Øystein Olsen: Monetary policy and interrelationships in the Norwegian economy

Address by Mr Øystein Olsen, Governor of Norges Bank (Central Bank of Norway), at the Centre for Monetary Economics (CME)/BI Norwegian School of Management, Oslo, 5 September 2011.

Please note that the text below may differ slightly from the actual presentation.

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When Trygve Haavelmo was awarded the Nobel Prize in Economic Sciences in 1989 for his pathbreaking work to quantify economic interrelationships, the Nobel Committee summarised his contributions[1]. First, empirical science must be based on theories which reflect reality. Second, data and observations must conform to theoretical concepts. Third, a methodology is needed which can be used to quantify and test theoretical relationships on the basis of empirical observations.

The interrelationships in the Norwegian economy serve as a backdrop for my address. The purpose of the Centre for Monetary Economics (CME) is to be a venue where researchers and economists in banking and finance can exchange views and gather knowledge about the Norwegian economy, perhaps with particular emphasis on monetary policy. My contribution today will be an analysis of relationships between some key economic variables and how Norges Bank utilises that insight when setting the key policy rate.

As Haavelmo described, theories regarding economic interrelationships can never conform fully with empirical observations. Nor can economists carry out controlled experiments in the same way as in the natural sciences. Nevertheless, Haavelmo was an optimist. Empirical methodologies may be used to uncover interrelationships in the economy with a reasonable degree of accuracy.

Haavelmo's contribution can be put to good use when Norges Bank, as the central bank, is to set the interest rate with a view to stabilising inflation. The Bank's monetary policy assessments and decisions must be based on knowledge it can obtain on interactions within the Norwegian economy and how the interest rate interacts. The theory the Bank applies and the empirical methodology it employs will depend on the purpose of the analysis. A model apparatus that is to be used as an aid in making interest rate decisions requires different attributes and is based on different principles than models that seek to provide optimal near-term inflation and output forecasts.

Chart: Different time horizons – different models

Current statistics and anecdotal information can serve as a basis for providing some indication of how the economy has evolved up to the present. But the statistical basis is uncertain. Statistics are published with a lag and are often subject to revision. Data from different sources can provide different pictures of the situation at hand. Statistical models can provide us with good support and help distinguish between news and noise in the data. They can capture time series properties in data and correlations that in many cases will be able to produce good forecasts of developments in the next months ahead. It then makes little difference whether or not the models are based on economic theory.

There are certain similarities between projecting developments in the Norwegian economy in the coming months and forecasting the weather. Meteorologists have observed that averaging a large number of forecasting models generally produces more accurate forecasts.

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[1] Ysander, Bengt-Christer, "Award Ceremony Speech", Royal Swedish Academy of Sciences, 10 December 1989.

To project consumer price inflation in the coming quarters the Bank has developed a system for averaging forecasts from about 170 different statistical models, all of which are intended to project inflation in the Norwegian economy in the very near term. The models are grouped into three classes, and the models within each class may contain different variables or be variants of one another[2]. The weights are continually adjusted on the basis of historical accuracy, so that models with better predictive power are given greater weight in the subsequent round. The Bank has a similar system including almost 250 models for forecasting mainland GDP. The projections from these systems of models extend four quarters ahead in time and are published at regular intervals on the Bank's website. We call this apparatus SAM (System for Averaging Models).

For projections with slightly longer horizons, the Bank parts company with weather forecasters. While meteorologists are unlikely to influence the weather with their predictions, Norges Bank's interest rate setting can actually influence economic developments in the medium term. This places particular demands on the system of analysis and involves other demands than if the sole purpose were to make forecasts. Norges Bank has developed the Norwegian Economy Model (NEMO), which we use as an aid when drawing up one-year-ahead to four-year-ahead forecasts.

NEMO is a model for analysing cyclical fluctuations around a long-term trend. In the medium term, the economy may in periods deviate substantially from trend, but when the fluctuations subside, we must assume that the economy is moving towards equilibrium. The model does not explain the long-term trend so we have to look to other economic theory. For example, economic growth over time will be determined by technological developments and the supply of labour and capital, and there will likely be a relationship between the real interest rate and potential growth.

When we set the interest rate, we give weight to the current situation and the outlook two to three years ahead. The statistical models help us understand the current situation, while the equilibrium properties frame the analysis. NEMO describes how the interest rate can be set to bring the economy from its current starting point back to the long-term equilibrium path. As a support tool in making monetary policy decisions, such a model apparatus is thus particularly relevant. I will come back to the main features of NEMO later.

Chart: Monetary policy model requirements

Norges Bank operates under a formal monetary policy mandate. The Bank's objective is to stabilise inflation and provide the economy with a nominal anchor. As a minimum, an economic model to be used as support for interest rate decisions should be based on the assumption that monetary policy can steer inflation.

Economic agents can be expected to look ahead when making consumption and investment decisions. It is not only current economic policy that is likely to matter to them, but also what they expect it will be in the future. *Expectations* must therefore be incorporated and play a role in a monetary policy model.

Furthermore, the functioning of monetary policy should be in line with theory and experience. For example, Norway's recent history tells us that there is little likelihood that monetary policy will be able to influence the economy's long-term growth potential.

Chart: Growth and inflation

Many economists previously argued that unemployment could be reduced by accepting slightly higher inflation over time. Monetary policy was oriented accordingly and inflation

[2] Factor models, indicator models and VAR models. For a detailed discussion, see Aastveit, K.A, K. Gerdrup, A.S. Jore (2011) "Short-term forecasting of GDP and inflation in real time: Norges Bank's system for averaging models", *Staff Memo* 9/2011, Norges Bank.

accelerated in many countries, without a sustained decline in unemployment. It turned out that bringing rising inflation under control involved substantial real economic costs. In the past 20 years, inflation has been consistently low and stable. Economic growth has been just as high, if not higher, since inflation came down to a low level, compared with the years when inflation was high and at times at double-digit levels.

Chart: Monetary policy model requirements

For the model to be relevant it should build on long-term relationships that we believe to be valid and it should be consistent with data. For example, the model's relationships should describe how the interest rate works, in line with relevant empirical observations of the Norwegian economy.

It is also of considerable importance to us that the economic mechanisms in the model should be understandable and easy to communicate. The model apparatus is to function as a useful tool, both in the internal process ahead of the monetary policy meetings and in Norges Bank's external communication.

Chart: Quote George Box

A model will never be able to provide an exhaustive description of reality. In 1979, the British statistician George Box stated: "Essentially, all models are wrong, but some are useful". Models can help to identify key driving forces, ensure a valid line of reasoning and consistency over time. This will enable the model to play an important role in the analytical basis for interest rate setting. At the same time, we must use common sense and experience when evaluating the model-based results and supplement these results with our own professional judgement. In this respect, the Bank has a pragmatic attitude regarding the use of models.

Before I discuss Norges Bank's suite of models in greater detail, I would like to look at a few key macroeconomic variables and their interaction. Studying fundamental statistical relationships provides important insight into the functioning of the economy. Along with the theoretical foundation, such insight is one of the most important building blocks of a good analytical apparatus for implementing monetary policy.

Chart: Output and inflation

Let me begin by taking a look at the relationship between output and inflation. In recent years, consumer price inflation (CPI) has fluctuated between 0 and 3 per cent. Mainland GDP growth has also fluctuated, giving rise to economic cycles. The chart shows developments in the two variables measured as deviations from long-term trend growth, in other words an "inflation gap" and an "output gap"[3]. The blue line in the chart shows that GDP growth was markedly higher than trend growth in the latter half of the 1990s and in the period from 2003 to 2008, but that it has risen somewhat more slowly in the period following the financial crisis. When developments in output are compared with inflation, a pattern emerges. A pickup in GDP growth has consistently occurred 4–5 quarters before a rise in inflation[4]. While the chart says nothing about causality, turning points in GDP growth seem to be a fairly reliable leading indicator of turning points in inflation.

Chart: Output and employment

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[3] The gaps express deviations from estimated trends in seasonally adjusted figures for mainland GDP and CPI adjusted for tax changes and excluding energy products (CPI-ATE), respectively. The trends are estimated using a Hodrick Prescott (HP) filter on quarterly data with λ=40000. The output gap is a technical estimate and does not fully correspond with the output gap in Norges Bank's *Monetary Policy Report*.

[4] The correlation between these two data series is highest when the output gap is deferred 4–5 quarters into the future.

The path from changes in output to inflation passes through the labour market, among others. We have seen that when economic growth has picked up, unemployment[5] has declined one to two quarters thereafter. The relationship between the "output gap" and the "unemployment gap" is fairly strong. This is a useful observation because GDP figures are published with a considerable lag and often subject to revision, while unemployment data are published at the end of each month and are not revised. If there is uncertainty about the GDP figures – which there often may be – falling unemployment can be an indication of a recovery in economic growth.

Chart: Unemployment and wage growth

Labour market developments, in turn, affect wage growth, as illustrated by the blue line in the chart. High unemployment results in low wage growth, and vice versa. The chart shows that in periods of falling unemployment, wage growth[6] moves up fairly rapidly. Changes in unemployment appear to have a fairly immediate impact on wage growth.

Chart: Wage growth and domestic inflation

Not unexpectedly, there is also a close statistical relationship between wage growth and the rise in prices for domestically produced goods in the CPI[7]. It appears to take about one year for changes in wage growth to feed through to inflation.

Such observations of data provide a picture of some of the interrelationships in the economy, but they say little about causality or how interest rates feed through to the economy. Correlations are nevertheless interesting as a background for the analytical tools that are used in interest rate setting.

Chart: The interest rate is an endogenous variable

Historically, the interest rate has been set in response to various developments and shocks. In this respect, the interest rate is an endogenous variable. The relationship between the interest rate and other key variables has through history also been influenced by shifting monetary policy objectives. If the interest rate is raised today in response to an unexpected change in price and cost inflation, a fall in capacity utilisation must be expected. However, if the interest rate is increased in response to an unexpected pickup in demand for goods and services, the path will be a different one. In historical data, a higher interest rate can go hand in hand with both lower growth and higher growth. It is therefore demanding to identify the effects of interest rate changes when studying historical data series.

Moreover, the effect of an interest rate change will depend on whether the change is anticipated or comes as a surprise. For example, a lower-than-expected interest rate increase might easily be perceived as an expansionary monetary stance, even though the rate is actually being raised. Expectations may also result in a change in market interest rates well in advance of an actual adjustment in the key policy rate. This may influence how quickly an interest rate change feeds through to the economy.

Furthermore, the impact will depend on the expected duration of the interest rate change. If the Bank were to embark on a totally new monetary policy course, we would have to assume that this would result in a different path for the economy than if an interest rate hike occurs one month earlier than planned.

Chart: VAR model

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[5] Unemployment measured according to LFS.

[6] Mainland hourly wage growth from quarterly national accounts.

[7] Adjusted for tax changes and excluding energy products, seasonally adjusted figures.

In order to analyse the effects of the interest rate, we need to study more than pure correlations. We need an analytical apparatus that allows the interest rate to be endogenous. A vector autoregressive model (VAR) model on Norwegian data quantifies how the interest rate has reacted historically to other key economic variables. The model is based on statistical relationships between GDP, interest rates, exchange rates and inflation, taking into account that variables may be interdependent. All the variables are a function of lagged values of themselves and the other variables. To estimate the model, the relationship between some of the variables is predetermined in line with economic theory. For example, on the basis of well known economic relationships, assumptions can be made concerning the sequence in which the different variables will affect one another and we can impose the assumption that the interest rate will not affect GDP in the long term.

A common approach to analysing the effect of the interest rate in models where it is endogenously determined is to apply an exogenous impulse or a shock to the interest rate. This means that the interest rate is raised in response to factors other than those that can be explained historically by the other variables in the model. Thereafter the model takes over, and the interest rate moves in line with the model's estimated reaction pattern.

The effect of an interest rate shock will depend on the variables included in the model, the model's structure and estimation period. The result can be more robust if we use a long time-series in the estimation. On the other hand, changes in monetary policy regimes can influence the results. It may therefore be of greater interest to confine the estimation period to, for instance, the period of inflation targeting.

First, I would like to look at the implications of the choice of estimation period for the results. I will then compare the VAR model with a corresponding interest rate shock in NEMO.

Chart: Isolated effect on GDP of an interest rate increase in two different VAR models

In order to further explore the extent to which the estimation period has a bearing on the results, we have estimated VAR models with successive starting points from 1986 to 1996[8]. Each model is quantified on quarterly data up to 2009. In the analysis, the interest rate increases by 1 percentage point and then gradually falls back. The increase in the interest rate will result in a temporary decline in GDP growth. The chart shows the effect in two of the models, one that is estimated from the mid-1980s and the other where the estimation period starts ten years later. The impact on GDP occurs somewhat earlier, but is a little smaller when we start the estimation period later. This may reflect the change in monetary policy regime during the period or structural changes in the Norwegian economy.

Chart: Maximum impact of a 1 percentage point interest rate increase, different estimation periods

If we only look at the maximum impact of an interest rate increase in each of the models, we obtain a picture of how this has changed over time. Each point in the chart represents the impact on the level of GDP and inflation when the effect of an interest rate increase is strongest in each model (estimation period).

The charts show that an unexpected change in the key policy rate of 1 percentage point results in a maximum downward shift in GDP of 0.4–0.7 per cent and a maximum decline in inflation of 0.2–0.3 percentage point.

Chart: Number of quarters to maximum effect of interest rate change, different estimation periods

The timing pattern of the impact of interest rates on the economy has also changed. Using the same models, this chart shows how many quarters it takes before the impact of an

[8] The VAR models are based on mainland GDP data, inflation adjusted for tax changes and excluding energy products (CPI-ATE), the krone exchange rate (I-44) and 3-month NIBOR.

interest rate increase on GDP and inflation reaches its maximum. As shown in the chart, the impact occurs slightly faster if the estimation period starts later. The maximum impact on GDP occurs on average with a lag of 5–6 quarters, while the maximum impact on inflation occurs on average after 9–11 quarters.

Chart: Effect of monetary policy shocks, different models/estimation periods

If we illustrate the entire profile of the monetary policy response in all the VAR models in a single chart, we obtain an overall picture of the degree of spread between the results. If we were to draw a fan chart around each model, it would become clear that the uncertainty is even greater than the spread alone indicates. If we were nevertheless to draw a conclusion on this basis, it must be that an interest rate increase will dampen GDP growth in the course of the subsequent year – all else being equal. Somewhat further ahead, inflation will also recede. As the interest rate returns to normal, GDP growth and inflation will pick up again.

As mentioned, the VAR models are based on a number of theoretical assumptions about how the economy works. However, they only provide a rough description of the structure of the economy and the behaviour of economic agents. The results from the VAR-based analyses must therefore be interpreted with caution.

Chart: NEMO

Our macroeconomic model NEMO has a more precise theoretical construction than the VAR models. NEMO is a dynamic stochastic general equilibrium (DSGE) model, and has many features that are similar to corresponding models used by other central banks. It describes the behaviour of households and firms. Economic agents are forward-looking when making decisions so that expectations are of significance. In the model, monetary policy is geared towards stabilising inflation at 2.5 per cent and weight is also given to stabilising developments in output. The long-term growth potential of the economy is determined by technological developments. There is no long-term trade off between inflation and unemployment. As prices and wages respond with some lag, monetary policy can, however, influence demand, output and employment in the short and medium term. NEMO is an empirical model, that is to say it is estimated on Norwegian data.

NEMO can help us provide economic interpretations of observed developments. Changes in key variables such as GDP and inflation can be explained by factors such as productivity, competitiveness in labour and product markets and the propensity to save. In that respect, NEMO is quite different from the “weather forecasting models” I cited earlier, which provide little scope for interpretations based on economic theory.

Chart: Effect of monetary policy shocks in the VAR models and in NEMO

As indicated by the red line in the chart, NEMO provides a description of monetary policy that is broadly consistent with that derived from the VAR models[9]. In NEMO, an unexpected interest rate increase of 1 percentage point implies, in isolation, a decline in GDP of around 0.4 per cent around one year later. Inflation is reduced by about ¼ percentage point with a lag of around two years. Compared with the VAR models, NEMO is in the upper part of the area for GDP and in the lower part for inflation. NEMO is estimated from the mid-1990s and the results are also close to those derived from the VAR models that are estimated over the same time period.

A model will never be able to provide an exact indication of how the interest rate should be set. The ultimate assessment is, as mentioned, a result of Norges Bank’s professional

[9] The estimation is based on a one percentage point increase in the interest rate, followed by a gradual reduction in line with the response pattern in the model. The analysis shows the impact of the interest rate increase on mainland GDP for Norway and inflation adjusted for tax changes and excluding energy products (CPI-ATE).

judgement and will also capture considerations that are not sufficiently safeguarded by our models. As such, the models are only a tool. But, a model such as NEMO is a very useful tool for analysing developments and in interest rate setting. It helps us interpret and understand the dynamics of the Norwegian economy. The model apparatus is continually being developed. Among other things, we are exploring how financial markets and the linkage to the real estate market can be incorporated into such a model.

Norges Bank's response pattern expresses the assessments we make and how we set the interest rate to attain our objectives. We must use professional judgement and our experience of how the Norwegian economy functions. We attempt to incorporate our response pattern into NEMO by setting the interest rate in the model so as to stabilise inflation at target while reducing fluctuations in output and employment. The model can in this respect be a tool for ensuring consistency over time when we set the interest rate.

In our communication, we seek to be open about our response pattern. Many important economic decisions depend on economic agents' expectations concerning the future. The inflation target and our response pattern influence and can change their expectations. The task of stabilising inflation is facilitated when households, firms and market participants have a good understanding of how monetary policy works and how Norges Bank sets the interest rate.

Chart: Forecasts of inflation and the output gap in the June 2011 Monetary Policy Report

The monetary policy response pattern can be communicated in several ways. In our *Monetary Policy Report*, we present a chart with our forecasts of inflation and the output gap. Combined, they provide a picture of key assessments underlying our interest rate decisions, and hence our response pattern. The interest rate is set so that inflation and the output gap move in balance. If inflation is well below target, the interest rate will normally be low so that the output gap increases and eventually pushes up inflation. Inversely, if inflation is too high, the interest rate will be raised so that the output gap narrows and inflation recedes.

As shown in the chart, in our latest *Report* from June we presented a scenario where the output gap increases somewhat further ahead, with the downturn in the wake of the financial crisis being followed by a mild upturn. The low level of inflation would then move up to target.

Chart: Interest rate forecast with fan chart in the June 2011 Monetary Policy Report

The interest rate forecast is shown in a fan chart. Our forecasts provide an expression of what we consider to be the baseline path. But the forecasts are uncertain, as illustrated by the fan chart. Our interest rate forecast is not an unconditional promise, but signals how we will set the interest rate if developments in the Norwegian economy are in line with our projections. The interest rate path presented in June indicated that the interest rate would gradually be raised towards a normal level in the next years. It followed that the interest rate would, with some degree of probability, be increased in August. This was conditional on the economic outlook we presented at that time.

Chart: Interest rate forecast with fan chart and alternative scenarios in the June 2011 Monetary Policy Report

The Bank's *Monetary Policy Report* also presents alternative scenarios for the Norwegian economy. If developments are broadly in line with expectations, economic agents can expect that the interest rate will be set in line with that projected by Norges Bank. If conditions change, as was the case in August, Norges Bank will naturally adapt the monetary policy stance in the light of new economic prospects. Through our communication and the reports we publish, it is possible for an external observer to anticipate this reaction with a fair degree of accuracy. My impression is that economic agents and analysts are generally fairly close to the mark in their analyses when they attempt to predict the interest rate level.

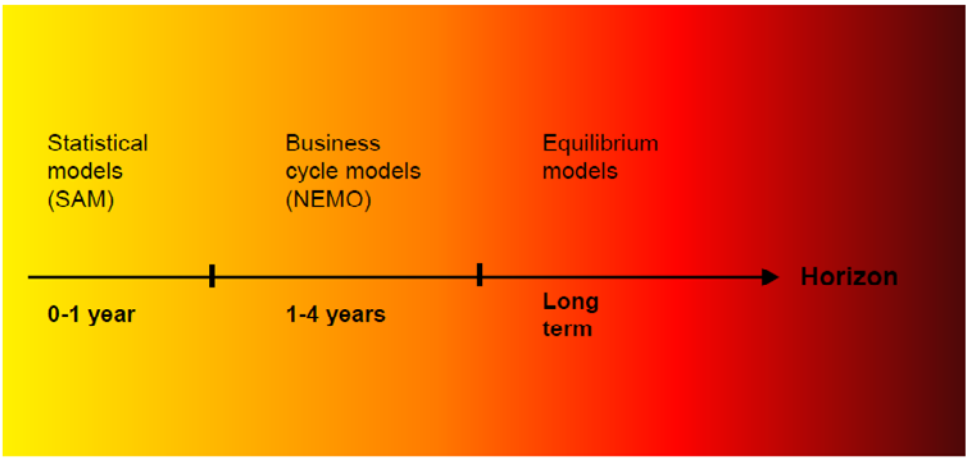
Chart: Summary

When the inflation target was introduced, Norges Bank stated that it would place particular emphasis on stabilising inflation in the initial years. As inflation became more firmly anchored, there was broader scope for giving more weight to stabilising output and employment. In addition, we now have ten years of experience and insight. Compared with the first years, inflation targeting is now more flexible.

When Haavelmo received the Nobel Prize, he reminded us that economic policy can be demanding. A failure to react to the build-up of imbalances undermines confidence in economic policy. If we tighten policy to rein in imbalances – and succeed – we are viewed in retrospect as having been unduly pessimistic. There is, though, reason for a certain degree of optimism. Theoretically anchored models and improved methods for quantifying them empirically provide a better basis for conducting an effective economic policy. Moreover, we use professional judgement, which we take on board when we apply and further develop models and the analytical apparatus in Norges Bank. Knowledge about relationships in the Norwegian economy, in conjunction with professional judgement, provides a good platform.

Thank you for your attention.

Different horizons – different models

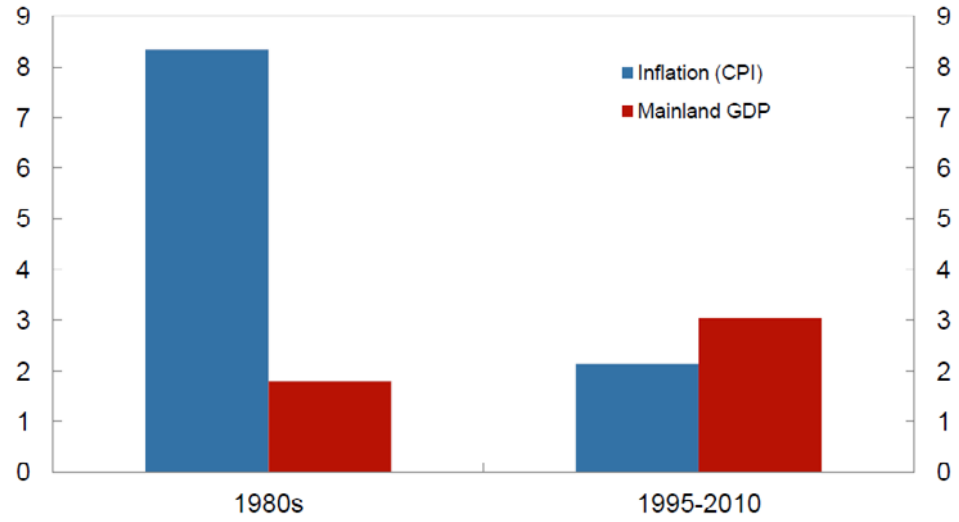


Main requirements for a model for monetary policy

1. Monetary policy controls inflation
2. Expectations must be included
3. Based on theory and empirical data
4. Understandable and easy to communicate

Growth and inflation

Percentage annual growth. Average



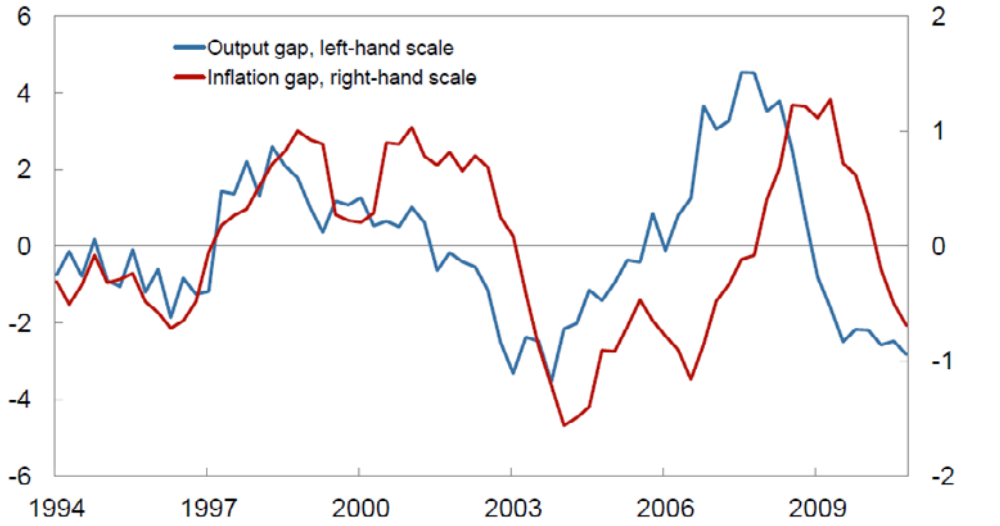
Sources: Statistics Norway and Norges Bank

"Essentially, all models are wrong, but some are useful."

George Box (1979)

Output and inflation

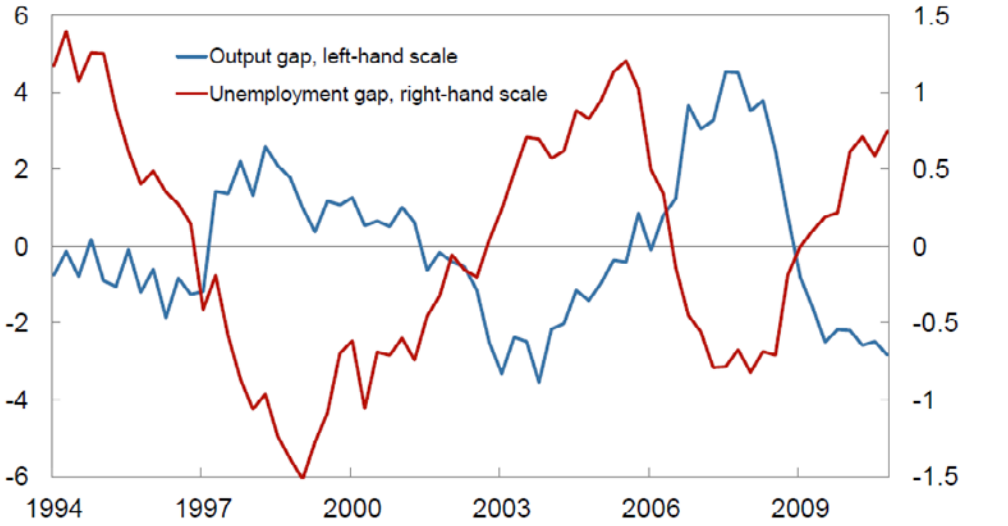
Percentage deviation from trend



Sources: Statistics Norway and Norges Bank

Output and unemployment

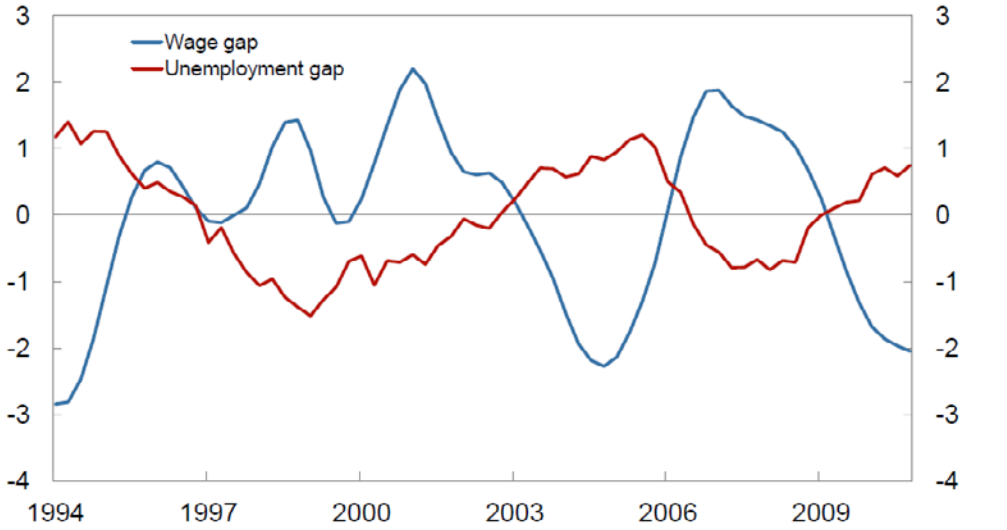
Percentage deviation from trend



Sources: Statistics Norway and Norges Bank

Unemployment and wage growth

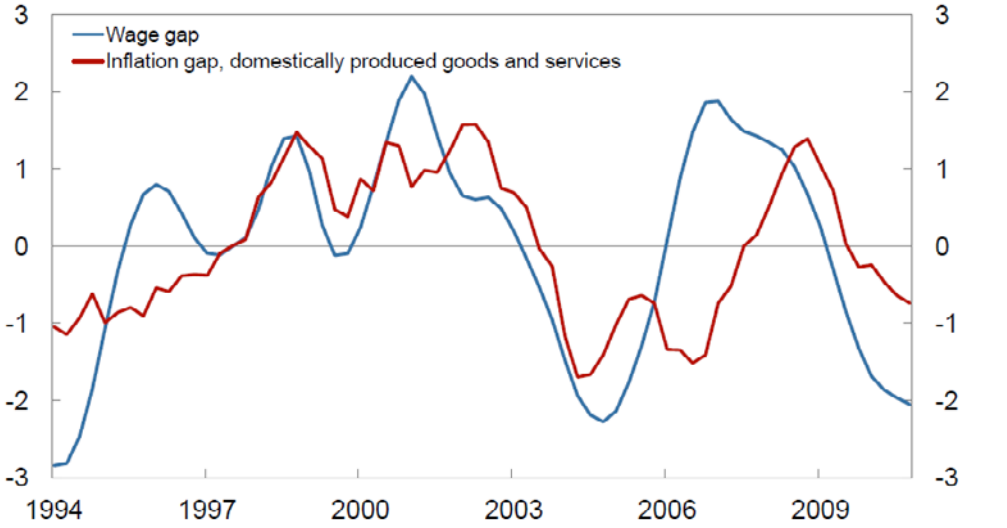
Percentage deviation from trend



Sources: Statistics Norway and Norges Bank

Wage growth and inflation

Percentage deviation from trend



Sources: Statistics Norway and Norges Bank

The interest rate is an endogenous variable

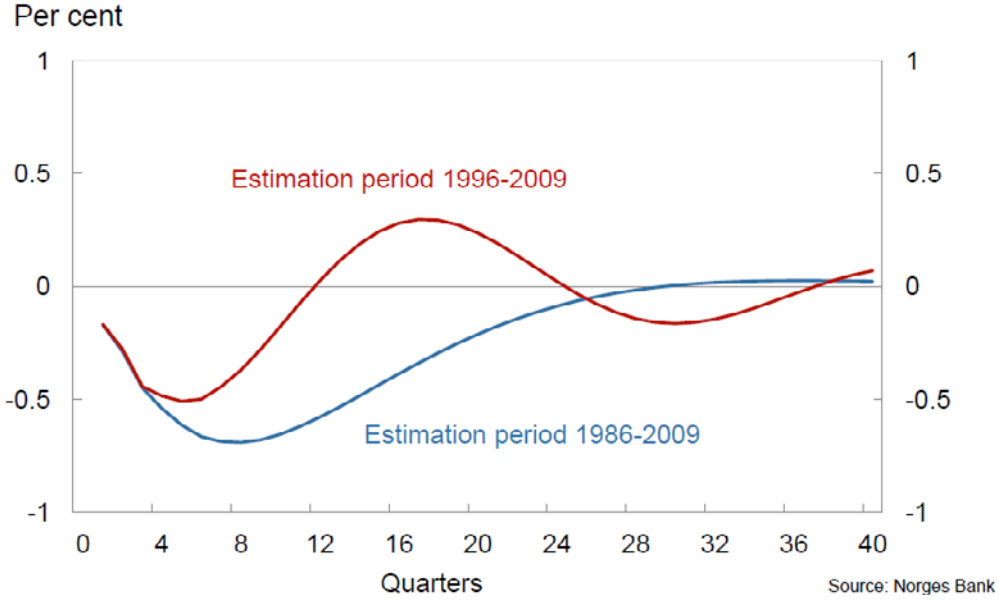
The effect of a change in the interest rate depends on:

- The reason for the change
- Whether the change is a surprise
- Whether the change is temporary or of long duration

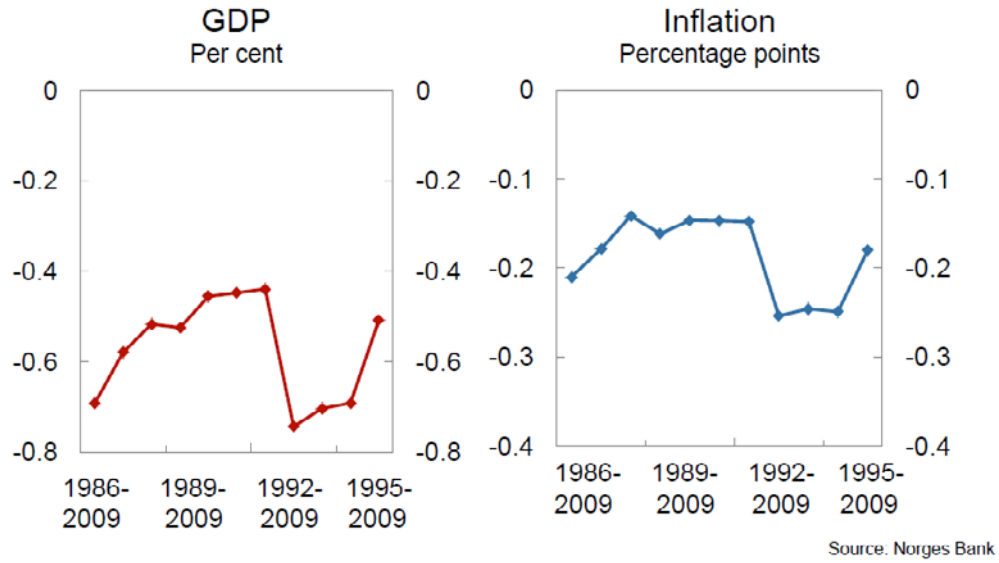
VAR model
(vector autoregressive model, structural)

- Mainland GDP
- Inflation (CPI-ATE)
- Exchange rate
- Interest rate

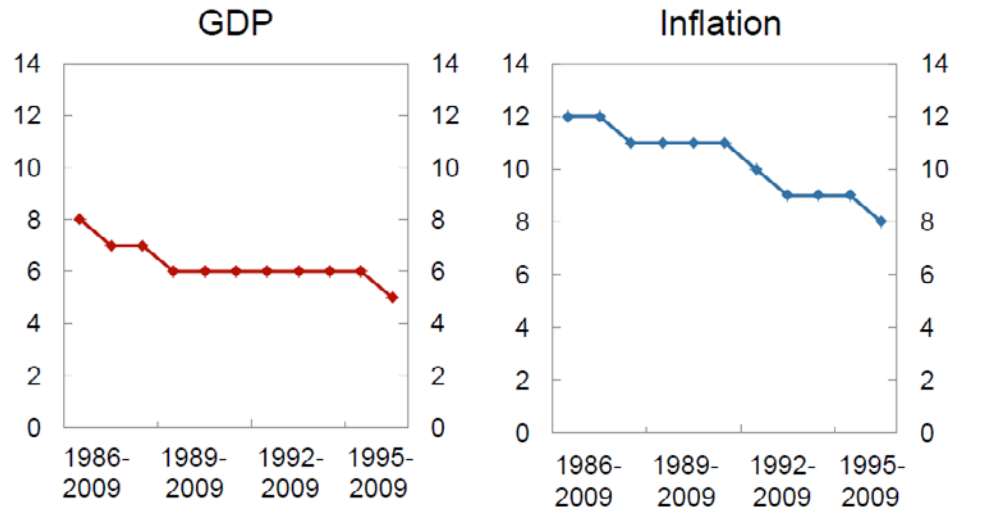
Isolated effect on GDP of an interest rate increase in two different VAR models



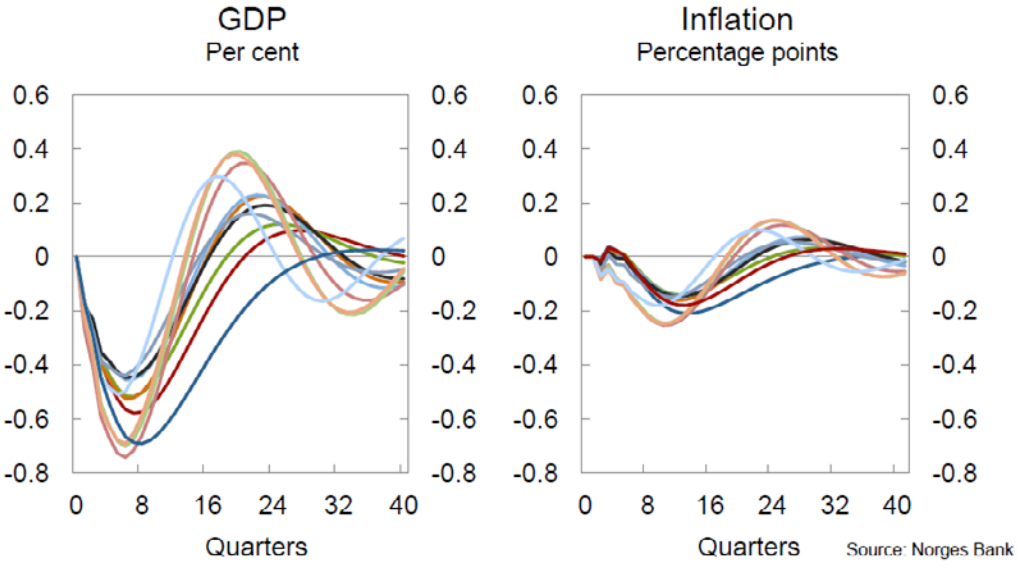
Maximum impact of a 1 percentage point interest rate increase, different estimation periods



Number of quarters to maximum effect of interest rate change, different estimation periods



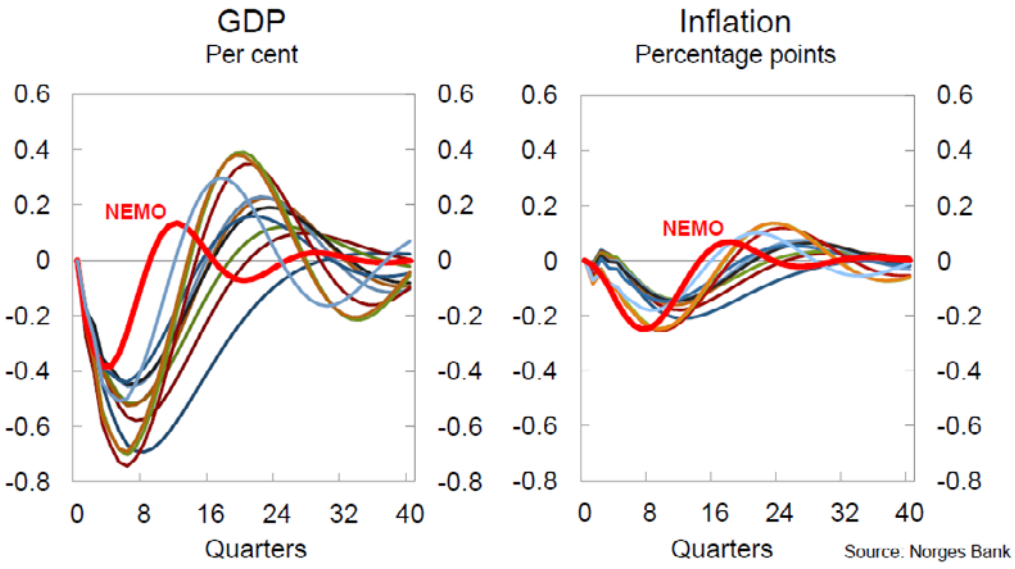
Effect of monetary policy shocks, different models/estimation periods



NEMO (Norwegian Economy Model)

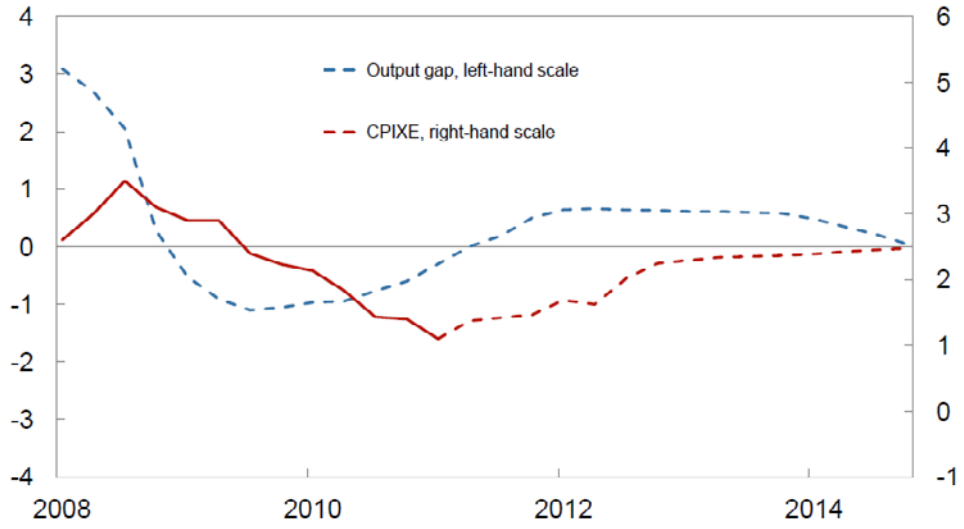
- General equilibrium model (DSGE)
- Forward-looking participants
- Monetary policy controls inflation and gives weight to stabilising output
- No long-term trade-off between inflation and unemployment
- Estimated on Norwegian data

Effect of monetary policy shocks in the VAR models and in NEMO



Projected inflation and output gap in the baseline scenario from MPR 2/11

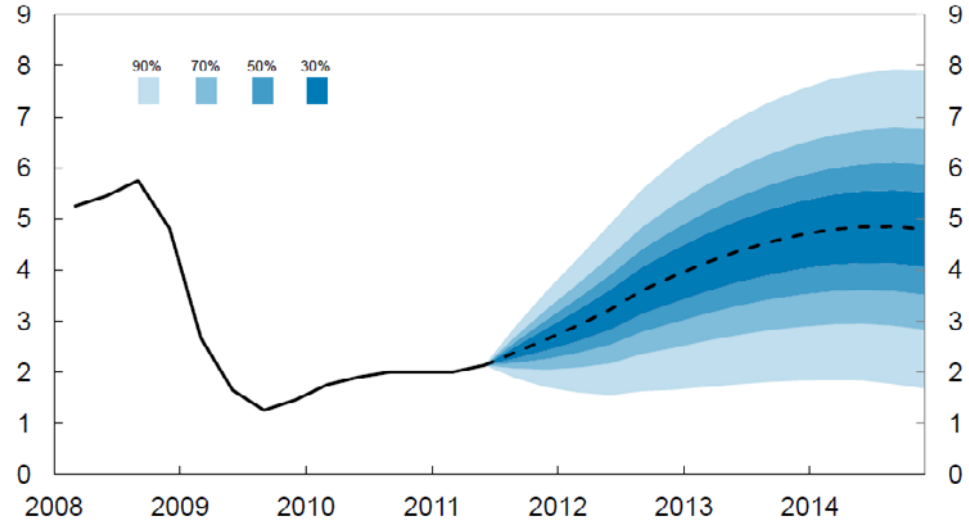
Per cent. Quarterly figures. 2008 Q1 – 2014 Q4



Sources: Statistics Norway and Norges Bank

Projected key policy rate in the baseline scenario from MPR 2/11 with fan chart

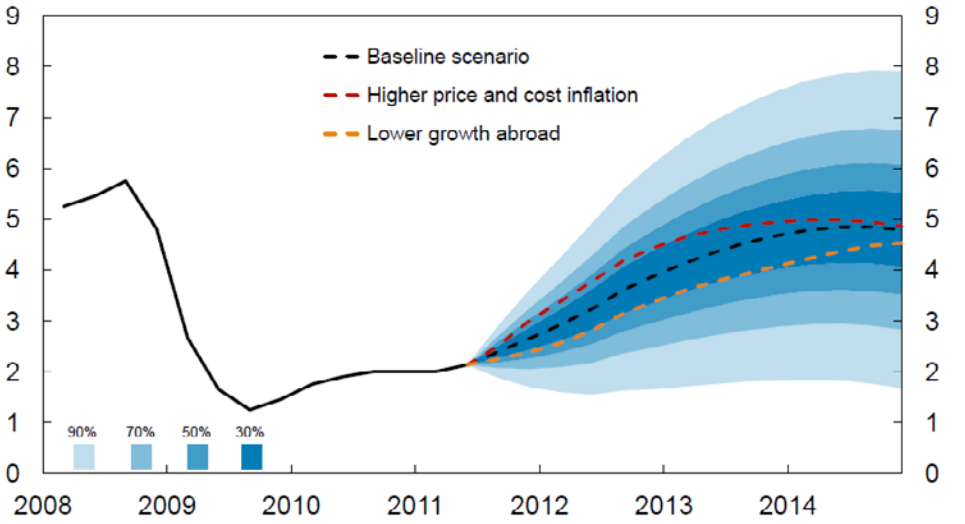
Per cent. Quarterly figures. 2008 Q1 – 2014 Q4



Source: Norges Bank

Key policy rate in the baseline scenario and in the alternative scenarios from MPR 2/11

Per cent. Quarterly figures. 2008 Q1 - 2014 Q4



Source: Norges Bank

Summary:
Response pattern in interest rate setting

- Empirically anchored
- Theory-based
- Professional judgement
- Learning