Macroeconomic models are used to create simplified versions of the actual economy. If they are successful, their components describe the economic relationships that are most important; however, it is inevitable that they will omit many others of lesser significance. Data are also subject to measurement errors. When forecasts are prepared, they must be based on preliminary figures for the recent past, as data will not be available in their final form until perhaps several years later. It follows from this that macroeconomic forecasts will virtually always contain some errors. Studying past forecasting errors can provide some indication of the uncertainties in the current forecast. These can be used for further development of the Bank's economic models, their use in forecast preparation, and overall improvements in analysis and forecast presentation.

Macroeconomic and inflation forecasts
Four times a year, the Central Bank prepares macroeconomic and inflation forecasts covering a forecast horizon of three years. The forecasts are based on an in-depth analysis of the state of the economy at the time they are prepared. The assumptions concerning global economic developments are based, among other things, on international forecasts and the information implied by forward commodity prices. The national accounts provide the main foundation for the assessment of the state of the economy. In addition, Bank staff prepare an independent assessment of the state of the economy through surveys; discussions with corporate executives, institutional directors, and labour market institutes; and statistical analysis of developments in key variables. The Central Bank's quarterly macroeconomic model (QMM) is the tool used to manage this information. Some of the equations in the model are accounting equations, while others are behavioural equations that are evaluated using econometric methods. The Bank's forecast – particularly for the recent past and immediate future – is determined not least by staff assessments, various simple statistical models, and a variety of information not included in the QMM.

  Monetary policy performance during the forecast horizon is a key factor in the preparation of each forecast. In the QMM, monetary policy is set with a forward-looking monetary policy rule wherein the Central Bank policy interest rate is determined by the expected deviation of inflation from the inflation target and the current output gap. This rule ensures that the policy rate brings inflation back to target by the end of the forecast horizon if it is not already there. The monetary policy rule in the model was selected so as to minimise the sacrifice cost in ensuring that inflation is at target.[1]

Central Bank inflation forecasts for 2014
Inflation subsided markedly year-on-year in 2014. Inflation averaged 2% for the year, down from 3.9% in 2013. Inflation excluding the effects of indirect taxes also measured 2%. As has been discussed in previous issues of *Monetary Bulletin*, inflation was driven mainly by rising house prices in 2014, while falling prices of imported goods and services, declining oil prices, and the appreciation of the króna pulled in the opposite direction.

  Chart 1 illustrates the forecasting record for the inflation forecasts within the year. In all instances, twelve-month inflation for each quarter was overforecast. The deviation in the fourth quarter

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1. Further discussion of the QMM can be found in Box 5. See also Ásgeir Daníelsson, Bjarni G. Einarsson, Magnús F. Gudmundsson, Svava J. Haraldsdóttir, Thórarinn G. Pétursson, Signý Sigmundardóttir, Jósef Sigurdsson, and Rósa Sveinsdóttir (2015), "QMM: A quarterly macroeconomic model of the Icelandic economy – Version 3.0", Central Bank of Iceland, *Working Paper*, forthcoming.

Box 6

The Central Bank of Iceland forecasting record

Chart 1
Quarterly inflation 2014 and forecasts in *Monetary Bulletin*

Deviation (percentage points)

- MB 2014/1
- MB 2014/2
- MB 2014/3
- MB 2014/4
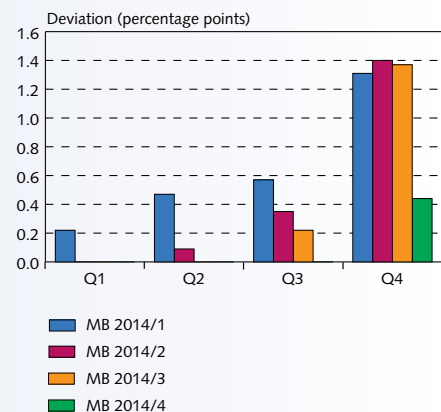
Source: Central Bank of Iceland.

was affected strongly by an unforeseen drop in oil prices late in the year: in the February *Monetary Bulletin*, oil prices were projected to fall by just over 6% year-on-year in Q4, whereas they actually fell by nearly 30%. Table 1 shows that average inflation for the year was overforecast in all four issues of *Monetary Bulletin*; however, the forecasts became more accurate as the year progressed and more information became available, although inflation was still overestimated by 0.2 percentage points in Q4.

Table 1 Inflation forecast for 2014

	Monetary Bulletin				*Final*
Change from prior year (%)	*2014/1*	*2014/2*	*2014/3*	*2014/4*	*result*
Inflation	2.7	2.5	2.4	2.2	2.0
Inflation excl. effects of indirect taxes	2.6	2.4	2.4	2.1	2.0

Errors in long-term inflation forecasts

In assessing long-term inflation forecasts, it is important to consider the mean forecast error and the root mean square error (RMSE) of the forecasts concerned. The mean forecast error shows the average deviation of the forecast from observed inflation. It gives an indication of whether inflation is being systematically over- or underforecast. The RMSE is a measure of the variability of the forecast error and therefore of the uncertainty in the forecast itself. The error can generally be expected to increase as forecasts extend further ahead in time.

Table 2 Central Bank of Iceland inflation forecast errors since Q1/1994

	One	*Two*	*Three*	*Four*
%	*quarter*	*quarters*	*quarters*	*quarters*
Mean forecast error	0.0	-0.2	-0.6	-1.0
RMSE	0.6	1.6	2.2	2.5

Table 2 shows the mean forecast error and RMSE in the Bank's inflation forecasts up to four quarters ahead, from 1994 through August 2015 (81 forecasts). By this criterion, inflation has been underforecast two to four quarters ahead, to an increasing degree along the horizon. The mean deviation of the forecasts three and four quarters ahead proved to be statistically significant from zero based on a 5% threshold, which means that the forecasts were skewed to the downside. The forecast errors one and two quarters ahead were not significant from zero, however. The mean forecast error three and four quarters ahead has been strongly affected by the years 2008 and 2009. Excluding the forecasts prepared for those years reduces the mean error by 0.3 percentage points for the forecasts three quarters ahead and by 0.4 percentage points for the forecasts four quarters ahead. Furthermore, the mean forecast error for the forecasts three quarters ahead becomes statistically insignificant from zero based on a 5% threshold, although the mean error for the four-quarter forecasts is still significant.

After adopting the inflation target in March 2001, the Central Bank published inflation forecasts two years ahead, and since March

Table 3 Central Bank of Iceland inflation forecast errors since Q2/2001

	No. of measurements	*Mean forecast error (%)*	*RMSE (%)*
Four quarters ahead	52	-1.2	2.7
Eight quarters ahead	48	-2.1	3.9
Twelve quarters ahead	22	-1.1	2.1

2007, it has published forecasts over a horizon of three years. Table 3 shows the mean forecast error and the RMSE for the period since the Bank introduced inflation targeting. A comparison of the RMSE for the one-year forecasts (see Tables 2 and 3) shows that the RMSE has been greater since the Bank adopted the inflation target than it was for the entire period, as, until recently, fluctuations in inflation have been greater since the króna was floated than they were during the fixed exchange rate period of the 1990s.[2] It should also be borne in mind that the Bank did not begin using the QMM until the beginning of 2006, and it prepared no forecasts of the ISK exchange rate or Central Bank interest rates before 2007.[3] In recent years, the Bank's macroeconomic and inflation forecasts have been based on the assumption that the exchange rate of the króna will remain broadly unchanged over the forecast horizon. Experience shows that large errors in inflation forecasts in Iceland are usually related to exchange rate volatility, as can be seen in Chart 2, as the correlation between the mean absolute errors in inflation and exchange rate forecasts is 0.64.

The Bank's forecasts in recent years are compared in Chart 3. The RMSE averaged 0.5% in 2014, which indicates slightly less forecasting accuracy than in 2012 and 2013, when it was 0.4%. The forecasting errors three and four quarters ahead were considerably larger in 2014 than in the previous two years, owing to the unforeseen decline in oil prices in late 2014. The forecasting errors are noticeably larger for the forecasts for Q4/2014 and Q1/2015, when the impact of the drop in oil prices affected prices, resulting in an overestimation of inflation.

**Comparison of selected inflation forecasting methods**
Simple time series models that forecast inflation are also used in forecast preparation. It is possible to use them as cross-checks in preparing the forecast by comparing the Bank's forecasts to the results generated by such models (Chart 4).[4] Three ARIMA models, a simple cost-push model, a random walk, and a VEC model are used for the comparison.[5] In 2014, the Bank's forecasts were the most accurate three and four quarters ahead. For forecasts one quarter ahead, the cost-push model and the VEC model showed smaller errors, and for forecasts two quarters ahead, the cost-push model performed best. A comparison of forecasting errors for various periods

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2. See Central Bank reports "Monetary policy in Iceland after capital controls", *Special Publication* no. 4, and "Iceland's currency and exchange rate policy options", *Special Publication* no. 7 (Chapters 3, 4, and 12).

3. See Thorvardur Tjörvi Ólafsson (2007), "Publication of its own policy rate path boosts the effectiveness of central bank monetary policy", *Monetary Bulletin* 2007/1, pp. 71-86.

4. In all models, care is taken to ensure that they have the same information on inflation when the forecast is prepared. In comparing them, it should be borne in mind that the forecasts are not entirely impartial, as the Bank's final forecast each time frequently takes account of the results obtained with simple time series models, particularly for short-term forecasts.

5. According to the simple cost-push model, inflation is determined by historical developments in unit labour costs and the import price level in domestic currency. The ARIMA 1 model draws on forecasts for the principal subcomponents of the consumer price index and weights them together to create a single overall index. The twelve subcomponents of the consumer price index are as follows: agricultural products less vegetables, vegetables, other domestic food and beverages, other domestic goods, imported food and beverages, new cars and spare parts, petrol, other imported goods, alcohol and tobacco, housing, public services, and other services. ARIMA 2 forecasts the CPI directly, and ARIMA 3 forecasts the overall index excluding indirect taxes and then factors in the estimated tax effects. A discussion of the use of ARIMA models for inflation forecasting can be found in A. Meyler, G. Kenny, and T. Quinn (1998), „Forecasting Irish inflation using ARIMA models", Central Bank of Ireland, *Technical Paper*, no. 3/RT/98. The VEC (vector error correction) model is a multivariate time series model that takes account of developments in import prices, output gap, and wage costs.

Chart 2

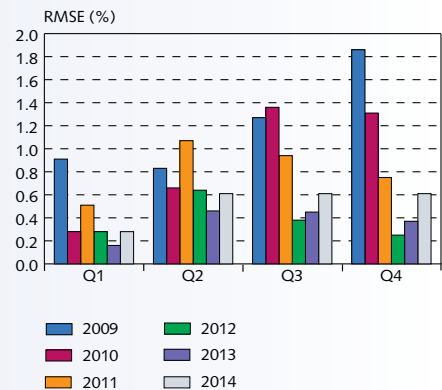Forecasting errors for inflation in *Monetary Bulletin* and deviation of average exchange rate from forecast 2001-2014
Forecast one year ahead
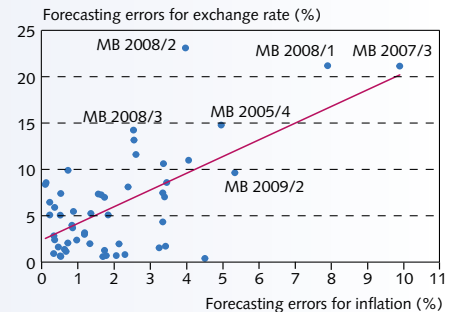
Source: Central Bank of Iceland.

Chart 3

Forecasting errors for inflation in *Monetary Bulletin* 2009-2014[1]

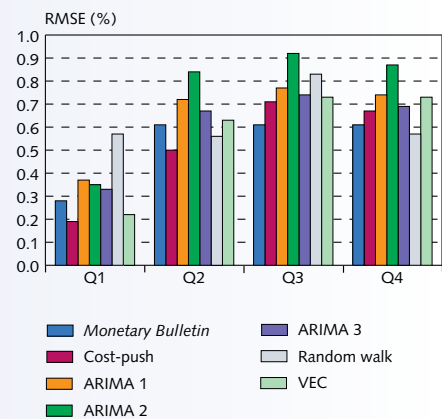|	
2009	2012
2010	2013
2011	2014

1. Q1 is the quarter in which the report is published or the first quarter forecasted; Q2 is the quarter after the report has been published; Q3 is the following quarter.
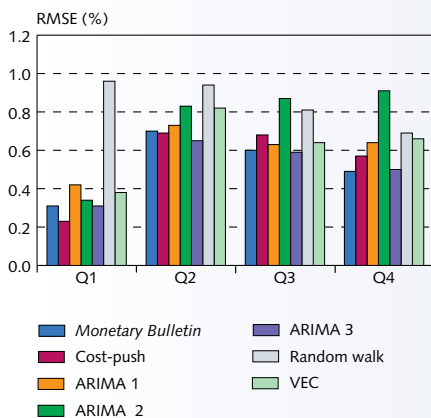*Source:* Central Bank of Iceland.

Chart 4

Forecasting errors for inflation in *Monetary Bulletin* and from simple models in 2014[1]

Monetary Bulletin	ARIMA 3
Cost-push	Random walk
ARIMA 1	VEC
ARIMA 2	

1. Q1 is the quarter in which the report is published or the first quarter forecasted; Q2 is the quarter after the report has been published; Q3 is the following quarter.
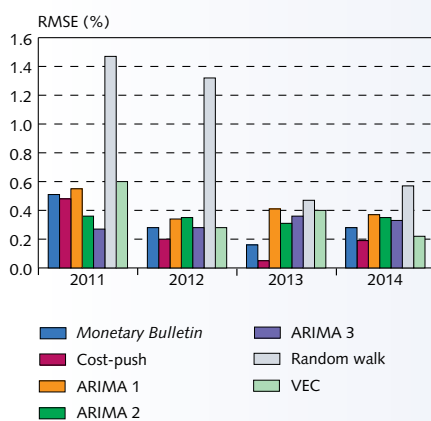*Source:* Central Bank of Iceland.

Chart 5

Forecasting errors for inflation in *Monetary Bulletin* and from simple models 2011-2014[1]

RMSE (%)

Chart 6

Forecasting errors for inflation in *Monetary Bulletin* and from simple models for Q1[1]

RMSE (%)

reveals that the error in the Bank's forecast is smallest one quarter ahead and broadly the same for the forecasts two to four quarters ahead. For the other forecasting models, the error grows greater further out the horizon.

It can also be informative to compare the forecasts with forecasts assuming that inflation in a given quarter will be the same as in the previous quarter throughout the forecast horizon. Such forecasts would generate the smallest errors if changes in inflation were a random variable with an expected value of zero; i.e., if inflation followed a so-called random walk pattern. Simple forecasting methods of this type are often used for reference in assessing forecast quality. A good forecast should be more accurate than a simple random walk forecast. For forecasts one quarter ahead, all of the models performed better than the random walk. This was not the case for the forecasts two quarters ahead, as only the cost-push model outperformed the random walk forecast. For three-quarter forecasts, almost all of the forecasts were more accurate than the random walk forecast. On the other hand, the random walk outperformed all of the other models for forecasts four quarters ahead. The accumulated error in the random walk forecasts was 2.1%, very similar to that for the Bank's forecast (2.2%).[6]

As has previously been stated, the forecasting errors in *Monetary Bulletin* were smallest in comparison with the other models for forecasts three and four quarters ahead. Chart 5 shows the average RMSE for forecasts from 2011 through 2014. The chart shows that over this period, the RMSE of *Monetary Bulletin* forecasts was smallest three and four quarters ahead, whereas in some instances the cost-push and ARIMA 3 models perform better for shorter-term forecasts. An examination of the recent performance of various models in one-quarter forecasting (Chart 6) indicates that, for all years shown, the cost-push model is more accurate than the *Monetary Bulletin* forecasts. This could indicate that greater consideration should be given to the cost-push model when forecasting one quarter ahead.

Central Bank GDP growth forecasts for 2014

In order to obtain a clearer view of the Central Bank's success in inflation forecasting, it is necessary to examine its success in forecasting developments in the real economy. For example, the Bank is likely to underforecast inflation during periods when it underforecasts growth in demand and overestimates the slack in the economy.

New national accounts standards (ESA 2010) were adopted by Statistics Iceland in September 2014. Various changes in data compilation and methodology were implemented at the same time. These changes necessitated a review of historical data back to 1997. The changes in the standards are discussed in greater detail in Box 1 of *Monetary Bulletin* 2014/4. They led to major revisions of historical national accounts, which must be borne in mind in any comparison between forecasts older than *Monetary Bulletin* 2014/4 and Statistics Iceland's published national accounts from September 2014. Forecasts prepared for *Monetary Bulletin* 2014/4 were based on figures compiled using the previous standards, ESA 95, and it is appropriate to expect a systematic difference between them and the results obtained using the revised national accounts. The change in standards does not affect observed inflation, but GDP growth from 1997 onwards is now considered to have been stronger, on average, than before.

6. The accumulated forecasting error is the combined error for the period. In order to give an accurate view of the performance, the absolute value of the error in each period is used. Otherwise, underforecasted values would offset overforecasted values, resulting in an underestimation of the forecasting error.

Statistics Iceland publishes preliminary national accounts figures for each quarter about two months after each quarter-end. The first estimates for Q4/2014 and the full year 2014 were published in March 2015, and revised figures were published in September. The *Monetary Bulletin* forecasts and Statistics Iceland's estimates of changes in key macroeconomic variables from the previous year can be seen in Table 4. Statistics Iceland's preliminary national accounts figures for Q3/2013 were available in February 2014, when *Monetary Bulletin* 2014/1 was published. As a result, the Bank had to base its forecast for 2014 on the forecast for Q4/2013.

Table 4 *Monetary Bulletin* macroeconomic forecasts and Statistics Iceland data for 2014

Forecast horizon from:	2013/4	2014/1	2014/2	2014/3	2014/4	Prelim. figures	Revised figures
% change from prior year	PM 2014/1	PM 2014/2	PM 2014/3	PM 2014/4	PM 2015/1	(March 2015)	(Sep. 2015)
Private consumption	4.6	4.4	4.4	4.3	3.6	3.7	3.1
Public consumption	0.6	0.9	1.1	1.0	0.9	1.8	1.8
Investment	5.4	19.0	22.2	17.6	13.7	13.7	15.4
National expenditure	3.6	5.6	5.8	5.3	4.4	5.3	5.2
Exports	1.4	2.9	4.3	3.6	4.3	3.1	3.1
Imports	3.1	6.4	8.9	8.3	9.4	9.9	9.8
GDP growth	2.6	3.7	3.4	2.9	2.0	1.9	1.8

Statistics Iceland figures changed between the publication of the preliminary figures in March and the revision in September. Investment was revised markedly upwards, owing to an underestimation of public sector activity in the preliminary figures. On the other hand, private consumption was overestimated in the preliminary figures, which led to a downward revision of national expenditure. This revision resulted in a 0.1 percentage point decrease in GDP growth for 2014.
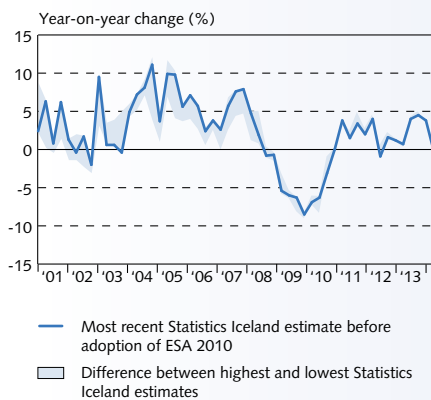
According to the most recent figures from Statistics Iceland, GDP growth for 2014 was considerably weaker than forecasts had indicated. The forecasts published in *Monetary Bulletin* in 2014/1 through 2014/3 overestimated GDP growth by 0.8-1.9 percentage points in comparison with the national accounts figures from September. It should be borne in mind, however, that this overestimation is due in part to the aforementioned change in standards, as these forecasts are based on data compiled according to the previous standards. In the forecasts in *Monetary Bulletin* 2014/4 through 2015/1, which are based on data compiled using the new standards, GDP growth is overestimated by 0.2-1.1 percentage points. This error is due in part to an overestimation of exports and an underestimation of imports. Chart 7 illustrates how errors in forecasts of expenditure items explain the errors in the GDP growth forecasts for 2014. The chart shows that the underestimation of imports is responsible for a large share of the error, while forecasts of exports were more accurate. Changes in inventories also proved to be underestimated in the Bank's forecasts. This was offset by the overestimation of private consumption in the forecasts in *Monetary Bulletin* 2014/2 and 2014/4, however, and the error in the GDP growth forecast was smaller as a result. The chart also shows the changes between Statistics Iceland's preliminary figures for 2014, published in March, and the revised figures from September. The revision of private consumption and investment led to the greatest changes.

Chart 7

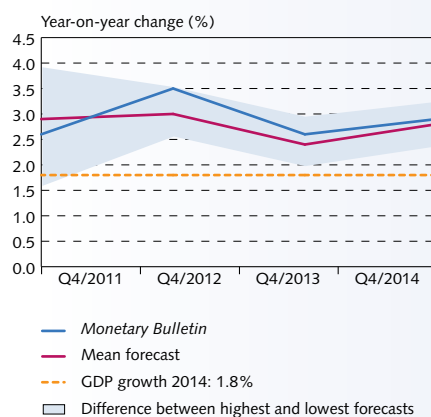Contribution of expenditure items to forecast errors in GDP growth 2014[1]
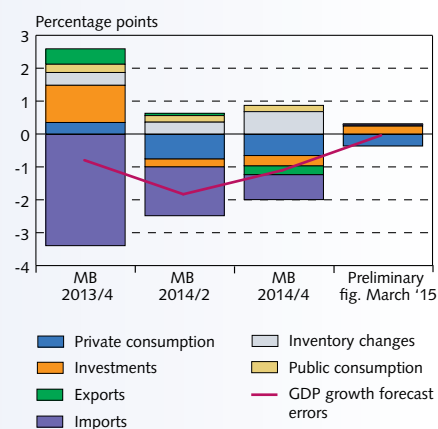
1. Based on real figures in September 2015.
Sources: Statistics Iceland, Central Bank of Iceland.
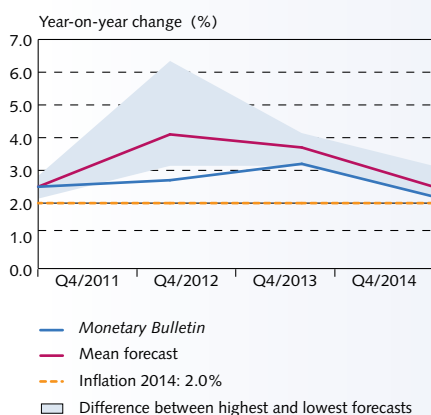
Chart 8

Revision of GDP growth

Year-on-year change (%)

— Most recent Statistics Iceland estimate before adoption of ESA 2010

▢ Difference between highest and lowest Statistics Iceland estimates

Sources: Statistics Iceland, Central Bank of Iceland.

Chart 9

GDP growth forecast for 2014

Year-on-year change (%)

— *Monetary Bulletin*

— Mean forecast

--- GDP growth 2014: 1.8%

▢ Difference between highest and lowest forecasts

Sources: Arion Bank, European Commission, Icelandic Confederation of Labour, IMF, Íslandsbanki, Landsbankinn, Statistics Iceland, Central Bank of Iceland.

Chart 10

Inflation forecasts for 2014

Year-on-year change (%)

— *Monetary Bulletin*

— Mean forecast

--- Inflation 2014: 2.0%

▢ Difference between highest and lowest forecasts

Sources: Arion Bank, European Commission, Icelandic Confederation of Labour, IMF, Íslandsbanki, Landsbankinn, Statistics Iceland, Central Bank of Iceland.

In Iceland and elsewhere, historical statistics are usually revised at regular intervals, and often the final results are often not available until several years later. In Iceland, the tendency seems to be that these figures are revised upwards rather than downwards.[7] For example, GDP growth during the period from 2001 through 2013 was revised by 1.8 percentage points, on average, from the first figures to the last. In over 60% of instances, the figures were revised upwards. Chart 8 shows developments in Statistics Iceland's GDP growth figures from Q1/2001 through Q1/2014. During the period from 2001 through 2009, GDP growth was revised by an average of 2.4 percentage points, and in 78% of instances the revision was upward. From 2010 onwards, GDP growth was revised by only 0.6 percentage points, on average, and only in one-fourth of instances was it revised upwards. The downward revision of private consumption during the 2010-2013 period could explain in part the difference in GDP growth revisions before and after 2010.

Central Bank forecasts in comparison with other forecasters' projections

Chart 9 gives a comparison of the Central Bank's output growth forecasts for 2014 and the average of projections from others that publish regular forecasts concerning the Icelandic economy. The Bank's forecasts were all prepared in the fourth quarter of the year during the period 2011-2014, and the mean is calculated from seven forecasts from the International Monetary Fund (IMF), the Icelandic Federation of Labour (ASÍ), Iceland's three large commercial banks, Statistics Iceland, and the European Commission. The range between the highest and lowest forecast values is indicated by the shaded area. In general, it widens during periods of marked uncertainty and further out the forecast horizon.

The Bank's output growth forecasts accord well with those of other forecasters. The GDP growth forecasts are well above Statistics Iceland's final figures for 2014. To some extent, this is because private consumption and investment in 2014 turned out weaker than had been forecast. There was also an error in the forecast of net exports, with exports overforecast and imports underforecast. As is mentioned above, Statistics Iceland has implemented new national accounts standards that were not taken into account during the preparation of the forecasts under examination here. A portion of the forecasting errors could be due to this.

Chart 10 gives a comparison of forecasted inflation for 2014. As can be seen, the Bank's forecasts turned out somewhat too high. The Bank's forecasts were below those of other forecasters and closer to the actual outcome from year-end 2012 onwards. The Central Bank projected year-2014 inflation at 2.7%, whereas the average of other forecasters was 4.2%. At year-end 2013, the Bank revised its inflation forecast upwards, while other forecasters lowered theirs. At the end of 2014, both the Bank and other forecasters lowered their inflation forecasts. On average, other forecasters estimated 2014 inflation at 2.5%, or 0.5 percentage points above its actual value, while the Central Bank forecast it at 2.2%. As is stated above, actual inflation for the year averaged 2%.

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7. See, for instance, Ásgeir Daníelsson (2008), "Accuracy in forecasting macroeconomic variables in Iceland", Central Bank of Iceland *Working Paper*, no. 39.