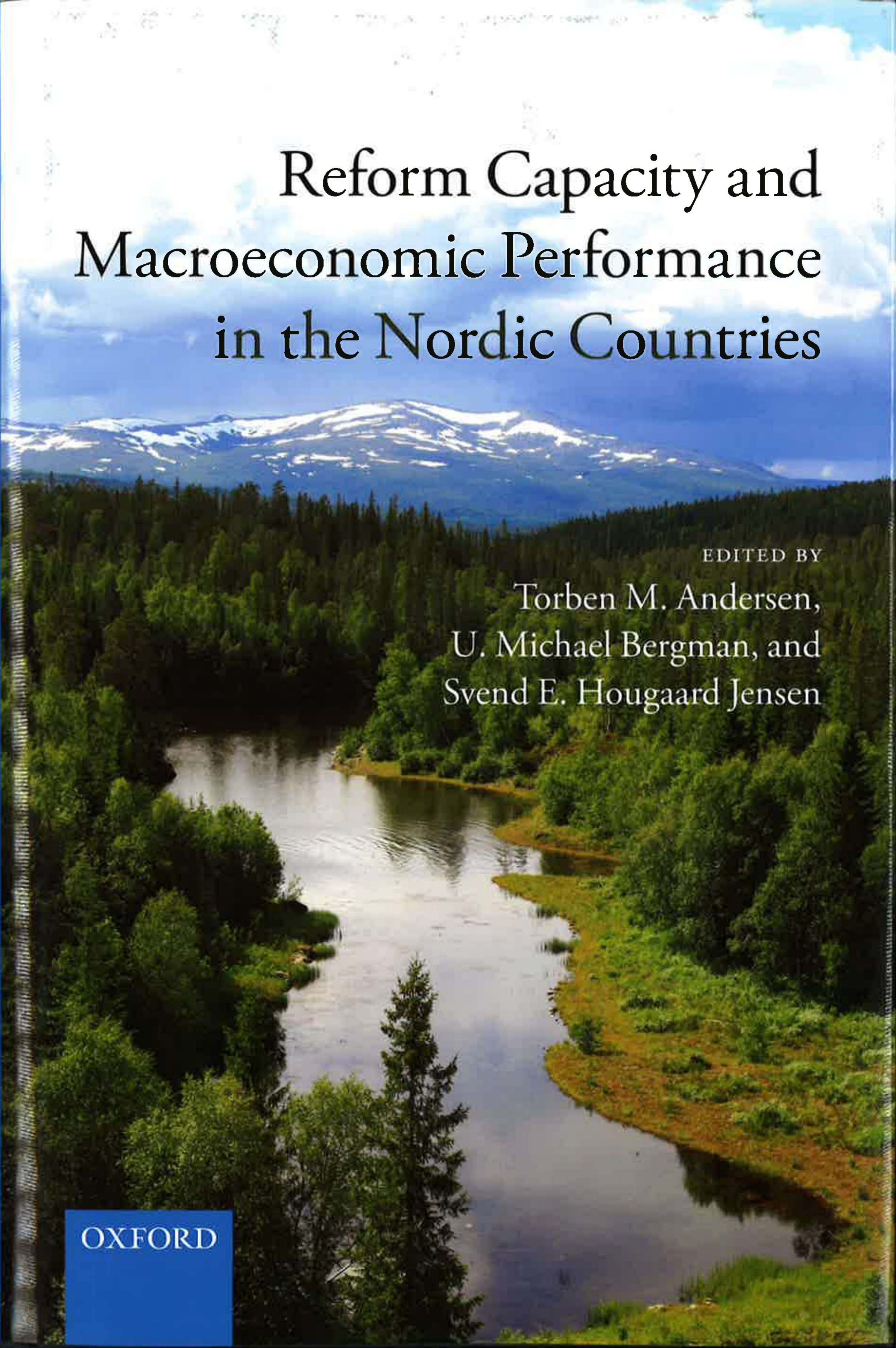

Reform Capacity and Macroeconomic Performance in the Nordic Countries

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6

Monetary Policy and Exchange Rate Stabilization in Norway and Sweden

Hilde C. Bjørnland and Junior Maih

6.1 Introduction

Norway and Sweden have both formally adopted inflation targeting as their framework for monetary policy.[1] Sweden switched to inflation targeting in the early 1990s after currency crises and the collapse of its fixed-exchange-rate regime to the ECU in the autumn of 1992.[2] The country has had a policy of not intervening systematically in the foreign exchange market since then.

Norway abandoned the fixed-exchange-rate system in December 1992, and the foreign exchange regime thereafter became more flexible. Monetary policy was still oriented towards maintaining a stable exchange rate in relation to European currencies, although without defining a central exchange rate with fluctuation margins that would be defended by interventions. Eventually, in early 2001, a formal inflation-targeting framework was adopted.

In this chapter we analyse in detail the economic performance of key economic variables in two small open economies: Norway and Sweden, prior to and after implementing inflation targeting as their framework for monetary policy. Having established some stylized facts, we investigate the role of monetary policy for stabilizing economic performance. Specifically, we analyse to what extent monetary policy has contributed to stabilizing the exchange rate (and thereby also inflation) over the period examined.

[1] The views expressed in this chapter are those of the authors and do not necessarily reflect the views of Norges Bank. We thank Michael Bergman, Roberto Billi, and the participants at the conference 'Reform Capacity and Macroeconomic Performance in the Nordic Countries' for constructive comments.

[2] The Swedish inflation target was announced in January 1993 and became operative in 1995 (Berg, 2005).

To examine this question, we build on previous work by Alstadheim, Bjørnland, and Maih (2013), who have developed a model that allows for regime changes in the monetary policy responses and shocks that hit small open economies. With this framework we explore the extent to which the inflation-targeting central banks in Norway and Sweden put the same emphasis on stabilizing the exchange rate throughout the period, independently of the known regime changes and the volatility of shocks that occurred over the period. Furthermore, we analyse whether the effects of terms-of-trade shocks on output and inflation are exacerbated in countries that respond strongly to the exchange rate.[3]

We have three main findings. *First,* we find that volatility has declined over time for all the key economic variables except GDP in Sweden and the exchange rate in Norway. Hence, good policies (and maybe also good luck), have made the Scandinavian economies overall more stable. The exception is the financial crisis when output in Sweden was hit hard.

Second, turning to the recent inflation-targeting period, we find that the interest rate and terms of trade are substantially more volatile in Norway than in Sweden, while the other domestic variables (including the exchange rate) have about the same volatility. This suggests that monetary policy could have a role in stabilizing the exchange rate (and subsequently inflation) in Norway, in particular when terms of trade shocks are a major source of disturbance to the economy.

Third, we find that the central bank in Sweden has put less weight on stabilizing the exchange rate, as measured by the response to the nominal effective exchange rate, since inflation targeting was adopted in the early 1990s. For Norway, we do not observe a systematic change in the response to the nominal effective exchange rate. In fact, the interest-rate response to the exchange rate has remained high throughout the period analysed. This could explain why the exchange rate remains relatively stable in Norway despite high volatility in the terms of trade. We also show that by responding strongly to the exchange rate, the adverse effects of terms-of-trade shocks on the exchange rate and subsequently output are lessened. Monetary policy therefore contributes to exacerbate a terms-of-trade-led boom in the economy, by boosting instead output and inflation.

The remainder of the chapter is structured as follows: in Section 2, we present some stylized facts of business cycles in Norway and Sweden, comparing with other countries wherever relevant. Section 3 briefly describes the small-open-economy New Keynesian model, while the estimation procedure is briefly described in Section 4. Section 5 presents the data, while in Section 6 we report the results. Section 7 concludes.

[3] To analyse this question we use new solution algorithms developed by Maih (2012).

6.2 Economic Performance in Norway and Sweden

We start by examining volatility of key economic variables in the period prior to and after inflation targeting was adopted in Norway and Sweden. Definition of variables and their sources is described in the Appendix. To be able to compare the two countries, we split the sample in 1999. That is, Table 6.1 displays the standard deviation of key variables for the period 1983–99, while Table 6.2 displays standard deviations from 2000–11. Although Norway adopted inflation targeting formally in 2001, monetary policy was already geared towards stable inflation rates, from 1999 (Gjedrem, 2001). Hence, splitting the sample at 1999 seems reasonable. Sweden had an operative inflation target in place from 1995 (Berg, 2005). However, splitting the sample in 1995 would not change the results much for Sweden, hence we keep the same sample for the two countries for ease of comparison.

Focusing first on the volatility of the domestic variables, GDP, annual inflation, the interest rate, and the nominal effective exchange rate, we find that volatility has fallen over time for most variables.[4] One exception is for GDP in Sweden and for the exchange rate in Norway, where volatility is substantially higher in the inflation-targeting period. Hence, good policies (and maybe also good luck), have made the Scandinavian economies more stable over time. Yet, there are some exceptions which merit some further analysis, that we will discuss in the end.

It is also interesting to note that for the early sample 1983–99, volatility of both inflation and the exchange rate are higher in Sweden than in Norway. This suggests one reason for why Sweden switched to an inflation-targeting framework earlier than Norway. The fixed-exchange-rate regime did not provide overall stability in the Swedish economy, at least compared to Norway.

Turning to the recent inflation-targeting period, among the four variables mentioned above, only the interest rate seems to be substantially more volatile in Norway than in Sweden (almost twice as volatile). This is actually quite extraordinary, as the terms of trade are about five times more volatile in Norway than in Sweden (see Tables 6.1 and 6.2), suggesting that inflation and the exchange rate should also be much more volatile.

This is not the case. The fact that the interest rate and terms of trade are more volatile in Norway than Sweden, while the other domestic economic variables have about the same volatility, motivates us to examine the role of monetary policy in stabilizing economic performance.

[4] GDP and the nominal effective exchange rate are transformed to first differences (quarter-on-quarter changes) to be stationary.

Table 6.1. Norway and Sweden: volatility (1983–99)

	GDP	Inflation	Interest rate	Exchange rate	Terms of Trade
Norway	1.28	2.19	3.76	1.59	5.48
Sweden	0.64	3.18	3.44	2.75	1.19

Table 6.2. Norway and Sweden: volatility (2000–11)

	GDP	Inflation	Interest rate	Exchange rate	Terms of Trade
Norway	1.01	1.15	2.02	2.76	5.59
Sweden	1.06	1.10	1.33	2.54	1.18

6.2.1 *Economic Performance in the Inflation-Targeting Period*

Having established some overall stylized facts prior to and after the inflation-targeting period, we now turn to examine in more detail economic performance in the last decade or so (i.e. the inflation-targeting period).

The Norges Bank Watch report from 2011 (Bjørnland and Wilhelmsen, 2011) concluded that many central banks in small open economies, including Norges Bank and Sveriges Riksbank, have successfully implemented their policy within an inflation-targeting framework as best reflected in a consumer price index (CPI) inflation that has moved around the target. This is confirmed in Figure 6.1, which graphs annual inflation in the last decade (2000–11).

Compared to the other countries analysed here, an average inflation rate in Norway of 2% is neither exceptionally low nor high, with the US experiencing the highest average inflation rate of 2.4% and Sweden, with 1.5%, the lowest. However, Figure 6.1 also illustrates that CPI inflation fluctuates a lot in all countries.

Annual growth rates for GDP in mainland Norway have been 2.3% on average in the inflation-targeting period, which of the countries compared here, is only surpassed (marginally) by Sweden (see Figure 6.2). Figure 6.2 also illustrates that throughout this period, the Swedish economy experienced a serious recession in 2008/2009 following the international financial crisis. However, the recession in Norway turned out to be relatively mild. Whether this is primarily due to good policies (an active monetary and fiscal policy) or good luck (being an oil exporter when terms of trade increase) is an issue we will discuss later in more detail.

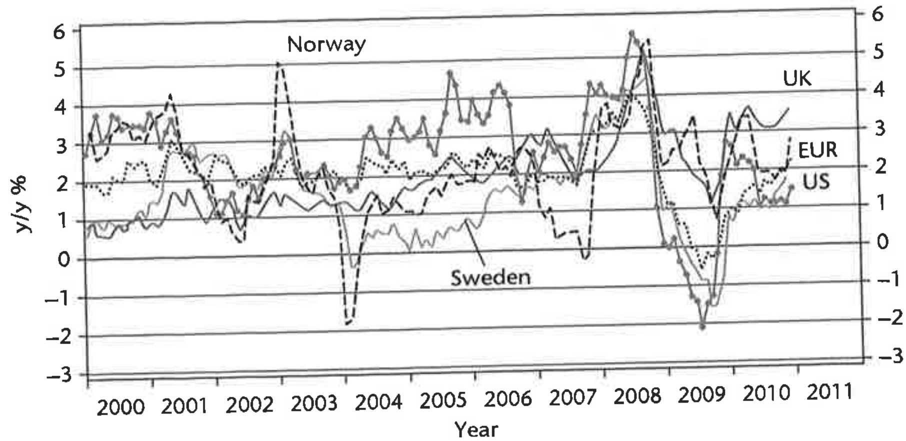


Figure 6.1. CPI inflation in selected countries
Source: Bjørnland and Wilhelmsen (2011).

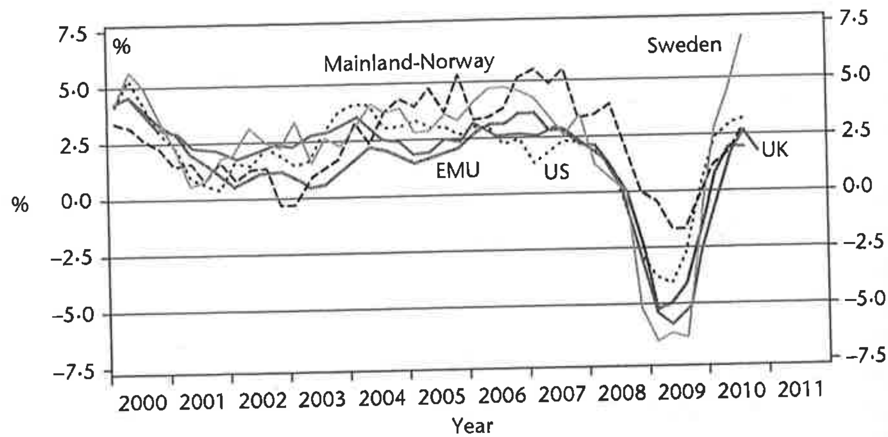


Figure 6.2. GDP in selected countries
Source: Bjørnland and Wilhelmsen (2011).

The main instrument in monetary policy is the interest rate. One important issue to explore with regard to monetary policy is how frequently and by how much the central banks have altered interest rates. Large and frequent (aggressive) interest rate changes can be beneficial if they bring about better economic performance, such as stable inflation and a lower inflation risk premium. On the other hand, large variations in interest rates increase the interest risk premium.

To evaluate the aggressiveness of monetary policy, one can look at the range of interest rates used, as well as the frequency and size of interest rate changes.

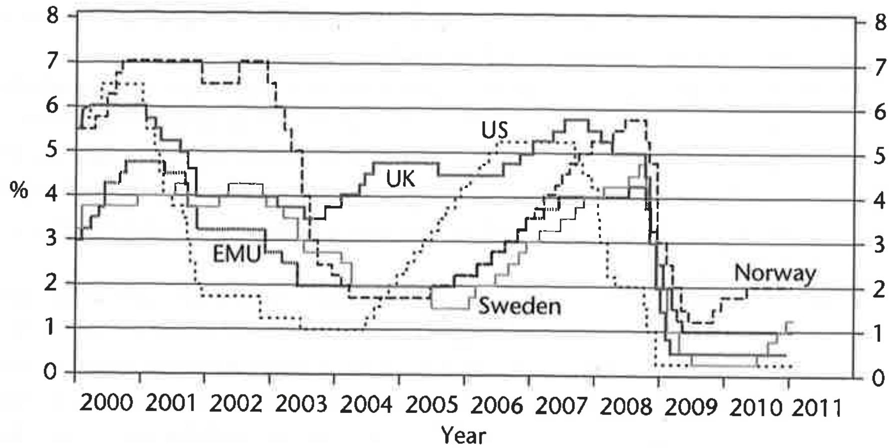


Figure 6.3. Interest rate in selected countries
Source: Bjørnland and Wilhelmsen (2011).

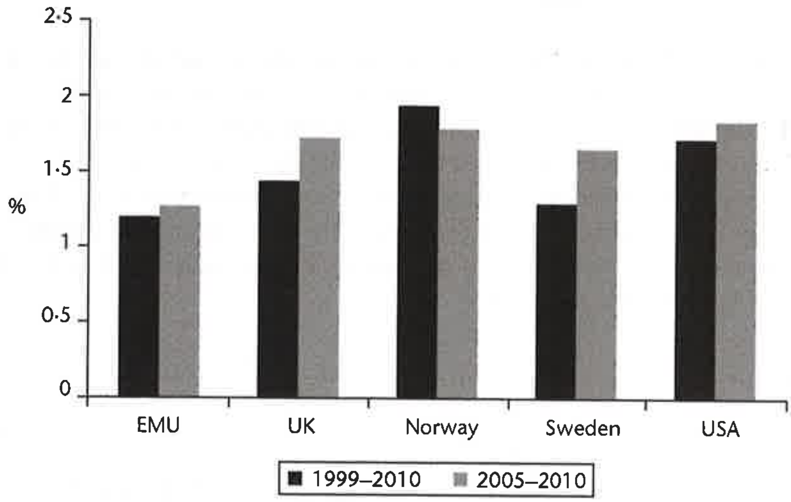


Figure 6.4. Interest rate volatility

Figure 6.3 presents the ranges, whereas Figure 6.4 presents the standard deviation of the annual changes of these interest rates.

In the period where Norges Bank has targeted inflation (informally from 1999 and then formally from 2001) Norges Bank ranks as one of the most aggressive central banks with regard to interest rate volatility (in this sample of countries, but also including other small resource-rich open economies such as Australia and New Zealand). This could reflect that Norway is exposed to more sizeable shocks/impulses or has less emphasis on gradualism, or it might also be a sign of more frequent policy errors.

The Norges Bank Watch report from 2011 believes that some of the volatility of the policy rate in Norway can be explained by the more aggressive interest rate changes in 2001–3—a period when, one could argue, policy errors may have played a role. Redoing the analysis from 2005 brings the volatility in Norway more in line with the other countries, although Norway still ranks high on volatility.

Another reason for the higher volatility of the interest rate could be that Norges Bank has a more flexible inflation target, contributing also to smoothing fluctuations in output, employment, and the exchange rate, while other central banks may tend to focus more on the stabilization of inflation. If that is the case, one would expect the growth rates in GDP and the exchange rate to be more stable in Norway than in many other countries.

This is partly confirmed. For the period 2001–11, the fluctuation in GDP has been less volatile in Norway than in countries such as Sweden and the UK. Compared to the EMU, however, Norway has only marginally more stable growth rates.

Figure 6.5 also shows that the nominal effective exchange rate in Norway appears to have been among the most stable (least volatile) exchange rates of the countries analysed here, although it has appreciated over the sample (10% since 1998). One exception to the stability is the period 2001–3, when the interest rate differential changed by a lot, thereby also contributing to exchange rate fluctuations (the exchange rate first appreciated sharply when interest rates increased, only to depreciate substantially when the interest rate was quickly brought down).

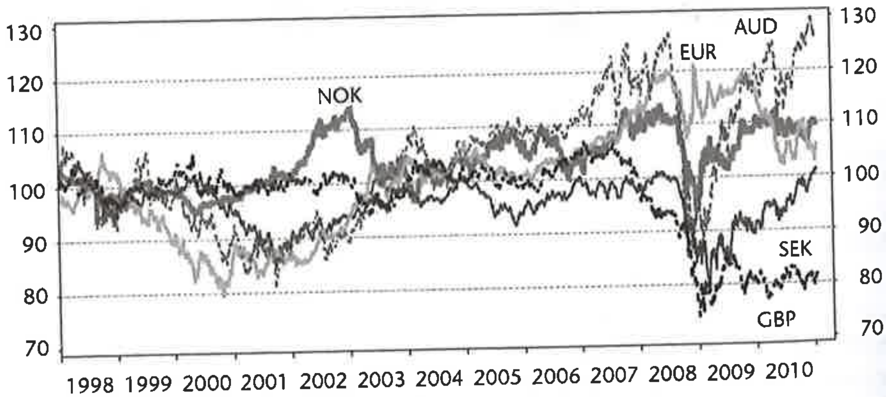


Figure 6.5. Exchange rate in selected countries (indices: 1998 = 100)
Source: Bjørnland and Wilhelmsen (2011).

The same picture of stability emerges if the nominal effective exchange rate in Norway is deflated by relative consumer prices (see Bjørnland and Wilhelmsen, 2011). The real exchange rate has appreciated slightly, particularly over the last decade, but compared to the mean of the period 1970–2010, the appreciation of the real exchange rate is modest. This could reflect the low inflation rates experienced in Norway due to the favorable terms of trade (low prices for imported consumer goods, combined with high prices for the commodities exports), preventing the real exchange rate from appreciating any further. It could also reflect that the central bank also stabilizes the exchange rate, which we will examine in more detail below.

This favorable picture changes somewhat if the nominal exchange rate is deflated by relative wages (see Bjørnland and Wilhelmsen, 2011). The resulting real exchange rate shows clear evidence of declining competitiveness in Norway compared to countries like Sweden in the inflation-targeting era. Hence, notwithstanding the low inflation rates, labour costs have not remained stable in the period. In fact, Norwegian labour costs, measured by relative unit labour costs, have reached an unprecedented high level and competitiveness has thereby weakened (see Figure 6.6).

Although some of the increase in labour costs could reflect increased productivity (having a highly productive petroleum sector), it illustrates a feature of the Norwegian economy that has become more prominent in the last decade: high

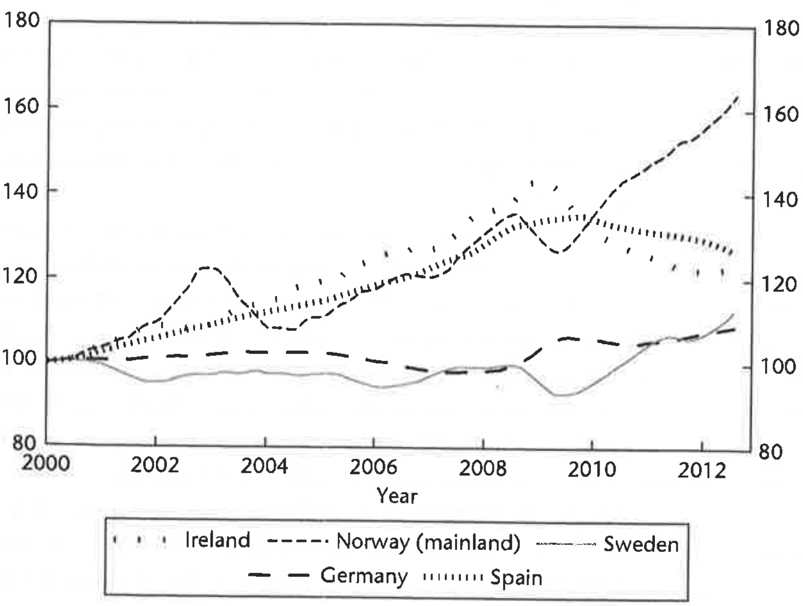


Figure 6.6. Unit labour cost in selected countries (indices: 1998 = 100)
Source: Norges Bank Annual Adresss (2013).

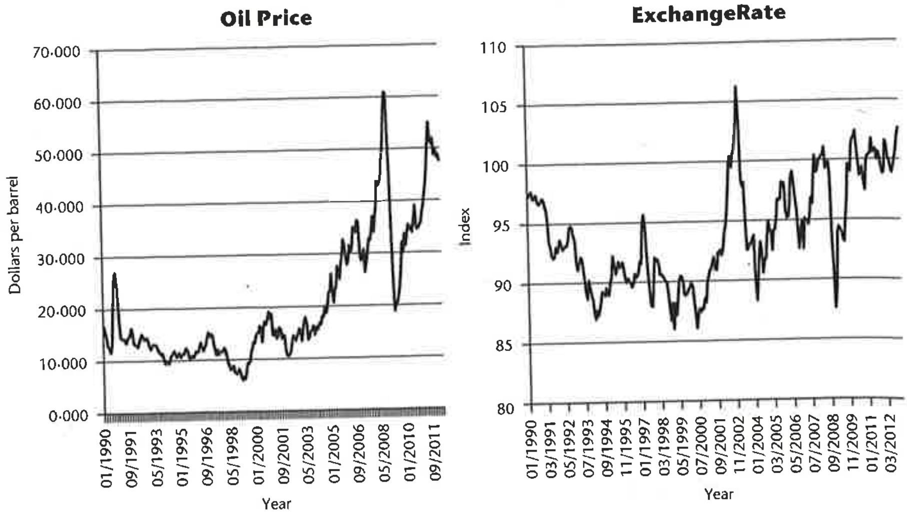


Figure 6.7. Real oil price and real exchange rate in Norway
Source: OECD.

growth in employment in the public sector has come at the expense of employment in the manufacturing sector, where there has been a gradual decline. While 1/3 of the labour force in Norway today is employed in the public sector, only 10 per cent of the labour force is employed in manufacturing industries. Although there has been a decline in manufacturing employment in many other industrial countries, the combination of the public sector's high share of employment, and the low share of employment in the manufacturing sector is unique for Norway. For instance, relative to Norway, Sweden's share of employment in manufacturing is twice as big. This has likely impacted upon wage formation and incentives.

Hence, we have shown that while both Norway and Sweden have had inflation rates close to the target and overall stable economic conditions, there are also differences between the countries in the inflation targeting-era. In particular, Norway has observed higher volatility in interest rate setting than Sweden, but volatility in inflation and the exchange rate is about the same. Furthermore, there is clear evidence of declining competitiveness in Norway compared to countries like Sweden. Hence, notwithstanding the low inflation rates, labour costs have not remained stable in the period.

Clearly, this is not all about monetary policy. Figure 6.7 shows the clear link (or at least correlation) between the real oil price (Brent prices) and real exchange rate in Norway.[5] A higher oil price has gone hand in hand with an

[5] Note that an increase is an appreciation.

appreciated exchange rate. However, if this is a concern for the central bank, stabilization of the exchange rate could be a motivation in itself.

6.3 A Structural Small Open Economy Model

In order to answer the simple question, if monetary policy has contributed to stabilizing the exchange rate, we examine a simplified version of the model in Galí and Monacelli (2005) which is adapted by Lubik and Schorfheide (2007). The model consists of a standard forward-looking (open economy) IS equation, a Phillips curve, an exchange rate equation, and a monetary policy (interest rate) rule. For a full description of the model, see Alstadheim, Bjørnland, and Maih (2013). Here we will only specify the equation for the nominal exchange rate and the policy equation, which are the focus in this chapter.

Following Lubik and Schorfheide (2007), we introduce the nominal exchange rate via the definition of consumer prices. Assuming that relative Purchasing Power Parity (PPP) holds, we have:

$$\Delta e_t = \pi_t - (1-\alpha)\Delta q_t - \pi_t^* \tag{1}$$

where e_t is the nominal exchange rate, π_t^* is world inflation, π_t is domestic inflation, and q_t is the terms of trade. In our set-up, the nominal exchange rate, domestic inflation, the terms of trade, and foreign inflation are observable variables. Of these, the exchange rate and domestic inflation rate are endogenous, while the other variables will be exogenous and follow AR-processes. From equation (1) we see that terms of trade can affect the exchange rate directly via the coefficient α, which measures the degree of openness (the import share). Hence, if $\alpha = 0$, the nominal exchange rate is determined by the inflation differential so that PPP holds.

Monetary policy is described by an interest rate rule where we assume that the central bank can adjust its instrument in response to inflation, output, and possibly a nominal exchange rate depreciation:

$$r_t = \rho_r r_{t-1} + (1-\rho_r)\left(\gamma_\pi \pi_t + \gamma_y y_t + \gamma_e \Delta e_t\right) + \varepsilon_{r,t} \tag{2}$$

We assume that the policy coefficients γ_π, γ_y and $\gamma_e \geq 0$. We also allow for a smoothing term in the rule, with $0 < \rho_r < 1$. $\varepsilon_{r,t}$ is the exogenous monetary policy shock, which can be interpreted as the unsystematic component of monetary policy (deviation from rule). With this set-up, the policy coefficients γ_π, γ_y, and γ_e should be interpreted as long-run responses—with high interest rate persistence, the estimated γ's may be quite large, and still entail small immediate responses.

Finally, we follow Lubik and Schorfheide (2007) and add a law of motion for the growth rate of the terms of trade to the system:

$$\Delta q_t = \rho_q \Delta q_{t-1} + \varepsilon_{q,t} \tag{3}$$

6.4 The Markov-Switching DSGE Model

All the algorithms used for the computations in this chapter are done using RISE, an object-oriented Matlab toolbox for solving and estimating Markov-switching rational expectations (MSRE) models.[6]

In the estimation, we will allow for two Markov chains, each with two states (for a total of four regimes). One of the chains governs the switching in the variance of shocks (high or low volatility), and the other one governs switches in the monetary policy parameters (high or low exchange rate response). The probabilities of going from one state to the other and vice versa are estimated.

Solving a general Markov-switching rational expectations model is not straightforward. The traditional solution methods for constant-parameter DSGE models cannot be used, since the solution in each state will be a function of the solution in all other states and vice versa.

In order to estimate the model, the likelihood has to be computed. Because of the presence of unobserved variables and unobserved states of the Markov chains, the likelihood has to be computed using a filtering procedure.

The chapter uses a Bayesian approach for estimating the models. In particular, we combine the likelihood with the prior density of the parameters, thereby forming the posterior kernel which we maximize to get the mode of the posterior distribution. While the estimate of the mode represents the most likely value, it also serves as a starting point for initializing the Markov chain Monte Carlo (MCMC) procedure aimed at constructing the full posterior distribution and computing the marginal data density (MDD).

Even for simple models as the one considered here, finding the mode is computationally challenging given that the posterior kernel has many peaks.

[6] RISE is the acronym for 'Rationality In Switching Environments'. It is available free of charge at <https://github.com/jmaih/RISE_toolbox> and is being developed by Junior Maih.

Our optimization strategy is to use a stochastic grid search algorithm, which is derivative-free, to locate areas of the parameter space in which the global peak may lie and then use a Newton-based optimization procedure to climb to that peak, see Maih (2012) and Alstadheim, Bjørnland, and Maih (2013) for more details.

6.5 Empirical Implementation

We proceed with a discussion on the data and a description of the choice of parameters in the model that are allowed to switch.

6.5.1 *Data*

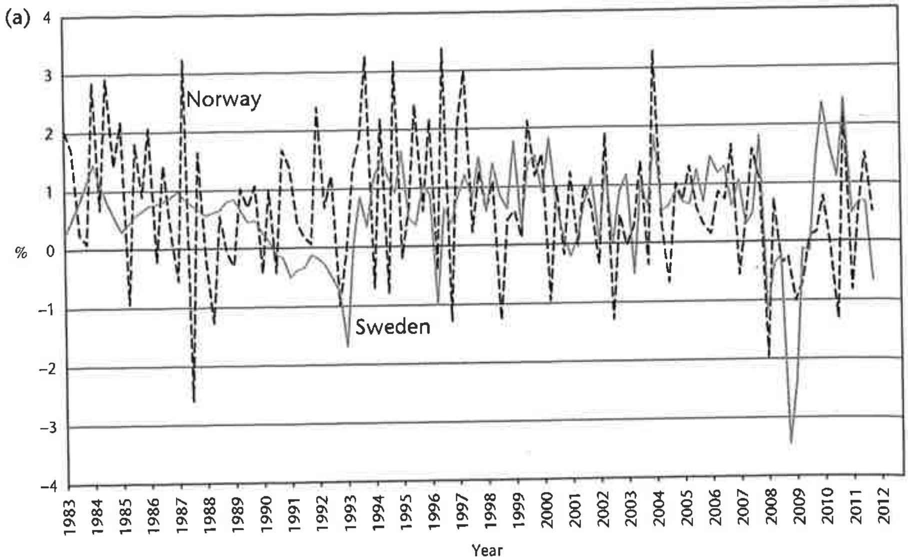
We use quarterly data for the period 1982:2–2011:4.[7] For both countries, there are four observable domestic variables: domestic real GDP, inflation, nominal effective exchange rate, and the short-term interest rate. In addition we include the terms of trade for each country and common foreign output and inflation (see Alstadheim, Bjørnland, and Maih, 2013 for how to include the foreign observables into the model). All data except the nominal interest rate and the exchange rate are seasonally adjusted.

Output growth rates are computed as log differences of GDP and multiplied by 100 to convert them into quarter-to-quarter percentages. Inflation rates are defined as log differences of the consumer price indices and multiplied by 400 to get annualized percentage rates. We approximate foreign output and inflation based on US GDP and CPI inflation respectively. We use the log differences (multiplied by 100) of the trade-weighted nominal effective exchange rate to obtain depreciation rates[8]. Percentage changes in the terms of trade are computed as log differences and multiplied by 100 while the nominal interest rate is measured in levels. All series are demeaned prior to analysis. For further details on data and the sources, see Appendix A.

Figure 6.8 plots the four domestic variables used in the analysis for Norway and Sweden over the sample 1983–2011. The picture described above is confirmed in this longer sample. First, there is definitely co-movement between

[7] The start date reflects data availability for the interest rate series in Sweden.

[8] Note that in order to make an increase correspond to a depreciation rate, we invert the exchange rate.



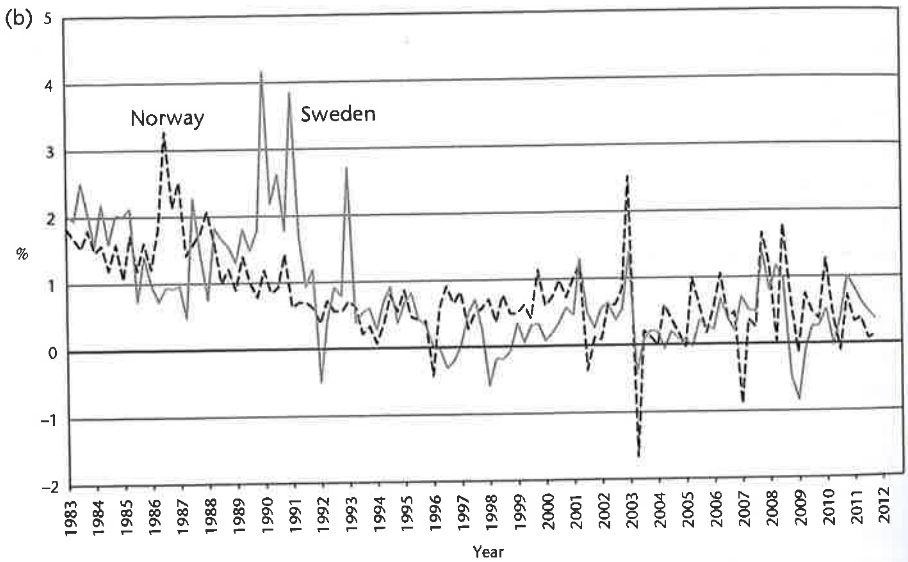


Figure 6.8. Data in the analysis, per cent changes; a) GDP and b) inflation

the series in the two countries. In particular, the interest rate series drift together across the two countries. A similar pattern is also found for inflation, although there is some variation across the two countries. Second, GDP growth in Norway is much more volatile than GDP growth in Sweden, with the possible exception of the latter part of the sample (the inflation-targeting period).

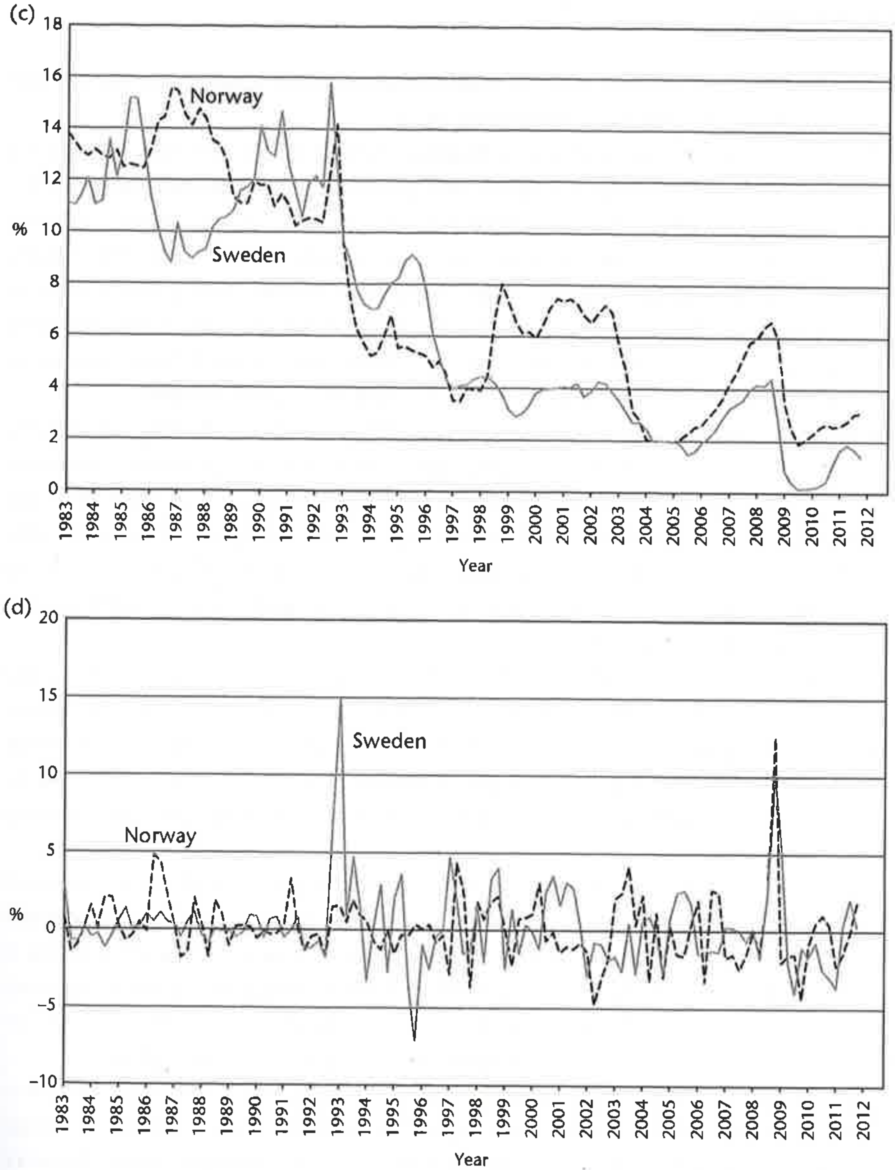


Figure 6.8. Continued; c) interest rate and d) exchange rate

Finally, the exchange rate displays more idiosyncratic movement across the two countries, being clearly more volatile in Sweden prior to the break-up of the fixed-exchange-rate regime in 1992/3.

We next set out to investigate whether empirical evidence of regime shifts and spurs of volatility can be extracted from the data, given our model framework.

6.6 Results

The structural parameters that are switching are presented in Tables 6.3 and 6.4 along with the estimated posterior mode.[9]

For each country, we will use a Markov switching model that allows for (independent) switches in volatility and parameters in the monetary policy rule. That is, we allow the parameters ρ_r, γ_π, γ_y, and γ_e to follow an independent two-state Markov process, where we denote the low-response regime as $(policy, low)$ and the high-response regime as $(policy, high)$. For a systematic comparison between the two countries, we normalize the high-response regime $(policy, high)$ to be the regime where the central bank responds strongly to the exchange rate, i.e. $\gamma_e(policy, low) < \gamma_e\ (policy, high)$.

Furthermore, we allow for regime switching in the volatility of shocks, by letting all structural shock variances follow an independent two-state Markov process. We denote the low-volatility regime as (vol, low) and the high-volatility regime as $(vol, high)$. Again, to compare systematically across the two countries, we normalize the high-volatility regime $(vol, high)$ to be the regime where the volatility (in productivity) is highest, i.e. $\sigma_z(vol, low) < \sigma_z(vol, high)$.

The choices of prior distribution for the structural parameters in the policy rule are presented in Table 6.3, along with the estimated posterior mode for the parameters. We find that the size of policy responses has not stayed constant during the sample period (1982–2011). For both countries, there is a substantial difference between the high and low policy responses.

In particular, there is clear evidence that the central banks have responded strongly to the exchange rate in the high-response regime, while the response to inflation is highest in the low-response regime. Interest rate smoothing is more pronounced in the low-response regime in Sweden, while in Norway it is more pronounced in the high-response regime. However, both countries respond more strongly to output in the high-response regime.

Hence, the low-response regime can be characterized by high inflation response, while the high-response regime is characterized by high exchange rate and output gap response. Note that, between the two countries, Norway has by far the strongest interest rate response to the exchange rate.

Regarding the Markov state processes for volatility (Table 6.4), comparing Norway and Sweden, volatility seems to be of the same size for productivity and output in the high-volatility regime. The two countries differ, however, with respect to the interest rate and the terms of trade, which have

[9] For a full treatment of the model with results, see Alstadheim, Bjørnland, and Maih (2013).

Table 6.3. Estimated policy parameters in two regimes

Parameters	Prior distribution	Prior probability low–high	Norway	Sweden
ρ_r (*policy, low*)	Beta	0.05–0.95	0.07	0.95
ρ_r (*policy, high*)	Beta	0.05–0.95	0.97	0.10
γ_π (*policy, low*)	Gamma	0.5–3.0	0.85	0.13
γ_π (*policy, high*)	Gamma	0.5–3.0	0.51	0.12
γ_y (*policy, low*)	Gamma	0.1–3.0	2.11	2.00
γ_y (*policy, high*)	Gamma	0.1–3.0	2.94	3.15
γ_e (*policy, low*)	Gamma	0.05–3.0	0.001	0.001
γ_e (*policy, high*)	Gamma	0.25–3.0	4.069	0.061

Note: See equation (2) for parameter definitions.

Table 6.4. Estimated volatility in two regimes

Parameters	Prior distribution	Prior probability low–high	Norway	Sweden
σ_r (*vol, low*)	InvGam	0.005–1	0.003	0.001
σ_r (*vol, high*)	InvGam	0.005–1	0.008	0.002
σ_q (*vol, low*)	InvGam	0.005–1	0.064	0.010
σ_q (*vol, high*)	InvGam	0.005–1	0.039	0.019
σ_z (*vol, low*)	InvGam	0.005–1	0.003	0.003
σ_z (*vol, high*)	InvGam	0.005–1	0.011	0.009
σ_y (*vol, low*)	InvGam	0.005–1	0.007	0.002
σ_y (*vol, high*)	InvGam	0.005–1	0.009	0.007
σ_π (*vol, low*)	InvGam	0.005–1	0.019	0.015
σ_π (*vol, high*)	InvGam	0.005–1	0.008	0.039

Note: σ_r is volatility of a monetary-policy shock, σ_q is volatility of terms-of-trade shock, σ_z is volatility of a productivity shock, σ_y is volatility of a demand shock (from the IS equation), and σ_π is volatility of inflation/cost-push shock (from the Phillips curve).

much higher volatility in Norway, and for inflation, which has a substantially higher volatility in Sweden. This confirms what we discussed earlier, in Section 2.

Norway also stands out in the low volatility regime (again as emphasized above) by observing higher volatility in its terms of trade and in the interest rate than Sweden. This is most likely due to the relative size of the petroleum sector in that country. There is also some evidence that the variance of output is higher in Norway than in Sweden in the low-volatility regime. We will discuss possible reasons for this when we examine the terms-of-trade shocks below.

Figure 6.9 displays the smoothed probabilities in Norway and Sweden together (Norway has a dotted line, Sweden a solid line). The figure displays in the upper panel the smoothed probabilities of being in high-policy-response regime $(policy, high)$ and in the bottom panel, the probability of being in a high-volatility regime $(vol, high)$.

The figure emphasizes that the central bank in Sweden switched from primarily responding strongly to the exchange rate in the 1980s to responding more to inflation shortly after inflation targeting was implemented in the early 1990s.

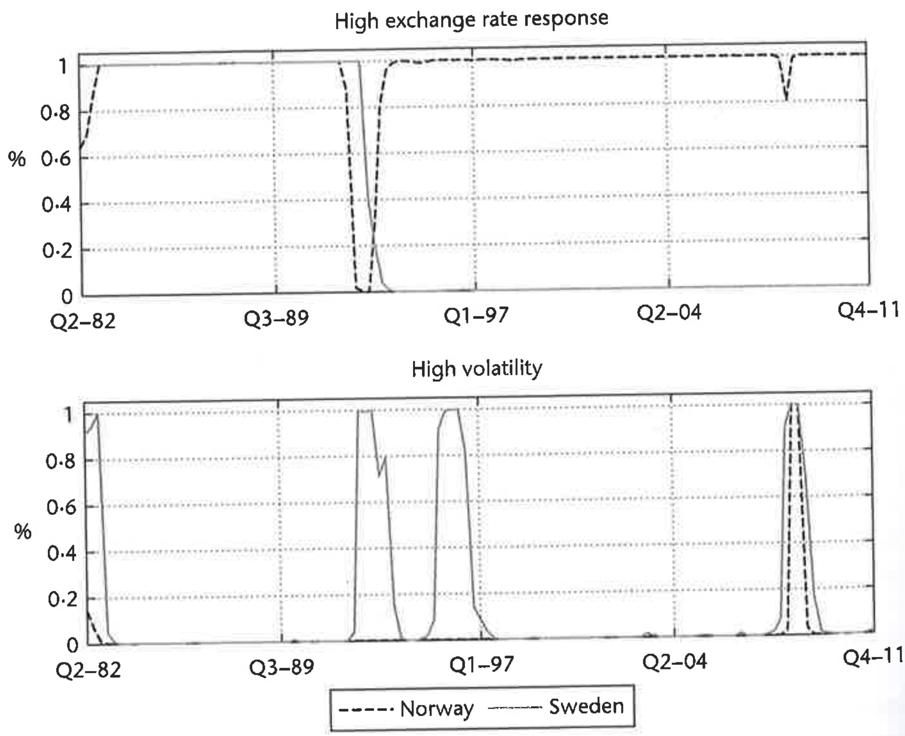


Figure 6.9. Smoothed probabilities—Norway and Sweden

Note: The upper row displays the smoothed probabilities of being in a high-policy-response regime $(policy, high)$ and the bottom row shows the probability of being in a high-volatility regime $(vol, high)$.

The results for Norway are different. With the exception of the brief period in 1992/3, the central bank has responded strongly to the exchange rate both before and after implementing inflation targeting (in 2001). Recall that this regime also involves high-output response. In 1992/3 Norway stopped intervening in the foreign exchange market to defend the fixed-exchange-rate regime, and left the strict exchange rate peg. This is being picked up as a regime switch by the data, and for 1–2 years there is virtually no exchange rate response. The year after, the policy rule in Norway is again best described by a high response to the exchange rate (as well as a concern for output stabilization).

A high monetary policy response to the exchange rate is consistent with the findings in Bjørnland and Halvorsen (2014). But why does monetary policy in Norway respond so much to the exchange rate relative to inflation? First, and as noted earlier, Norway was the country that last formally adopted inflation targeting. Second, terms-of-trade shocks are much more volatile in Norway than in Sweden. As emphasized, they also contribute to much of the exchange rate appreciation of the last decade, which the central bank in this period has tried to stabilize, thereby also stabilizing inflation.

Hence, Norway observes high exchange rate response in the interest rate both before and after authorities stopped intervening to peg the exchange rate. In one way, that is not so different from Sweden. There the interest rate has become more persistent in the inflation-targeting period.

Turning to the lower panel of Figure 6.9, there is a striking similarity in the timing of the switch between the high- and low-volatility regimes in the inflation-targeting periods, although the weights in the policy rule vary. In particular, independently of the chosen policy rules, the probability of staying in a regime of low volatility was high from the mid 1990s and until 2007 (the period of the great moderation). There is also a high probability of staying in a high-volatility regime in the period of the financial crisis in both countries. The period where the countries vary the most is the early 1990s, when Sweden experienced high volatility, as discussed extensively earlier.

6.6.1 *Terms of Trade*

Given the focus on openness in this chapter, we now study the response to a terms-of-trade shock (which increases export prices relative to import prices) in Norway and Sweden. Figures 6.10 and 6.11 display the impulse responses (averaged over all the regimes) to the terms-of-trade shock in Norway and Sweden respectively. The impulse responses are constructed from the regime-specific responses. That is, we have four possible regimes: (Regime 1): low exchange rate response and low volatility; (Regime 2): low exchange rate response and high volatility; (Regime 3): high exchange rate response and low volatility; and (Regime 4): high exchange rate response and high volatility.

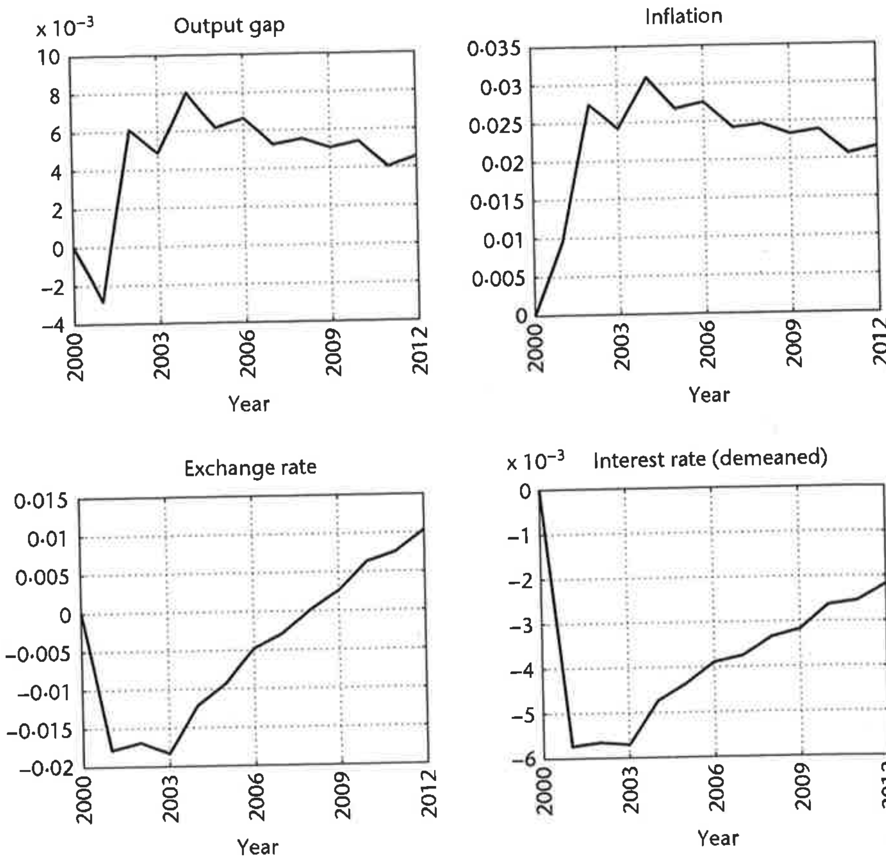


Figure 6.10. Norway: impulse responses to terms-of-trade shocks

Based on the four regime-specific impulse responses and the duration of each regime, we can construct the generalized impulse responses. Appendix B explains in more detail how the impulse responses are constructed and also displays the regime-specific responses.

The impulse responses emphasize that responding strongly to the exchange rate will exacerbate the effects of a terms-of-trade shock on both output and domestic inflation. In particular, a favorable terms-of-trade shock appreciates the exchange rate and increases output on impact. Since both the terms of trade and the real interest rate enter the model through expectation terms, the effect on output (and inflation) will depend on the expected interest rate response.

If the central bank is in a policy regime of high interest rate response to the exchange rate (*regimes 3 and 4*) the exchange rate will appreciate by much

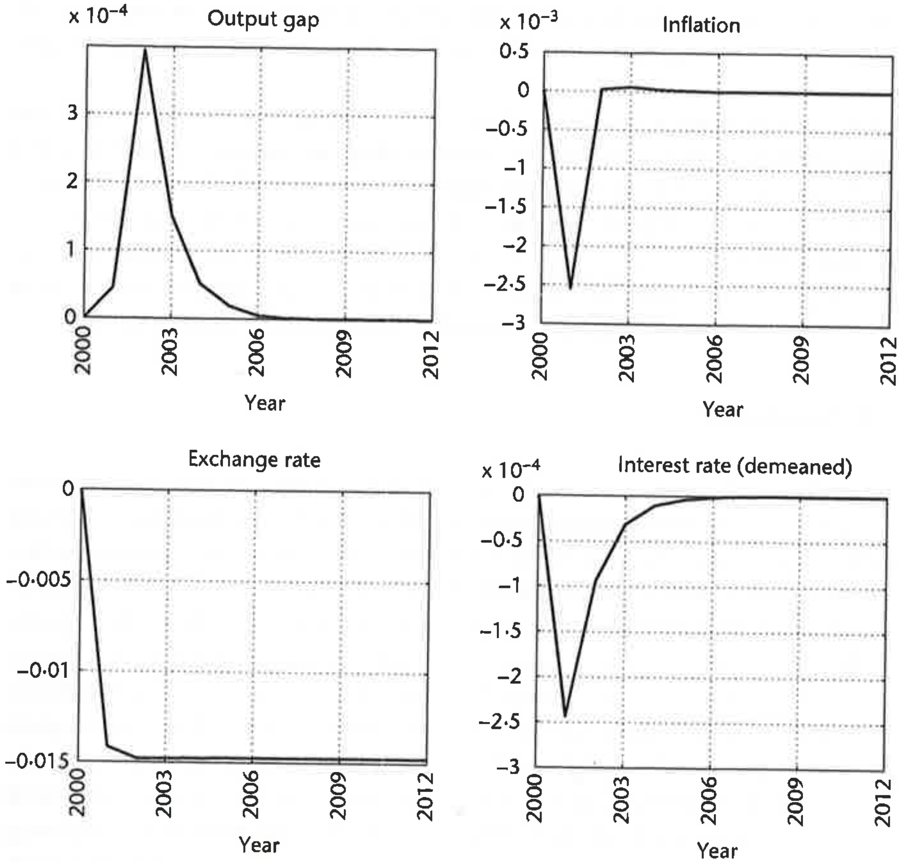


Figure 6.11. Sweden: impulse responses to terms-of-trade shocks

less, as the interest rate will also take into account the fact that the exchange rate has appreciated. This will reverse the initial exchange rate response and push up output and inflation relative to a regime of no interest rate response (see in particular the differences between high- and low-response regimes in Norway and Sweden in Appendix B).

Hence, the exchange rate response reinforces the effect of the terms-of-trade shock on output (and to a certain extent for inflation), and may explain why output was also more volatile (in the low-volatility regime) in Norway than in Sweden, as discussed above. On the other hand, if the central bank is mostly in a regime of low response to the exchange rate, it will ignore the exchange rate and set the interest to curb the effect on inflation.

The different responses are seen clearly in Figure 6.10 and Figure 6.11 for Norway and Sweden respectively. Norway has remained in a regime of high exchange rate response in most of the sample, and the effect of the terms-of-trade shocks on output and inflation are therefore clearly exacerbated relative to Sweden.

On a final note, recall from above that volatility of the terms of trade (and output) is much higher in Norway than in Sweden, which is most likely due to the size of the petroleum sector. Given this volatility, and a formal regime of inflation targeting, it may seem surprising that the terms-of-trade shocks do not explain even more of the variance in the nominal exchange rate in Norway than they do. The fact that the central bank in Norway has stabilized the exchange rate somewhat may have contributed to this.

6.7 Conclusion

We analyse and compare key economic variables in Norway and Sweden before and after the inflation-targeting implementation. Having established the stylized facts, we investigate the role of monetary policy for stabilizing economic performance. Using a Markov-switching DSGE model explicitly allowing for parameter changes, we find that while the central bank in Sweden reduced its response to the exchange rate (and output) shortly after inflation-targeting was implemented, the central bank in Norway has responded strongly to the exchange rate both before and after the inflation-targeting implementation. This could explain why the exchange rate remains relatively stable in Norway despite the high volatility in the terms of trade and also while the interest rate is much more volatile than in Sweden. Finally we show that by responding strongly to the exchange rate, the adverse effects of terms-of-trade shocks on the exchange rate and subsequently output and inflation are lessened. Monetary policy therefore contributes to exacerbate a terms-of-trade-led boom in the economy.

Appendix A: Data and Sources

We use the trade-weighted nominal effective exchange rate, NEER, from the IMF's IFS database for both countries. Note that in order to make an increase correspond to a depreciation rate, we invert the NEER. For the other series, we use the following:

Norway

Terms-of-trade data are from Statistics Norway, seasonally adjusted (SA).
The interest rate is three month NIBOR interest rate, Norges Bank.
CPI is from Statistics Norway, SA.
Real GDP data is from Statistics Norway, SA.

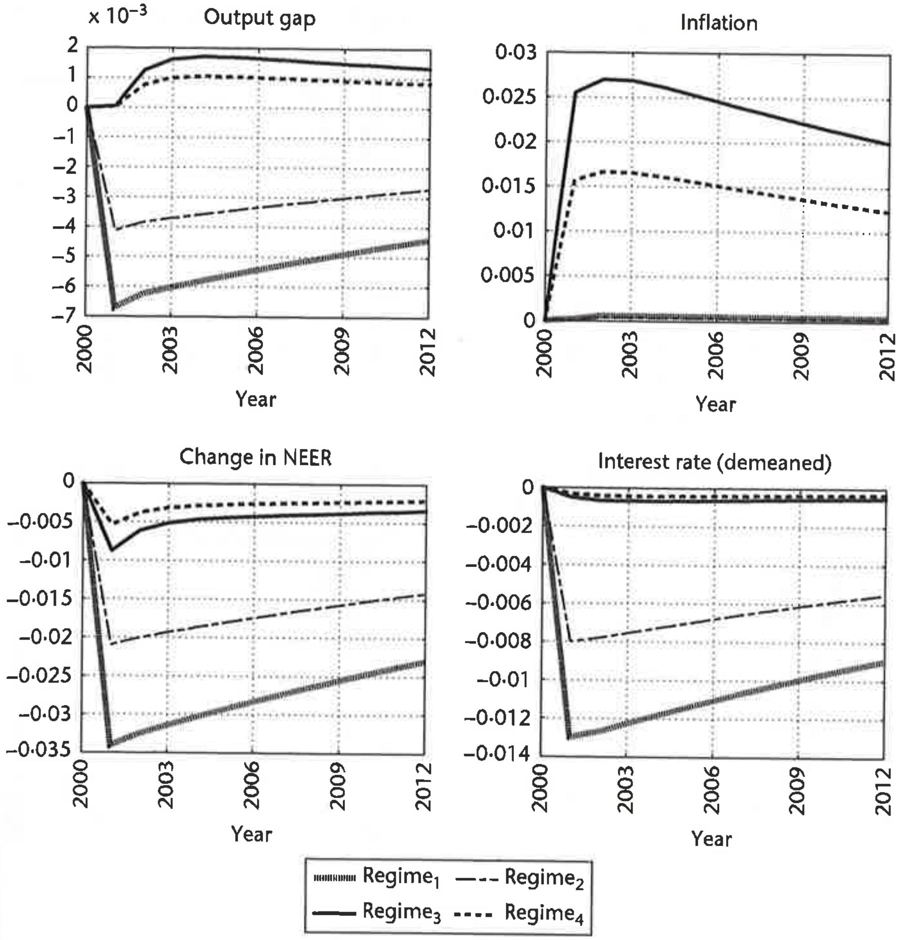


Figure 6.12. Norway: regime-specific impulse response to terms-of-trade shocks

Note: (Regime 1): low exchange rate response and low volatility; (Regime 2): low exchange rate response and high volatility; (Regime 3): high exchange rate response and low volatility; and (Regime 4): high exchange rate response and high volatility.

Sweden

Terms-of-trade data are from Statistics Sweden, SA.

The short-term rate is average quarterly short-term rate from the Swedish Riksbank from 1982.

The CPI data is from Statistics Sweden, SA.

Real GDP is from OECD MEI, we have seasonally adjusted it.

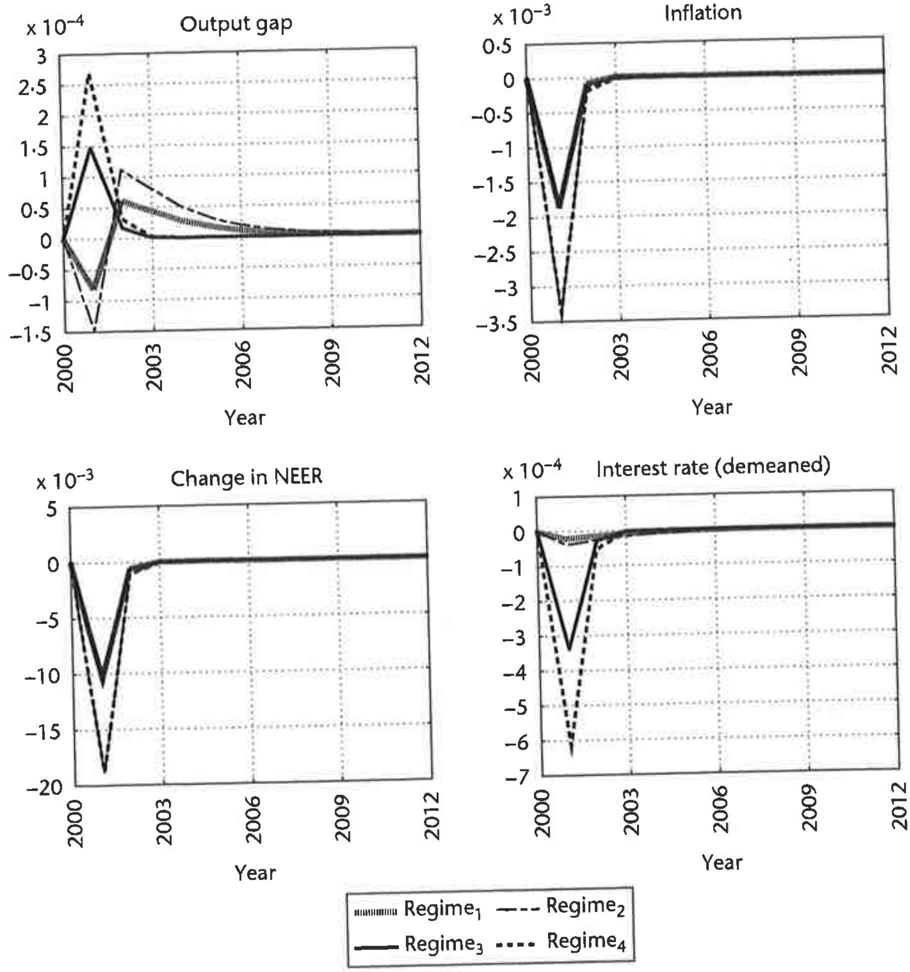


Figure 6.13. Sweden: regime-specific impulse response to terms-of-trade shocks

Note: (Regime 1): low exchange rate response and low volatility; (Regime 2): low exchange rate response and high volatility; (Regime 3): high exchange rate response and low volatility; and (Regime 4): high exchange rate response and high volatility.

Foreign GDP and Inflation

For the foreign variables, we use US data.

Real GDP is US: Gross Domestic Product (SAAR, Bil.Chn.2005$), from the Bureau of Economic Analysis, SA.

The CPI is from the Bureau of Labor Statistics, SA.

Appendix B: Regime-specific impulse responses

We would like to compute the impulse responses (*irf*) for a given horizon $t + h$, conditional on the information at time $t - 1$:

$$irf\left(h,d,|\,I_{t-1}\right)=E\left(x_{t+h}\,|\,e_t=d\right)-E\left(x_{t+h}\right)$$

1) At time *t*, a shock *e* hits the system with a magnitude *d*.
2) We randomly draw shocks in all directions (the whole vector of shocks) that are going to hit the system from period *t+1* onward.
3) We compute the path followed by the system after the initial shock in direction *e* (period *t*) and the 'all directions' shocks for the subsequent periods.
4) We compute a second path, where we do not shock the system in the first period, but shock it in the subsequent ones with the same 'all directions' shocks.
5) The impulse is computed as the difference between the first and second paths.

We repeat steps 1 to 5 *N* times and average the results obtained in step 5.

Figures 6.12 and 6.13 show the results.

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Comments on 'Monetary Policy and Exchange Rate Stabilization in Norway and Sweden' by Hilde C. Bjørnland and Junior Maih

Roberto M. Billi

The chapter written by Bjørnland and Maih is, in my opinion, an informative study that sheds light on the role of the exchange rate in the conduct of monetary policy in Norway and Sweden. The two small open economies formally adopted inflation targeting as their framework for monetary policy. Sweden switched to inflation targeting first in the early 1990s, while Norway waited until the early 2000s. Using a Markov-switching setup that explicitly allows for regime changes in the monetary policy responses and the shocks that hit the two economies, the chapter supports the view that the adoption of inflation targeting has contributed to an overall improvement in economic performance in both Norway and Sweden. In addition, as the authors argue, the central bank has put more weight on stabilizing the exchange rate in Norway rather than in Sweden, likely in response to the declining competitiveness of Norway compared to other countries like Sweden. In my brief comments, I will appraise the study in four steps, namely by raising four questions: Why is the analysis relevant? How do the authors proceed with their investigation? What do they find? And, what else is there to consider in further analysis?

By shedding light on the role of the exchange rate in monetary policy, the analysis is relevant both from theoretical and empirical perspectives. In theory, international trade can lead central banks to explicitly take into account the exchange rate in setting policy. Intuitively, foreign shocks, such as the terms of trade, can alter domestic business-cycle fluctuations which may lead the monetary authority to explicitly take into account international variables. Thus, central banks may have a specific interest in explicitly reacting to and smoothing exchange rate movements as a predictor of domestic volatility. But whether central banks, in actuality, react systematically to the exchange rate to stabilize the business cycle is clearly debatable from an empirical perspective. In a recent line of research, available empirical evidence suggests that some inflation-targeting central banks do respond to the exchange rate while others do not. Namely, Lubik and Schorfheide (2007) argue that, for instance, Bank of Canada and the Bank of England include the nominal exchange rate in their policy rule, while the central banks of Australia and New Zealand do not.

To proceed with their investigation of monetary policy and exchange rate stabilization in Norway and Sweden, the authors estimate a simple structural model of a small open economy. Thus, rather than estimating policy reaction functions in a single variable setting, the authors pursue a multivariate approach and estimate the entire structural model of the economy following the recent strand of research. The structural model is accordingly based on Lubik and Schorfheide (2007) and, in turn, on Galí and Monacelli (2005). In brief, the model consists of a forward-looking (open economy) Euler equation and a Phillips curve, which explain respectively the demand and supply side of the economy. Monetary policy is described by a simple interest rate rule, while the exchange rate is introduced via the definition of the consumer price index (CPI) and under the assumption of purchasing power parity. Thus, overall, the structural model is not very different compared with earlier studies in this line of research. But the empirical implementation is innovative. The important technical novelty is that the estimation procedure allows for regime switching. Both the policy rule coefficients and the variability of the structural shocks hitting the economy are allowed to change over time in the estimation. Because estimating the model is not as straightforward as in earlier studies, the authors face a computational challenge in estimating the regime-switching model.

The results stemming from the estimation of the structural model indicate that economic performance in Norway and Sweden is quite similar in some aspects, yet rather different in other ways. Regarding similarities, foremost, both countries have successfully implemented their policy within an inflation-targeting framework. This success is reflected in CPI inflation that has not moved far from the target. Regarding differences in economic performance, however, the business cycle has generally become more stable in Sweden since the adoption of inflation targeting. The exception is clearly the financial crisis when output in Sweden was hit hard. As a further difference, the interest rate and terms of trade have been substantially more volatile in Norway than in Sweden, which suggests that monetary policy could have a more explicit role in stabilizing the exchange rate in Norway. Furthermore, the central bank in Sweden has put less weight on stabilizing the exchange rate since the adoption of inflation targeting. In Norway, by contrast, the interest rate response to the exchange rate has remained high throughout the period analysed. In sum, while both Norway and Sweden have had inflation rates close to the target and overall stable economic conditions, there is clear evidence of declining competitiveness in Norway compared to other countries including Sweden.

Though the analysis is carefully executed and the results are clearly presented, some additional tests may help clarify the relevance of the empirical findings. In particular, the structural model imposes cross-equation restrictions in the estimation of the policy rule, while by contrast a statistical model would not impose such restrictions. The statistical model abstracts from considerations of the more detailed description of the functioning of the economy. The authors could therefore compare their model-based estimates to estimates from statistical models, along the lines of Lubik and Schorfheide (2007). Such a comparison can help assess the role of the cross-equation restrictions. To be clear, I am certainly not suggesting the presence of any shortcomings in the investigation. Rather, the authors' interesting findings would seem to motivate them to continue with this interesting and promising line of research.

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