Øystein Olsen: Use of models and economic theory in Norges Bank

Lecture by Mr Øystein Olsen, Governor of Norges Bank (Central Bank of Norway), at the Department of Economics, University of Oslo, Oslo, 8 September 2011.

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The lecture is based on previous speeches and newspaper articles. A brief comment on recent developments is included in the final section.

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

Allow me to start by thanking you for your invitation to give this year's Schweigaard lecture. Anton Martin Schweigaard was one of the leading statesmen of 19th century Norway. He was a jurist, a politician and an economist. Although "revival of productive forces" and "expansion of national wealth" were to Schweigaard important objectives for economic policy, most important was the promotion of "moral progress", "public decency" and "the perfection of political and legal institutions".[1]

I doubt that Schweigaard was always impressed by the perfection of political institutions, perhaps in particular the institution of Norges Bank. Schweigaard grew up in modest circumstances in the small market town of Kragerø on the coast of southern Norway – a town severely affected by the British blockade of Norway during Denmark-Norway's involvement in the Napoleonic Wars in the early 1800s. Norges Bank was established in 1816, the year after the Wars ended. The Storting decided that a compulsory silver tax would be levied to provide capital for Norges Bank. Schweigaard's brother wrote[2]: "When the compulsory payment to Norges Bank came in addition – Anton and I witnessed our parents' silverware and gold ornaments being melted down to pay the tax – it is easy to understand that many of the town's inhabitants found it difficult to make ends meet, which unfortunately was also the case with my parents and grandmother, and times were hard." But Schweigaard was a talented man and it was said that he had probably never been as happy as when he passed his examen artium with flying colours and was admitted here to the University of Christiania.

I expect that as you embark on your economics studies, you will get down to business with the same energy and enthusiasm as Schweigaard did then. I expect you will learn that economics is not a perfect subject. But I know that the study of economics will provide you with a useful tool to further improve both the subject and the institutions. In my lecture today, I will provide some insight into how Norges Bank makes use of economic models and touch upon the issues you will have the opportunity to explore further in the course of your studies.

Inflation is a persistent rise in the general price level or, in other words, a fall in the value of money. When inflation is high, it is as a rule also variable. This generates uncertainty for households and firms. It is costly to bring high inflation under control. However, inflation should not become too low either. Deflation is often synonymous with recession.

Central banks have always had a natural responsibility for stabilising the value of money. Schweigaard was concerned with stabilising the krone's value in silver terms. Since that time, Norway has operated various regimes with the aim of stabilising the value of money. A silver standard for the krone was followed by the gold standard. Later Norges Bank sought to stabilise the krone's value against other currencies, first the pound sterling and thereafter the US dollar. For a long period after the war, various fixed exchange rate systems were introduced under international agreements, which were subsequently abandoned in favour of

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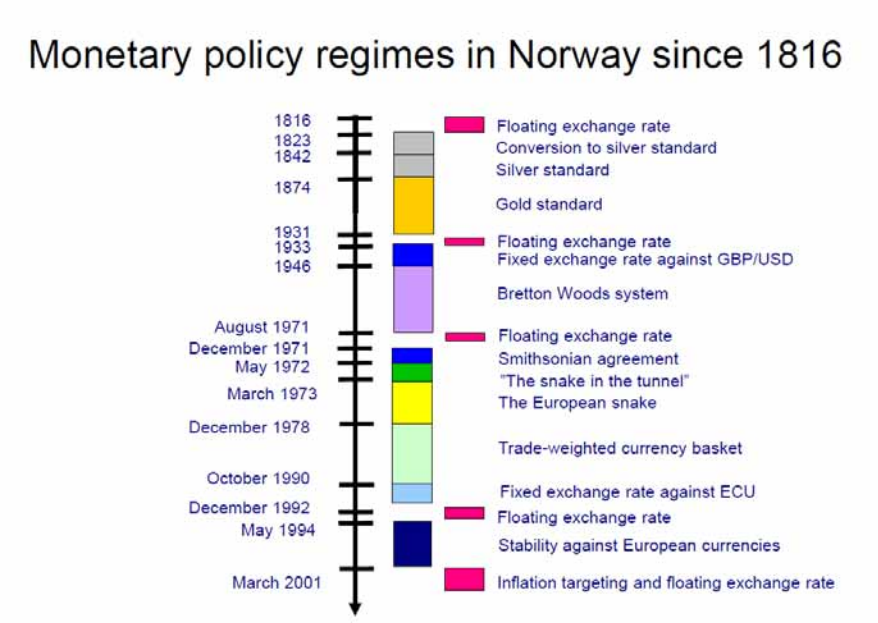
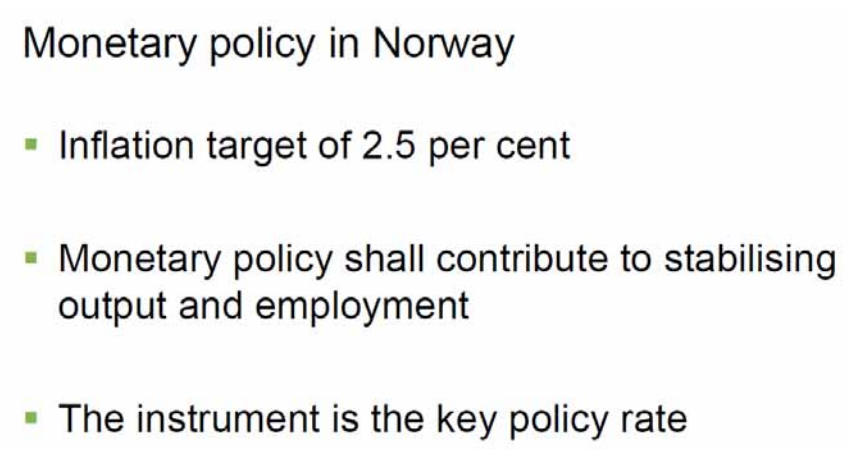
1 Slagstad, Rune (1998), "De nasjonale strateger" (National strategists), Pax

2 Aubert, L. M. B. (1883), "Anton Martin Schweigaards barndom og ungdom" (Anton Martin Schweigaard's early years), P.T. Mallings Boghandels Forlag

a more unilateral stabilisation of the krone against various currencies. Since 2001, the objective of monetary policy has been low and stable inflation. Rather than stabilising the value of money indirectly through an exchange rate target, we now aim to attain a more direct objective which we believe monetary policy can achieve over time.





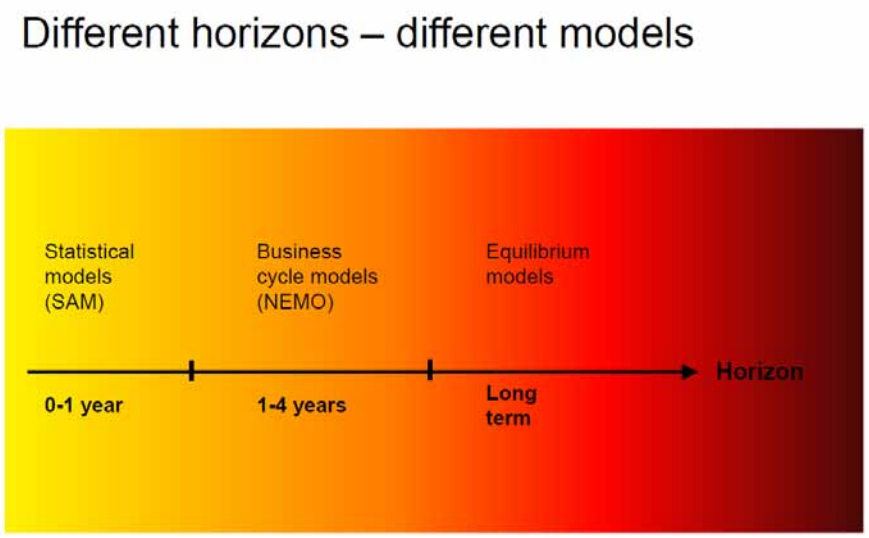
The operational target of monetary policy is annual consumer price inflation of close to 2½ per cent over time. Monetary policy shall also contribute to stabilising output and employment. In this respect, inflation targeting is flexible.

The inflation target is symmetrical – it is just as important to avoid an inflation rate that is too low as an inflation rate that is too high. The inflation target provides economic agents with an anchor for inflation expectations. Decisions concerning saving and investment can be based on the assumption that inflation in Norway will be around 2½ per cent over time.

Norges Bank's instrument to meet the inflation target is the key policy rate, which is the interest rate on banks' deposits in Norges Bank. This interest rate forms the basis for banks' lending and deposit rates.

The Bank' 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. But we need a methodical apparatus to structure this knowledge.

Like other central banks, Norges Bank uses economic models as an aid in monetary policy analysis. Economic models can help us to interpret historical developments, make forecasts for the future and analyse the effect of the interest rate. For an economic model to be relevant, it must be fit for its intended purpose. A model 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 for example seek to provide optimal near-term inflation and output forecasts.



In this chart, the time axis has been divided into three: short term, medium term and long term. There are no sharp dividing lines between these horizons. Nonetheless, the time horizon imposes various requirements on economic theory and models for our purposes.

The starting-point for the analyses is important. 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 information set is uncertain. Statistics are published with a lag and are often revised. 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 months ahead.

There are certain similarities between projecting developments in the Norwegian economy in the coming months and forecasting the weather. Meteorologists have observed that averaging forecasts from a large number of models generally produces more accurate forecasts. 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.[3] The model weights are determined on the basis of historical accuracy and are continually adjusted so that models with better predictive power are given greater weight in the

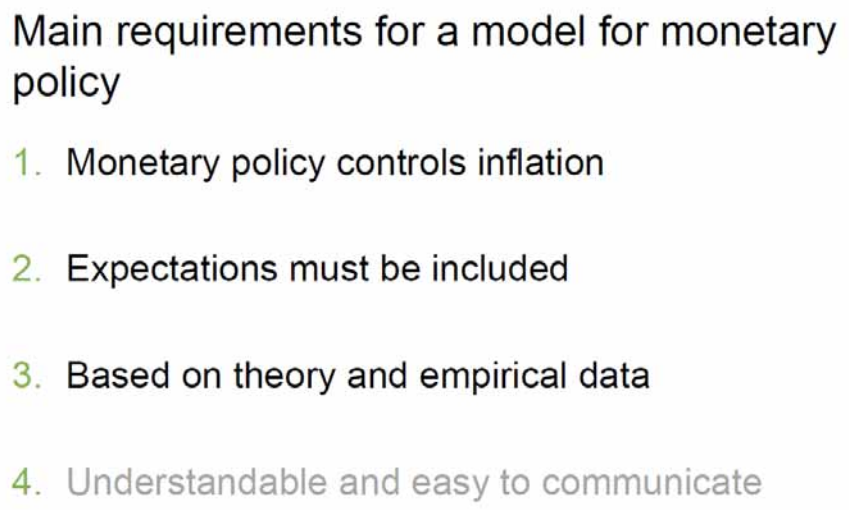
[3] The models are grouped into three classes: factor models, indicator models and VAR models. The models within each class may contain different variables or be variants of one another. For a detailed discussion, see Aastveit, K.A, K. Gerdrup, A.S. Jore (2011) "Short-term forecasting of GDP and inflation in real time: Norges Bank's system for averaging models", Staff Memo 9/2011, Norges Bank

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.

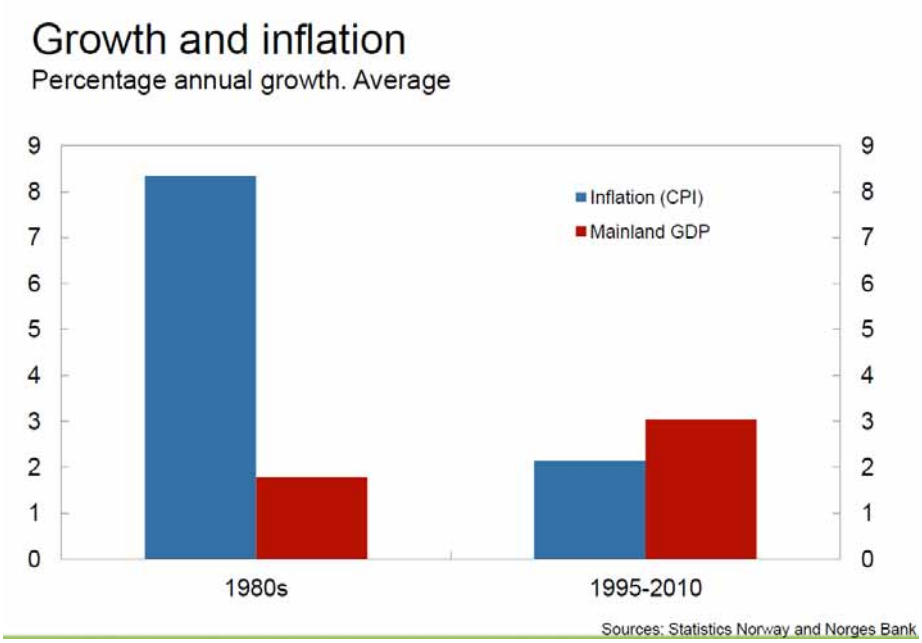
NEMO is a model for analysing fluctuations in the Norwegian economy around a long-term trend. In the medium term, the economy may in periods deviate substantially from trend, referred to as cyclical fluctuations. When the fluctuations subside, we must assume that the economy is moving towards equilibrium. The long-term trend is not determined by monetary policy, but by assumptions regarding technological developments and the supply of labour and capital.

When we set the interest rate, we give weight to both 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.



As I mentioned earlier, 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.



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

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

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.

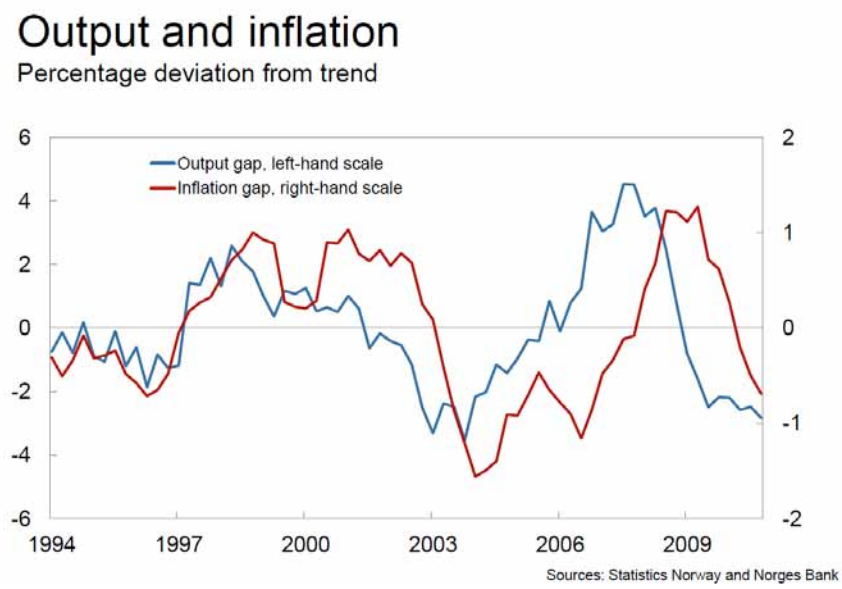
It is also of considerable importance to us that the economic mechanisms in the model should be understandable and easy to communicate. The model apparatus is to function as a useful tool, both in the internal process ahead of the monetary policy meetings and in Norges Bank's external communication.

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

George Box (1979)

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 and 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.

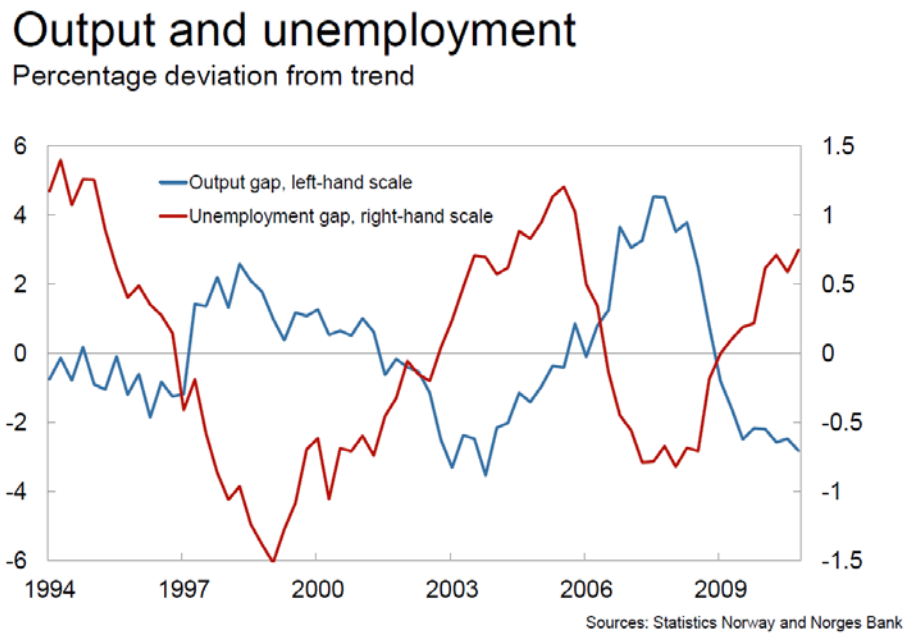


Let me begin by taking a look at the relationship between output and inflation. In recent years, consumer price inflation (CPI) has fluctuated between 0 and 3 per cent. Mainland GDP growth has also fluctuated, giving rise to economic cycles. The chart shows developments in the two variables measured as deviations from long-term trend growth, in other words an "inflation gap" and an "output gap".[4] When the output gap is positive, the

[4] 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 in this analysis is a technical estimate and does not fully correspond with the output gap in Norges Bank's *Monetary Policy Report*.

economy is usually in an upturn, while the economy is in a downturn when the gap is negative.

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.[5] 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.



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[6] 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 the unemployment data published at the end of each month 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.

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[7] moves up fairly rapidly. Changes in unemployment appear to have a fairly immediate impact on wage growth.

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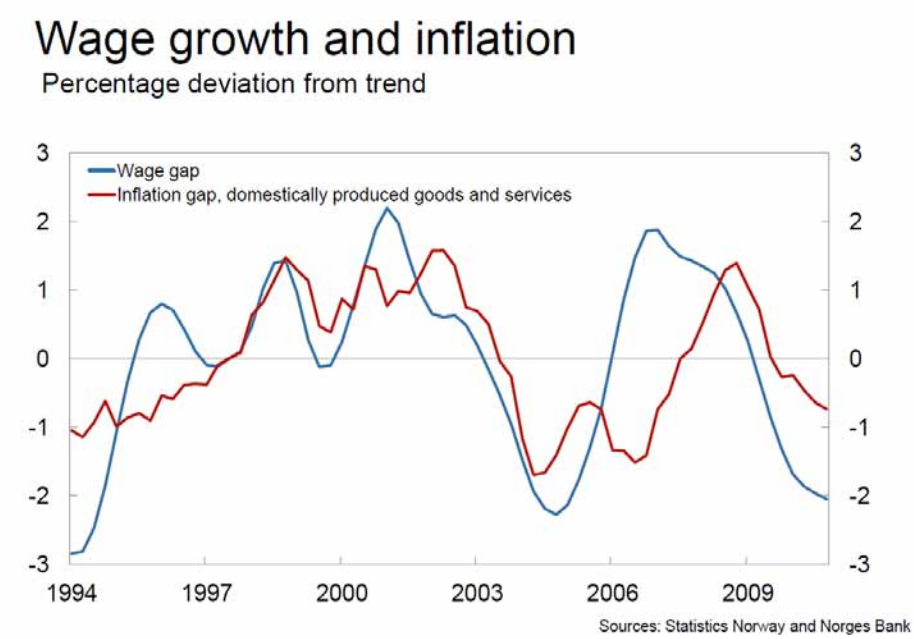
[5] The correlation between these two data series is highest when the output gap is deferred 4–5 quarters into the future.

[6] Unemployment measured according to LFS

[7] Mainland hourly wage growth from quarterly national accounts



Not unexpectedly, there is also a close statistical relationship between wage growth and the rise in prices for domestically produced goods. 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.

The interest rate is an endogenous variable

- Interdependency between the interest rate and other variables in the economy
- Demanding to identify the effects of interest rate changes

Historically, the interest rate has been set in response to various developments and shocks. In this respect, the interest rate is an endogenous variable, that is to say it is dependent on other economic variables. The relationship between the interest rate and other key variables has through history also been influenced by shifting monetary policy objectives.

Let us look at two different situations. In the first, there is an unexpected sharp rise in inflation. In response, the interest rate could be raised to bring inflation down again, which will curb growth in household and corporate consumption and investment. In the second, there is a sudden sharp pickup in demand for goods and services. The interest rate might be raised in this case too in order to prevent inflation from rising at a later stage. In historical data, a higher interest rate can go hand in hand with both lower growth and higher growth. It is demanding to identify the effects of interest rate changes when studying historical data series. Trygve Haavelmo, Nobel Prize winner and a former professor here in the Department of Economics, called this a problem of identification.

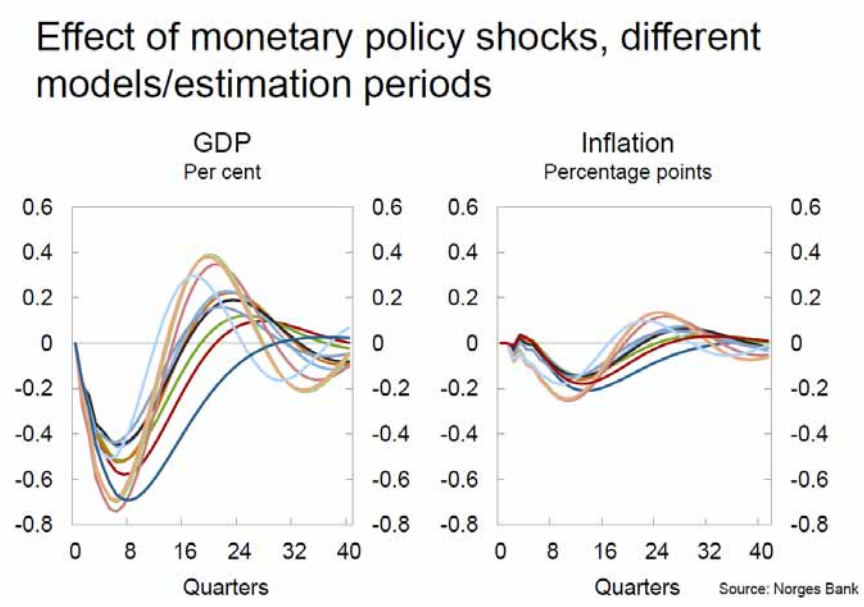
VAR model
(Vector Autoregressive Model, structural)

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

In order to analyse the effects of the interest rate, we need an analytical apparatus that can take into account the interdependency between the interest rate and the other variables we want to analyse. A simple approach involves using a vector autoregressive (VAR) model. You may come across this type of model in your statistics and economics courses. The VAR model I am going to present here includes mainland GDP, the interest rate, the krone exchange rate and inflation.[8] All the variables are a function of lagged values of themselves and the other variables. The system of equations is estimated on historical data. To estimate the model, the relationship between some of the variables is predetermined in line with economic theory. For example, assumptions can be made concerning the sequence in which the different variables will affect one another.

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.

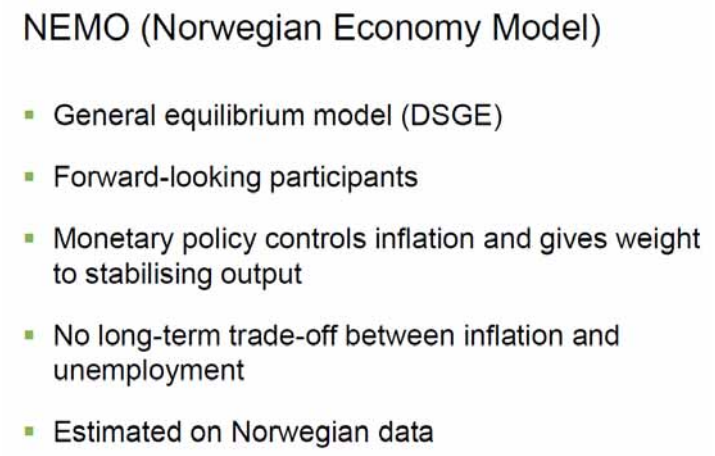
The effect of such a rise in the interest rate will depend on the variables included in the model, the model's structure and estimation period. On the one hand, the result can be more robust if we use a long time-series in the estimation. On the other hand, historical changes in monetary policy regimes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



[8] Consumer price inflation adjusted for tax changes and excluding energy products (CPI-ATE)

The chart shows the effect of an interest rate increase on output and inflation over time in 11 VAR models. These models only differ in that they are estimated on data from slightly different time periods. In each estimation we use data up to the present, but start the estimation at different points in time between 1986 and 1996.

In the analysis, the interest rate is raised by 1 percentage point, that is, an interest rate shock is applied. Thereafter the model takes over and the interest rate gradually falls back, in line with the model's estimated reaction pattern. In the course of a couple of years, the interest rate has returned to its starting point.[9] As the chart shows, the degree of spread in the results is considerable. If we were to draw a fan chart, or confidence intervals, around each model, it would become clear that the uncertainty is even greater than the spread alone indicates. The results must therefore be interpreted with caution. 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.



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 in 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. There are three economic agents: households, firms and a central bank. Households demand goods and supply labour. They assess how much to spend relative to saving and how much they should work subject to their budget constraints. Firms decide how much to produce and set prices to maximise their profits, given expected prices for the input factors labour and capital. These are key mechanisms in microeconomic theory.

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. In the light of these mechanisms, NEMO can be called a New Keynesian model, with Keynesian properties in the short and medium term and classical properties in the long term.

You will learn more about this type of model in your macroeconomics courses and the method for estimating such models in econometrics, although perhaps not until you reach Master's level.

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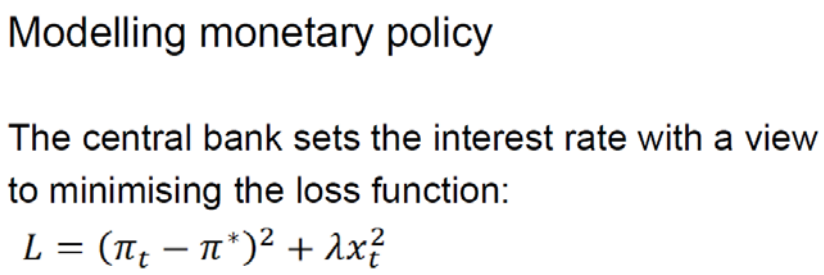
[9] Thereafter the interest rate falls slightly below the starting point for a period.

Before I show you how the interest rate works in NEMO and compare the results with the VAR model, I would like to show you how monetary policy is modelled in a model such as NEMO.

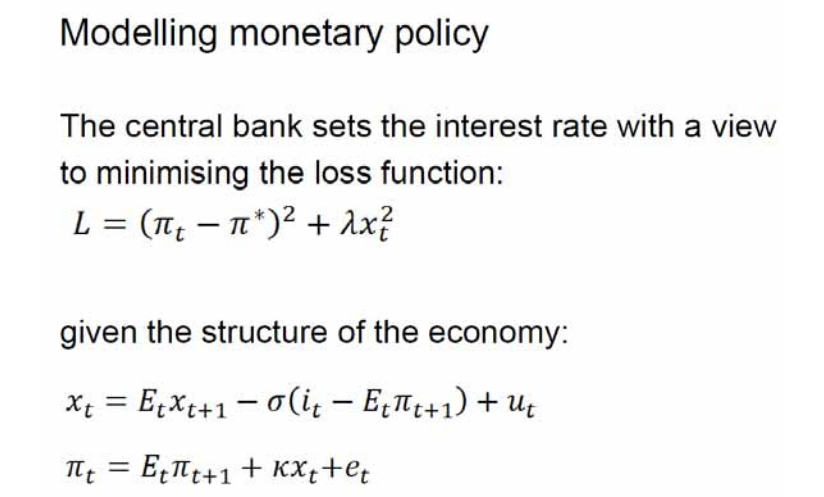
In the model, the central bank's objective is to steer inflation. The interest rate is set to stabilise inflation at 2.5 per cent somewhat further ahead and weight is also given to stabilising developments in output. In some cases, a change in the interest rate will enable both objectives to be met at the same time. But situations can also arise where an interest rate change cannot bring inflation back to target without output moving in the wrong direction. Then, a trade-off must be made between the objectives and attaining them will take longer.

The central bank's objective is formalised through a loss function. The loss function can, somewhat simplified, be illustrated as follows:



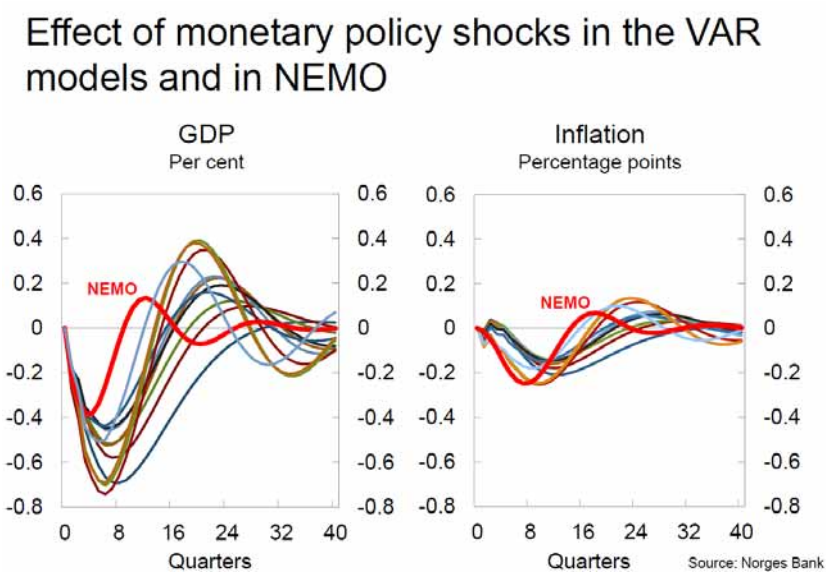
In the equation, π denotes inflation, π * the inflation target and x is the output gap. The loss function includes deviations of output from potential output and deviations of inflation from the inflation target. The deviations enter the loss function quadratically, that is the central bank's "loss" – or disadvantage – increases with large deviations from the targets either way.

The trade off between stabilising inflation close to target and avoiding fluctuations in output and employment is expressed by the parameter λ. The lower λ is, the greater the weight given by the central bank to stabilising inflation. If λ is equal to zero, all other considerations are set aside, while λ greater than zero is the expression of a system of flexible inflation targeting.

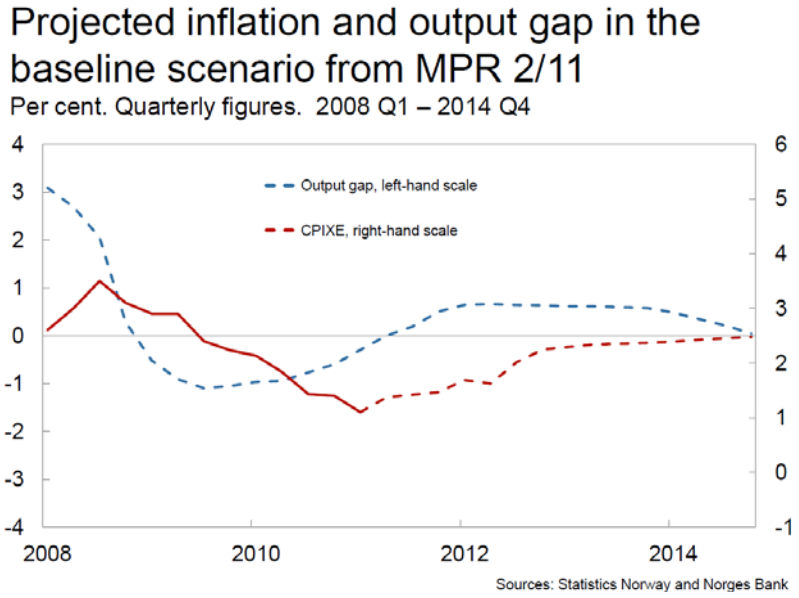


In NEMO, the interest rate is set with a view to minimising the overall "loss" as expressed in such a loss function. Consideration is then given to the effect of the interest rate it on inflation and output and their interaction. The chart is a simplified illustration of the model. The

economic relationships are illustrated here by a simple New Keynesian model, which you will become more familiar with in the course of your studies.[10]



NEMO is an empirical model, that is to say it is estimated on Norwegian data. In order to see how monetary policy works in NEMO, we have increased the interest rate to the same extent as in the VAR models. 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,[11] in spite of the different principles on which the models are based. Overall, it appears that a one percentage point increase in the interest rate dampens output growth by about ½ percentage point and inflation by around ¼ percentage point. The effect of the interest rate increase on GDP reaches its maximum after about one year, while the maximum effect on inflation occurs with a lag of close to two years.

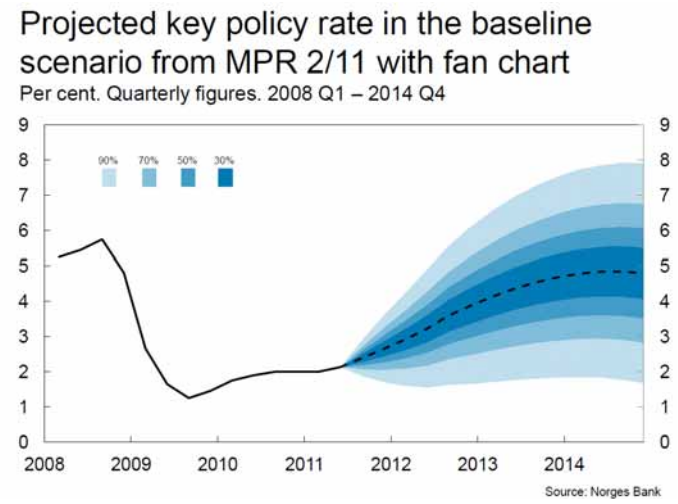


[10] See Alstadheim, Ragna et.al (2010), "Monetary Policy Analysis in Practice", Norges Bank *Staff Memo* 11/2010

[11] 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

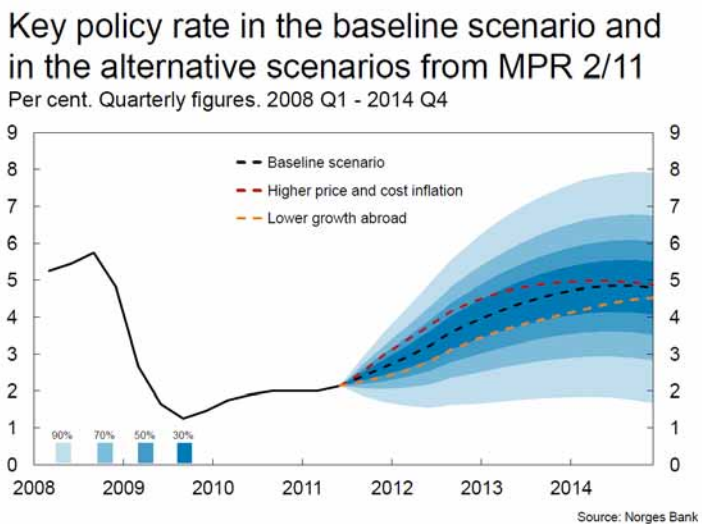
The *Monetary Policy Report*, which Norges Bank publishes three times a year, includes a discussion of key trends and an analysis of the interest rate path ahead. The models I have described here are key support tools. But a model will never be able to tell us exactly how the interest rate should be set. The ultimate assessment is, as mentioned, a result of Norges Bank's professional judgement and will also capture considerations that are not sufficiently taken into account by our models. As such, the models are only a tool. But, a model such as NEMO is a useful tool for analysing developments and in interest rate setting. It helps us interpret and understand the dynamics of the Norwegian economy and can help us to achieve consistency in our monetary policy response pattern.

The chart shows our forecasts for inflation and the output gap in the June Report (2/11). The output gap was assumed to increase 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 gradually move up to target.



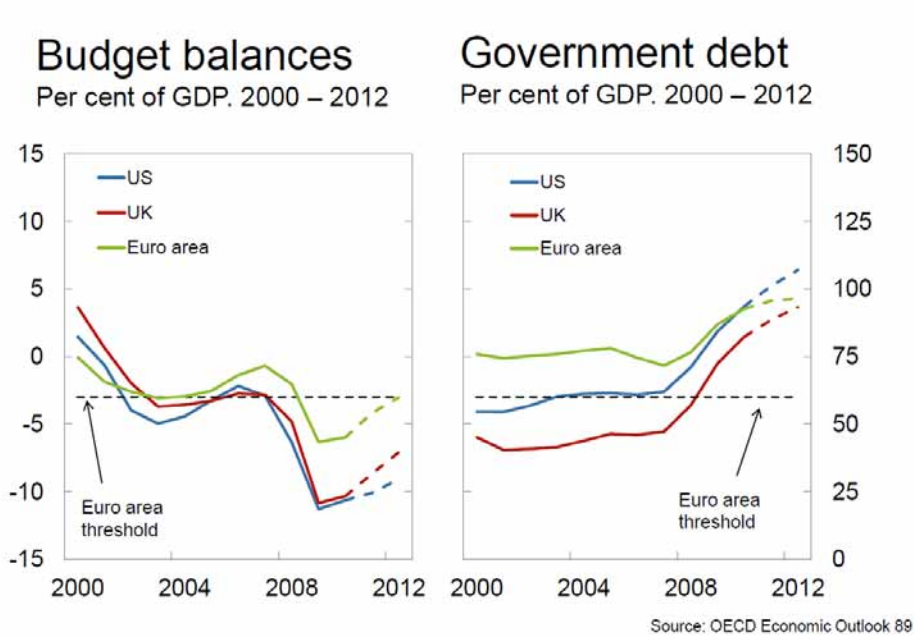
The interest rate path presented in June indicated that the interest rate would gradually be raised towards a normal level in the next years. This was conditional on the economic outlook we presented at that time.

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 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 summer, dramatic falls on stock exchanges and political unrest made the headlines. There are now prospects of lower economic growth in many countries. In both the US and many countries in Europe, public debt is high and fiscal deficits are substantial. At the same time, measures to reduce the deficit in the short term will also dampen activity. Some economists fear a renewed economic setback in the US and the financial markets are characterised by turbulence and uncertainty.



The US and EU authorities are facing demanding decision-making processes. In the US, the political parties and the people are divided in their views on taxation and the exercise of central government authority, reflected for example in the absence of measures to strengthen central government revenues. The debt problems in the EU are being aggravated by the lack of a similar coordination of fiscal policy to support the European monetary union. Government finances in many of the countries now experiencing problems have been weaker than required under the EU's own rules for several years.

Measures have been put in place. The EU countries have established a joint fund to provide loans for countries with debt problems. The ECB has intervened with support purchases of government bonds. These measures are limited in scope and duration and are intended to be replaced by more permanent resolution mechanisms once they have been implemented. The political authorities may still, in time, find suitable and more permanent solutions, both in Europe and the US. But the road ahead may be both bumpy and long.

The Norwegian economy is robust. Government finances are sound, banks are solid, unemployment is low and the economy is growing at a fairly solid pace. At the same time, we must acknowledge that we are influenced by turbulence and weaker prospects internationally. Norway is an open economy. Norwegian firms will be affected if demand slows or funding becomes more difficult. Monetary policy can respond rapidly to changes in the outlook, for example as reflected in Norges Bank's decision to keep the key policy rate unchanged at the August monetary policy meeting.

Earlier this week, the Swiss National Bank decided to announce a minimum exchange rate for the Swiss franc against the euro owing to the substantial appreciation of the Swiss franc. Interest rates and inflation in Switzerland are close to zero and growth is low. According to the Swiss National Bank, a further appreciation could have resulted in a recession with deflationary developments. Measures were therefore introduced to prevent such developments. The Norwegian krone appreciated sharply after the announcement. A krone that is too strong can over time result in inflation that is too low and growth that is too weak. In that case, monetary policy measures will be taken. In Norway, the key policy rate is the relevant instrument.

The Norwegian krone market is small by international standards. This means that the krone exchange rate can fluctuate considerably in times of international turbulence. This will also be the case the day foreign exchange market participants decide to shift out of their krone positions. The exit may prove narrow if too many investors decide to withdraw at the same time.

I began my lecture with Schweigaard's childhood experience of his family having to surrender gold and silver for the establishment of Norges Bank. This experience cannot have given him much confidence in public institutions. As an adult, both as a professor of economics and a national politician, Schweigaard became a trendsetter in the area of monetary policy conduct.

Schweigaard's fundamental view was based on "*empirical methods*" rather than the "*empty speculation*" of idealism.[12] This still applies to monetary policy. Theoretically anchored models and improved methods for quantifying them empirically provide a better basis for conducting an effective economic policy, 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 and good luck with your studies!

[12] Slagstad, Rune (1998), "De nasjonale strateger" (National strategists), Pax