample is 1973Q2–1994Q4. All variables except the real exchange rate and the real oil price are seasonally adjusted quarterly variables, taken from Kvarts Database, Statistics Norway. Gross Domestic Product, *mainland Norway* (GDP less petroleum activities and ocean transport) constant 1991 prices (y); Real wage in mainland Norway; nominal wages deflated by the implicit price deflator of GDP mainland Norway,[10] (rw); Unemployment rate (u); Consumer price index (p).

The real exchange rate (s) is taken from Troll8, Norges Bank, and is the Central Bank exchange rate index, deflated by a set of relative consumer prices. The real oil price (op) is calculated from the nominal oil price (Saudi Arabian Light-34, USD per barrel, fob- (n.s.a.). Prior to 1980, posted prices, thereafter spot prices) and deflated by the implicit GDP deflator, mainland Norway. (Source: OPEC BULLETIN and Statistics Norway. All variables except the unemployment rate are in logarithms.)

Table A.1. Augmented Dickey-Fuller unit-root tests, 1974Q2–1994Q4[1,2].

Series	ADF (lags)	t_{ADF}	Series	ADF (lags)	t_{ADF}
y	ADF (1)	−2.01	Δy	ADF (5)	−4.51***
s	ADF (4)	−1.88	Δs	ADF (4)	−4.27***
rw	ADF (5)	−3.27	Δrw	ADF (4)	−3.88***
u	ADF (2)	−2.25	Δu	ADF (1)	−5.03***

[1] The number of lags used are determined by selecting the highest lag with a significant t value on the last lag, as suggested by Doornik and Hendry (1994).
[2] A constant and a time trend are included in the regression for levels, a constant is included when testing first differences.
**Rejection of the unit root hypothesis at the 5 pct. level.
***Rejection of the unit root hypothesis at the 2.5 pct. level.

Table A.2. Sequential unit-roots test 1974Q2–1994Q4[1].

Series	Model	Period	Minimum t-statistics
y	A	1988Q2	−4.08
s	C	1989Q4	−3.34
rw	B	1976Q4	−4.01
u	A	1988Q2	−4.68*

[1] Critical values were taken from Zivot and Andrews (1992, pp. 256–257). Three alternative hypothesis for the trend are considered: (A) Change in the level; (B) Change in the growth rate; (C) Change in both the level and the growth rate.
*Rejection of the unit root hypothesis at the 10 percentage level.

Table A.3. Mis-specification tests, benchmark model, 1973Q2–1994Q4[1].

Test	Statistic	Δy	Δs	Δrw	U
Q Test[2]	Q (21)	10.88	16.60	21.70	26.58
		(0.96)	(0.74)	(0.42)	(0.18)
AR 1-2[3]	X^2 (2)	3.48	3.98	0.81	4.05
		(0.18)	(0.14)	(0.66)	(0.13)
ARCH[4]	X^2 (4)	5.91	5.69	9.44	0.52
		(0.21)	(0.22)	(0.06)	(0.97)
Normality[5]	X^2 (2)	6.99	2.91	4.70	42.57
		(0.05)	(0.23)	(0.10)	(0.00)

[1] The number in brackets are the p-values of the test statistics. All statistics have been calculated using RATS, except the normality test in (5), that has been calculated using PcFiml 8.0 (see Doornik and Hendry, 1994).
[2] The Ljung-Box Q test against high-order serial correlation.
[3] General LM test for serial correlation of order 2.
[4] LM test for 4th order ARCH in the residuals, proposed by Engle (1982).
[5] Test of normality, see Doornik and Hendry (1994) for references and descriptions.

Table A.4. Johansen cointegration tests; Cointegrating vector (y_t, rw_t, s_t, u_t), 1973Q2–1994Q4[1,2].

H_0	H_1	Critical value 5% λ_{max}	Critical value 5% λ_{trace}	λ_{max}	df-adj[3] λ_{max}	λ_{trace}	df-adj[3] λ_{trace}
$r = 0$	$r \geq 1$	31.46	62.99	30.62	24.99	71.09	58.01
$r \leq 1$	$r \geq 2$	25.54	42.44	21.13	17.24	40.46	33.02
$r \leq 2$	$r \geq 3$	18.96	25.32	13.25	10.81	19.33	15.78
$r \leq 3$	$r \geq 4$	12.25	12.25	6.09	4.97	6.09	4.97

[1] All test-statistics are calculated using PcFiml 8.0 (see Doornik and Hendry, 1994). Critical values are taken from Table 2* in Osterwald-Lenum (1992), corresponding to the case where the constant is unrestricted but the trend restricted.
[2] u refers to unemployment rate adjusted for the structural break in 1988.
[3] df-adj refers to the eigenvalue adjusted for degrees of freedom (see Reimers, 1992).

Appendix B. Sensitivity analysis

B.1. The inflation model

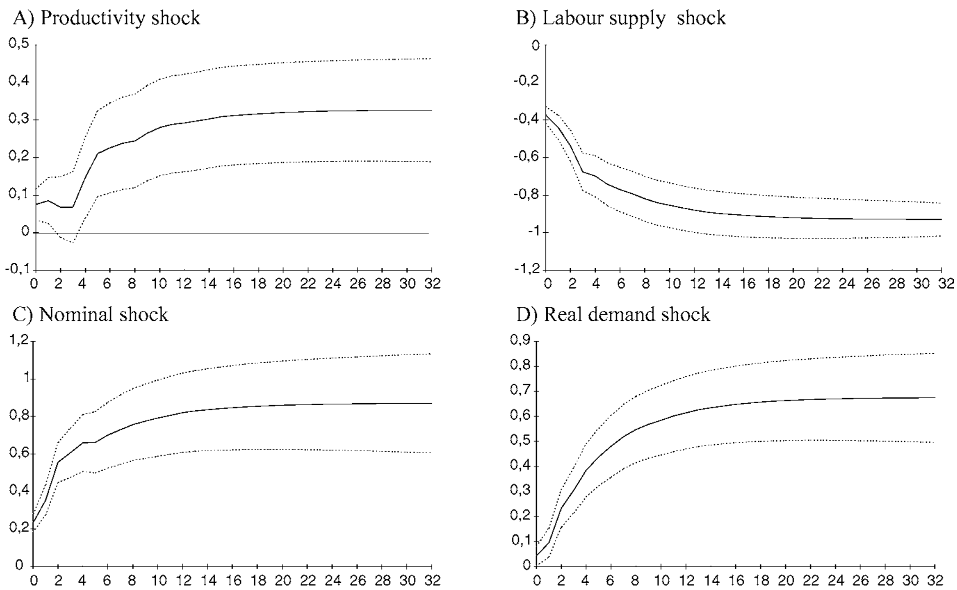

Figure B.1. Impulse responses: price.

Table B.1. Variance decompositions of GDP and price[1].

	GDP				Price			
Quarters	PR	LS	NOM	RD	PR	LS	NOM	RD
1	18.4	58.5	17.4	5.7	2.8	69.2	27.1	0.9
4	27.2	56.5	9.4	6.9	1.1	50.9	40.5	7.5
12	24.0	68.9	4.0	3.2	3.4	43.6	36.6	16.4
32	19.8	77.6	1.5	1.2	4.4	40.8	35.2	19.5

[1] PR: productivity shock, LS: labour supply shock, NOM: nominal shock and RD: real demand shock.

Table B.2. Variance decompositions of real exchange rate and real wage[1].

	Real exchange rate				Real wage			
Quarters	PR	LS	NOM	RD	PR	LS	NOM	RD
1	18.1	5.1	7.6	69.2	82.1	1.3	0.3	16.4
4	19.9	3.2	9.8	67.0	88.1	1.5	1.6	8.9
12	22.6	5.7	3.7	68.0	94.4	0.8	0.9	3.9
32	22.6	8.1	1.1	68.1	97.7	0.3	0.4	1.6

[1] See footnote 1, Table B.1 for definitions.

B.2. Oil prices included in the benchmark model

Table B.3. Variance decompositions of GDP and unemployment[1].

	GDP					Unemployment				
Quarters	OP	PR	LS	NOM	RD	OP	PR	LS	NOM	RD
1	4.2	17.0	39.8	38.4	1.0	4.8	1.9	33.6	48.6	11.1
4	5.4	22.1	40.8	31.2	0.5	4.5	5.9	16.3	60.2	13.2
12	12.6	18.1	53.0	15.5	0.8	3.2	5.2	11.1	68.1	12.5
20	14.3	16.3	60.0	9.9	0.5	3.2	5.3	10.9	68.1	12.7

[1] OP: oil price shock, PR: productivity shock, LS: labour supply shock, NOM: nominal shock and RD: real demand shock.

Table B.4. Variance decompositions of real exchange rate and real wage[1].

	Real exchange rate					Real wage				
Quarters	OP	PR	LS	NOM	RD	OP	PR	LS	NOM	RD
1	3.6	12.4	11.7	5.3	67.1	0.0	88.6	1.5	0.0	9.9
4	3.2	14.3	9.1	4.2	69.2	1.7	91.2	1.5	0.2	5.4
12	1.0	18.9	8.9	1.8	69.4	2.8	93.9	0.7	0.3	2.4
20	0.7	20.6	8.9	1.1	68.8	3.0	94.9	0.4	0.2	1.5

[1] See footnote 1, Table B.3 for definitions.

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Notes

1. A similar representation was presented in Dolado and Lopez-Solido (1996), although they also introduced a labour supply discouragement factor into (5).
2. The inclusion of the real exchange rate into the VAR model is also important when analysing the effects of different shocks on an open economy. For instance, studies that fail to take account of the real exchange rate channel, may typically misrepresent the importance of monetary shocks as a driving force of the business cycle (see also Cushman and Zha, 1997).
3. A related explanation for why supply side factors like productivity may appreciate the real exchange rate in the long run, is due to Balassa (1964) and Samuelson (1964). The Balassa-Samuelson hypothesis states that the real exchange rate may appreciate if there are exceptionally large differences between productivity growth in the traded and the nontraded sector. A rise in productivity in the traded goods sector will lead to a wage effect only (as prices are tied down by the world price level). With no corresponding increase in productivity in the nontraded sector, prices in the nontraded sector must rise (to match the higher wage level), appreciating the real exchange rate.
4. The assumptions of stationarity are discussed and verified empirically below in Section 4.
5. To allow for somewhat more flexibility, I let the structural break occur for two quarters, 1988Q2–1988Q3. A deterministic trend is also included in the regression as it comes out significant (although it is virtually flat before and after the break date).
6. The non-normality in the unemployment rate vanishes when we focus on the period prior to the break in 1988. As the results using this shorter sample will be virtually unchanged from when we use the full sample, I choose to ignore the remaining non-normality in the unemployment rate (results can be obtained from the author on request).

7. The standard errors reported are calculated using Mount Carlo simulation based on normal random drawings from the distribution of the reduced form VAR. The draws are made directly from the posterior distribution of the VAR coefficients. The standard errors that correspond to the distributions in the $D(L)$ matrix are then calculated using the estimate of D_0.
8. Strictly speaking, Faust and Leeper's (1997) critique of the use of long run restrictions in VAR models refers to a bivariate model using only *one* long run restriction like that of Blanchard and Quah (1989), where the problem stems from the fact that the underlying model has more sources of shocks (with sufficiently different dynamic effects on the variables considered) than does the estimated model. The fact that I here allow for more variables and use several long run restrictions together, may by itself be sufficient to side step this criticism.
9. To be consistent with the benchmark model, all VAR models reported below contain four lags. With four lags, all models satisfy misspecification tests, and there is no evidence of cointegration between the levels of the variables.
10. Although the theoretical model presented in Section 1 suggested that the real wage should be deflated by the CPI, here real wages are deflated by the GDP deflator for mainland Norway, since nominal wages are also measured for mainland Norway.

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