

EVALUATION OF NORGES BANK'S PROJECTIONS

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As a means to drawing up the most accurate projections possible for economic developments, Norges Bank regularly evaluates its model-based forecasts. Analyses of forecast errors may make an important contribution to improving projections. It is also desirable to compare Norges Bank's projections with those of other institutions.

The strength of the cyclical upswing was clearly underestimated in the projections for the period 1994-1996. Projections for employment growth were particularly low, also for the 1997 projections albeit to a lesser extent. On the other hand, forecasts for price and wage inflation were fairly accurate. The forecast errors were to a large extent ascribable to erroneous assumptions about economic policy, particularly growth in public demand. Petroleum investment was also much higher than projected. If the model-based projections are corrected for these factors, they are very close to the outturn, particularly for price and wage inflation. Over the past year, Norges Bank took steps to improve the accuracy of the exogenous variables used in the projections. Among other things, the estimate for public spending growth is supplemented by Norges Bank's own assessment of local government demand. Furthermore, data on oil-related activities are collected from a larger number of sources than earlier.

A preliminary analysis of forecast errors for 1998, based on figures from the national accounts figures published in February 1999, indicates that previous analyses of forecast errors may have improved the projections. Forecast errors seem to have been reduced in 1998 compared with the two previous years.

A comparison with projections from Statistics Norway and the Ministry of Finance for the period between 1994 and 1998 indicates that the degree of forecast errors from the three institutions has been fairly similar. On average, however, projections from Statistics Norway and Norges Bank have been more accurate than forecasts from the Ministry of Finance.

In this article, we focus on forecast errors stemming from erroneous estimates of economic policy and inaccurate projections for other exogenous variables. A more thorough analysis would also include a further disaggregation of errors stemming from the incorrect use of the model and those errors occurring due to model deficiencies. Such an analysis will be undertaken once the revision of the national accounts system that took place in the mid-1990s has been fully incorporated in the model data.

Introduction

Pursuant to the Norges Bank Act, Norges Bank is an executive and advisory body in the area of monetary and foreign exchange policy. Analyses of the macroeconomic situation, including forecasts for economic developments in the Norwegian and international economy, which are published in the Bank's quarterly Inflation Report, are an important basis for the formulation of monetary policy. In addition, the analyses are used as a basis for advice on the orientation of general economic policy.

Norges Bank aims to produce the best possible projections for the Norwegian economy. The macroeconomic model RIMINI, developed in Norges

Bank's Research Department, has been the principal tool for Norges Bank's analyses since 1994. RIMINI is an econometric model with approximately 370 equations. About 70 of these equations are estimated on the basis of historical data, while the remaining equations are definitional relationships.

It must be possible to evaluate the outturn of Norges Bank's projections if they are to be credible over time. For this reason, Norges Bank has placed considerable emphasis on transparency and the availability of its forecast work, including adjustments of previous errors. Projections are based on a model that is publicly known, and the Bank's use of the model is published. The purpose is to provide

*With thanks to my colleagues at Norges Bank for their useful comments.

others with the basis for evaluating how we have arrived at our projections. Systematic evaluation of the use of the model places greater demands on the Inflation Report and ensures that projections are not actively used in an attempt to influence the market in any way.

It is important that errors are revealed if projections are to improve and become more accurate. This will lay the foundation for better exogenous projections and for improving the model and the way the model is used. We also wish to compare Norges Bank's projections with those of other institutions in order to determine whether our projections are at least on a par with those of other institutions.

Analyses of Norges Bank's projections have been published previously. In an article published in *Penger og Kreditt* 1996/1 (Madsen 1996), Norges Bank's projections for the years 1987-1994 are compared with those of other institutions. An article published in *Economic Buletin* 1998/1 (Jore 1997) provides an analysis of Norges Bank's projections for the period 1994-1996 that focuses on the factors behind forecast errors in 1996. The article also provides some summary measures of forecast errors for the Ministry of Finance, Statistics Norway and Norges Bank, showing that these institutions' projections were almost equally accurate. The article also shows that the strength of the cyclical upswing was considerably underestimated by all the institutions.

The first section of this article briefly describes the main sources of forecast error. This is followed by an analysis of forecast errors in Norges Bank's projections for 1997. The evaluation was carried out using the same method employed in the evaluation of projections for 1996 (Jore 1997). Forecast errors in the projections for 1998 are examined briefly on the basis of preliminary national accounts figures published in February this year. We will publish a more thorough analysis of 1998 at a later date. The last section of the article presents an overview of projections for the entire period 1994-1998, comparing projections from Norges Bank with those of Statistics Norway and the Ministry of Finance.

Forecast errors

The macroeconomic model RIMINI has been the most important tool for Norges Bank's projections since 1994. In the model, important economic relationships are represented by quantified empirical

relationships. The model also takes account of the simultaneity in the economy: the explanatory variables in the individual equation are taken as given, but by combining several equations account is taken of the fact that the explanatory variables in one equation are determined in another. The model also ensures consistency in that demand equals supply in the various market segments.

However, there are significant sources of forecast errors in an economic model. The model's coefficients are quantified on the basis of historical data. There are uncertainty intervals around each coefficient, and the interaction between many equations in a model increases the uncertainty around each variable. Changes in the functioning of the economy may not be captured by the quantification of coefficients. Finally, there are areas where the model does not take sufficiently into account important economic relationships.

These factors require the use of some degree of discretion, particularly for the shortest projections. The interpretation of current short-term statistics is an important basis for these discretionary evaluations. In practice, the evaluations are taken into account by adjusting the add factors in each equation. Erroneous adjustments of add factors therefore represent another important source of forecast errors. However, correct adjustments result in better forecasts.

In addition to forecast errors ascribable to incorrect assumptions on exogenous variables and model errors and deficiencies, projections may be affected by inaccurate estimates of the previous year's developments and a change in the base year of the national accounts. For projections for 1997 and 1998, forecast errors are also ascribable to the use of data from the old national accounts. This is examined more thoroughly by Jore (1997).

Owing to the main revision of the national accounts, it is not possible to make an exhaustive analysis of forecast errors due to the model and the use of the model. Norges Bank's Research Department is in the process of re-estimating the model relationships, however, so that a more complete analysis will be possible in due course.

In this article we will analyse the forecast errors for 1997 in the same way the analysis was undertaken in *Economic Bulletin* 1998/1. First, errors stemming from incorrect economic policy assumptions are eliminated, followed by errors ascribable to deviations of other exogenous variables from

actual developments. The errors remaining after adjusting for incorrect forecasts of policy variables and other exogenous variables are due to random effects, incorrect model use or model deficiencies. The projections are evaluated against the preliminary national accounts published in September of the following year. Revisions to the national accounts figures are also made after this time, but are usually minor. We will also briefly examine forecast errors for 1998 against accounts published in Statistics Norway's Economic Survey at the beginning of February 1999. These accounts usually undergo substantial revisions which, to a considerable extent, are based on projections for the fourth quarter. An analysis of forecast errors for 1998 is therefore of a provisional nature.

Errors in forecasts for 1997 and 1998

1997

In *Economic Bulletin* 1996/4, Norges Bank projected continued strong but moderating growth. We projected that growth in private and public consumption, traditional exports and mainland business fixed investment would be considerably lower than in 1996, while fixed investment in the petroleum sector would be substantially higher than the previous year. The lower growth in demand would, according to the projections, be accompanied by slower growth in mainland GDP and traditional imports. Following very high growth rates in employment in previous years, Norges Bank projected that employment growth would be reduced by half compared with the previous year. Pressures in the labour market were increasing, and it was assumed that price and wage inflation would be higher than in 1996.

Projections for key variables for 1997 are shown in Table 1, along with preliminary national accounts figures from Statistics Norway. As shown in the table, mainland demand was more robust than anticipated. The forecast for growth in private consumption was fairly accurate, while projections for public consumption and mainland business fixed investment were underpredicted. Petroleum investment was substantially higher than assumed. Total export growth was approximately as projected, but this was because the forecast errors in the sub-groups, traditional exports and oil and

gas exports, offset each other

Table 1 Projections for 1997 made in December 1996, and actual figures for 1997. Percentage growth from the previous year unless otherwise indicated

	Projection	Actual	Forecast error ¹⁾
Mainland demand	3¼	4.5	1¼
Private consumption	3½	3.4	-
Public consumption	1	3.0	2
Fixed investment	5½	9.7	4¼
Petroleum investment ²⁾	8	23.7	15¾
Exports	6	5.8	-¼
Oil, gas and pipeline transport	6½	2.3	-4¼
Traditional goods	6¾	8.0	1¼
Imports	6½	12.3	5¾
Traditional goods	5	8.6	3½
GDP	3½	3.4	-
Mainland GDP	3	3.7	¾
Employment	1½	2.9	1½
Annual wages	4¾	4.6	-¼
Consumer prices	2½	2.6	-
LFS unemployment	4	4.1	-

¹⁾ Percentage point difference between actual and projected value.

²⁾ Excluding services related to oil and gas production.

Sources: Statistics Norway (Economic Survey 3/98) and Norges Bank (Economic Bulletin 1996/4)

As a result of higher than expected demand, growth in both imports and mainland GDP was higher than implied by our projections. The higher growth in production also resulted in higher employment growth. Unemployment turned out as projected because higher employment growth was offset by higher growth in the supply of labour. An important factor behind the fairly accurate projection for consumer price inflation and wage growth is that unemployment was in line with projections. It is also clear that the main forecast errors, calculated as relative errors, related to variables that are exogenously determined, ie public consumption and petroleum investment.

The contribution of inaccurate exogenous assumptions to forecast errors is found by incorporating actual growth rates for the variables determined exogenously. The first line in Table 2 repeats the forecast errors for some of the variables in Table 1. The second line shows how large the forecast errors are after incorporating correct economic policy assumptions. In addition to public expenditure, these include money market interest rates and exchange rates. The projections for 1997 were based as usual on technical assumptions

Table 2 Forecast errors. The effect of changes in assumptions. Positive figures denote underprediction. Percentage points

	Mainland GDP	Employment growth	Wage growth	Consumer price inflation	Private consumption	Mainland business fixed investment
Aggregate error	¾	1½	-¼	0	0	4¼
Error after changes in policy assumptions	0	1	0	0	-¼	1
and after incorporation of correct estimates for all exogenous variables	0	1	0	-¼	0	¾

Source: Norges Bank

regarding exchange rates and money market rates. These entailed an average appreciation of 1 per cent from 1996 to 1997. The appreciation turned out to be somewhat lower, at 0.5 per cent. Interest rates averaged 3.7 per cent in 1997, 0.6 percentage point lower than the technical assumption.

If the economic policy assumptions for 1997 had been correct, the estimates for that year would have been more accurate. The forecast error for the estimate of growth in fixed investment would have been substantially reduced, primarily because the exogenously determined variable public investment was higher than anticipated. On the other hand, the estimate for private consumption would have been a little too high. Employment growth has increased by ½ percentage point in relation to the estimates, since public employment growth is now correctly projected. There is nevertheless still a substantial error in the employment estimate, whereas growth in mainland GDP is now correctly estimated.

The forecast errors remain virtually the same when the actual figures for the other exogenous variables are incorporated. The most important variables now assumed to be correct are petroleum investment and foreign price inflation. The increased petroleum investment helps to bring growth in mainland fixed investment closer to actual figures, but estimated consumer price inflation is now ¼ percentage point too low. The reason for this is that price inflation among our trading partners was lower in 1997 than assumed when the estimates were made. The accuracy of our estimate for consumer price inflation is due to the fact that the erroneous assumptions about external price inflation were offset by other types of error.

On balance, the forecast errors for 1997 were

smaller than for 1996. When correct assumptions for exogenous variables are incorporated, however, the estimated growth in employment still remains substantially underestimated. The remaining forecast error for growth in mainland fixed investment is almost as large, but the relative error is small, as is the forecast error for consumer price inflation.

The errors remaining after correct assumptions about economic policy and the other exogenous variables are incorporated are partly due to incorrect estimates for 1996, a change in the constant-price year, the break in the national accounts, and aspects of the model and its use. In future analyses of forecast errors, we will also look at the latter two causes of forecast errors, and the break in the national accounts will no longer have an effect. The analysis can then be more complete.

An evaluation of Norges Bank's projections for 1996 revealed that overly high forecasts for productivity growth, which is endogenous in the model, explained a large proportion of the forecast errors remaining after correct exogenous estimates had been incorporated. Productivity growth was also appreciably overestimated in the estimates for 1997. For a given GDP growth, this means that employment growth has been correspondingly underestimated. In recent years there has been a tendency to overestimate productivity growth and underestimate employment growth. If this is not attributable to the assumptions concerning exogenous variables, the cause must lie in factors relating to the underlying data, the model relationships or our use of the model. As described in Jore (1997), the main revision of the national accounts has led to problems in making model-based estimates. Forecast work for 1997 also had to be based on the old national accounts prepared up to and including 1994. Corrections of the add factors in the model's relationships are therefore used

to reconstruct historical growth rates. This has resulted in methodology problems with respect to arriving at values for the corrected add factors. Problems of this nature will affect the accuracy of the projections.

1998

Table 3 shows preliminary forecast errors in the estimates for 1998 presented in Economic Bulletin 1997/4. The estimates are compared here with the preliminary national accounts for 1998, published in February 1999. These are the first estimates for the national accounts, and the figures may be subject to major or minor revision.

From the preliminary figures, it appears that the forecast for economic growth was slightly overestimated in 1998, in contrast to previous years when economic growth was consistently underpredicted. Once again, factors exogenous to the model contributed to forecast errors – in particular, developments relating to the petroleum sector. Fixed investment in this sector again increased more strongly than expected, while oil and gas exports were substantially weaker than expected. In addition, the dramatic fall in oil prices, by a substantially larger margin than expected, resulted in a deficit on the current account instead of the large surplus projected.

Table 3 *Norges Bank's projections for 1998 presented in December 1997, and actual figures for 1998. Percentage increase on previous year unless otherwise indicated*

	Projection	Actual	Forecast error ¹⁾
Mainland demand	3¼	2.9	-¼
Private consumption	4	3.2	-¾
Public consumption	2	2.8	¾
Fixed investment	2½	2.0	-½
Petroleum investment ²⁾	2	18.8	16¾
Exports	7¾	0.5	-7¼
Oil, gas and pipeline transport	13½	-3.2	-16¾
Traditional goods	6	3.7	-2¼
Imports	4¾	6.9	2¼
Traditional goods	5	9.5	4½
GDP	5	2.0	-3
Mainland GDP	3¼	2.9	-¼
Employment	2	2.3	¼
Annual wages	5	6.3	-1¼
Consumer prices	2¾	2.3	-½
LFS unemployment, per cent	3¼	3.2	-

¹⁾ Difference in percentage points between actual and estimated value.

²⁾ Excluding services associated with oil and gas production.

Sources: Statistics Norway and Norges Bank

Overestimated growth in both private consumption and mainland fixed investment was partly offset by underestimated growth in public sector expenditure, but growth in mainland demand was still slightly overestimated. Exports of traditional goods were also overestimated. These errors were offset by the overprediction of GDP and import growth.

Employment growth was again underestimated, but the forecast error was appreciably smaller than in previous years. This can to some extent be viewed in the light of the experience of previous years. In the estimates for 1998, account was taken of the fact that there has been fairly systematic underestimation of employment growth and overestimation of productivity growth in the past.

Despite the fact that wage growth was underestimated and exchange rate movements were weaker than the technical assumption, consumer price inflation was overestimated. The main reason for this is that imported price inflation was substantially lower than anticipated, despite the weakening of the exchange rate.

Evaluation of estimates through the whole cyclical upturn

Charts 1 to 8 show Norges Bank's projections for some key macroeconomic aggregates for the period 1994 to 1998, together with forecasts from Statistics Norway, the Ministry of Finance, and growth rates in preliminary national accounts published in September of the following year¹⁾. The estimates are published in Economic Bulletin (1993/4, 1994/4, 1995/4, 1996/4 and 1997/4), Economic Survey (4/93, 4/94, 4/95, 4/96 and 4/97), the Final Budget Bill (1993, 1994, 1995, 1996) and the "Supplementary Proposition" (1997).

The three institutions have fairly similar projections for economic growth. Chart 1 shows that growth in mainland demand has been clearly underestimated throughout this cyclical upturn. Not until 1998, when growth in demand slowed, did the forecasts accurately predict growth in demand. The picture for growth in traditional

¹⁾ National accounts figures for 1998 were published in February 1999.

Chart 1-8. Growth estimates from Statistics Norway (SN), the Ministry of Finance (MoF) and Norges Bank (NB), compared with actual growth (Actual). Per cent. 1994 to 1998

■ SN ■ MoF ■ NB □ Actual

Chart 1. Mainland GDP

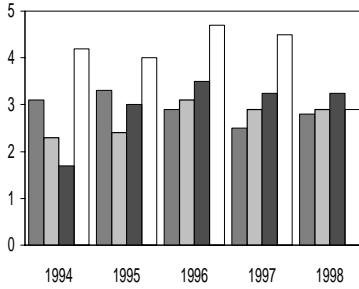


Chart 2. Export of traditional goods

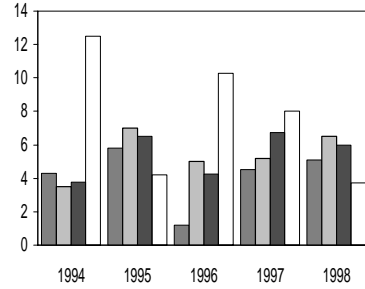


Chart 3. Petroleum investment

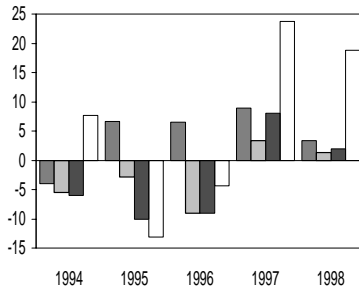


Chart 4. Mainland GDP

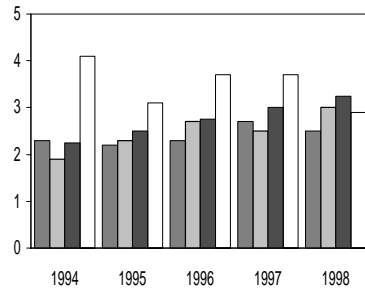


Chart 5. Import of traditional goods

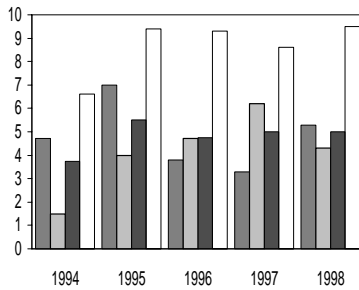


Chart 6. Annual wage growth

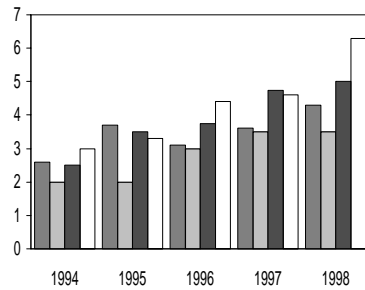


Chart 7. Consumer price inflation

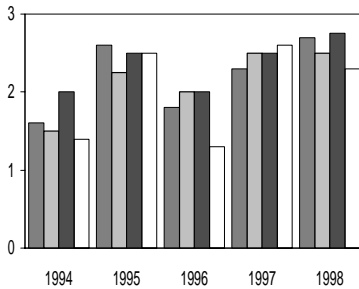
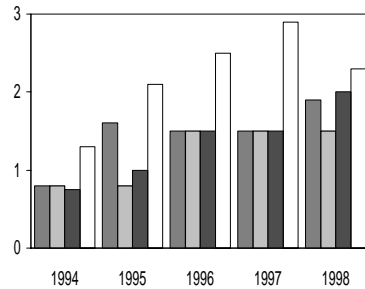


Chart 8. Employment growth



exports is more mixed, and there are both positive and negative forecast errors in Chart 2. Petroleum investment, which is determined exogenously, proves to be very difficult to estimate (see Chart 3). Although petroleum investment represents only a modest share of total demand, the changes in investment are so substantial from one year to the next that it makes a substantial contribution to changes in total demand.

Because growth in demand was underestimated, production and import growth was also underestimated (see Charts 4 and 5). The forecast errors for mainland GDP growth were reduced through the period, while projected import growth remained substantially lower than actual import growth.

Forecast errors for wage and price inflation are consistently smaller than those for demand and production (see Charts 6 and 7). This is partly because growth in nominal variables normally varies less than growth in real variables, but this may also be due to the general accuracy of the estimates for unemployment. Although there were large forecast errors for employment growth in the years 1995 to 1997 (see Chart 8), they were offset by corresponding errors in estimated labour force growth. The forecast errors for price inflation are largest in 1996 and 1998. The errors in 1996 are mainly due to the reduction of car taxes, while errors in 1998 can be attributed to imported price inflation being lower than expected, partly as a result of the ripple effects of the Asian crisis.

Table 4 contains two different measures of average forecast errors for selected variables in the period 1994 to 1998. The measures are calculated on the basis of the forecast errors shown in the charts. These measures summarise the information in Charts 1 to 8. MAE²⁾ provides an indication of the average size of the actual forecast error, in

²⁾MAE (mean absolute error) is defined as:

$$(1/N) \sum_{n=1}^N |y_n - \hat{y}_n|$$

where y_n presents the actual growth rate, and the \hat{y}_n estimated growth rate.

³⁾RRMSE (relative root mean squared error) is defined as

$$\sqrt{1/N \sum_{n=1}^N \left((y_n - \hat{y}_n) / y_n \right)^2}$$

where y_n presents the actual growth rate and the \hat{y}_n estimated growth rate.

percentage points, over this period, while RRMSE³⁾ indicates the size of the relative forecast error. The measures also provide an indication of which institution provided the best projections during the period. The table also includes sub-components of domestic demand.

There are no major differences in the forecast errors of the three institutions in terms of the average errors for these five years. The average relative forecast error is decidedly largest for public consumption and petroleum investment. The next poorest forecasts were generally made for growth in traditional imports and exports and employment. The forecasts for the other variables were better, but the average relative forecast errors nevertheless range between 25 and 35 per cent. Norges Bank's wage growth projections stand out with a relative error of only 14 per cent.

Table 4 Mean absolute error (MAE) and relative root mean squared error (RRMSE), 1994-1998

		SN	MoF	NB
Mainland GDP	MAE	1.1	1.1	0.9
	RRMSE	0.32	0.33	0.27
Employment	MAE	0.8	1.0	0.9
	RRMSE	0.35	0.46	0.42
Exports of traditional goods	MAE	4.8	4.5	4.1
	RRMSE	0.58	0.62	0.56
Imports of traditional goods	MAE	3.9	4.5	3.9
	RRMSE	0.46	0.56	0.45
Mainland demand	MAE	1.1	1.3	1.3
	RRMSE	0.30	0.35	0.34
Private consumption	MAE	0.7	1.1	0.9
	RRMSE	0.25	0.34	0.26
Fixed investment	MAE	2.2	2.8	2.6
	RRMSE	0.42	0.50	0.33
Public consumption	MAE	1.2	1.4	1.3
	RRMSE	1.27	1.70	1.69
Petroleum investment	MAE	14.5	13.1	10.8
	RRMSE	1.54	1.12	1.06
Annual wages	MAE	1.0	1.5	0.6
	RRMSE	0.23	0.35	0.14
Consumer prices	MAE	0.3	0.3	0.4
	RRMSE	0.21	0.25	0.32

Sources: The Ministry of Finance, Statistics Norway and Norges Bank

Conclusion

A thorough analysis of forecast errors entails analysing contributions to errors from exogenous variables and errors due to deficiencies in or incorrect use of the model. In this article, we have only looked at the contributions from exogenous variables. A more detailed study of the model's forecasting properties and our use of the model will be presented when the equations in the model have been re-estimated on the basis of new national accounts data. Norges Bank intends to present analyses of the quality of estimates and causes of forecast errors at regular intervals.

The general impression of the analysis is that in 1997 Norges Bank again underestimated the strength of the cyclical upturn, as was the case in the period 1994 to 1996. Nevertheless, projections for wage and price inflation were good. A substantial portion of the forecast errors is due to incorrect assumptions about exogenous variables, particularly public demand and petroleum investment. Adjusting for this, the model-based projections are close to the mark, particularly with regard to wage and price inflation. During the past year, Norges Bank has taken steps to improve its estimates of exogenous variables. Estimates of growth in public expenditure are supplemented with the Bank's own evaluations of local government demand, and information about petroleum activities is obtained from a wider range of sources than previously.

The preliminary analysis of 1998 indicates that forecast errors for demand and production growth

will be smaller this year. In particular, the estimate for employment growth appears to have improved. One reason for this may be that previous analyses of forecast errors revealed that overly high forecasts for productivity growth had been used in the model, thereby contributing to underprediction of employment growth. It is also clear that developments in the petroleum sector were very different from what was expected in terms of price, fixed investment, production and exports.

A comparison with projections from Statistics Norway and the Ministry of Finance for the period 1994 to 1998 indicates that the forecast errors of the three institutions are not substantially different. On the whole, however, Statistics Norway and Norges Bank provided estimates with somewhat smaller average errors than the Ministry of Finance.

References:

- Jore, Anne Sofie (1997): "Evaluation of Norges Bank's projections from 1994 to 1996", *Economic Bulletin* 1998/1, pp. 69-78
- Madsen, Robert (1996): "Norges Banks prognoser 1987-94: hvor godt traff de?" (Norges Bank's forecasts for 1987-94: how accurate were they?), *Penger og Kreditt* 1996/1, pp. B48-B64