STAFF MEMO

A statistical analysis of Norges Bank's forecasts

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NORGES BANK

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In this paper, we perform a statistical analysis of the forecasting properties of Norges Bank's macroeconomic forecasts in the period 1998 – 2019. As a part of the analysis we assess Norges Bank's forecasts against similar forecasts by Statistics Norway and forecasts from simple models. The review shows that Norges Bank's projections have stood up well compared with Statistics Norway's projections and have generally been better than forecasts from simple models, especially in the short run. The projections were for the most part unbiased, but for wages and CPI inflation adjusted for tax changes and excluding energy prices (CPI-ATE), the projections were too high one and two years ahead. The productivity growth projections were too high at all horizons. Exchange rate projections based on "random walk" models were better than Norges Bank's projections.

Key words: Forecasts, forecasting properties, evaluation.

1. Introduction

Norges Bank's evaluations of projections are published regularly, normally every year, in *Norges Bank Papers*.[2] The purpose is to improve our understanding of the economy and improve our forecasts. A background for the annual assessments is the historical forecast errors. This *Staff Memo* documents historical forecast errors for the period 1998-2019.

Assessing the accuracy of macroeconomic projections is a challenge. Forecast errors can have numerous causes. Structural changes or shocks may occur that are difficult or impossible to foresee. Errors may also occur because data available at the time of the projection were revised afterward and the current state of the economy was thus different from that assumed. But it is also possible that information existed that was insufficiently utilised. Furthermore, economic relationships may be different from those enshrined in the modelling system or forecasting error was due in part to the exercise of

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[2] See *Norges Bank Papers* 5/2020.

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judgement. Thus, the probability that the outturn of a variable will be precisely consistent with a point estimate will, in practice, be very small.

A forecast error for one variable may be linked to a forecast error for another variable. For example, an exchange rate projection that is too strong may lead to a price rise projection that is too low. In this *Staff Memo*, we have not formally looked more closely at the correlation between forecast errors. A complete analysis of this problem is difficult and would normally be based on a model-based analysis.

Forecast errors can be assessed along a number of dimensions. The average size of forecast errors indicates forecast accuracy. We also provide an overview of any systematic errors in the forecasts, ie whether the forecasts for a variable are generally too high or too low.

To assess the quality of a projection, we can also compare it with other projections over time. If Norges Bank's projections systematically show greater errors than others, it may help us to identify areas for improvement. Here we compare Norges Bank's projections in the period with Statistics Norway's projections and forecasts using simple models and rules.

For the period 1998-2019, Norges Bank's projections have stood up well compared to Statistics Norway's projections and generally better than forecasts from simple models, particularly in the short run. The projections were for the most part unbiased, but for wages and CPI inflation adjusted for tax changes and excluding energy products (CPI-ATE), the projections were too high one and two years ahead. The projections for productivity growth were too high at all horizons. Exchange rate projections based on "random walk" models[3] were more accurate than Norges Banks' projections.

Section 2 of this *Staff Memo* accounts for data and method. The results are presented in Section 3. Data are discussed further in Appendix A, while simple models and rules are accounted for in Appendix B.

2. Data and method

The variables that have been evaluated are shown in Table 1. The table also shows from which year the variable was evaluated and whether projections were evaluated in level form or in growth form. The data are at annual frequency. In recent years, Norges Bank has also published

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[3] See Appendix B.

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projections at monthly or quarterly frequency for a sample of variables, but for most of the variables, there are no forecasts at these frequencies for the entire evaluation period. Annual frequency was also chosen in the interest of comparability with Statistics Norway's projections, which are annual.

For projections for the current and following year, data for most variables are available for the entire period. Norges Bank and Statistics Norway began publishing projections two years ahead in 2000 and 2003, respectively, so that the data set for this horizon is somewhat smaller. For some demand components, Norges Bank limited the projection horizon to one year ahead in the period 2007 – 2014. For these variables we have not looked at forecasting properties for the longer horizon.

Table 1 Variables evaluated, year of first available projection and transformation used in the evaluation

Variable	First projection	Trans-formation
Private consumption, public consumption, mainland investment, petroleum investment, mainland exports, import, GDP for mainland Norway, employment, productivity, annual wages, CPI	1998	Annual change
LFS unemployment	1998	Level
Exchange rate (I44)	2000	Level
Registered unemployment[1]	2001	Level
CPI adjusted for tax changes and excluding energy products (CPI-ATE)	2002	Annual change
Output gap	2003	Level

1) Between 2007 and 2009, no projections for registered unemployment were published. For these years, we have constructed projections based on Norges Bank's projections for changes in LFS unemployment.

We have compared Norges Bank's projections from the first and second *Monetary Policy Report* each year with projections from Statistics Norway published at around the same time and with forecasts from simple models. Since 2013, Norges Bank has published *Monetary Policy Report* four times a year, while three reports annually were published previously.[4] The reason why we limit the evaluation to the projections from the first and second reports is that these reports were published at around the same time each year in the period under investigation. For the third report and fourth report, owing to the change in publication timing and too few observations, respectively, it is not possible to conduct a consistent evaluation of forecast errors over time.

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[4] Prior to 2001, four reports were published annually.

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Forecasts from simple models mean forecasts made using standard time series models in accordance with simple rules. The model-based forecasts are made using linear and non-linear time series models with and without breaks. In the evaluation, we have used a simple (arithmetic) mean of the model-based forecasts for the variable.[5] To the extent possible, the simple forecasts are based on information available on the cut-off date[6] for Norges Bank's projections (see Appendix A).

The comparison has been made for projections at annual frequency for a horizon up to two years ahead. The time series models and the simple rules are documented in Appendix B. Charts of current projections and actual outturns for the variables are shown in Appendix E.

All statistical tests are performed as panel versions. That is, we treat projections from the first and second report each year as a single data set. The purpose is to obtain more observations, thereby increasing the strength of the test being performed. The projections are assessed at three horizons: the current year, one year ahead and two years ahead.

Projection accuracy is assessed along two dimensions[7]:
- Tendency toward systematic over- or underestimation.
- Size of forecast error.

The forecast error for a variable is defined as the actual outturn for the variable minus the projection:

$$e^z_{t+h} = z_{t+h} - z^F_{t+h}$$

Where e^z_{t+h} is the forecast error for projections for variable z for horizon h made at time t, z^F_{t+h} is the projection made at time *t*, and z_{t+h} is the actual outturn for the variable. A positive forecast error implies that the projection is lower than the actual outturn, and vice versa.

Systematic over- and underestimation is measured by the average forecast error. The average forecast error for variable z for horizon h is given by:

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[5] The accuracy of individual models is shown in Appendix Table B3.
[6] The *Monetary Policy Report* is normally published on a Thursday, and the forecasts in the report are ordinarily based on information in the period to the previous Friday. The cut-off date is thus the Friday prior to publication.
[7] See, for example, Bank of Canada (2017), Bank of England (2015) and Reserve Bank of New Zealand (2016).

$$MFE_{h,t}^z = \frac{\sum_{i=T}^t e_{i+h}^z}{t - T}$$

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Where T is the first year in the period for evaluation, so that t-T is the number of years with projections that are evaluated at time t. If the average forecast error has been equal to zero, we may conclude that the projections are unbiased. We test this by testing the hypothesis $\alpha = 0$ in the equation:

$$e_{t+h}^z = \alpha + \varepsilon_{t+h}$$

Where α is a constant that takes the value zero if the projections are unbiased and ε_{t+h} is an error term.

The size of forecast errors (accuracy) is measured as a root mean square error (RMSE). The RMSE for variable z for horizon h is given by:

$$RMSE_{h,t}^z = \sqrt{\frac{\sum_{i=T}^t {e_{i+h}^z}^2}{t - T}}$$

The higher the RMSE, the larger the forecast error has been. If the difference in the RMSE between two projections is sufficiently large, we can say that it is statistically significant, ie there is reason to rule out chance factors.[8]

For the actual value of the variables, we use the historical data for the previous year in the first *Monetary Policy Report* each year. For variables that are subsequently revised, this means that we use the initial publication as the basis for estimating the forecast error.

3. Results

3.1. Systematicity in the forecast errors

Chart 1 and Table 2 show calculations of the direction of the forecast error. If the average forecast error is close to zero, the projection is unbiased. If the average forecast error is statistically significantly different from zero, the projection is not unbiased. A negative (positive) value indicates that the average projection has been too high (low). The coefficient estimates are normalised using the standard deviation of the

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[8] The test of whether the difference is sufficiently large has been performed using Diebold and Mariano (1995) on squared forecast errors.

series to make possible cross-variable comparisons. The non-normalised coefficients are shown in Appendix Table C1.

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For most variables, we cannot statistically reject the null hypothesis that they are unbiased regardless of horizon. In particular, the average forecast error for mainland GDP and the output gap[9] have been close to zero. There are some exceptions:

- The projections for wage growth and CPI-ATE inflation two years ahead have been significantly too high. Also at one year ahead, the projections for these variables have tended to be too high. However, we cannot reject the projections for CPI inflation as unbiased. This reflects the fact that the projections for taxes and energy products have generally been somewhat too low.[10]

- The employment projections have been significantly too low during the current year, and also generally somewhat low for projections one and two years ahead.

- The projections for productivity growth have been too high, and the null hypothesis of biased projections is rejected at all horizons. Viewed from the supply side of the economy, employment projections that are too low combined with productivity projections that are too high implies that the composition of GDP growth turned out differently from that envisaged.

- Of the remaining variables, the projections for petroleum investment have been significantly too low one year ahead.

The sign and value of the average forecast error largely coincide with corresponding data from Statistics Norway and to a somewhat lesser degree with simple models (see Table 1 and Chart 2).

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[9] The evaluation of the output gap differs from the other variables in two ways. First, the output gap is unobservable, also in hindsight. There is therefore no correct actual. Second, the projections for the periods ahead are evaluated against Norges Bank's assessments in hindsight. For the other variables, historical series are compiled by other parties than Norges Bank.
[10] Projections for taxes and energy prices are based on budget documents and futures prices, respectively.

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Chart 1 Unbiasedness of Norges Bank's projections. Regression of forecast errors on a constant. Normalised with the standard deviation of the series. 1998 - 2019
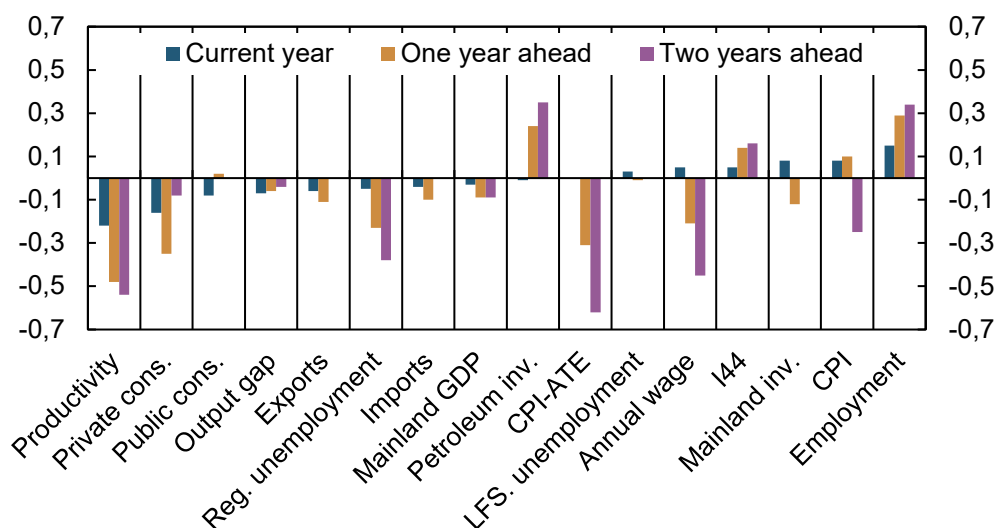

Table 2 Unbiasedness of projections from Norges Bank, Statistics Norway (SSB) and simple models. Regression of forecast errors on a constant, normalised with the standard deviation of the series.[1] 1998 - 2019

	Current year			One year ahead			Two years ahead		
	MPR	SSB	Mod.	MPR	SSB	Mod.	MPR	SSB	Mod.
Mnl.GDP	-0.03	0.12	-0.11	-0.09	-0.07	-0.12	-0.09	-0.14	0.04
Priv.cons.	-0.16	-0.15	0.04	-0.35	-0.49**	-0.06	-0.08	-0.63**	-0.01
Pub.cons.	-0.08	-0.09	-0.17	0.02	-0.09	-0.33	-	-	-
Mnl.inv.	0.08	0.09	-0.03	-0.12	0	-0.13	-	-	-
Petr.inv.	-0.01	0.04	0.08	0.24*	0.22	0.04	0.35	0.33	0.26
Exports	-0.06	-0.02	-0.23	-0.11	-0.14	-0.37	-	-	-
Imports	-0.04	-0.08	-0.01	-0.10	-0.18	-0.18	-	-	-
Outp.gap	-0.07	-	0.04	-0.06	-	-0.02	-0.04	-	-0.11
Reg.unm.	-0.05	-	0	-0.23	-	-0.06	-0.38	-	-0.09
LFS.unm.	0.03	-0.08	0.14	-0.01	-0.19	0.19	0.00	-0.18	0.17
CPI	0.08	0.06	-0.09	0.10	0.33*	-0.17	-0.25	0.09	-0.27
CPIATE	0.00	-0.07	0.01	-0.31	-0.13	0.00	-0.62**	-0.26	-0.01
I44	0.05	0.05	0.02	0.14	0.21	0.06	0.16	0.42	0.1
Ann.wag.	0.05	0.13	-0.15	-0.21	0.17	-0.44**	-0.45**	-0.15	-0.57**
Productiv.	-0.22**	-0.14	-0.18	-0.48**	-0.45**	-0.16	-0.54**	-0.49*	-0.04
Employm.	0.15*	0.28***	0.03	0.29	0.29	-0.01	0.34	0.23	0.09

1) *, ** and *** indicate that the average forecast error has been significantly different from zero at the 10, 5 and 1 percent significance level, respectively.

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Chart 2 Covariation of normalised forecast errors (FE) between Norges Bank and Statistics Norway and simple models, respectively.[1] 1998 - 2019
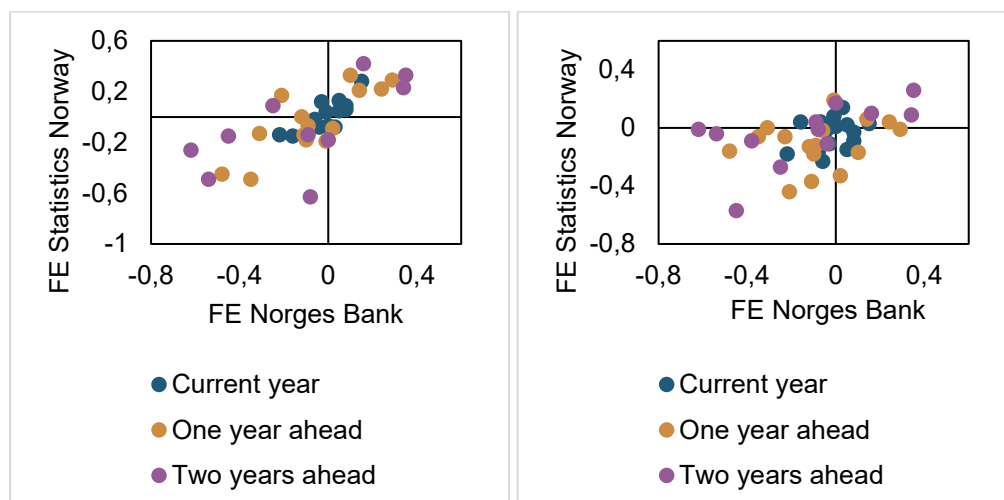
1) The chart is a graphic presentation of the data in Table 2.

3.2. Accuracy

Table 3 and Chart 3 show the RMSE normalised with the standard deviation for the series. The normalisation makes possible a comparison of accuracy across variables.

Accuracy falls with the length of projection horizon for all variables. At the same time, there is a clear distinction between the accuracy of short-run projections (the current year) and of those somewhat further out (one and two years ahead). The difference in the RMSE between the current year and one year ahead is, with one exception (petroleum investment), clearly greater than the difference between the RMSEs one and two years ahead.

Another possible measure of accuracy is whether the RMSE is greater or less than the standard deviation of the variable being projected. For a stationary variable, a projection that the variable will remain at its historical average should, in principle, yield a RMSE approximately equal to the standard deviation. In Table 3, values above (below) 1 indicate that the RMSE has been less (greater) than the standard deviation of the series. For Norges Bank's projections for the current year, the values generally lie well below 1. For projections one year ahead, the values lie closer to 1, but mostly below. On the other hand, for projections two years ahead, the values lie above 1 for most variables. A possible reason is that there may be a trend shift in the variables.

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Projections from Statistics Norway show a similar pattern in the normalised RMSE over the projection horizon to Norges Bank's projections. On the other hand, for the simple models, the RMSE for many variables is greater than the standard deviation already one year ahead. This indicates that Norges Bank and Statistics Norway utilise information more effectively for forecasts one year ahead.

These projection characteristics are not surprising and are consistent with findings in other countries (see for example Bank of England (2015)). For the short-run projections, we have current statistics, our Regional Network and various expectations surveys, which can provide some indication of developments in the coming year. In the longer run, the economy will be affected by factors that are not predictable at the time of the projection, and the underlying economic trends are uncertain, such as for example productivity developments.

Further review of individual variables
The most accurate projections for the current year, when correcting for the volatility of the individual macroeconomic variable, are for CPI-ATE inflation, petroleum investment, the output gap and registered unemployment. This partly reflects the fact that when the projections are made for the current year, we have more current data for CPI-ATE inflation and registered unemployment than for other variables. The least accurate are public consumption, private consumption and productivity. The differences in accuracy between the variables is somewhat smaller one and especially two years ahead.

For the current year, Norges Bank's projections, with a few exceptions, have been significantly more accurate than projections from Statistics Norway and simple models. Statistics Norway has published its projections around two weeks earlier than Norges Bank. Norges Bank's forecasts are thus based a larger data set, which may have had a bearing on the accuracy. However, exchange rate projections from simple models have been more accurate than those of both Norges Bank and Statistics Norway. The model-based forecast for the exchange rate is a simple random walk. The lower accuracy of Norges Bank's exchange rate projections than such a forecast is consistent with findings in the literature (see for example Killian and Taylor (2003)).[11] Simple model-based forecasts of registered unemployment are also significantly better than Norges Bank's projections. For the current year,

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[11] Statistics Norway now bases its exchange rate projections on a random walk. Tests based on Hungnes (2018) showed than it was difficult to improve such a projection (see box 2.1 in Economic trends 2019/1).

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Statistics Norway's public consumption and LFS unemployment projections are more accurate than Norges Bank's.

For projections one year ahead, Norges Bank's projections have been as accurate or better than Statistics Norway's. The simple model-based forecasts have been worse overall than Norges Bank's projections, but the simple models forecast I-44 and productivity better than Norges Bank.

For projections two years ahead, Norges Bank's projections have been broadly as good as Statistics Norway's overall. But Statistics Norway's projections for both CPI-ATE and CPI inflation were better than Norges Bank's. The model-based forecasts were broadly as good as Norges Bank's projections overall. At this horizon, too, however, simple models' forecasts for I-44 and productivity were more accurate than Norges Bank's.

The accuracy of the simple models is discussed further in Appendix B.

Table 3 Accuracy. Normalised RMSE for projections from Norges Bank, Statistics Norway (SSB) and simple models.[1] 1998 - 2019

	Current year			One year ahead			Two years ahead		
	MPR	SSB	Mod.	MPR	SSB	Mod.	MPR	SSB	Mod.
Mnl.GDP	0.42	0.49†††	0.70†††	0.91	0.95	1.08†††	1.02	1.26†††	1.05
Priv.cons.	0.65	0.71†††	0.80†††	1.05	1.13††	1.14††	1.15	1.38†††	1.16
Pub.cons.	0.71	0.67*	0.83†††	0.88	0.96†††	1.06†††	-	-	-
Mnl.inv.	0.41	0.44†††	0.74†††	0.84	0.93†††	1.20†††	-	-	-
Petr.inv.	0.30	0.32†††	0.77†††	0.62	0.74†††	1.01†††	0.96	1.03†††	0.86***
Exports	0.69	0.80†††	0.76†††	0.98	1.11†††	1.10†††	-	-	-
Imports	0.54	0.53	0.86†††	1.02	1.02	1.07†	-	-	-
Outp.gap	0.33	-	0.40†††	0.78	-	0.90†††	0.95	-	1.17†††
Reg.unm.	0.33	-	0.23***	0.84	-	0.88	1.25	-	1.30†
LFS.unm.	0.44	0.40***	0.49††	0.87	0.87	1.00†††	1.05	1.32†††	1.35†††
CPI	0.36	0.49†††	0.78†††	0.92	0.92	1.51†††	1.16	1.14**	1.28†
CPIATE	0.29	0.47†††	0.33†††	1.05	1.08	1.12††	1.35	1.14**	1.30
I44	0.35	0.38†††	0.27***	0.86	0.87	0.74***	1.14	1.10	1.04***
Ann.wag.	0.37	0.46†††	0.73†††	0.75	0.73	0.99†††	0.95	0.89	1.14†††
Productiv.	0.58	0.58	0.72†††	1.03	0.99	0.93***	1.19	1.14*	1.07***
Employm.	0.42	0.54†††	0.49†††	0.90	0.91	1.07†††	1.01	1.21†††	1.24†††

1) *(†), **(††) and ***(†††) indicate that the projection is significantly more (less) accurate than Norges Bank's projections at the 10, 5 and 1 percent significance level, respectively.

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*Chart 3 Accuracy of Norges Bank's projections. Normalised RMSE.
1998 – 2019*
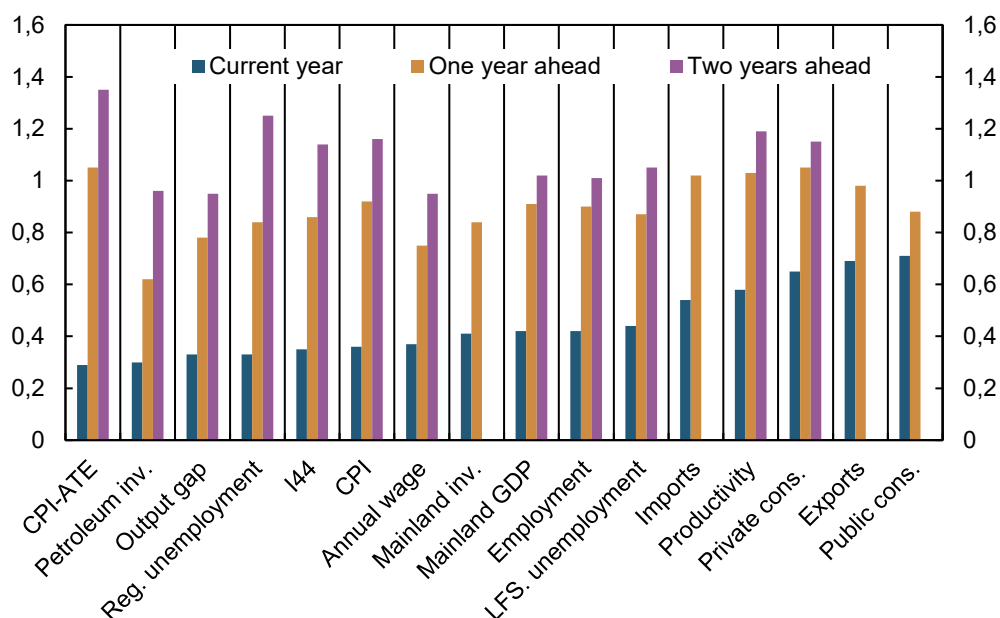
3.3. Accuracy over time

The forecasts have been assessed over a nearly 20-year period. In this period, considerable changes have taken place in forecasting work. Among other things, the modelling system was developed further, new data utilised and Norges Bank's Regional Network has been given a key role in the assessments. A formal statistical analysis of whether the projections have improved over time is difficult because it must be based on a relatively small data set. Changes in accuracy can also be due to unpredictable shocks to the economy or changes in underlying structural trends that it takes time to uncover.

We can get a rough impression if we divide the period in two, between 1998 and 2008 and between 2009 and 2019. With regard to systematic over- and underprediction, the null hypothesis of unbiased projections is rejected in somewhat more cases in the latter period than in the former (see Annex Tables D1 and D2). It may thus appear that Norges Bank has shown a somewhat greater tendency towards systematic erroneous prediction in the latter period. The deterioration pertains especially to the current and following years. An important exception is the projections for CPI-ATE inflation. For the latter period, we cannot reject

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the null hypothesis that the projections for CPI-ATE inflation are unbiased.

In Chart 4, we look at changes in accuracy by dividing the normalised RMSE for the latter period by the corresponding value for the former period. Values below 1 will then indicate that accuracy was better in the latter period and vice versa. Overall accuracy was fairly identical in both periods at all horizons. But there were fairly large differences across variables.

For the current year, the projections of I-44 and some of the national accounts variables were more accurate, while the projections of both unemployment measures were less accurate. The projections of registered unemployment were also less accurate one and two years ahead. The accuracy of the projections of productivity growth deteriorated at all horizons, and at one and two years ahead for the output gap ahead. For registered unemployment, the lower accuracy is primarily due to the smaller rise in unemployment following the Global Financial Crisis, which began in 2007, than Norges Bank had projected.

Chart 4 Change in accuracy of Norges Bank's projections. Normalised RMSE for 2009 - 2019 divided by the corresponding value for 1998 - 2008
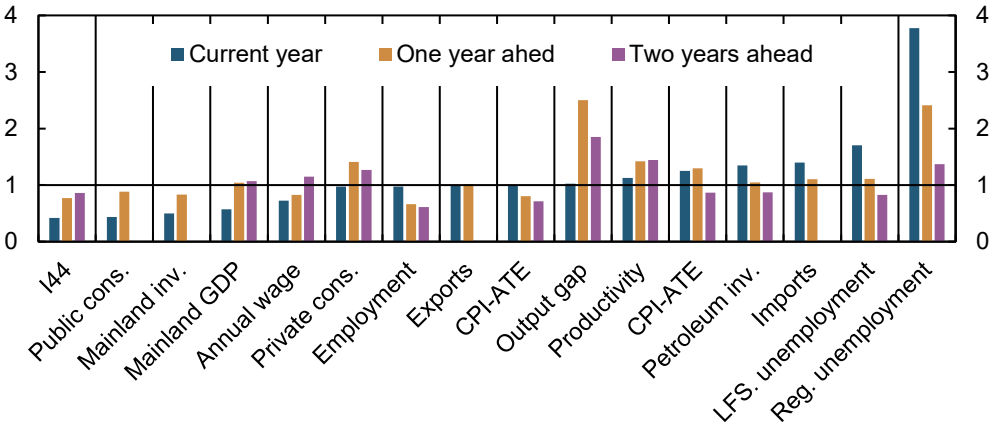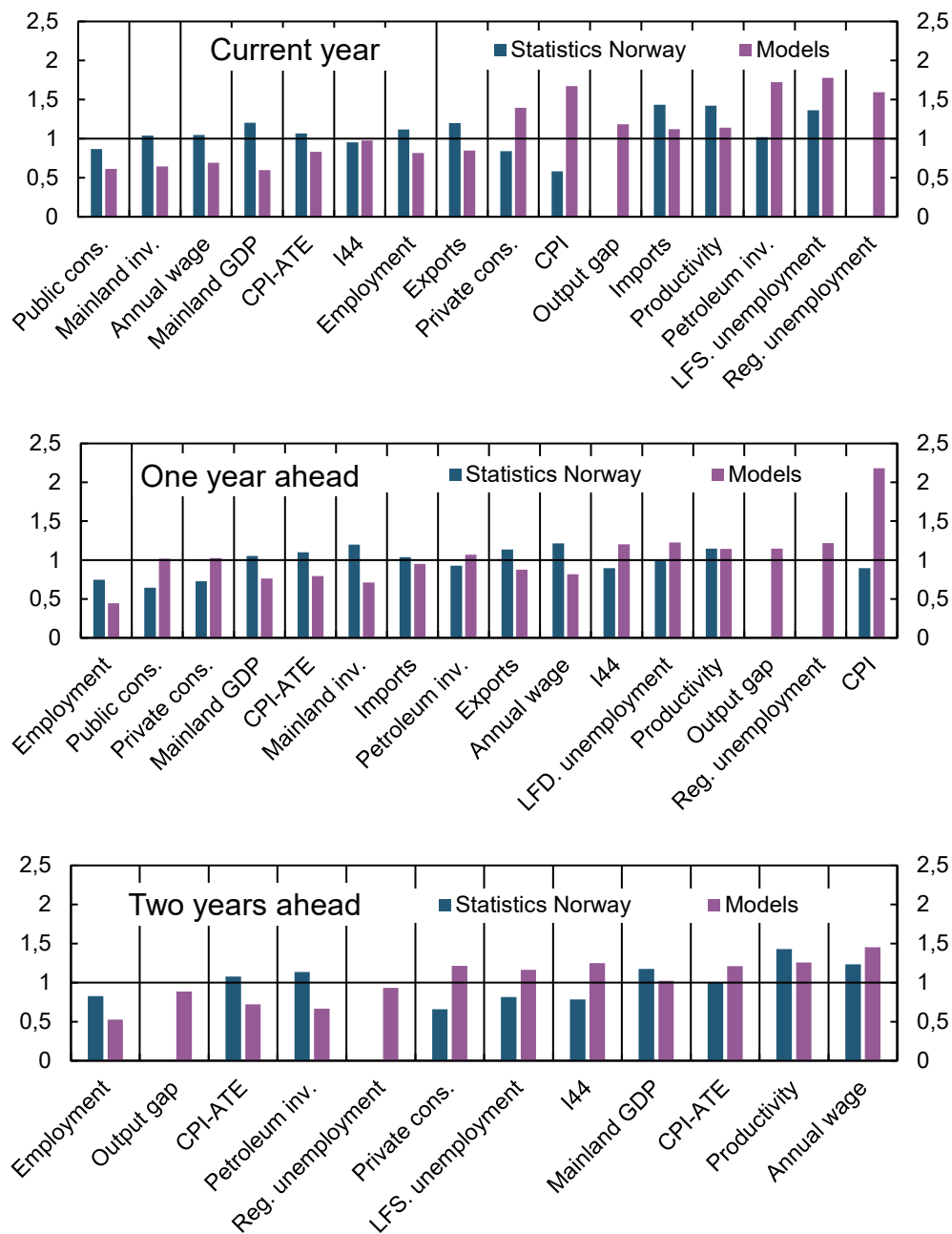

In Chart 5, we have compared the change in the accuracy of Norges Bank's projections with the corresponding change for projections from Statistics Norway and simple models. This may provide an indication that changes in accuracy may be due to unpredictable circumstances. Values below 1 indicate that the accuracy of Norges Bank's projections have improved more, or deteriorated less, than the accuracy of the projections we are comparing them with.

Overall, there has not been a systematic tendency towards improvement or deterioration in the accuracy of Norges Bank's

projections. Compared with projections from Statistics Norway and simple models, the changes in accuracy are, for the most part, relatively small. Note than even though the relative accuracy of Norges Bank's projections is deteriorating, their absolute accuracy may still be better in both periods we consider, and vice versa. Normalised RMSE for the periods separately is shown in Appendix Tables D3 and D4.

Chart 5 Change in accuracy of Norges Bank's projections relative to change in accuracy of projections from Statistics Norway (SSB) and simple models. Accuracy measured as normalised RMSE.

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4. Conclusions/Summary

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This *Staff Memo* assesses Norges Bank's projections over a lengthy period and is a supplement to Norges Bank's other evaluations, which focus on shorter horizons. The magnitude of forecast errors over time indicates how accurate the projections are and may be an important backdrop for the annual evaluation of the projections. We have also investigated whether the projections have been systematically too high or too low over time. Furthermore, Norges Bank's forecasts have also been assessed against Statistics Norway's forecasts and against forecasts from simple models.

Overall, Norges Bank's forecasts have stood up well compared with Statistics Norway's projections. Norges Bank's forecasts are, for the most part, better than forecasts from simple models. An important exception is the exchange rate, where a simple random walk model provides better forecasts.

For the most part, Norges Bank's projections have been unbiased. Some important exceptions are projections for prices and wages, which two years ahead are significantly too high. Too high wage projections may be viewed in the context of the fairly marked decline in productivity growth from 2005, which eventually proved to be permanent. Too high price projections must be attributed to the period 1998 – 2008. For the period 2009 – 2019, we cannot reject the null hypothesis that the projections of CPI-ATE inflation are unbiased.

In this *Staff Memo*, we have performed a statistical analysis of the projections of each variable individually but have not assessed the reasons for the forecast errors or the correlations among them.

Norges Bank publishes projections for a number of key variables at quarterly and monthly frequency. These projections are assessed on an ongoing basis to determine quickly whether developments systematically deviate from the forecasts. Any forecast errors are also discussed in the *Monetary Policy Report*. A systematic evaluation of projections at higher frequency than we have done in this *Staff Memo* may be interesting, among other reasons to assess how well the forecasts utilise available information.

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Appendix

A. Time of publication and data availability

In this *Staff Memo*, projections from the *Monetary Policy Report* (MPR) are compared with those from Statistics Norway and simple model-based forecasts.

The projections from Statistics Norway have been obtained from publications on the Statistics Norway website. We have generally used projections published closest in time to the publication of MPR. For an overview of MPR publication dates and projections from Statistics Norway, see Appendix Table A1.

The purpose of comparing projections made at approximately the same time is to ensure that the projections are based on approximately the same underlying data. During the period, the MPR was published an average of 15 days after Statistics Norway's projections. Norges Bank's projections are therefore based on slightly more up-to-date underlying data than Statistics Norway's projections, which should in isolation be reflected in the forecasting properties.

For the simple models, we have as far as possible also attempted to recreate the underlying data that was available when the MPR in question was published. This is done by using real-time data when available. Real-time data refer to data as they were at a specified point in time. The separation between final data[12] and real-time data moves along the *length of the time series* and *changes in the statistical basis*. The first separation between final data and real-time data applies to all time series: As time passes, more data will become available.

The krone exchange rate is a good example of a time series where only the *length of the time series* is relevant for real-time data. Since historical values of exchange rates are never revised, real-time data can be constructed by using data that were available at the cut-off dates for MPR. In this evaluation, real-time data for I-44, CPI and CPI-ATE inflation, annual wage growth and registered unemployment are constructed in this manner.

National accounts figures are a good example of time series where both the length and the *historical statistical basis* are changed over time. National accounts figures are normally revised as the statistical basis expands. While preliminary national accounts data are to some degree

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[12] In this context, at any given point in time, *final data* are the latest available version of a time series.

based on projections and historical relationships, final figures are based on broader set of underlying data. In this evaluation, we have used actual real-time data (ie time series as they actually were when the MPR was published) where they are available. When actual real-time data are not available, the oldest versions of real-time data are used and adjusted by cutting the time series at the point of the most recently available data in connection with the MPR in question.

Appendix Table 1A shows the latest available observation from the reports included in the evaluation. Reports without available real-time data are marked with "*". For certain time series in some reports, only the last two years of real-time data are available. These are marked with a "†" in the table.

Appendix Table A1 Overview of publication dates for MPR and forecasts from Statistics Norway (SSB), and latest available observations for the evaluated series.[1]

Report	Publication MPR	Publication SSB	Mainland GDP	Private consumption	Public consumption	Mainland investment	Petroleum investment	Mainland exports	Imports	Output gap	Registered unemployment	LFS	CPI/CPI-ATE	I44	Wages	Employment
1/98	11 Mar	05 Feb	1997 Q4†	1997 Q4†	1997 Q4†	1997 Q4†	1997 Q4*	1997 Q4*	1997 Q4*		Feb 98	1997 Q4*	Feb 98		1997	1997 Q4*
2/98	11 Jun	11 Jun	1998 Q1†	1998 Q1†	1998 Q1†	1998 Q1†	1998 Q1*	1998 Q1*	1998 Q1*		May 98	1998 Q1*	May 98		1997	1998 Q1*
1/99	18 Mar	04 Feb	1998 Q4†	1998 Q4†	1998 Q4†	1998 Q4†	1998 Q4*	1998 Q4*	1998 Q4*		Feb 99	1998 Q4*	Feb 99		1998	1998 Q4*
2/99	16 Jun	03 Jun	1999 Q1†	1999 Q1†	1999 Q1†	1999 Q1†	1999 Q1*	1999 Q1*	1999 Q1*		Jun 99	1999 Q1*	May 99		1998	1999 Q1*
1/00	17 Mar	10 Feb	1999 Q4†	1999 Q4†	1999 Q4†	1999 Q4†	1999 Q4*	1999 Q4*	1999 Q4*		Mar 99	1999 Q4*	Feb 00	16 Mar 00	1999	1999 Q4*
2/00	15 Jun	08 Jun	2000 Q1	2000 Q1	2000 Q1	2000 Q1	2000 Q1*	2000 Q1*	2000 Q1†		Jun 99	2000 Q1*	May 00	15 Jun 00	1999	2000 Q1*
1/01	01 Mar	08 Feb	2000 Q4	2000 Q4	2000 Q4	2000 Q4	2000 Q4*	2000 Q4*	2000 Q4†		Jan 01	2000 Q4*	Jan 01	01 Mar 01	2000	2000 Q4*
2/01	14 Jun	15 Jun	2001 Q1	2001 Q1	2001 Q1	2001 Q1	2001 Q1*	2001 Q1*	2001 Q1†		May 01	2001 Q1*	May 01	14 Jun 01	2000	2001 Q1*
1/02	21 Feb	06 Feb	2001 Q4	2001 Q4	2001 Q4	2001 Q4	2001 Q4*	2001 Q4*	2001 Q4†		Jan 02	2001 Q4*	Jan 02	21 Feb 02	2001	2001 Q4*
2/02	01 Jul	14 Jun	2002 Q1	2002 Q1	2002 Q1	2002 Q1	2002 Q1*	2002 Q1*	2002 Q1†		May 02	2002 Q1*	May 02	27 Jun 02	2001	2002 Q1*
1/03	03 Mar	21 Mar	2002 Q3	2002 Q3	2002 Q3	2002 Q3	2002 Q3	2002 Q3*	2002 Q3†	2003 Q1*	Feb 03	2002 Q4*	Jan 03	28 Feb 03	2002	2002 Q3*
2/03	23 Jun	24 Jun	2003 Q1	2003 Q1	2003 Q1	2003 Q1	2003 Q1*	2003 Q1*	2003 Q1†	2003 Q2*	May 03	2003 Q1*	May 03	19 Jun 03	2002	2003 Q1*
1/04	08 Mar	19 Mar	2003 Q3	2003 Q3	2003 Q3	2003 Q3	2003 Q3	2003 Q3*	2003 Q3†	2004 Q1*	Feb 04	2003 Q4*	Jan 04	04 Mar 04	2003	2003 Q3*
2/04	01 Jul	17 Jun	2004 Q1	2004 Q1	2004 Q1	2004 Q1	2004 Q1	2004 Q1*	2004 Q1	2004 Q2*	May 04	2004 Q1*	May 04	24 Jun 04	2003	2004 Q1*
1/05	16 Mar	10 Mar	2004 Q4	2004 Q4	2004 Q4	2004 Q4	2004 Q4	2004 Q4*	2004 Q4*	2005 Q1	Feb 05	2004 Q4*	Feb 05	10 Mar 05	2004	2004 Q4*
2/05	30 Jun	16 Jun	2005 Q1	2005 Q1	2005 Q1	2005 Q1	2005 Q1	2005 Q1*	2005 Q1*	2005 Q2	May 05	2005 Q1*	May 05	24 Jun 05	2004	2005 Q1*
1/06	16 Mar	16 Mar	2005 Q3	2005 Q3	2005 Q3	2005 Q3	2005 Q3	2005 Q3*	2005 Q3*	2006 Q1	Feb 06	2005 Q4*	Feb 06	10 Mar 06	2005	2005 Q3*
2/06	29 Jun	15 Jun	2006 Q1	2006 Q1	2006 Q1	2006 Q1	2006 Q1	2006 Q1*	2006 Q1*	2006 Q2	May 06	2006 Q1*	May 06	22 Jun 06	2005	2006 Q1
1/07	15 Mar	22 Feb	2006 Q4	2006 Q4	2006 Q4	2006 Q4	2006 Q4	2006 Q4*	2006 Q4*	2007 Q1	Feb 07	2006 Q4*	Feb 07	09 Mar 07	2006	2006 Q4
2/07	27 Jun	01 Jun	2007 Q1	2007 Q1	2007 Q1	2007 Q1	2007 Q1	2007 Q1*	2007 Q1*	2007 Q2	May 07	2007 Q1*	May 07	21 Jun 07	2006	2007 Q1
1/08	13 Mar	21 Feb	2007 Q4	2007 Q4	2007 Q4	2007 Q4	2007 Q4	2007 Q4*	2007 Q4*	2008 Q1	Feb 08	2007 Q4*	Feb 08	10 Mar 08	2007	2007 Q4
2/08	25 Jun	02 Jun	2008 Q1	2008 Q1	2008 Q1	2008 Q1	2008 Q1	2008 Q1*	2008 Q1*	2008 Q2	May 08	2008 Q1*	May 08	20 Jun 08	2007	2008 Q1
1/09	25 Mar	19 Feb	2008 Q4	2008 Q4	2008 Q4	2008 Q4	2008 Q4	2008 Q4*	2008 Q4*	2009 Q1	Feb 09	2008 Q4*	Feb 09	19 Mar 09	2008	2008 Q4
2/09	17 Jun	02 Jun	2009 Q1	2009 Q1	2009 Q1	2009 Q1	2009 Q1	2009 Q1*	2009 Q1*	2009 Q2	May 09	2009 Q1*	May 09	11 Jun 09	2008	2009 Q1
1/10	24 Mar	18 Feb	2009 Q4	2009 Q4	2009 Q4	2009 Q4	2009 Q4	2009 Q4*	2009 Q4*	2010 Q1	Feb 10	2009 Q4	Feb 10	18 Mar 10	2009	2009 Q4
2/10	23 Jun	10 Jun	2010 Q1	2010 Q1	2010 Q1	2010 Q1	2010 Q1	2010 Q1	2010 Q1	2010 Q2	May 10	2010 Q1	May 10	17 Jun 10	2009	2010 Q1
1/11	16 Mar	17 Feb	2010 Q4	2010 Q4	2010 Q4	2010 Q4	2010 Q4	2010 Q4	2010 Q4	2011 Q1	Feb 11	2010 Q4	Feb 11	10 Mar 11	2010	2010 Q4
2/11	22 Jun	08 Jun	2011 Q1	2011 Q1	2011 Q1	2011 Q1	2011 Q1	2011 Q1	2011 Q1	2011 Q2	May 11	2011 Q1	May 11	16 Jun 11	2010	2011 Q1
1/12	14 Mar	15 Feb	2011 Q4	2011 Q4	2011 Q4	2011 Q4	2011 Q4	2011 Q4	2011 Q4	2012 Q1	Feb 12	2011 Q4	Feb 12	09 Mar 12	2011	2011 Q4
2/12	20 Jun	07 Jun	2012 Q1	2012 Q1	2012 Q1	2012 Q1	2012 Q1	2012 Q1	2012 Q1	2012 Q2	May 12	2012 Q1	May 12	15 Jun 12	2011	2012 Q1
1/13	14 Mar	07 Mar	2012 Q4	2012 Q4	2012 Q4	2012 Q4	2012 Q4	2012 Q4	2012 Q4	2013 Q1	Feb 13	2012 Q4	Feb 13	11 Mar 13	2012	2012 Q4
2/13	20 Jun	30 May	2013 Q1	2013 Q1	2013 Q1	2013 Q1	2013 Q1	2013 Q1	2013 Q1	2013 Q2	May 13	2013 Q1	May 13	13 Jun 13	2012	2013 Q1
1/14	27 Mar	13 Mar	2013 Q4	2013 Q4	2013 Q4	2013 Q4	2013 Q4	2013 Q4	2013 Q4	2014 Q1	Feb 13	2013 Q4	Feb 13	20 Mar 14	2013	2013 Q4
2/14	19 Jun	05 Jun	2014 Q1	2014 Q1	2014 Q1	2014 Q1	2014 Q1	2014 Q1	2014 Q1	2014 Q2	May 13	2014 Q1	May 13	12 Jun 14	2013	2014 Q1
1/15	19 Mar	12 Mar	2014 Q4	2014 Q4	2014 Q4	2014 Q4	2014 Q4	2014 Q4	2014 Q4	2015 Q1	Feb 13	2014 Q4	Feb 13	12 Mar 15	2014	2014 Q4
2/15	18 Jun	04 Jun	2015 Q1	2015 Q1	2015 Q1	2015 Q1	2015 Q1	2015 Q1	2015 Q1	2015 Q2	May 13	2015 Q1	May 13	12 Jun 15	2014	2015 Q1
1/16	17 Mar	10 Mar	2015 Q4	2015 Q4	2015 Q4	2015 Q4	2015 Q4	2015 Q4	2015 Q4	2016 Q1	Feb 16	2015 Q4	Feb 16	11 Mar 16	2015	2015 Q4
2/16	23 Jun	02 Jun	2016 Q1	2016 Q1	2016 Q1	2016 Q1	2016 Q1	2016 Q1	2016 Q1	2016 Q2	May 16	2016 Q1	May 16	17 Jun 16	2015	2016 Q1
1/17	16 Mar	09 Mar	2016 Q4	2016 Q4	2016 Q4	2016 Q4	2016 Q4	2016 Q4	2016 Q4	2017 Q1	Feb 17	2016 Q4	Feb 17	10 Mar 17	2016	2016 Q4
2/17	22 Jun	08 Jun	2017 Q1	2017 Q1	2017 Q1	2017 Q1	2017 Q1	2017 Q1	2017 Q1	2017 Q2	May 17	2017 Q1	May 17	16 Jun 17	2016	2017 Q1
1/18	15 Mar	08 Mar	2017 Q4	2017 Q4	2017 Q4	2017 Q4	2017 Q4	2017 Q4	2017 Q4	2018 Q1	Feb 18	2017 Q4	Feb 18	09 Mar 18	2017	2017 Q4
2/18	21 Jun	07 Jun	2018 Q1	2018 Q1	2018 Q1	2018 Q1	2018 Q1	2018 Q1	2018 Q1	2018 Q2	May 18	2018 Q1	May 18	15 Jun 18	2017	2018 Q1
1/19	21 Mar	07 Mar	2018 Q4	2018 Q4	2018 Q4	2018 Q4	2018 Q4	2018 Q4	2018 Q4	2019 Q1	Feb 19	2018 Q4	Feb 19	15 Mar 19	2018	2018 Q4
2/19	20 Jun	06 Jun	2019 Q1	2019 Q1	2019 Q1	2019 Q1	2019 Q1	2019 Q1	2019 Q1	2019 Q2	May 19	2019 Q1	May 19	14 Jun 19	2018	2019 Q1

1) * indicates that real-time data are not available. The first available vintage of the series is then used as an approach to real-time data. † indicates that real-time data are available for the past eight quarters.

B. Simple models and rules

The simple model-based forecasts are made using simple rules and linear and non-linear univariate time series models. Univariate time series models are specifications that seek to explain and project a time series with only the help of historical observations of the time series being modelled. [13] The simple model-based forecast for each variable is given by an individual (arithmetic) mean of the projections for the variable (see Appendix Table B1 for an overview of models).

The modelling system is set up to be simple and automatic. We have selected the types of models that will be used for each variable, but model specification is automated. The modelling system is set up in Eviews and any model specification options are set to the software's default. The number of lags (*n*) for both linear and non-linear autoregressive models is given by minimising the Akaike information criterion (AIC) and is at least 1 and at most 12, 4 and 2 for monthly, quarterly and annual data frequencies, respectively. The models are estimated using a 20-year rolling sample.

The model specification for each MPR is thus given by an objective rule. In this way, we avoid choosing the specification, which has later proved to function best.

In some instances, the simple model-based forecasts will be far beyond what would be a considered reasonable outturn. We have chosen to omit such projections. More specifically, the modelling system is set up so that estimates entailing a periodic change (monthly, quarterly, annually) that is higher (lower) than the average in the estimation period plus (minus) two standard deviations is replaced with the average change in the estimation period plus (minus) two standard deviations.

The following model types have been used:
<u>Random Walk (RW):</u> y_{t+h} is assumed to remain equal to the average level/change for the past *n* observations, ie $y_{t+h} = \frac{1}{n}\sum_{i=1}^{n} y_{t-i}$, where *n* is 1, 12, 4 and 1 for data at monthly, quarterly and annual frequencies, respectively. Daily data are thus assumed to remain equal to the most recent observed value, while lower frequency data are assumed to remain at the average level/change from the previous year.

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[13] Unlike multivariate models, where other explanatory variables are also included.

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Exponential smoothing (ES): y_t is given as a weighted average of previous values of y_t. For stationary time series, simple smoothing is used, where $\hat{y}_t = \alpha y_t + (1 - \alpha)\hat{y}_{t-1}$ and $0 < \alpha \leq 1$ constitute the smoothing factor. The forecasts from simple smoothed series are given by $y_{t+h} = \hat{y}_t$. For time series with a linear trend, double smoothing is used, so that $S_t = \alpha y_t + (1 - \alpha)S_{t-1}$ and $D_t = \alpha S_t + (1 - \alpha)D_{t-1}$, where S is the simple smoothed series and D is the double smoothed series. The projection from the double smoothed series is given by $y_{t+h} = \left((2S_t - D_t) + \frac{\alpha}{1-\alpha}(S_t - D_t)h \right)$ (see Eviews (2020) p 553).

Autoregressive model (AR): we estimate a linear AR(n) model $y_t = c + \sum_{i=1}^{n} \beta_i \pi_{t-i} + e_t$, where c is a constant and e_t is a residual term and use it to project y_{t+h}.
The number of lags for both linear and non-linear autoregressive models is given by AIC and is at least 1 and at most 12, 4 and 2 for data at monthly, quarterly and annual frequencies, respectively.[14]

Autoregressive model with breakpoints (BreakLS): we estimate a linear model that corresponds with the AR model above but allow for the constant term c to vary over the estimation period. We allow up to five breakpoints in the constant term. The slope coefficient β_i is assumed to be constant (See Eviews (2020) p 471).

Discrete threshold autoregression model (TAR): we estimate a non-linear model that corresponds with the AR model above but allow for the process to change depending on the value of the modelled variable. We allow for up to five different versions of the process and let the constant term in the equation vary between the different regimes. The slope coefficient β_i is assumed to be the same as in all regimes (see Eviews (2020) p 491).

Smooth transition autoregression model (LSTAR): we estimate a non-linear model that corresponds with the TAR model above, but with the number of regimes limited to two and regime switching that occurs smoothly instead of discretely. As in the TAR model, we assume that the slope coefficient β_i will be the same in both regimes (see Eviews (2020) p 507).

Markov Switching autoregression model (MS-AR): we estimate a non-linear model that corresponds with the AR model above, but where the

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[14] Daily frequencies are forecast exclusively using RW.

constant term can switch between two regimes. The regime probability is specified by a first-order Markov process (see Eviews (2020) pp 583).

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Appendix Table B1 Overview of model types used for different data variables, data frequencies, transformation[1] and smoothing[2].

	RW	AR	TAR	LSTAR	BreakLS	MS-AR	ES	Frequency	Transformation[1]	Smoothing[2]	Seasonal adjustment[3]
Mainland GDP	x	x	x	x	x	x	x	Quarterly	dlog	D	Yes
Private consumption	x	x	x	x	x	x	x	Quarterly	dlog	D	Yes
Public consumption	x	x	x	x	x	x	x	Quarterly	dlog	D	Yes
Mainland investment	x	x	x	x	x	x	x	Quarterly	dlog	D	Yes
Petroleum investment	x	x	x	x	x	x	x	Quarterly	dlog	D	Yes
Mainland exports	x	x	x	x	x	x	x	Quarterly	dlog	D	Yes
Imports	x	x	x	x	x	x	x	Quarterly	dlog	D	Yes
Output gap	x	x	x	x	x	x	x	Quarterly	Level	S	Yes
Registered unemployment	x	x	x	x	x	x	x	Monthly	Level	S	Yes
LFS	x	x	x	x	x	x	x	Quarterly	Level	S	Yes
CPI	x	x	x	x	x	x	x	Monthly	dlog	S	Yes
CPI-ATE	x	x	x	x	x	x	x	Monthly	dlog	S	Yes
I44							x	Daily	Level		No
Annual wages	x	x	x	x	x	x	x	Annually	dlog	S	Yes
Employment	x	x	x	x	x	x	x	Quarterly	dlog	D	Yes

1) Transformation of data for RW, AR, TAR, LSTAR, BreakLS and MS-AR. "Dlog" denotes the first difference of the log. "Level" specifies that no transformation has been performed.
2) Smoothing methods in ES. "D" indicates double smoothing, "S" indicates single smoothing.
3) Whether or not seasonally adjusted data have been used in the models.

Comparison of model-based and SAM system forecasts

In the following, we compare the forecasting properties (an arithmetic average) of the simple models and rules that are used in this evaluation with the forecasting properties of a richer modelling system. The purpose is to assess the accuracy of the forecasts from the simple models used in this evaluation compared with a modelling system that has been shown to provide accurate forecasts.

Norges Bank's short-term forecasting is based on a number of statistical and econometric models and judgement. Experience and theory show that the average of multiple models is often more accurate than individual model forecasts. Norges Bank has therefore developed

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a system, SAM (System for Averaging Models), to weight together forecasts from different models for CPI-ATE inflation and mainland GDP.

Appendix Table B2 compares the forecasting properties of the simple models used in this evaluation with SAM. Since SAM provides forecasts extending up to five quarters ahead, we only examine projections for the current year. SAM forecasts are available from 2004.

The comparison shows that forecasts from both SAM and the simple models have been unbiased for both CPI-ATE inflation and mainland GDP in the period. The simple models have had slightly a lower average forecast error, but the difference is not significant. With regard to accuracy as measured by (normalised) RMSE, the forecast error of the simple models was significantly larger for mainland GDP, but exactly the same for CPI-ATE inflation.

Overall, it appears that the simple models provide just as accurate forecasts of CPI-ATE inflation as a richer modelling system, while forecasts of GDP growth are significantly less accurate.

Annex Table B2 Forecast properties for SAM, simple models and rules and MPR in the period 2004-2019. Unbiasedness[1] and RMSE[2], both normalised using the standard deviation of the series.

	Unbiasedness			Normalised RMSE		
	SAM	Simple models and rules	MPR	SAM	Simple models and rules	MPR
Mainland GDP	-0.08	-0.00	0.03	0.52	0.69†††	0.41***
CPI-ATE	0.08	0.06	0.02	0.31	0.31	0.27***

1) All forecasts are statistically unbiased.
2) *(†), **(††) and ***(†††) indicate that the projection is significantly more (less) accurate than the projection from SAM at the 10, 5 and 1 percent significance level, respectively.

Documentation of accuracy of individual models

In the following, we briefly review the accuracy of the individual models used in this evaluation. The purpose is to assess whether certain model types are generally more accurate in forecasting actual outturns over time.

The results are presented in Appendix Table B3. The table shows that a simple average of model-based forecasts has historically provided the highest (or close to the highest) level of accuracy for most variables at all horizons.

Of individual models, the AR model forecasts have been the most accurate overall, while RW forecasts have generally been least accurate.

In the period that we examine, there have nevertheless been certain exceptions from the rule of thumb that an average of models will normally provide more accurate forecasts than individual models. For LFS unemployment, the AR models have provided the highest level of accuracy at all horizons. For mainland investment, AR, TAR, LSTAR and MS-AR have been more accurate at all horizons.

Appendix Table B3 Accuracy. Normalised RMSE for forecasts from simple average of models and individual models. 1998 - 2008

		Average	AR	TAR	LSTAR	BREAKLS	MS-AR	ES	RW
Current year	Mnl.GDP	0.70	0.74†††	0.74†††	0.69	0.76†††	0.70	0.79†††	0.73
	Priv.cons.	0.80	0.81†	0.80	0.85†††	0.77***	0.84†††	0.82	0.97†††
	Pub.cons.	0.83	0.86†††	0.90†††	0.93†††	0.86†††	0.83	0.84	1.18†††
	Mnl.inv.	0.74	0.71***	0.71***	0.71**	0.94†††	0.72**	0.85†††	0.88†††
	Petr.inv.	0.77	0.76***	0.80†††	0.83†††	0.76***	0.75***	0.76	0.95†††
	Exports	0.76	0.76	0.79†††	0.79†††	0.76	0.78†††	0.75	1.14†††
	Imports	0.86	0.86	0.89†††	0.90†††	0.86	0.86**	0.91†††	1.21†††
	Outp.gap	0.40	0.43†††	0.42†††	0.42†††	0.43†††	0.45†††	0.39	0.52†††
	Reg.unm.	0.23	0.21*	0.21**	0.21***	0.26†††	0.36†††	0.25†††	0.50†††
	LFS.unm.	0.49	0.48***	0.55†††	0.62†††	0.50	0.49	0.53†††	0.73†††
	CPI	0.78	0.66***	0.78	1.14†††	0.63***	1.12	1.06†††	0.91††
	CPIATE	0.33	0.36†††	0.36†††	0.34††	0.34††	0.37	0.36†††	0.66†††
	I44	0.27							0.27
	Ann.wag.	0.73	0.75††	0.75††	0.78†††	0.75†	0.79†††	0.78†††	0.77†††
	Productiv.	0.72	0.83†††	0.89†††	0.76†	0.80†††	0.72	0.80†††	0.83†††
	Employm.	0.49	0.49	0.51†††	0.48*	0.60†††	0.54†††	0.54†††	0.53†††
	Avg per model	**0.62**	**0.65**	**0.67**	**0.70**	**0.67**	**0.69**	**0.70**	**0.80**
One year ahead	Mnl.GDP	1.08	1.08	1.08	1.23†††	1.15†††	1.09	1.47†††	1.52†††
	Priv.cons.	1.14	1.15	1.15	1.21†††	1.15†	1.22†††	1.17	1.71†††
	Pub.cons.	1.06	1.09†††	1.08†††	1.26†††	1.04**	1.08†††	1.15†††	1.57†††
	Mnl.inv.	1.20	1.11***	1.11***	1.08***	1.49†††	1.09***	1.64†††	1.60†††
	Petr.inv.	1.01	1.03†††	1.00**	1.02	1.03†††	1.03†††	1.07†††	1.51†††
	Exports	1.10	1.12†††	1.12†††	1.13†††	1.12†††	1.14†††	1.02***	1.81†††
	Imports	1.07	1.04***	1.09	1.25†††	1.04***	1.08††	1.18†††	1.74†††
	Outp.gap	0.90	0.93††	0.94†††	0.96†††	0.93††	1.02†††	1.14†††	1.32†††
	Reg.unm.	0.88	0.81***	0.80***	1.39†††	1.04†††	1.37†††	0.96†††	1.22†††
	LFS.unm.	1.00	0.98**	1.17†††	1.24†††	1.03†	1.03††	1.09†††	1.28†††
	CPI	1.51	1.45	1.50	2.37†††	1.30***	2.29	1.83†††	1.27***
	CPIATE	1.12	1.15†††	1.15†††	1.17††	1.11**	1.30	1.20†††	1.41†††
	I44	0.74							0.74
	Ann.wag.	0.99	1.01††	1.03†††	2.10†††	0.96	1.07†††	1.01	1.07†††
	Productiv.	0.93	0.95	1.02†††	1.52†††	1.17†††	1.00††	1.30†††	1.44†††
	Employm.	1.07	0.98***	0.95***	1.22†††	1.17†††	1.15†††	1.32†††	1.40†††
	Avg per model	**1.05**	**1.06**	**1.08**	**1.34**	**1.12**	**1.20**	**1.24**	**1.41**
Two years ahead	Mnl.GDP	1.05	1.07	1.06	1.60†††	1.14†††	1.11†††	1.58†††	1.63†††
	Priv.cons.	1.16	1.19†††	1.19†††	1.19†††	1.21†††	1.20†††	1.19	1.72†††
	Pub.cons.	1.07	1.05	1.06	2.53†††	1.03***	1.05	1.23††	1.72†††
	Mnl.inv.	1.19	1.08***	1.11***	1.04***	1.34†††	1.09***	1.86†††	1.84†††
	Petr.inv.	0.86	0.84	0.84	0.85	0.84	0.84	1.03†††	1.57†††
	Exports	1.16	1.19†††	1.19†††	1.17	1.19†††	1.19†††	1.10***	1.83†††
	Imports	1.02	1.03	1.02	0.95***	1.05†††	1.02	1.16†††	1.60†††
	Outp.gap	1.17	1.20†	1.28†††	1.27†††	1.20†	1.31†††	1.60†††	1.67†††
	Reg.unm.	1.30	1.30	1.29	2.27†††	1.74†††	1.77†††	1.51†††	1.63†††
	LFS.unm.	1.35	1.32*	1.60†††	1.49†††	1.43†††	1.40††	1.51†††	1.63†††
	CPI	1.28	1.30	1.36†††	1.98†††	1.23	2.33	1.62†††	1.37†
	CPIATE	1.30	1.32††	1.30***	1.55†††	1.26***	1.71	1.52†††	1.63†††
	I44	1.04							1.04
	Ann.wag.	1.14	1.16††	1.19†††	2.14†††	1.06***	1.12**	1.19	1.24†
	Productiv.	1.07	1.07	1.08	2.56†††	1.27†††	1.22†††	1.31†††	1.49†††
	Employm.	1.24	1.13***	1.13***	1.35†††	1.27†	1.23	1.63†††	1.78†††
	Avg per model	**1.15**	**1.15**	**1.18**	**1.60**	**1.22**	**1.31**	**1.40**	**1.59**

1) *(†), **(††) and ***(†††) indicate that the projection is significantly more (less) accurate than the projection from a simple average of models at the 10, 5 and 1 percent significance level, respectively.

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C. Non-normalised forecasting errors

*Appendix Table C1 Unbiasedness of projections from Norges Bank,
Statistics Norway (SSB) and simple models. Regression of forecast
errors on a constant. 1998 - 2019[1)]*

	Current year			One year ahead			Two years ahead		
	MPR	SSB	Mod.	MPR	SSB	Mod.	MPR	SSB	Mod.
Mnl.GDP	-0.05	0.19	-0.17	-0.14	-0.11	-0.19	-0.14	-0.22	0.07
Priv.cons.	-0.2	-0.2	0.05	-0.45	-0.64**	-0.08	-0.1	-0.81**	-0.01
Pub.cons.	-0.07	-0.08	-0.15	0.02	-0.08	-0.3	0.14	-0.12	-0.3
Mnl.inv.	0.44	0.49	-0.15	-0.67	-0.03	-0.68	0.76	-0.73	-0.05
Petr.inv.	-0.08	0.49	1.04	3.22*	2.95	0.48	4.67	4.41	3.51
Exports	-0.21	-0.06	-0.84	-0.42	-0.51	-1.37	-0.33	-0.55	-1.4
Imports	-0.18	-0.36	-0.04	-0.45	-0.81	-0.8	1.21	-0.63	-0.25
Outp.gap	-0.09	-	0.05	-0.07	-	-0.02	-0.05	-	-0.13
Reg.unm.	-0.03	-	0	-0.12	-	-0.03	-0.21	-	-0.05
LFS.unm.	0.02	-0.05	0.09	0	-0.12	0.12	0	-0.11	0.11
CPI	0.07	0.05	-0.07	0.08	0.29*	-0.14	-0.22	0.08	-0.23
CPIATE	0	-0.05	0.01	-0.24	-0.1	0	-0.48**	-0.2	-0.01
I44	0.35	0.36	0.15	0.94	1.41	0.39	1.07	2.75	0.64
Ann.wag.	0.06	0.16	-0.18	-0.26	0.21	-0.53**	-0.55**	-0.19	-0.70**
Productiv.	-0.23**	-0.14	-0.18	-0.49**	-0.46**	-0.16	-0.55**	-0.50*	-0.04
Employm.	0.18*	0.33***	0.04	0.35	0.34	-0.01	0.41	0.28	0.11

1) *, ** and *** indicate that the average forecast error has been significantly different
from zero at the 10, 5 and 1 percent significance level, respectively.

D. Forecast errors and accuracy for divided sample

*Appendix Table D1 Unbiasedness of projections from Norges Bank,
Statistics Norway (SSB) and simple models. Regression of forecast
errors on a constant, normalised with the standard deviation of the
series.1) 1998 - 2008*

	Current year			One year ahead			Two years ahead		
	MPR	SSB	Mod.	MPR	SSB	Mod.	MPR	SSB	Mod.
Mnl.GDP	0.01	0.22	-0.03	0.23	0.26	0.11	0.52	0.91*	0.51
Priv.cons.	-0.12	0	0.36	0.13	0.04	0.59*	0.76*	0.44	0.96**
Pub.cons.	0.11	0.2	-0.25	0.31	0.19	-0.52	0.41	0.17	-0.53
Mnl.inv.	0.04	0.11	-0.11	0.05	0.19	-0.01	0.2	0.47	0.4
Petr.inv.	0.02	0.05	0.19	0.43***	0.38**	0.06	0.89***	1.09***	0.63***
Exports	0.11	0.18	-0.15	0.32	0.16	0.03	0.56	1.33**	0.31
Imports	0.01	0.04	0.12	0.2	0.09	0.12	0.74**	0.81**	0.66**
Outp.gap	-0.12	-	0.15	0.25	-	0.42	0.82**	-	0.85**
Reg.unm.	-0.01	-	-0.01	-0.14	-	-0.12	-0.39	-	-0.22
LFS.unm.	0.06	-0.05	0.11	-0.03	-0.23	0	-0.13	-0.71	-0.22
CPI	0.06	-0.01	-0.14	-0.03	0.15	-0.38	-0.51	-0.15	-0.76*
CPIATE	-0.09	-0.25*	0.02	-0.82**	-0.86*	-0.15	-1.25**	-1.03*	-0.32
I44	-0.02	-0.1	-0.06	-0.43	-0.59**	-0.45	-0.76**	-0.80***	-0.77*
Ann.wag.	0.19	0.32*	0.09	0.01	0.71**	-0.31	-0.03	0.63	-0.38
Productiv.	-0.16	-0.05	-0.15	-0.13	-0.22	-0.11	0	-0.02	-0.01
Employm.	0.13	0.29**	0.08	0.37	0.48*	0.21	0.59	1.05**	0.58

1) *, ** and *** indicate that the average forecast error has been significantly different
from zero at the 10, 5 and 1 percent significance level, respectively.

*Table D2 Unbiasedness of projections from Norges Bank, Statistics Norway
and simple models. Regression of forecast errors on a constant, normalised
with the standard deviation of the series.1) 2009 - 2019*

	Current year			One year ahead			Two years ahead		
	MPR	SSB	Mod.	MPR	SSB	Mod.	MPR	SSB	Mod.
Mnl.GDP	-0.09	0	-0.22	-0.49*	-0.49*	-0.41	-0.63**	-0.80**	-0.35
Priv.cons.	-0.29	-0.47**	-0.47***	-1.21***	-1.49***	-1.06***	-0.98**	-1.71***	-1.02***
Pub.cons.	-0.22**	-0.30***	-0.11	-0.18	-0.28	-0.19	-0.03	-0.28**	-0.29**
Mnl.inv.	0.12*	0.07	0.05	-0.27	-0.17	-0.22	0.05	0.11	0.09
Petr.inv.	-0.04	0.02	-0.06	0.03	0.04	0.01	-0.06	-0.08	-0.02
Exports	-0.18	-0.14	-0.32	-0.39	-0.33	-0.67**	-0.48	-0.44	-0.49
Imports	-0.09	-0.2	-0.14	-0.36	-0.42	-0.44	-0.26	-0.18	-0.3
Outp.gap	-0.08	-	-0.05	-0.39	-	-0.48	-0.67	-	-0.96
Reg.unm.	-0.17	-	0.04	-0.6	-	0.03	-0.68	-	0.08
LFS.unm.	-0.02	-0.11	0.18	0.03	-0.13	0.44*	0.13	0.16	0.55*
CPI	0.1	0.16	-0.01	0.26	0.55*	0.11	-0.03	0.24	0.15
CPIATE	0.06	0.08	0.01	0.01	0.35	0.1	-0.31	0.11	0.16
I44	0.09	0.13*	0.06	0.38*	0.55***	0.27	0.50*	0.71***	0.41
Ann.wag.	-0.07	0	-0.54*	-0.60***	-0.28	-0.88***	-1.05***	-0.66**	-1.08***
Productiv.	-0.33**	-0.28**	-0.23	-1.00***	-0.78***	-0.22	-1.13***	-0.90***	-0.07
Employm.	0.18**	0.28**	-0.06	0.21	0	-0.37	0.12	-0.38	-0.46

1) *, ** and *** indicate that the average forecast error has been significantly different
from zero at the 10, 5 and 1 percent significance level, respectively.

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Appendix Table D3 Accuracy. Normalised RMSE for projections from Norges Bank, Statistics Norway (SSB) and simple models.[1] 1998 - 2008

	Current year			One year ahead			Two years ahead		
	MPR	SSB	Mod.	MPR	SSB	Mod.	MPR	SSB	Mod.
Mnl.GDP	0.49	0.59††	0.72†††	0.92	0.98	0.95	1.03	1.43	1.08
Priv.cons.	0.73	0.76	0.96†††	1.05	0.95	1.15	1.23	1.14	1.35†
Pub.cons.	0.99	0.90	0.99	0.92	0.74**	1.12††	1.1	1.27	1.06
Mnl.inv.	0.52	0.56†	0.81†††	0.9	1.08†††	1.06††	0.92	1.19	1.19†††
Petr.inv.	0.26	0.28†	0.82†††	0.6	0.69††	1.01†††	1.03	1.21	0.74***
Exports	0.75	0.97†††	0.73	1.03	1.28†††	1.05	1.33	1.9	1.24*
Imports	0.45	0.48	0.89†††	0.98	1.00	1.00	1.10	1.10	1.00**
Outp.gap	0.42	-	0.52	0.62	-	0.79	0.94	-	1.06
Reg.unm.	0.22	-	0.19**	0.71	-	0.80†	1.29	-	1.32
LFS.unm.	0.34	0.36	0.49†††	0.83	0.83	1.03†††	1.16	1.38	1.56††
CPI	0.32	0.32	0.83†††	0.81	0.76	1.70†††	1.25	1.28	1.47
CPIATE	0.29	0.49††	0.30	1.19	1.27	1.13	1.65	1.46	1.35
I44	0.57	0.61	0.44***	1.01	0.94	0.98	1.22	0.93	1.32
Ann.wag.	0.55	0.69†††	0.95†††	1.08	1.12	1.33†	1.19	1.40	1.61††
Productiv.	0.56	0.62†††	0.72†††	0.9	0.92	0.87	1.04	1.15	1.12†
Employm.	0.42	0.55†††	0.46†	0.97	0.93	0.94	1.19	1.48	1.24

1) *(†), **(††) and ***(†††) indicate that the projection is significantly more (less) accurate than Norges Bank's projections at the 10, 5 and 1 percent significance level, respectively.

Appendix Table D4 Accuracy. Normalised RMSE for projections from Norges Bank, Statistics Norway (SSB) and simple models.[1] 2009 - 2019

	Current year			One year ahead			Two years ahead		
	MPR	SSB	Mod.	MPR	SSB	Mod.	MPR	SSB	Mod.
Mnl.GDP	0.28	0.28	0.69†††	0.96	0.97	1.30††	1.10	1.30†††	1.13
Priv.cons.	0.71	0.88†††	0.67	1.48	1.84†††	1.58	1.56	2.19†††	1.41*
Pub.cons.	0.43	0.45	0.70†††	0.81	1.01†††	0.97†	0.37	0.38	0.42
Mnl.inv.	0.26	0.27	0.63†††	0.75	0.75	1.24†††	0.29	0.34	0.34
Petr.inv.	0.35	0.37††	0.64†††	0.63	0.78†††	0.99†††	0.90	0.93††	0.97††
Exports	0.75	0.81†	0.86††	1.05	1.15†††	1.22†††	1.09	1.10	1.01**
Imports	0.63	0.60	0.87†††	1.08	1.06	1.16	0.58	0.59	0.54
Outp.gap	0.43	-	0.45	1.55	-	1.72†	1.74	-	2.22††
Reg.unm.	0.83	-	0.45***	1.71	-	1.58	1.77	-	1.94
LFS.unm.	0.58	0.45***	0.47	0.92	0.93	0.93	0.96	1.40†††	1.11
CPI	0.4	0.69†††	0.62†††	1.05	1.10	1.01	1.08	1.10	1.05
CPIATE	0.29	0.46†††	0.36†††	0.96	0.93	1.15†††	1.18	0.97**	1.34†
I44	0.24	0.27	0.19***	0.78	0.81	0.63***	1.05	1.02*	0.91***
Ann.wag.	0.4	0.48†††	1.00†††	0.89	0.76**	1.34†††	1.37	1.11***	1.50††
Productiv.	0.63	0.49***	0.71††	1.28	1.14	1.08**	1.50	1.32**	1.13***
Employm.	0.41	0.48	0.55†††	0.64	0.82††	1.40†††	0.73	1.10†††	1.45†††

1) *(†), **(††) and ***(†††) indicate that the projection is significantly more (less) accurate than Norges Bank's projections at the 10, 5 and 1 percent significance level, respectively.

E. Charts of current projections and real-time data

Appendix Chart E1 Mainland GDP. Current year. Projection[1] and actual. Change. Percent
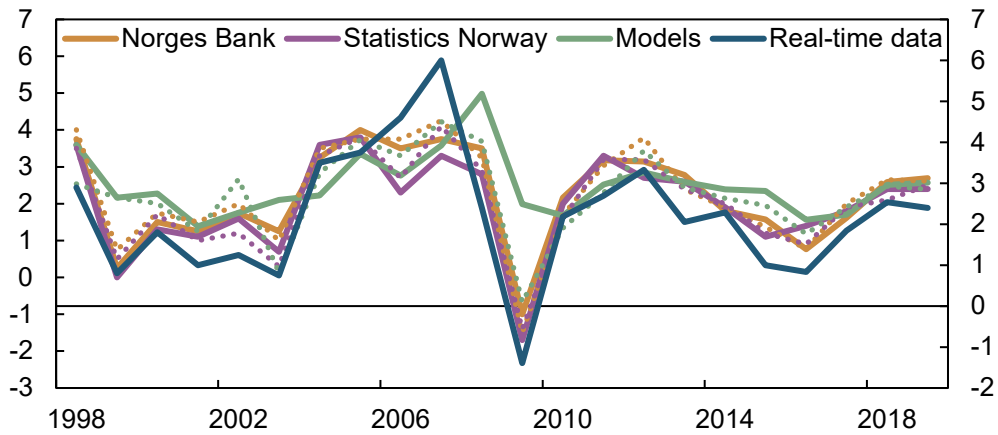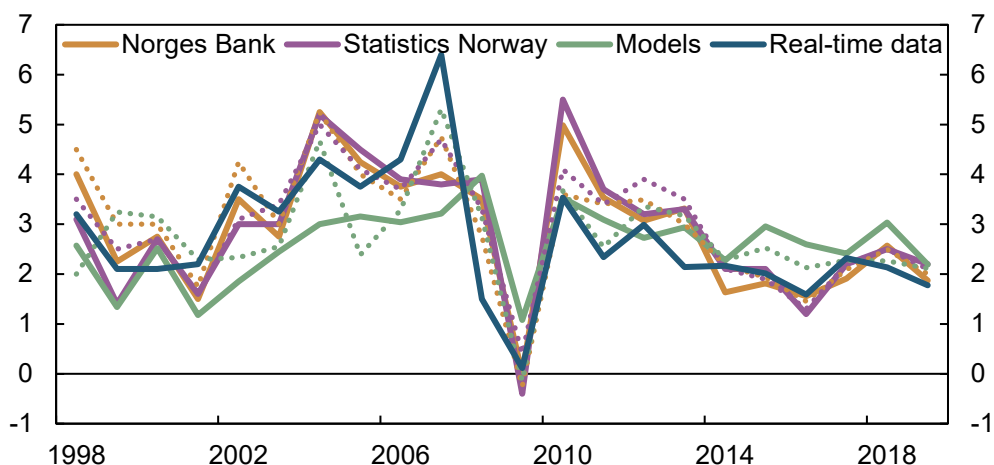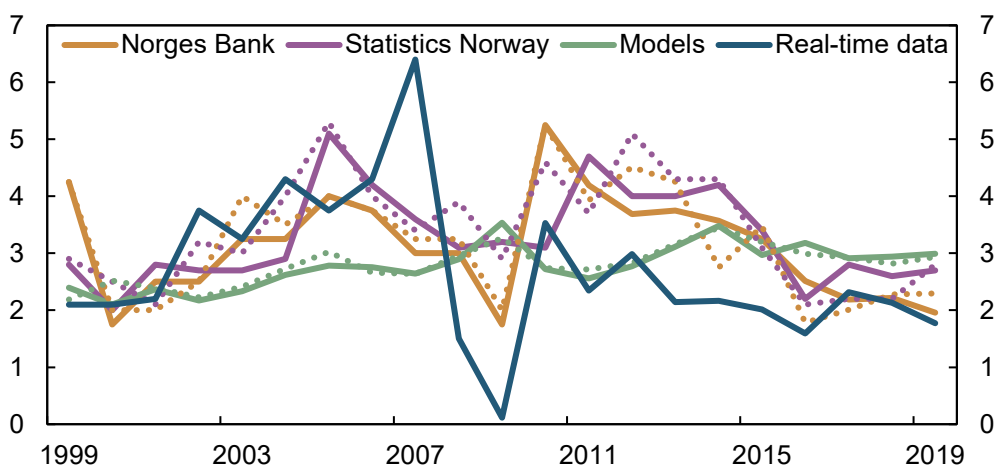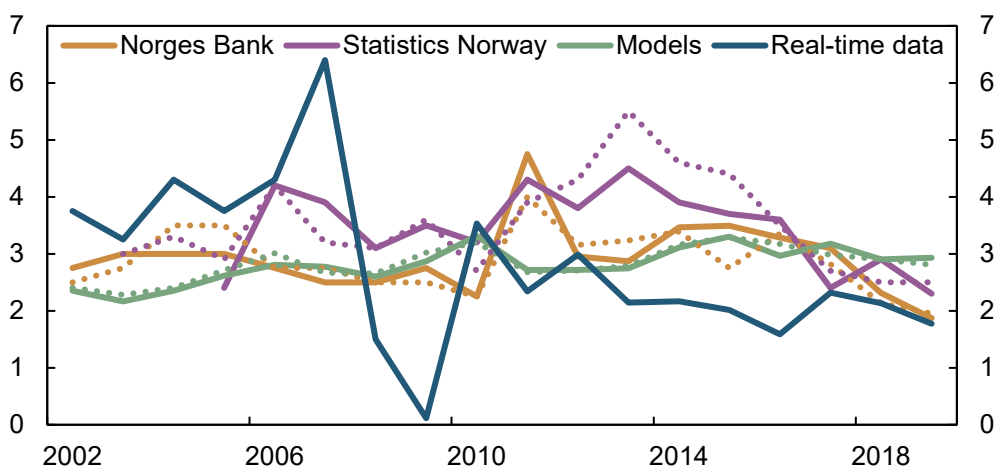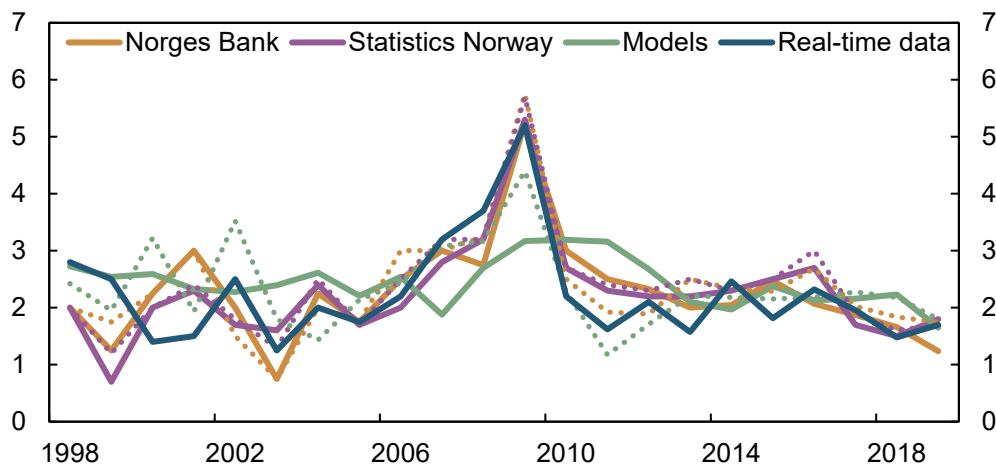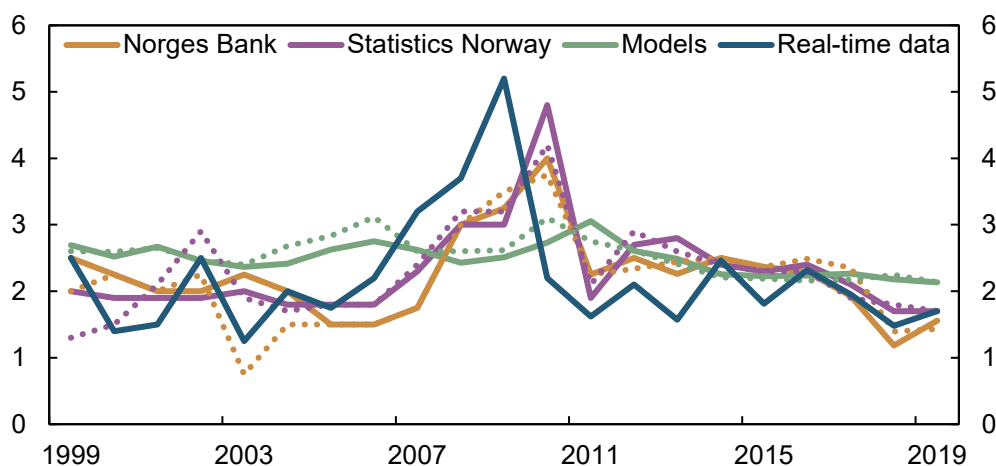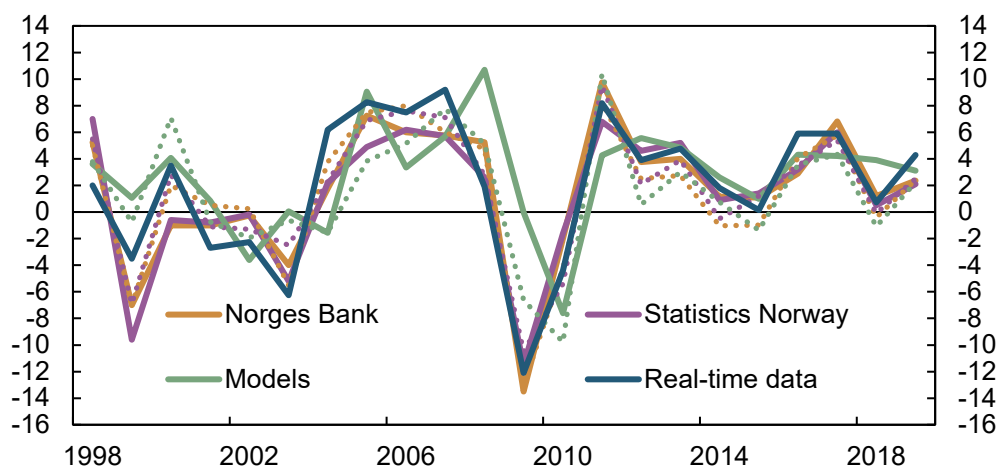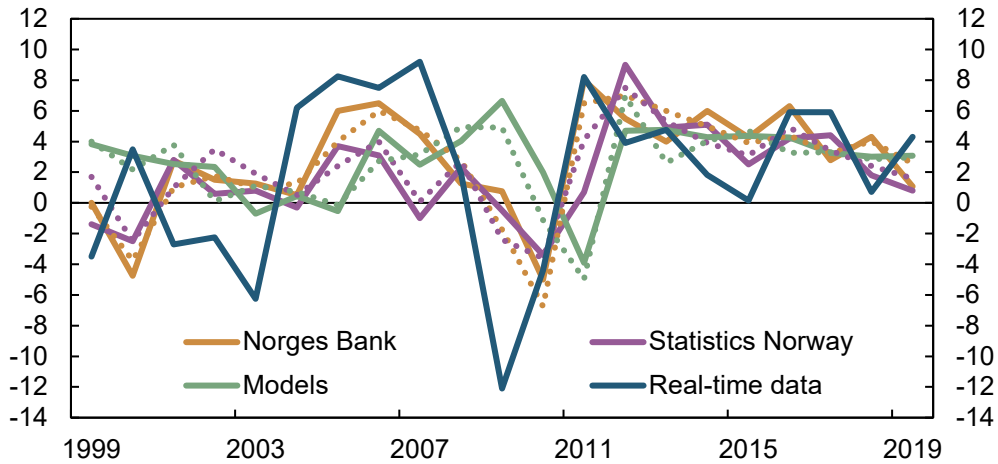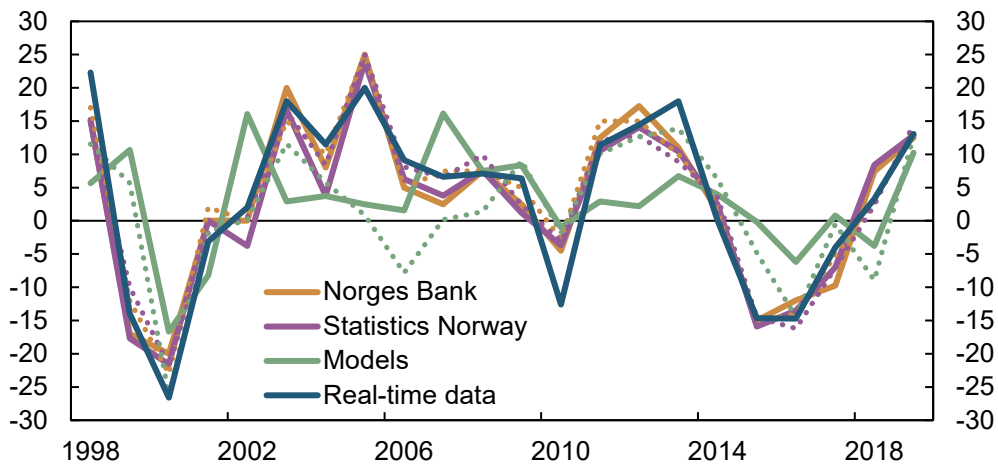

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E2 Mainland GDP. One year ahead. Projection[1] and actual. Change. Percent
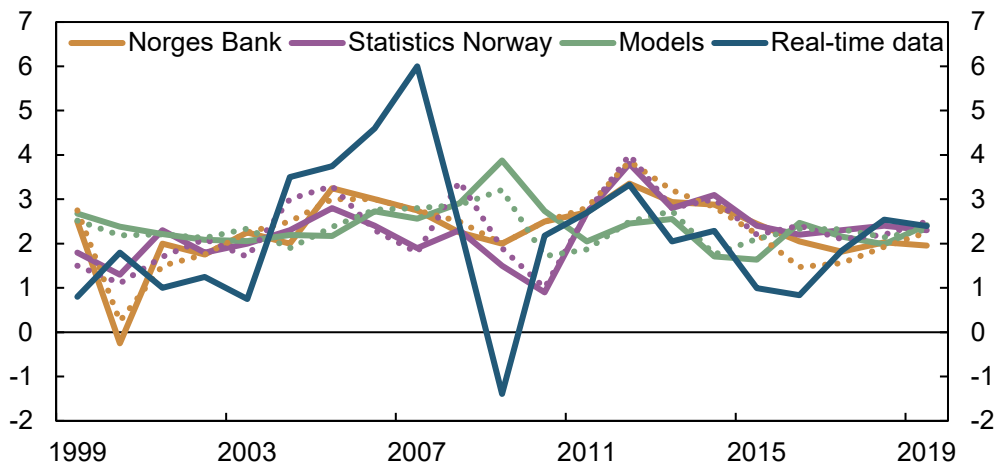
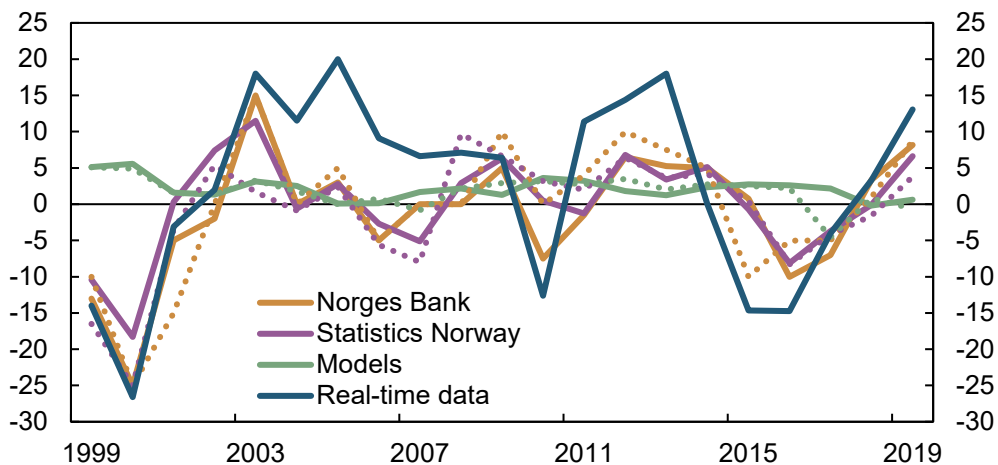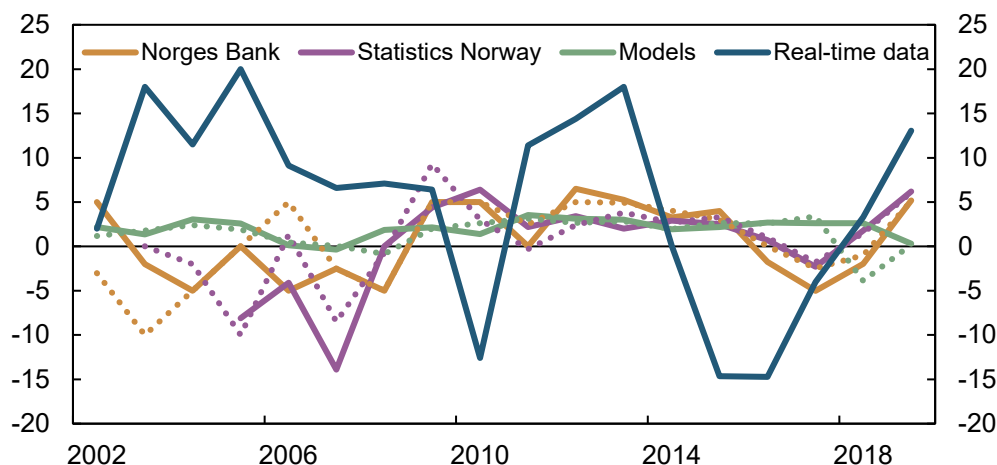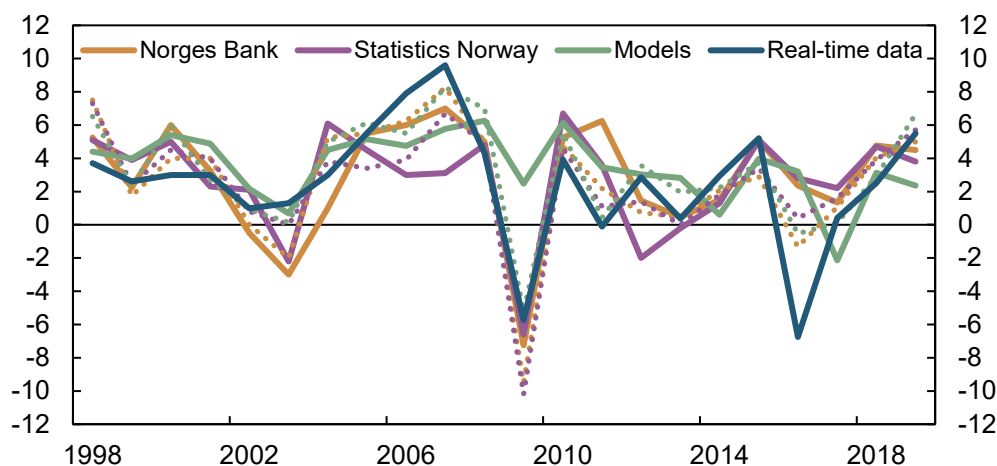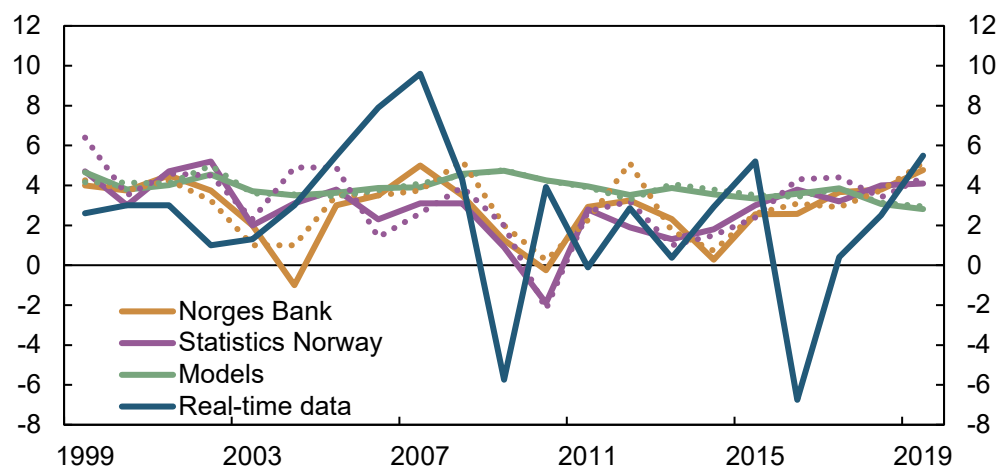1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E3 Mainland GDP. Two years ahead. Projection[1] and actual. Change. Percent
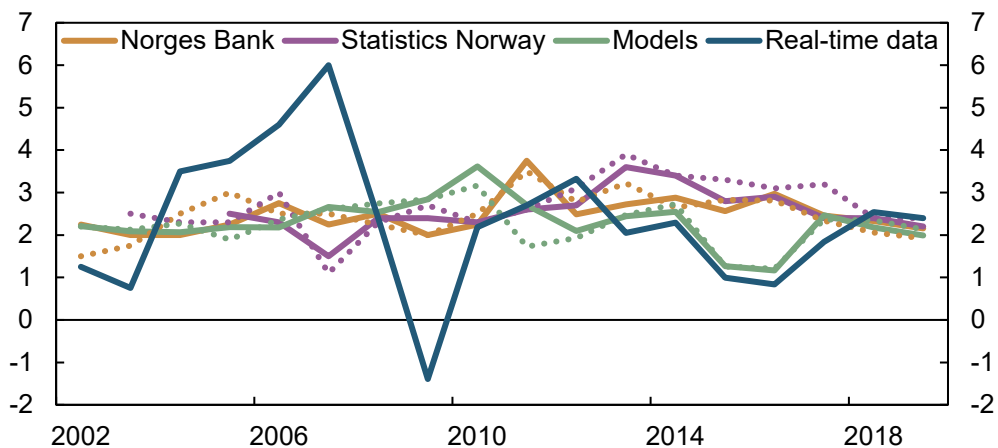
1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E4 Productivity. Current year. Projection[1] and actual. Change. Percent. 1998 – 2019
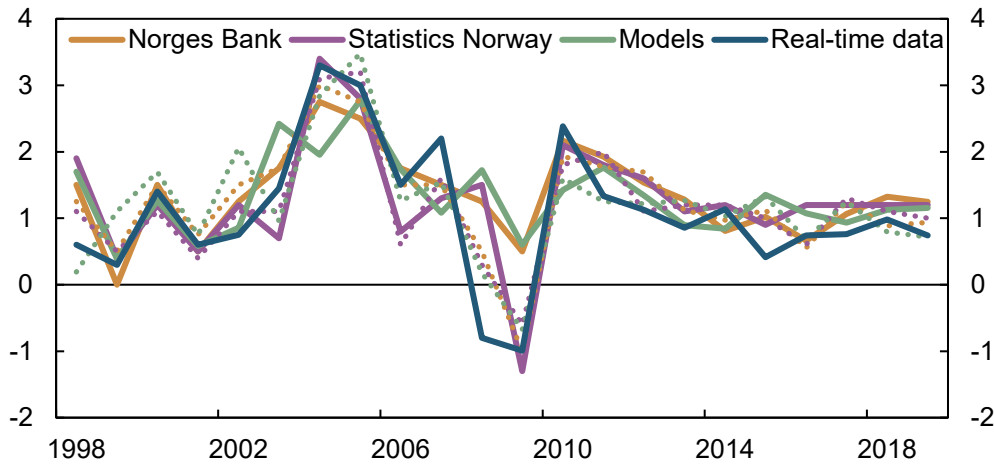
1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E5 Productivity. One year ahead. Projection[1] and actual. Change. Percent. 1999 – 2019
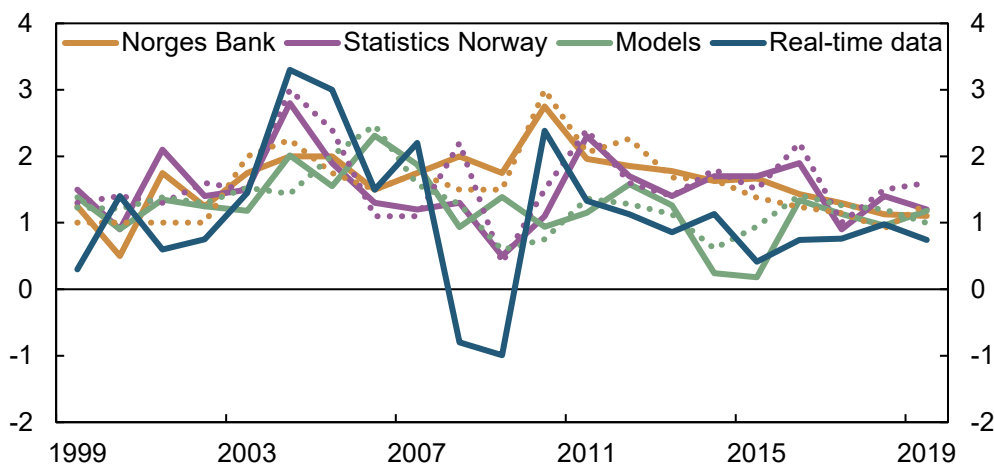
1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E6 Productivity. Two years ahead. Projection[1] and actual. Change. Percent. 2002 – 2019
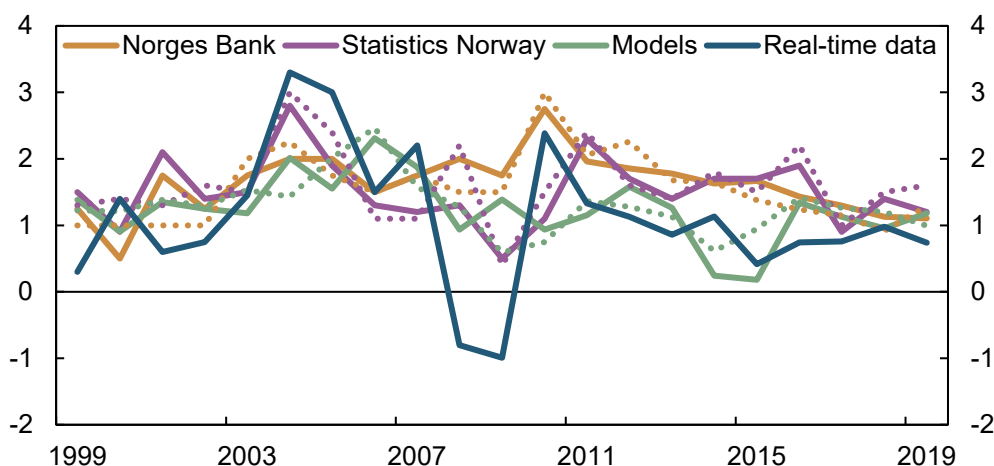
1) Solid and broken lines show projections from the first and second reports of each year, respectively.

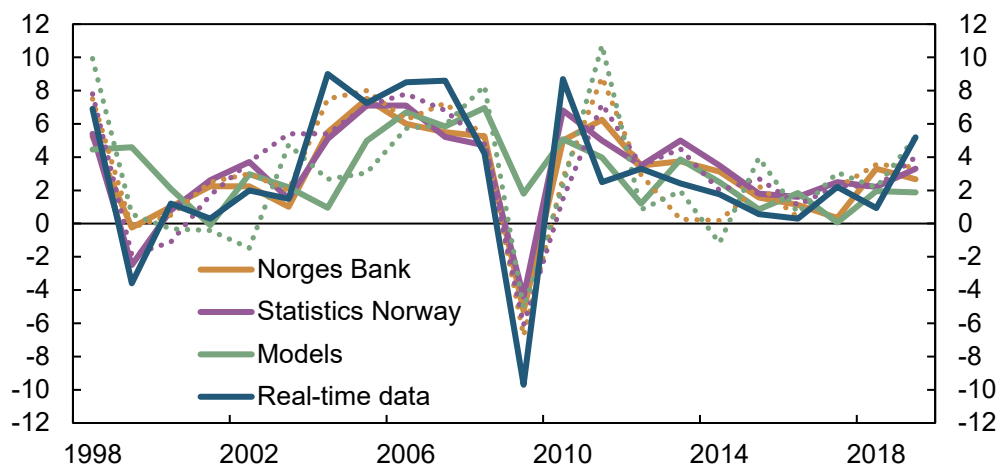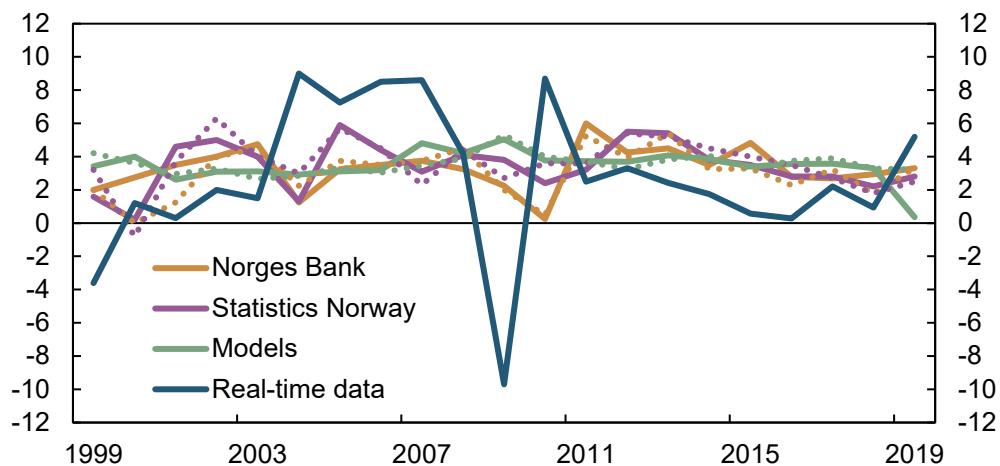*Appendix Chart E7 Employment. Current year. Projection[1] and actual. Change. Percent. 1998 – 2019*
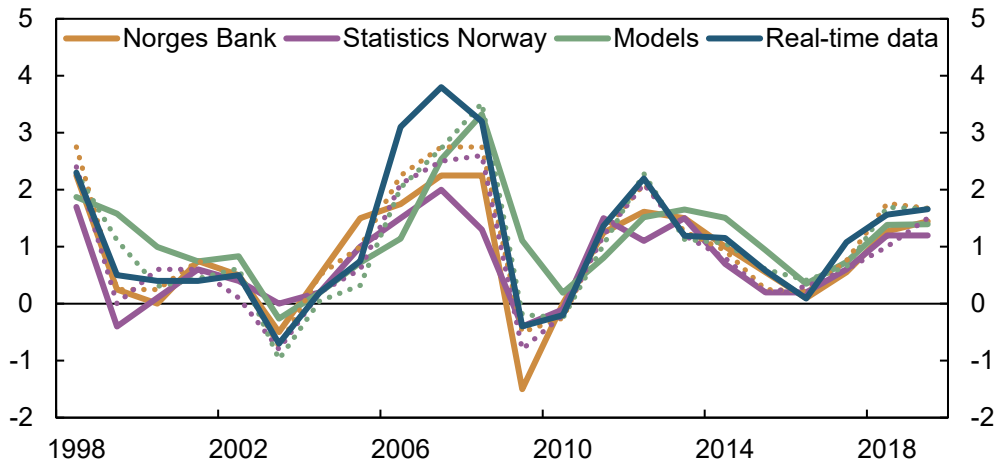
1) Solid and broken lines show projections from the first and second reports of each year, respectively.

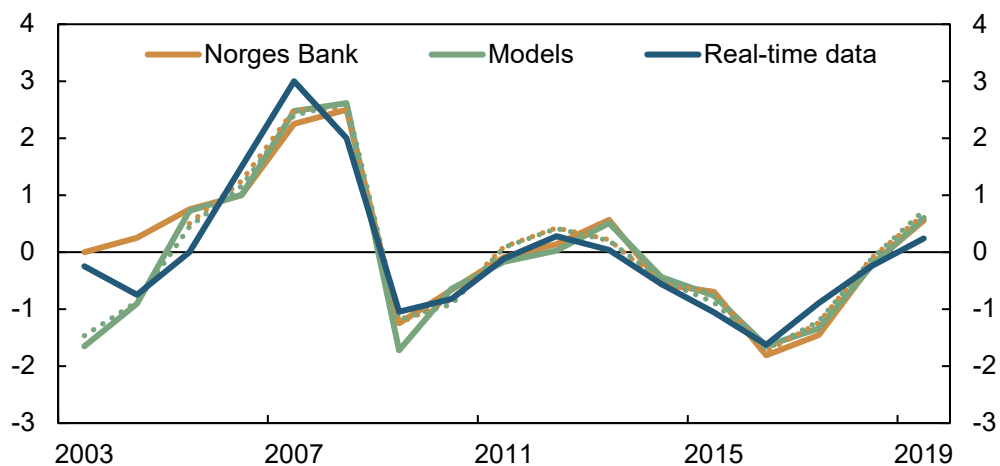*Appendix Chart E8 Employment. One year ahead. Projection[1] and actual. Change. Percent. 1999 – 2019*
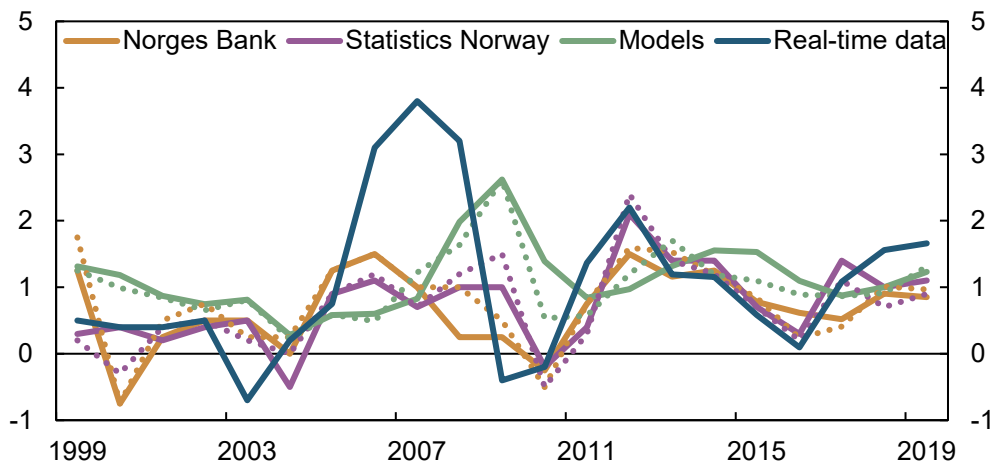
1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E9 Employment. Two years ahead. Projection[1] and actual. Change. Percent. 2002 – 2019
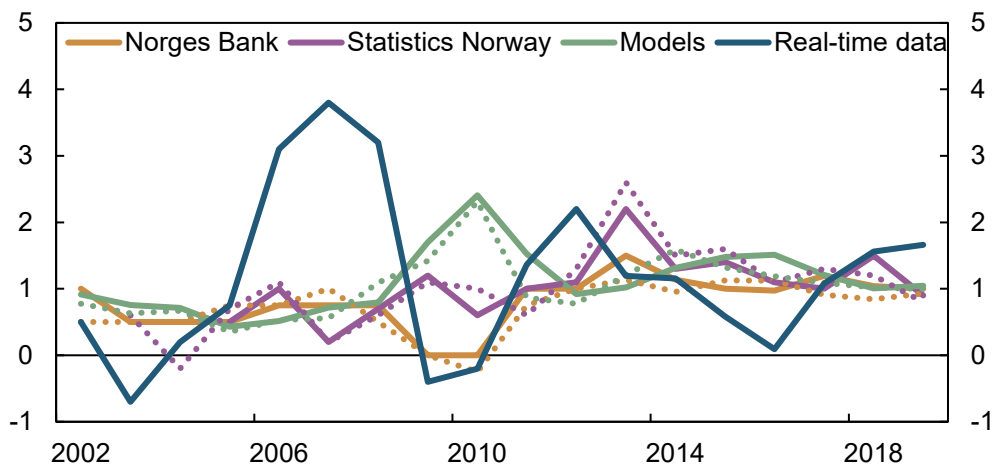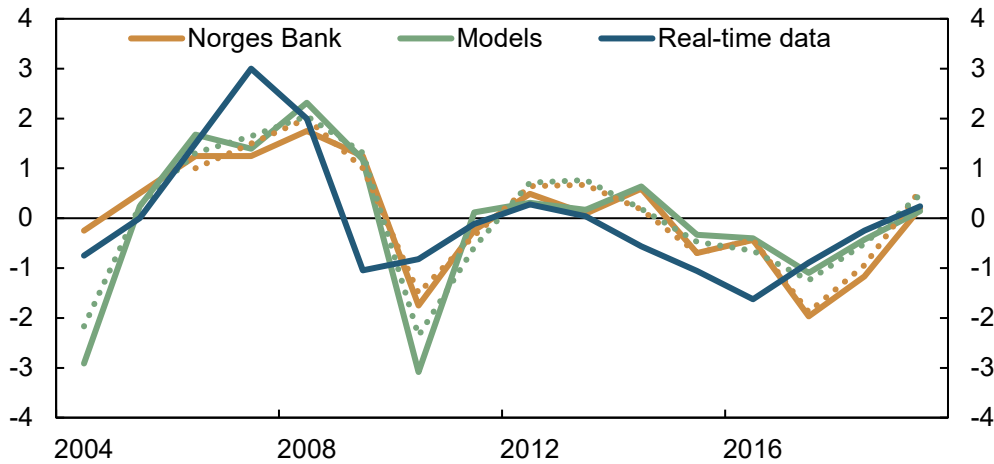

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

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Appendix Chart E10 Private consumption. Current year. Projection[1] and actual. Change. Percent

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E11 Private consumption. One year ahead. Projection[1] and actual. Change. Percent
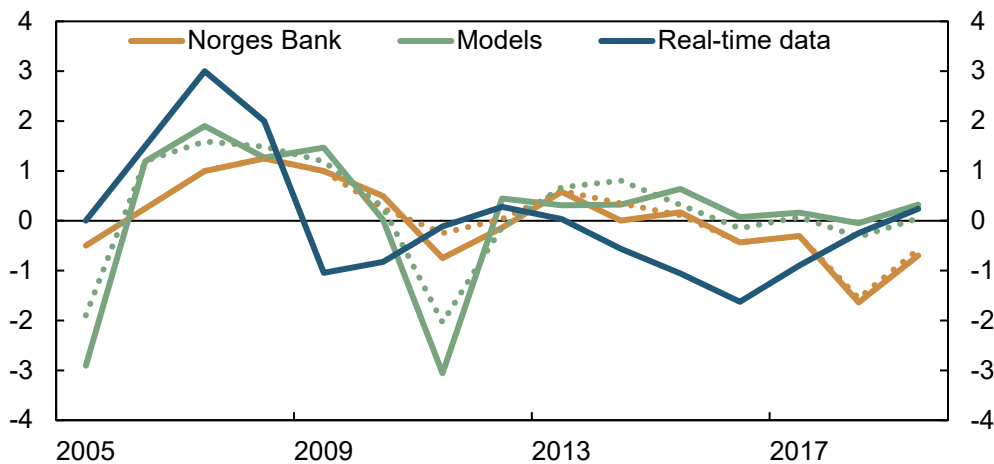

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E12 Private consumption. Two years ahead. Projection[1] and actual. Change. Percent

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

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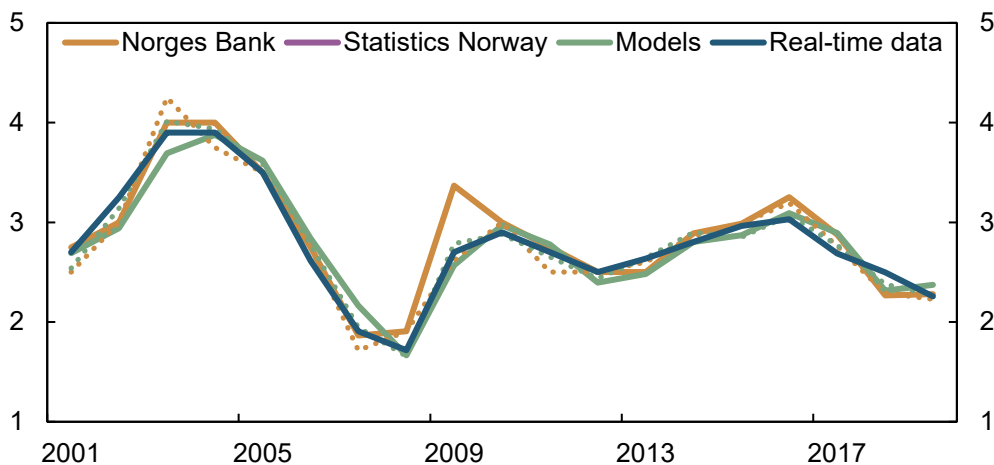*Appendix Chart E13 Public consumption. Current year. Projection[1] and actual.
Change. Percent*

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

*Appendix Chart E14 Public consumption. One year ahead. Projection[1] and actual.
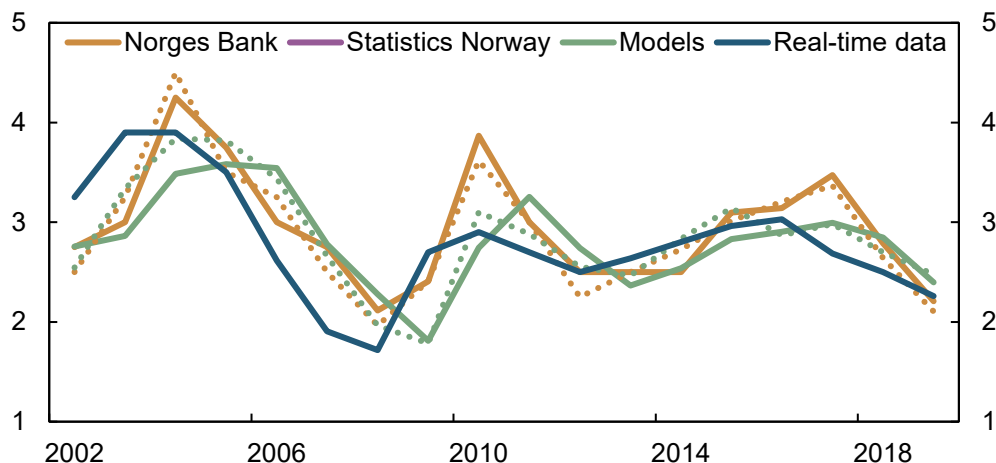Change. Percent*

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

*Appendix Chart E15 Mainland investment. Current year. Projection[1] and actual.
Change. Percent*

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

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*Appendix Chart E16 Mainland investment. One year ahead. Projection[1] and actual.
Change. Percent*

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

*Appendix Chart E17 Petroleum investment. Current year. Projection[1] and actual.
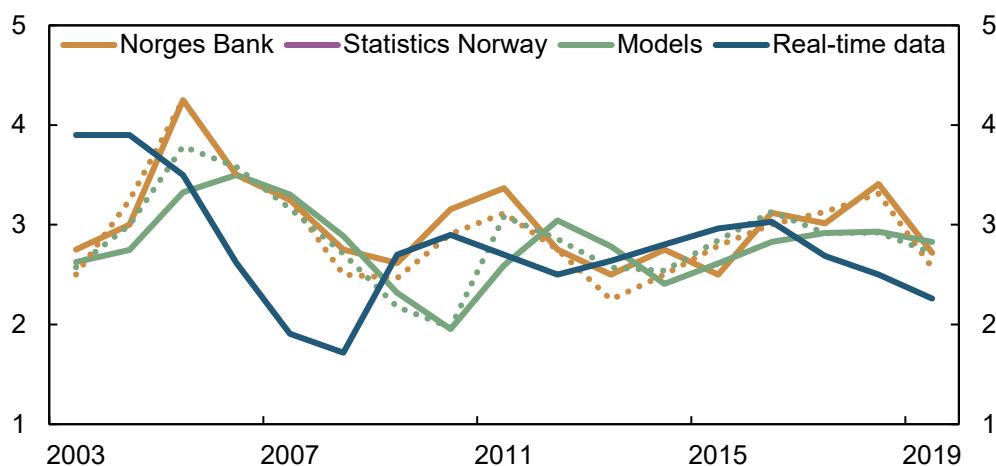Change. Percent*

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

*Appendix Chart E18 Petroleum investment. One year ahead. Projection[1] and actual.
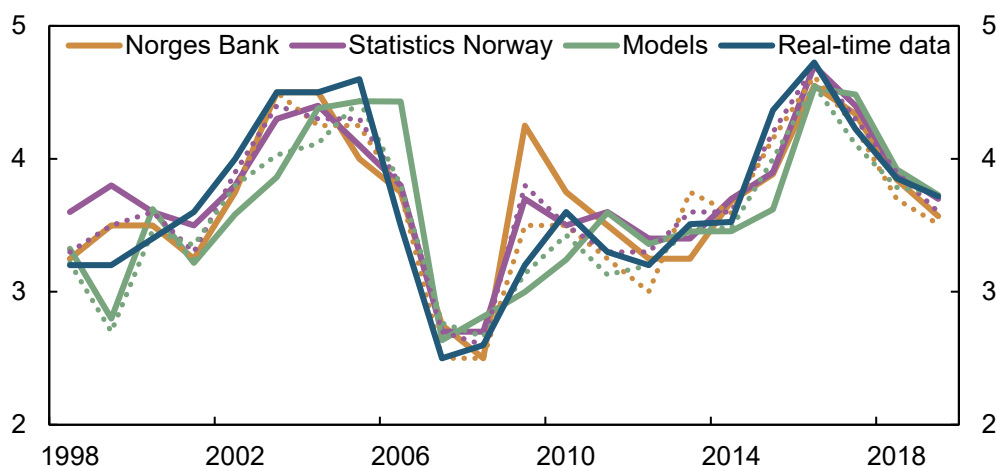Change. Percent*

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E19 Petroleum investment. Two years ahead. Projection[1] and actual. Change. Percent
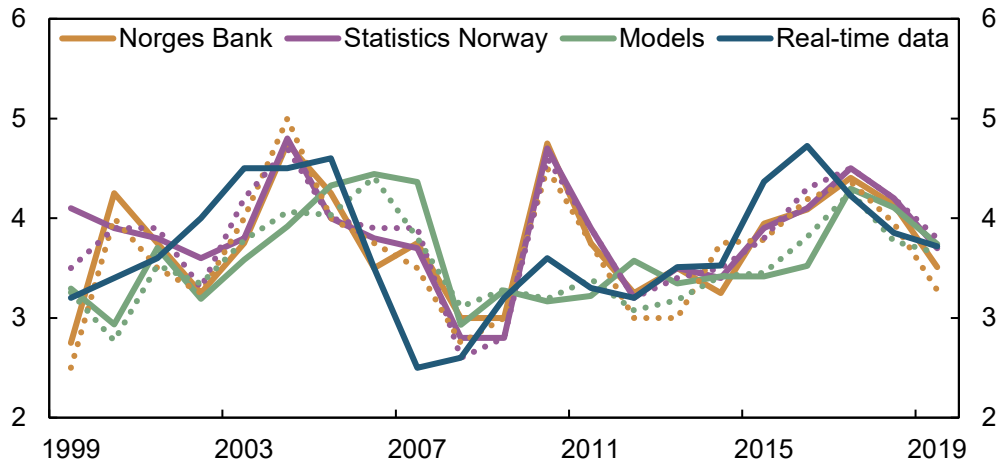

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E20 Mainland exports. Current year. Projection[1] and actual. Change. Percent

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E21 Mainland exports. One year ahead. Projection[1] and actual. Change. Percent

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

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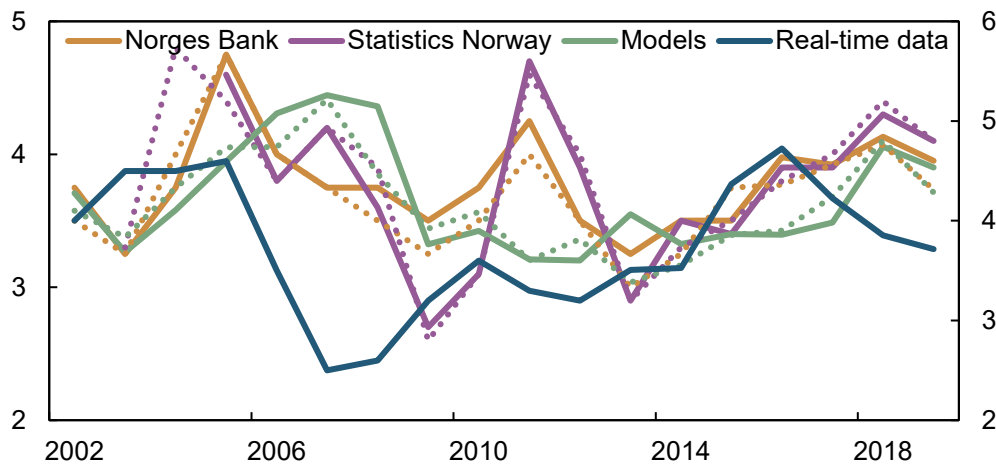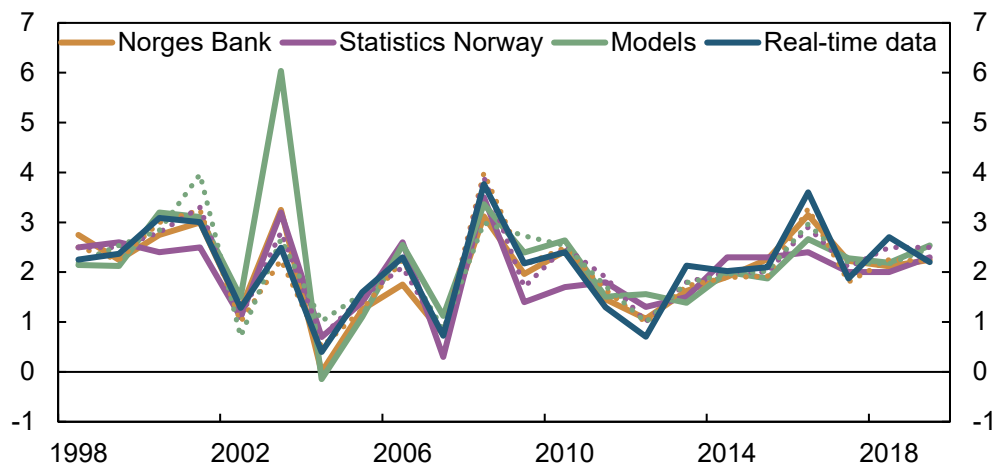*Appendix Chart E22 Imports. Current year. Projection[1] and actual. Change. Percent*

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E23 Imports. One year ahead. Projection[1] and actual. Change. Percent

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E24 Output gap. Current year. Projection[1] and actual. Change. Percent. 2003 – 2019

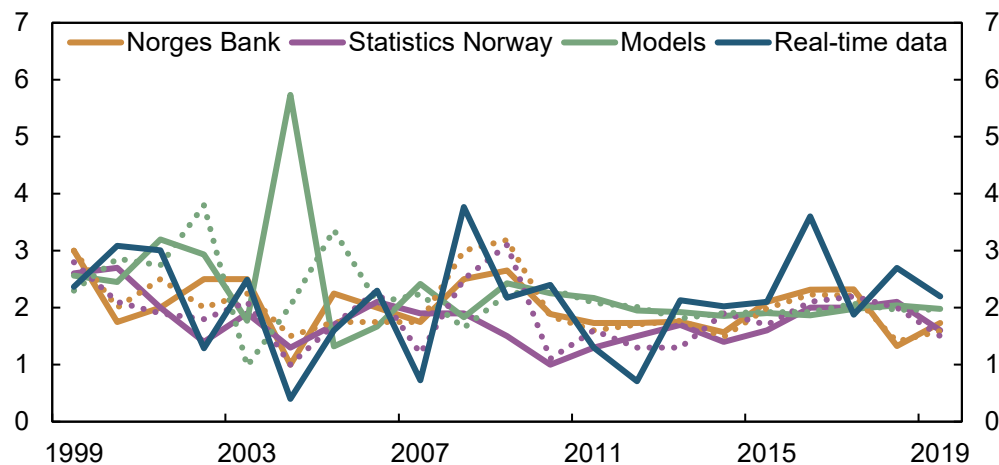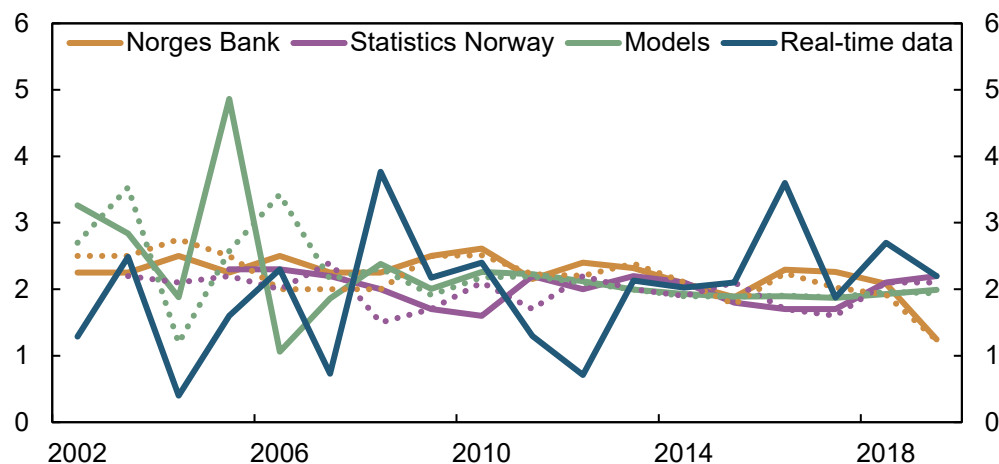
1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E25 Output gap. One year ahead. Projection[1] and actual. Change. Percent. 2004 – 2019

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E26 Output gap. Two years ahead. Projection[1] and actual. Change. Percent. 2005 – 2019

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E27 Registered unemployment. Current year. Projection[1] and actual. Percent. 2001 – 2019

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E28 Registered unemployment. One year ahead. Projection[1] and actual. Percent. 2002 – 2019

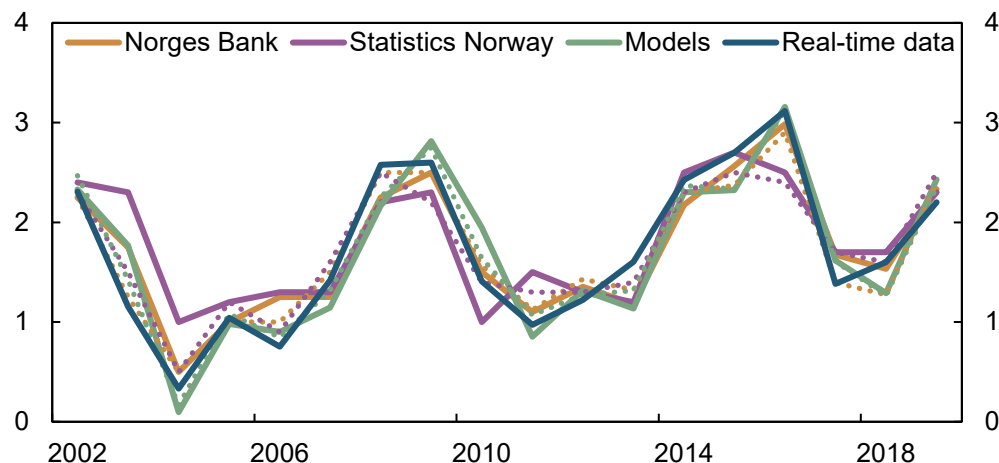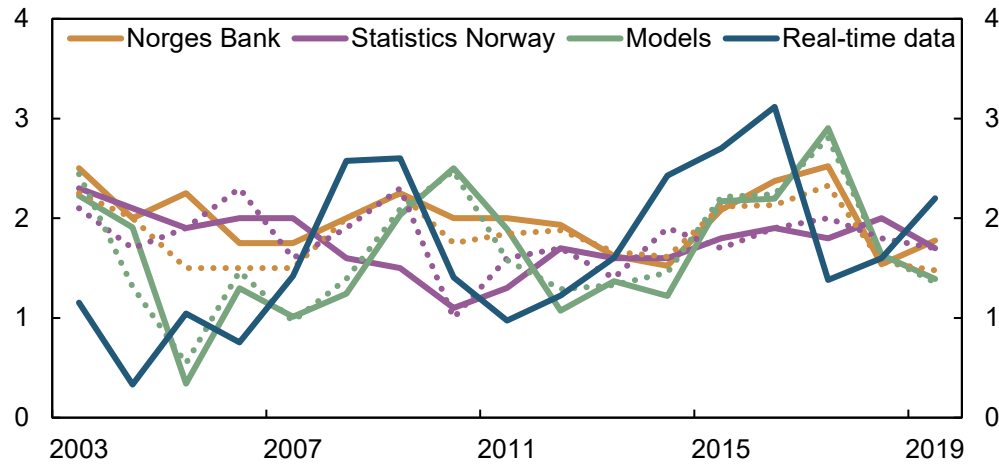
1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E29 Registered unemployment. Two years ahead. Projection[1] and actual. Percent. 2003 – 2019

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E30 LFS unemployment. Current year. Projection[1] and actual. Percent. 1998 – 2019

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E31 LFS unemployment. One year ahead. Projection[1] and actual. Percent. 1999 – 2019

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E32 LFS unemployment. Two years ahead. Projection[1] and actual. Percent. 2002 – 2019

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

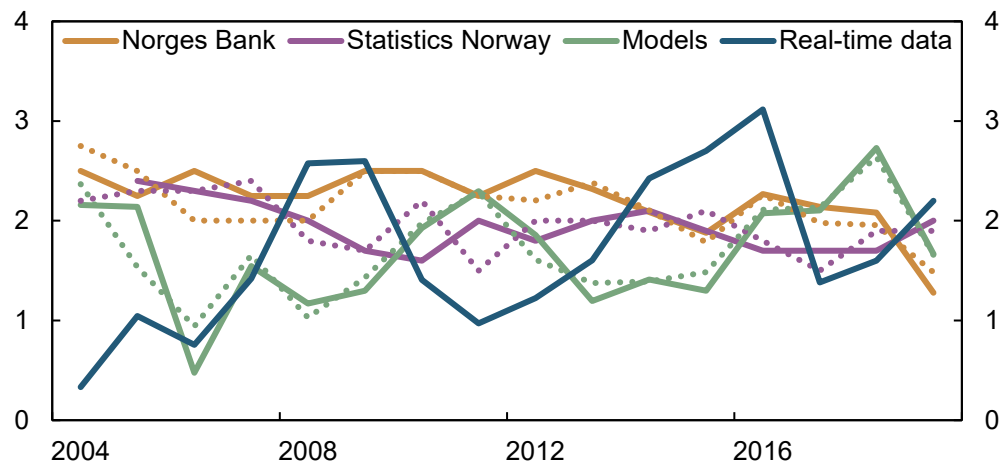*Appendix Chart E33 CPI. Current year. Projection[1] and actual. Change. Percent. 1998 – 2019*

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

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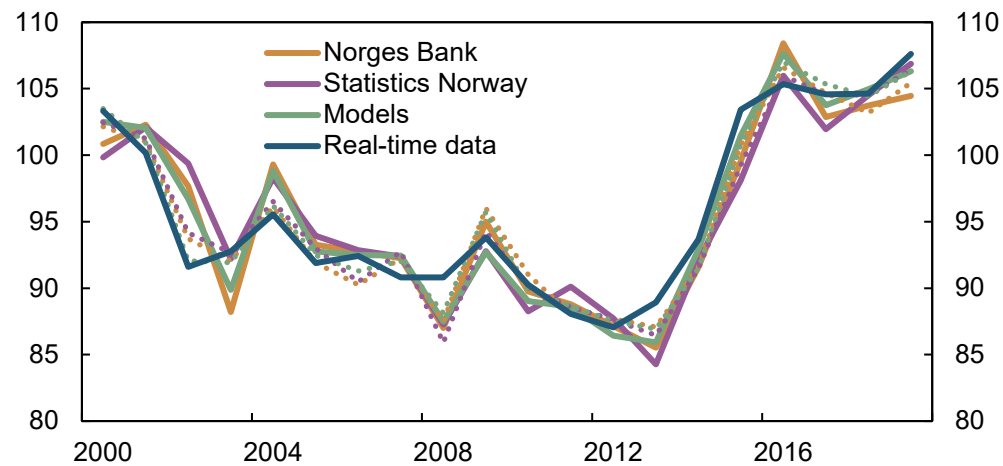*Appendix Chart E34 CPI. One year ahead. Projection[1] and actual. Change. Percent.
1999 – 2019*

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

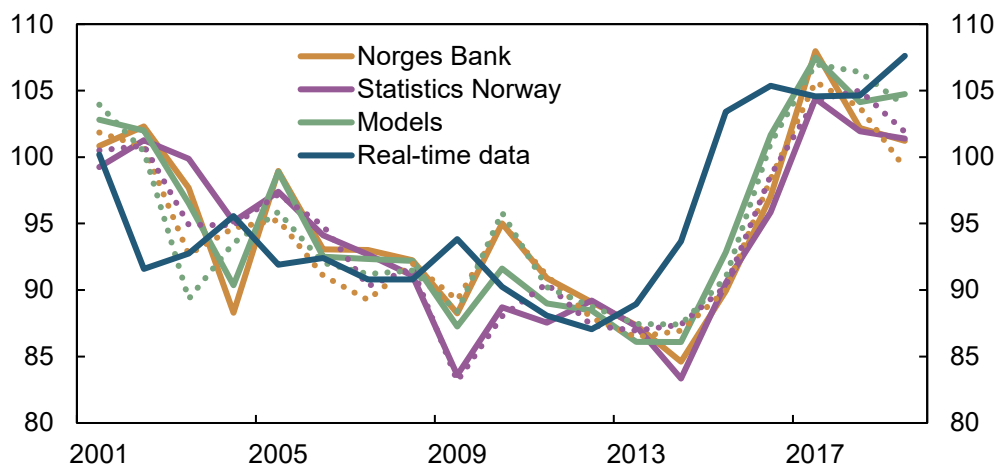*Appendix Chart E35 CPI. Two years ahead. Projection[1] and actual. Change. Percent.
2002 – 2019*

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

*Appendix Chart E36 CPI-ATE. Current year. Projection[1] and actual. Change. Percent.
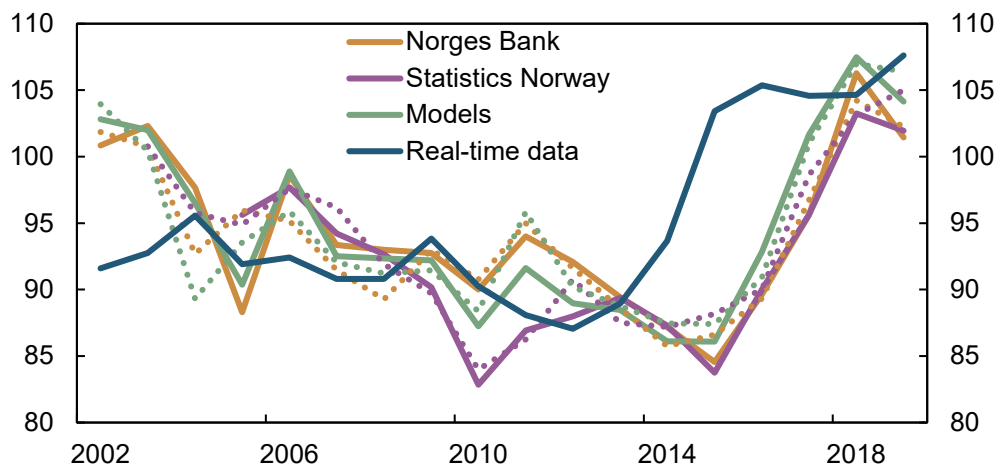2002 – 2019*

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E37 CPI-ATE. One year ahead. Projection[1] and actual. Change. Percent. 2003 – 2019

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E38 CPI-ATE. Two years ahead. Projection[1] and actual. Change. Percent. 2002 – 2019

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E39 I44. Current year. Projection[1] and actual. Level. 2002 – 2019

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

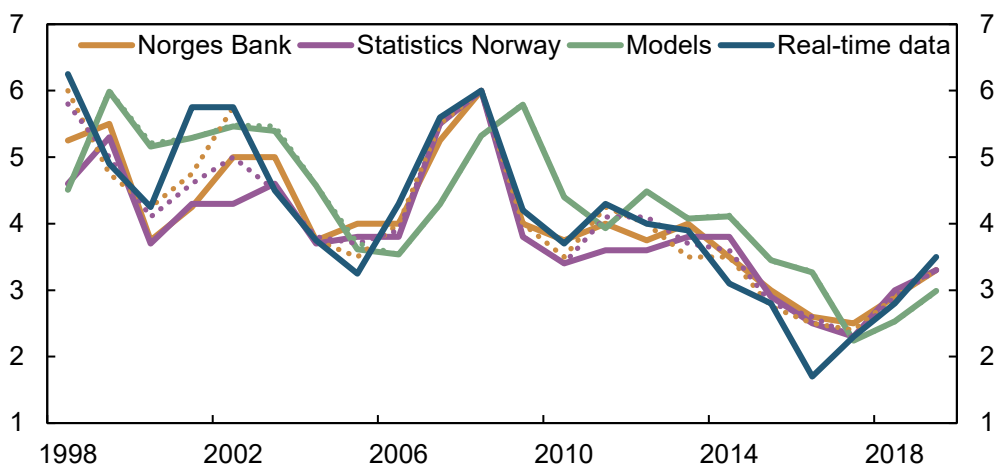*Appendix Chart E40 I44. One year ahead. Projection[1] and actual. Level. 2001 – 2019*

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

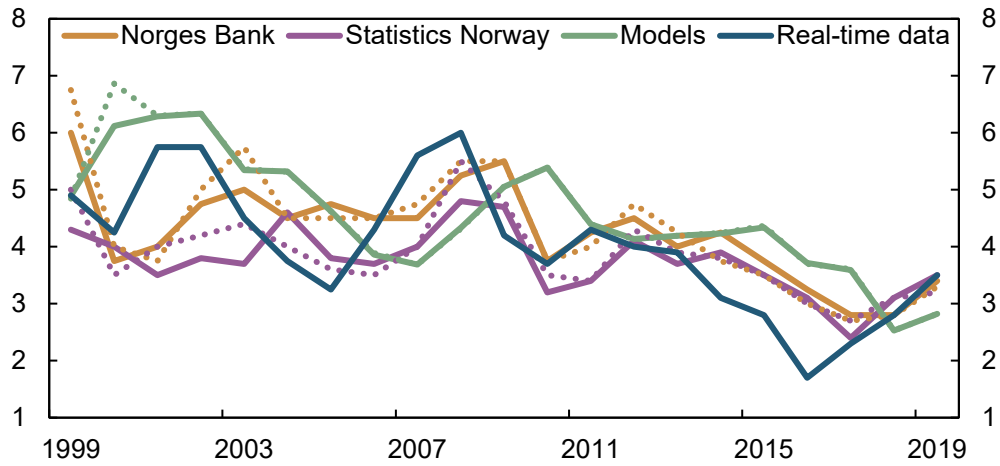*Appendix Chart E41 I44. Two years ahead. Projection[1] and actual. Level. 2002 – 2019*

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

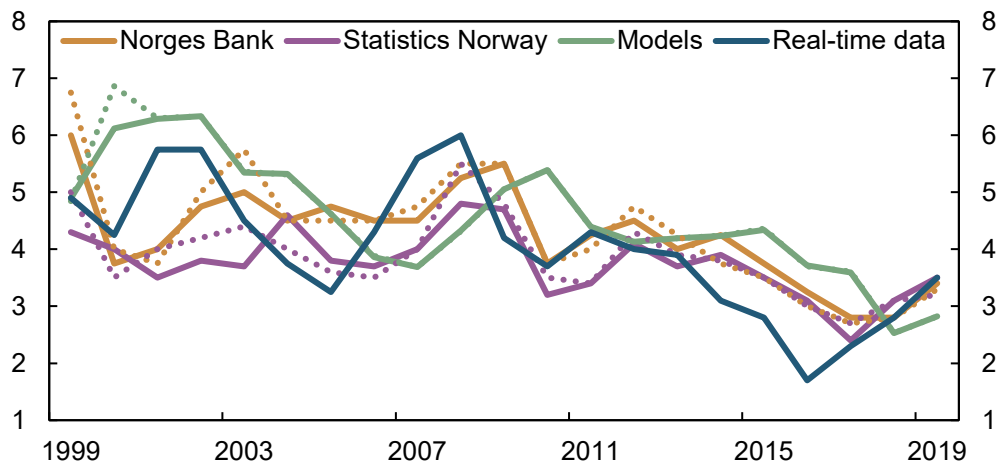*Appendix Chart E42 Annual wages. Current year. Projection[1] and actual. Change. Percent. 1998 – 2019*

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

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Appendix Chart E43 Annual wages. One year ahead. Projection[1] and actual. Change. Percent. 1999 – 2019

1) Solid and broken lines show projections from the first and second reports of each year, respectively.

Appendix Chart E44 Annual wages. Two years ahead. Projection[1] and actual. Change. Percent. 2002 – 2019

1) Solid and broken lines show projections from the first and second reports of each year, respectively.