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Research Report

Effects of a New Monetary Policy Loss Function in NEMO

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Staff Memo

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Kathrine Lund and Ørjan Robstad

Abstract

In this memo we provide technical documentation of the impulse responses to some representative shocks in NEMO. The impulse responses are shown both with the new specification of the monetary policy loss function presented in MPR 1/12 and with the specification used in the recent MPRs. The new monetary policy loss function entails a somewhat higher weight on output than the old. In addition, weight on deviations of the key policy rate from a simple rule in the old loss function is replaced by weight on deviations of the key policy rate from a normal level.

In general, with the new loss function, the interest rate response to supply shocks will be smaller than with the old loss function. The interest rate responses to demand shocks have not changed much, while the response from an exchange rate shock is marginally smaller with the new loss function than with the old.

1 Introduction

The Norges Bank forecasting system for medium to long-term economic developments is organised around our core macroeconomic model, NEMO (Norwegian Economy Model). NEMO is a medium-scale, small open economy DSGE model similar in size and structure to the DSGE models developed by many other central banks.¹

The interest rate projection is based on optimal policy in the sense of minimising an intertemporal quadratic loss function consistent with the monetary policy mandate and the response pattern of Norges Bank.

Over time new insights are gained, leading to new assessments regarding how monetary policy should be conducted. In addition, Norges Bank's Executive Board will apply judgement. Over time, this may lead to more systematic changes in the response pattern. Our aim is to embed these changes into the model so that they can be treated within the optimising framework. This facilitates both transparency and consistency over time.

How and whether to incorporate financial stability concerns into monetary policy decisions are questions that have attracted more interest over the past few years. Norges Bank has on several occasions in the past stated the view that low interest rates over time entail the risk of a build-up

¹ A more detailed description of NEMO is provided in Brubakk et al. (2006). See Gerdrup and Nicolaisen (2011) for a more general description of model use in Norges Bank.

of imbalances.² Previously, these concerns have been handled outside the model through supplementary assessments. In *Monetary Policy Report* (MPR) 1/12, a new specification of the operational loss function was presented to clarify Norges Bank's response pattern.³ The changes have been made to enable the Bank's model analyses to better capture the monetary policy response pattern since the financial crisis in autumn 2008.

In this Staff Memo, we examine how key variables in NEMO respond to a selection of representative shocks with both the new and the previous specification of the monetary policy loss function. The purpose is to give some representative examples of how changes in the loss function technically affect the propagation of shocks in the model and hence the projected optimal interest rate path in response to those particular shocks.

2 The loss function

In practice, an optimal interest rate forecast reflects a number of concerns. These concerns are sought incorporated into the loss function in our modelling framework. Thus, the loss function is to be regarded as an operational loss function that works well in combination with the specification of our core model. Neither is it welfare-based, nor does it represent the "true" preference function of the bank.

The loss function should be consistent with the monetary policy target which is low and stable inflation, with annual consumer price inflation of approximately 2.5 percent over time. Other considerations in interest rate setting, such as stabilisation of the real economy and interest rate smoothing should also be included in the operational loss function. The parameters λ , γ , κ and τ in the loss functions below express the relative weights attached to the various considerations.

The new loss function which is used in MPR 1/12 is given by:^{4,5}

$$L_t = (\pi_t - \pi^*)^2 + \lambda(y_t - y_t^*)^2 + \gamma(i_t - i_{t-1})^2 + \tau(i_t - i_t^*)^2 \quad (2.1)$$

The monetary policy target of stabilising inflation (π_t) at target is covered by the first term in the loss function. The first and second term cover the trade-off between stabilising inflation and stabilising the real economy (y_t). The third term of the loss function expresses that it will normally be robust to change the interest rate gradually, so that the current interest rate, i_t , does not deviate excessively from the rate in the previous period, i_{t-1} .

The last term states that the loss increases when the interest rate deviates substantially from a normal nominal interest level i_t^* .⁶ By incorporating the interest rate level in the loss function, the

² See for example *Monetary Policy Report* 3/10 and 3/11.

³ See box in *Monetary Policy Report* 1/12 for more information about the changes in the loss function.

⁴ See Evjen and Kloster (2012) (forthcoming) for a discussion of the changes in the loss function.

⁵ In the calculations in MPR 1/12, the model was solved using the loss function where $\lambda=0,75$, $\gamma=0,25$ and $\tau=0,05$.

Bank puts some weight on the risk associated with the build-up of financial imbalances⁷. This does not imply that the interest rate becomes an independent objective of monetary policy. Rather, it is intended to overcome shortfalls in our analytical tools, such as a failure to incorporate any non-linear effects of very low interest rates on long-term stability.

The ‘old’ loss function used in the previous MPRs is given by:⁸

$$L_t = (\pi_t - \pi^*)^2 + \lambda(y_t - y_t^*)^2 + \gamma(i_t - i_{t-1})^2 + \kappa(i_t - i^{simple})^2 \quad (2.2)$$

The first, second and third terms in the loss function are similar to the ‘new’ loss function. However, the weight (λ) on the output gap has been adjusted upwards from 0.5 in the old loss function to 0.75 in the new loss function. Experience shows that financial imbalances often build up in periods of high capacity utilisation. For that reason, increasing the weight (λ) on the output gap in the loss function may reduce the risk of a build-up of such imbalances.

The fourth term in the old loss function was a cross-check for the interest rate path and covered the criteria that any substantial and systematic deviations from simple robust monetary policy rules (i^{simple}) should be explained. This term is removed in the ‘new’ loss function and replaced by a weight on deviations from the normal nominal interest rate.

3 Model properties

NEMO includes almost 20 different shocks. In this Staff Memo we look at three representative shocks; a demand shock, a supply shock and a shock to the risk premium of NOK.

Supply shocks will typically have opposite effects on inflation and output and hence create a trade-off for the central bank between stabilising inflation and stabilising output. By contrast, demand shocks typically affect inflation and output in the same direction. An exchange rate shock is effectively a mix between a supply and a demand shock.

We start from steady state and look at the impulse responses from each shock separately. In reality, the economy is never in a steady-state equilibrium. At any point in time, it will be hit by a mix of different shocks. The shocks presented in this Staff Memo can thus only serve as illustrations.

It is important to recognise the role of monetary policy in these exercises. Monetary policy will, together with other mechanisms in the model economy, endogenously contribute to counteract

⁶ Our definition of the ‘normal interest rate’ is the interest rate that is consistent with an inflation and output gap at zero over the medium term. The normal interest rate will typically be time-varying.

⁷ See Evjen and Kloster (2012) (forthcoming).

⁸ In the calculations in MPR 3/11, the model was solved using the loss function where $\lambda=0,5$, $\gamma=0,25$ and $\kappa=0,25$.

the effects of the initial shocks. Agents in the economy are forward-looking and will anticipate the monetary policy reaction.

3.1 A temporary positive shock to labour productivity

In this experiment, we show the effects with both the previous and the new loss function of a temporary shock to labour productivity⁹ which causes inflation to fall by around ½ percentage point after four quarters, see chart 1.

In general, a positive labour productivity shock will enable firms to produce more for a given level of inputs. This will be equivalent to a reduction in marginal costs. Firms will find it profitable to produce more when costs are reduced. Since the demand curve is downward-sloping, an isolated increase in supply makes firms want to reduce prices. This leads to a downward pressure on prices and lower inflation.

As inflation falls, the central bank reduces the interest rate in order to bring inflation back to target. Nominal rates must be reduced sufficiently to cause the real interest rate fall.

Lower real interest rates will increase consumption and investment. In addition, higher labour productivity will raise the expected return on capital, which stimulates investment further. Higher demand will lead to an increase in output. Finally, lower interest rates will lead to a currency depreciation in the short run, putting upward pressure on import prices.

Overall inflation falls and output increases initially when labour productivity goes up. With the new loss function where the weight on stabilising output is higher, the central bank is less willing to reduce interest rates and raise output over its potential in order to increase inflation. The central bank therefore allows a larger drop in inflation compared with the old loss function. The weight on stabilising the interest rate around its normal level (τ) also reduces the interest rate response with the new loss function. The changes in the loss function thus unambiguously lead to a smaller interest rate response to labour productivity shocks. This will be true for all supply shocks in NEMO. As a consequence, compared with the old loss function, inflation will return to target a little more slowly, while output will deviate less from potential when supply shocks hit the economy with the new loss function, see red and black lines in chart 1.

3.2 A temporary negative shock to consumption

In this experiment, we show the effects of a negative consumption shock, i.e. a temporary negative shock to households' preferences for consumption relative to leisure, see chart 2. As a consequence, consumption decreases. The consumption shock occurs in period 1 and leads to a 0.5 percent initial fall in consumption¹⁰.

⁹ The shock follows an autoregressive process of order one with a persistence coefficient of 0.5.

¹⁰ The shock follows an autoregressive process of order one with a persistence coefficient of 0.3.

Generally, a negative consumption shock will reduce overall demand at current prices, and hence reduces output. Firms will therefore find it optimal to reduce input of both labour and capital services. Lower demand for labour will put downward pressure on wages. Following the fall in overall demand and marginal costs, firms will have an incentive to reduce their prices. The monetary policy authority reacts by lowering the nominal interest rate in order to stimulate output and inflation.

Overall, a negative shock to consumption leads to both lower output and lower inflation in the short run. With the new loss function, the higher weight on stabilising output (λ) leads in isolation to a lower interest rate compared with the old loss function, in order to stabilise output faster. The weight on stabilising the interest rate around its normal level (τ) will on the other hand reduce the interest rate response. The change in the loss function has therefore small effects on the overall responses to a consumption shock, see the red and black lines in chart 2. The interest rate response is marginally bigger with the new loss function compared with the old. This will be the case for most demand shocks in the model.

3.3. A temporary fall in the risk premium

Here we look at the effects with the new and old loss function of a temporary risk premium shock that leads to an unexpected initial appreciation of the real exchange rate by 2 percent.¹¹ The impulse responses from this shock are shown in chart 3.

A stronger currency will put downward pressure on inflation. As import prices move down and export prices move up, expressed in NOK, net exports falls. As inflation and output fall, the central bank reduces the interest rate in order to stimulate output and make inflation return to the target. Nominal rates must be reduced sufficiently to cause the real interest rate fall. Lower real interest rates will lead to higher consumption and investment.

Overall, a temporary fall in the risk premium leads to both lower inflation and output in the short run. The effect of higher investment and consumption will fairly quickly dominate the effect of lower net exports on output. Hence the output gap will be positive after a few periods and inflation will gradually return to the target, see chart 3.

The weight on stabilising output is higher with the new loss function (λ). In isolation this leads to a larger interest rate response to the initial fall in output. On the other hand, the weight given to deviation from a normal interest rate in the new loss function will in isolation lead to a smaller interest rate response. The changes in the loss function therefore have small effects on the overall

¹¹ The shock follows an autoregressive process of order one with a persistence coefficient of 0.7.

response to a risk premium shock. With the new loss function, the nominal interest rate is reduced slightly less than with the old loss function, see red and black lines in chart 3.

4. Concluding remarks

The responses to shocks presented in this paper only serve as illustrations. It is also important to note that situations may arise where weight will be given to considerations other than those expressed explicitly in the loss function. The interest rate responses shown in this Staff Memo illustrate the differences between the new and the old loss function excluding any such supplementary assessment.

We continually strive to improve NEMO and formalise all relevant considerations in monetary policy making. Norges Bank aims to be transparent about the changes in its modelling framework and will provide an account of any future adjustments of the loss function.

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Impulse responses

Chart 1: A temporary positive shock to labour productivity

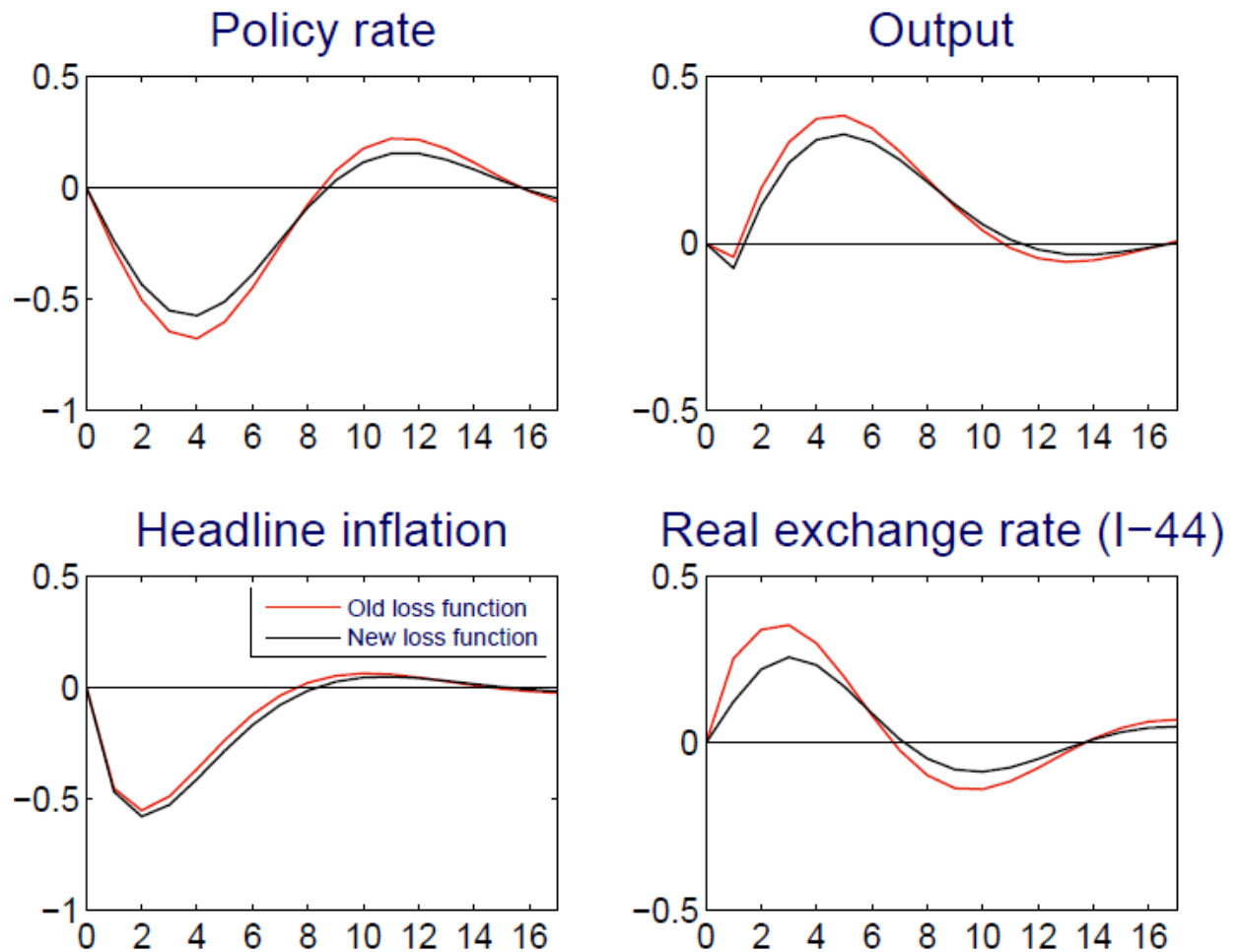


Chart 2: A temporary negative shock to consumption

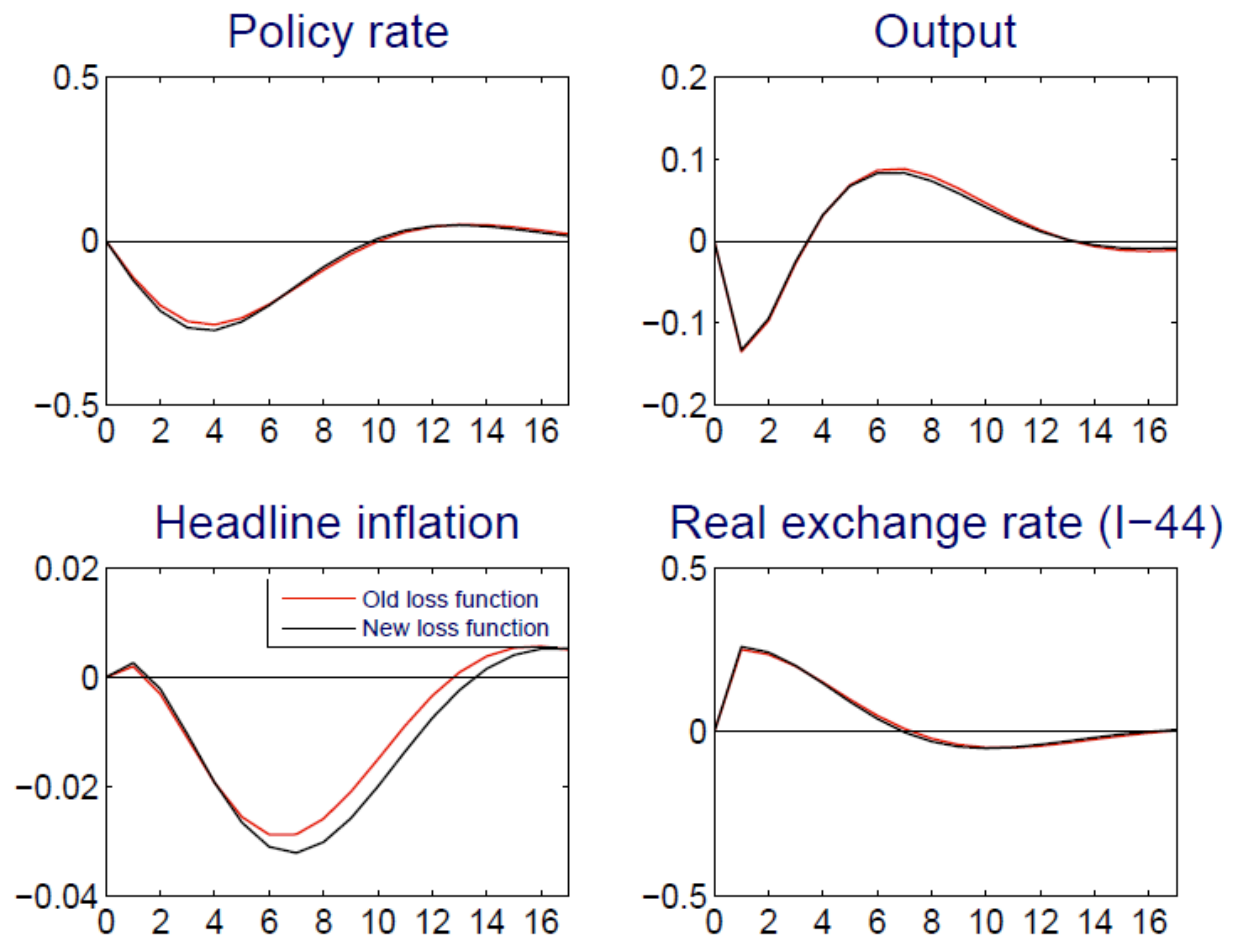


Chart 3: A temporary decrease in the risk premium

