Box 3

The Central Bank of Iceland forecasting record

Macroeconomic forecasts almost always contain some errors. Some can stem from shortcomings in forecasting models and others from errors in the data on which the models are based. When forecasts are prepared, they must be based on preliminary figures for the recent past, data that in some instances will not be available in their final form until several years later. In addition, there are always unforeseen events that are impossible to forecast. Studying past forecast errors helps to identify the uncertainties in new forecasts and can be useful in further developing macroeconomic models, using them for forecast preparation, and improving the procedures used for analysis and forecast presentation.

Forecasts of the real economy and inflation

Four times a year, the Central Bank prepares forecasts for the real economy and inflation covering a forecast horizon of three years. The forecasts are based on a detailed analysis of the current state of the economy. The assumptions concerning global economic developments are based, among other things, on forecasts from international institutions and the information extracted from key commodity futures. The national accounts are the primary source of data on the domestic 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 estimated using econometric methods. However, the Bank's forecast – particularly for the recent past and immediate future – is determined largely 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 Central Bank interest rates are determined by the expected deviation of inflation from the inflation target and the current output gap. This ensures that inflation will be close to target by the end of the forecast horizon. The monetary policy rule in the model was selected so as to minimise the sacrifice cost in ensuring that inflation is at target.[1]

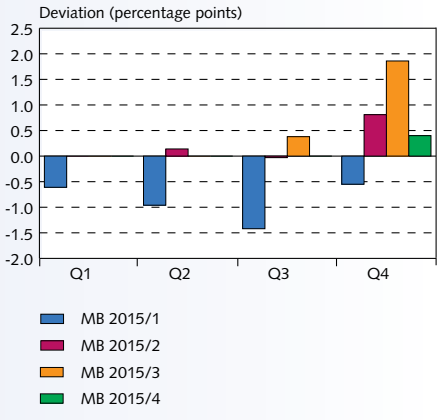
Central Bank inflation forecasts for 2015

Inflation subsided year-on-year in 2015. It averaged 1.6% for the year, down from 2% in 2014. Inflation excluding indirect tax effects was lower, at 1.2%. This excludes the effects of the increase in the lower value-added tax rate, which raised the price of food and beverages, among other things. As has been discussed in previous issues of *Monetary Bulletin*, inflation was driven mainly by rising house prices and domestic goods and services prices in 2015, while the appreciation of the króna and imported deflation pulled in the opposite direction.

Chart 1 illustrates the forecasting record for the inflation forecasts within the year 2015. The forecast in *Monetary Bulletin* at the beginning of the year assumed that inflation would be lower

Chart 1

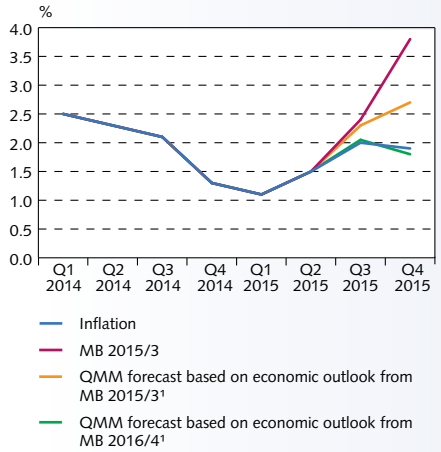
Inflation forecasting errors in *Monetary Bulletin* in 2015



Source: Central Bank of Iceland.

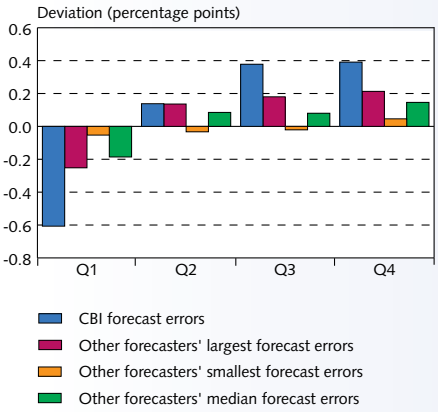
1. See Ásgeir Daníelsson, Bjarni G. Einarsson, Magnús F. Gudmundsson, Svava J. Haraldsdóttir, Thórarinn G. Pétursson, Signý Sigmundardóttir, Jósef Sigurdsson, and Rósa Sveinsdóttir (2015), "QMM: A quarterly macroeconomic model of the Icelandic economy – Version 3.0", Central Bank of Iceland, *Working Paper* no. 71. The most recent version of the handbook for the model can be found here: http://www.sedlabanki.is/library/Skraarsafn---EN/Working-Papers/WP_71_net_nytt.pdf.

Chart 2
Inflation forecasts for Q3/2015 based on differing assumptions



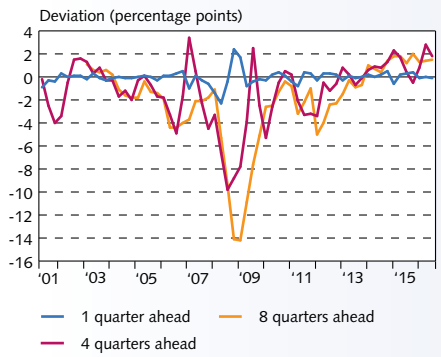
1. Inflation forecast from the inflation equation in QMM.
Sources: Statistics Iceland, Central Bank of Iceland.

Chart 3
Inflation forecasting errors in *Monetary Bulletin* and other forecasters' projections for Q1 in 2015¹



1. Q1 is the quarter in which the report is published or the first quarter forecasted.
Sources: Arion Bank, IFS, Íslandsbanki, Landsbankinn, Statistics Iceland, Central Bank of Iceland.

Chart 4
Inflation forecasting errors in *Monetary Bulletin*¹
Q2/2001 - Q3/2016



1. 1 quarter ahead is the quarter in which the report is published or the first quarter forecasted; 4 quarters ahead is three quarters after the report has been published; 8 quarters ahead is seven quarters after the report has been published.
Source: Central Bank of Iceland.

during the year than proved to be the case. The forecast was prepared following a period of international deflation and a steep drop in oil prices, whose effects on inflation appear to have been overestimated. As Chart 1 indicates, this reversed in the wake of the spring wage agreements, which provided for steep pay increases. This can also be seen in Table 1, which shows that average inflation for the year was underforecast at the beginning of the year. It was then overforecast in the May issue of *Monetary Bulletin* and even more so in the August issue, which presented the first baseline forecast that included an assessment of the impact of the wage settlements. The assessment was affected strongly by the sharp increase in inflation expectations following the wage settlements, and many factors were reminiscent of the situation in early 2011, when inflation was low but rose swiftly after wage agreements were signed that spring. As Chart 2 indicates, the overestimation of inflation following the wage settlements is due partly to changes in assumptions (concerning, for example, the exchange rate of the króna and global developments in inflation), but the forecasting error stems mainly from Bank staff's estimates of wage agreements' impact on short-term inflation, which were based on historical experience and assessments derived from other forecasting models. At the same time, the chart shows clearly that a pure model forecast using the QMM based on the most recent information was almost spot-on in predicting developments in inflation immediately following the wage settlements (see also Box 5 in *Monetary Bulletin* 2016/2).

Table 1 Inflation forecast for 2015

	Monetary Bulletin				*Final*
Year-on-year change (%)	*2015/1*	*2015/2*	*2015/3*	*2015/4*	*result*
Inflation	0.7	1.9	2.2	1.7	1.6
Underlying inflation (excluding indirect tax effects)	0.4	1.4	1.8	1.3	1.2

The Central Bank was not the only forecaster to estimate inflation in the wake of the wage settlements, however. Chart 3 shows the forecasting errors by the Central Bank and other forecasters for the same quarter as the forecast published in *Monetary Bulletin*. All forecasters underestimated inflation in the first quarter but overestimated it as the year progressed. The Central Bank's errors in forecasting inflation during the current quarter of 2015 proved larger than other forecasters' errors, however.

Forecasting errors over a longer period

Chart 4 shows developments in errors in Central Bank inflation forecasts one, four, and eight quarters ahead, from Q2/2001 through Q3/2016. Forecasts two years ahead have been published since March 2001, when the inflation target was adopted. Inflation forecasts for the first quarter of the forecast horizon showed no tendency towards either over- or underforecasting. Forecasting errors can generally be expected to increase as forecasts extend further ahead in time. One- and two-year forecasts tend to underestimate rather than overestimate inflation. The errors were greatest for 2008 and 2009, when inflation was significantly underestimated, owing largely to the steep depreciation of the króna at that time. In 2001-2013, there was a stronger tendency to underestimate inflation. This changed in 2014, when overforecasts became more common, partly due to declining oil prices, global deflation, and the appreciation of the króna.

Table 2 shows the mean deviation (which gives an indication of whether inflation is being systematically over- or underforecast)

and the root mean square error (RSME, which shows the uncertainty in the forecast) since the Bank began publishing inflation forecasts two years ahead. In March 2007, the Bank began publishing forecasts three years ahead. As has been discussed previously, the error was greatest for 2008 and 2009, as Table 2 omits forecasts prepared for those years. By this criterion, inflation has been underforecast three to twelve quarters ahead, and generally to an increasing degree along the horizon. The mean deviation of the forecasts four and eight 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 less than four quarters ahead were not significant from zero, however, nor were those in the three-year forecasts.

Tafble 2 Central Bank of Iceland inflation forecast errors since Q2/2001

%	*One quarter*	*two quarters*	*three quarters*	*Four quarters*	*Eight quarters*	*Twelve quarters*
No. of measurements	55	55	54	52	49	25
Mean deviation (%)	0.0	0.0	-0.2	-0.7	-1.1	-0.6
RMSE (%)	0.4	1.1	1.7	2.0	2.1	1.6

It should also be borne in mind that the Bank did not begin using its quarterly macroeconomic model (QMM) until the beginning of 2006, and it prepared no forecasts of the exchange rate or Central Bank interest rates before 2007.[2] In recent years, the Bank's macroeconomic and inflation forecasts have been based on the technical assumption that the exchange rate of the króna will remain unchanged over the forecast horizon. Experience shows that large errors in inflation forecasts in Iceland are usually related to exchange rate volatility (Chart 5), as the correlation between the absolute errors in inflation and exchange rate forecasts is 0.64. This applies in particular to 2015, where a portion of the inflation forecasting errors can be traced to underestimation of the exchange rate. Unforeseen appreciation of the króna counterbalanced wage increases, with the result that prices rose less than the Bank had forecast. For example, the króna was 6% stronger at the end of 2015 than was forecast in August. As is discussed in Chapter I, the exchange rate assumptions underlying the baseline forecast have been changed and the forecast is now based on an endogenous exchange rate path.

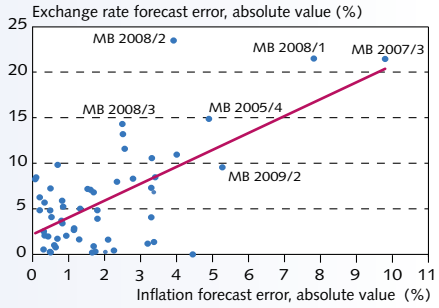
Comparison of selected inflation forecasting methods

The Central Bank also uses simple time series models to forecast inflation, particularly for the next few quarters. 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 6).[3] Three ARIMA models, a simple cost-push model, and a VEC model are used for the comparison.[4] A review of 2015 reveals that the

Chart 5

Forecast error for inflation in *Monetary Bulletin* and deviation of average exchange rate from forecast 2001-2015

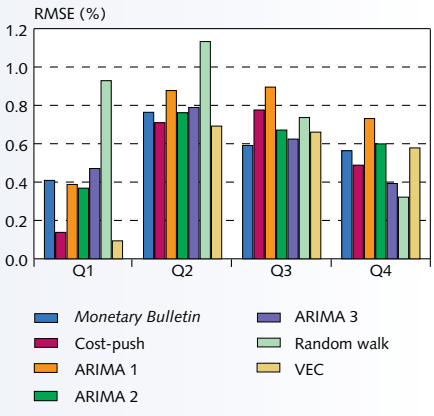
Forecast one year ahead



Source: Central Bank of Iceland.

Chart 6

Forecasting errors for inflation in *Monetary Bulletin* and from simple models in 2015[1]



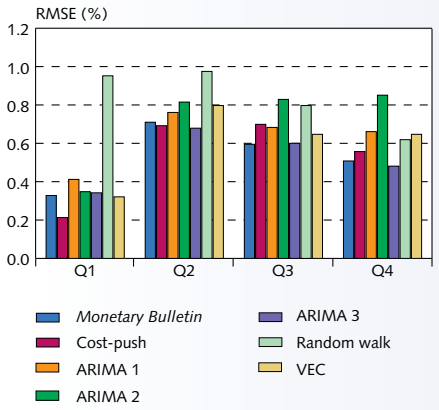
1. Q1 is the quarter in which the report is published or the first quarter forecasted; Q2 is the quarter after the report has been published; Q3 is the following quarter.
Source: Central Bank of Iceland.

2. 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.

3. In all models, care is taken to ensure that they have the same information on inflation when the forecast is carried out. 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.

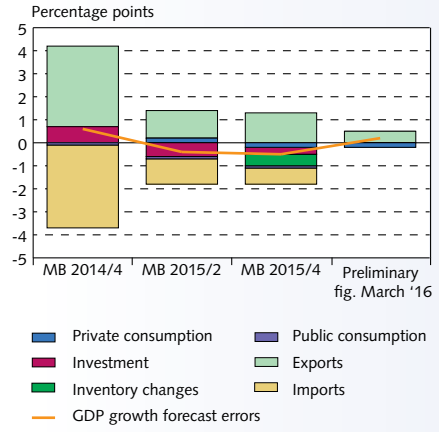
4. According to the simple cost-push model, inflation is determined by historical developments in unit labour costs and the import price level in domestic currency. The ARIMA 1 model draws on forecasts for the principal subcomponents of the consumer price index and weights them together to create a single overall index. The twelve subcomponents of the consumer price index are as follows: agricultural products less vegetables, veg-

Chart 7
Forecasting errors for inflation in *Monetary Bulletin* and from simple models 2011-2015[1]



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 8
Contribution of expenditure items to forecast errors in GDP growth 2015[1]



1. Based on real figures in September 2016.
Sources: Statistics Iceland, Central Bank of Iceland.

Bank's forecasts were most accurate three quarters ahead, whereas the cost-push model outperformed the Bank's forecasts one, two, and four quarters ahead.

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 entirely unpredictable; i.e., if inflation were a random walk process. Therefore, a reasonable forecasting model should outperform a random walk forecast. For forecasts one and two quarters ahead, all of the models performed better than the random walk forecast,[5] and for three-quarter forecasts, almost all of the forecasts were more accurate than the random walk. On the other hand, the random walk outperformed all of the other models for forecasts four quarters ahead. As Chart 7 shows, this is an exception, however: from 2011 through 2015, the mean deviation in *Monetary Bulletin* forecasts was always smaller than that in the random walk forecast. Furthermore, the mean deviation in *Monetary Bulletin* forecasts was always smallest three quarters ahead as compared with all of the time series models, whereas the cost-push model outperformed the Bank's forecasts one quarter ahead. It could therefore be appropriate to give greater weight to such models for short-term forecasts.

Central Bank GDP growth forecasts for 2015

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 or overforecasts the slack in the economy.

Statistics Iceland publishes preliminary national accounts figures for each quarter about two months after each quarter-end. The first estimates for Q4/2015 and the full year 2015 were published in March 2016, 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 3. In February 2015, when *Monetary Bulletin* 2015/1 was published, Statistics Iceland's preliminary national accounts figures were available only for Q3/2014. As a result, the Bank had to base its forecast for 2015 on the forecast for Q4/2014.

Statistics Iceland figures changed between the publication of the preliminary figures in March and the revision in September. Exports were underestimated in the preliminary figures, whereas domestic demand was overestimated. As a result, GDP growth turned out 0.2 percentage points stronger in the revised figures. In September, Statistics Iceland's revision of its calculation of private consumption resulted in a revision of historical figures as well. This explains in part the weaker private consumption growth in the revised numbers.

etables, 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, for example, 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.

5. It should be noted, however, that the random walk forecast receives less information about inflation in the first quarter of the forecast, whereas the other models use available information on inflation during past months in the quarter at the time the forecast is prepared.

Table 3 *Monetary Bulletin* macroeconomic forecasts and Statistics Iceland data for 2015

Forecast horizon from: *% change from prior year*	*2014/4* *MB 2015/1*	*2015/1* *MB 2015/2*	*2015/2* *MB 2015/3*	*2015/3* *MB 2015/4*	*2015/4* *MB 2016/1*	*Pre-liminary figures (March 2016)*	*Revised figures (Sept. 2016)*
Private consumption	3.7	3.9	4.2	4.6	4.9	4.8	4.3
Public consumption	1.4	1.4	1.8	1.4	1.5	1.1	1.0
Investment	13.7	22.6	22.5	20.9	19.6	18.6	18.3
Domestic demand	4.9	6.6	6.8	7.2	7.1	6.3	6.0
Exports	5.3	6.9	6.8	6.8	6.7	8.2	9.2
Imports	6.8	11.1	12.4	12.1	12.8	13.5	13.5
GDP growth	4.2	4.6	4.2	4.6	4.1	4.0	4.2

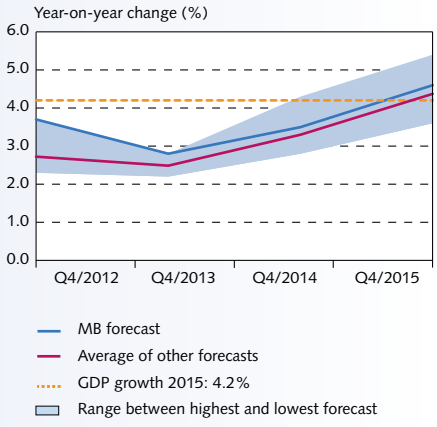
According to Statistics Iceland's most recent figures, year-2015 GDP growth was broadly in line with the Bank's forecasts and the largest forecasting error during the period was 0.5 percentage points (Chart 8). The largest forecasting error in components of domestic demand was in investment, as it is the national accounts item that is generally most volatile and final numbers often appear with a significant time lag. In *Monetary Bulletin* 2015/2, the underestimation of private consumption somewhat offset the overestimation of investment, while in the final forecast of the year all components of domestic demand were overestimated. Both imports and exports turned out higher than was forecast, but the errors were similar in both cases and therefore made little impact on the GDP growth forecast. In the forecast from November 2014, export growth was significantly underforecast, owing mainly to an underestimation of the impact of tourism, as there was a larger error in the forecast of services exports. The error in the forecast of goods imports pulled in the opposite direction, however, and the contribution of net trade to the GDP growth forecast error turned out to be only 0.6 percentage points. This error in external trade forecasts grew smaller as year-end 2015 approached, however.

Central Bank forecasts in comparison with other forecasters' projections

Chart 9 gives a comparison of the Central Bank's GDP growth forecast for 2015 and the average of other forecasters' projections (the International Monetary Fund (IMF), Icelandic Federation of Labour (ASÍ), Iceland's three large commercial banks, Statistics Iceland, and the European Commission). The Bank's forecasts were all prepared during the fourth quarter of the years 2012-2015. The range between the highest and lowest forecast values in other forecasters' projections is given by the shaded area. In general, it widens during periods of uncertainty and further out the forecast horizon. As the chart shows, all forecasters expect GDP growth to strengthen as the forecast horizon progresses, and the Bank's forecasts were well in line with those of other forecasters. The errors in the Bank's forecasts were smaller than the average of other forecasts for the entire period.

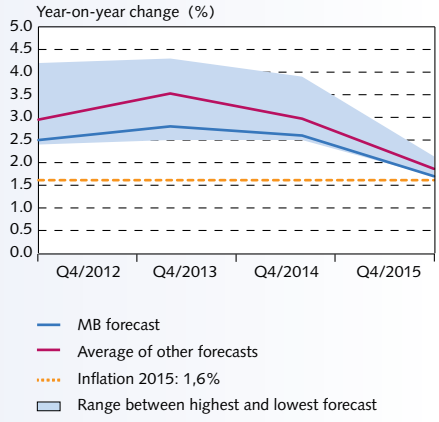
Chart 10 gives a comparison of inflation forecasts. Although the errors in the Bank's forecasts one quarter ahead in 2015 were larger than other forecasters' errors (Chart 3), the Bank's forecasts further ahead tend to be more accurate. This can be seen in the comparison of forecasts for 2015, where the Bank's forecasts are closer to the actual figure for the year than other forecasters' average for the entire period. The range between the highest and lowest forecasts narrows significantly as year-end 2015 approaches, as

Chart 9
GDP growth forecast for 2015



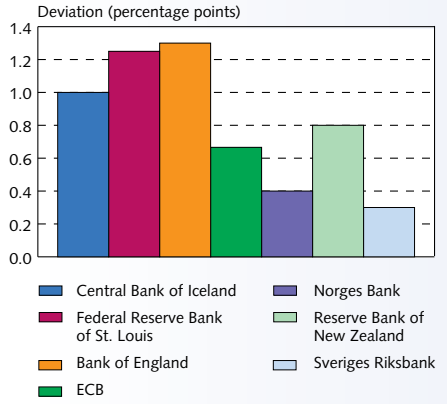
Sources: Arion Bank, European Commission, Icelandic Confederation of Labour, IMF, Íslandsbanki, Landsbankinn, Statistics Iceland, Central Bank of Iceland.

Chart 10
Inflation forecasts for 2015



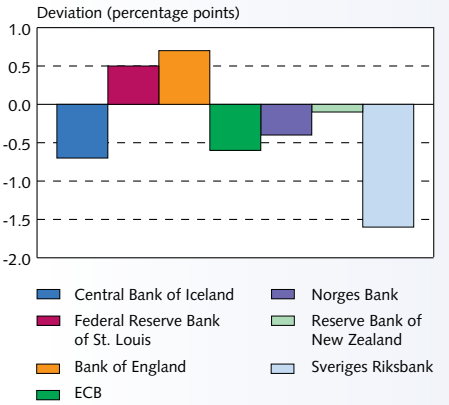
Sources: Arion Bank, European Commission, Icelandic Confederation of Labour, IMF, Íslandsbanki, Landsbankinn, Statistics Iceland, Central Bank of Iceland.

Chart 11
Inflation forecasting errors for 2015 in advanced economies[1]



1. Forecasts made at the end of 2014 except the Fed's, which was made in July 2014.
Sources: Bank of England, ECB, Federal Reserve Bank of St. Louis, Norges Bank, Reserve Bank of New Zealand, Sveriges Riksbank, Central Bank of Iceland.

Chart 12
GDP growth forecasting errors for 2015 in advanced economies[1]



1. Forecasts made at the end of 2014 except the Fed's, which was made in July 2014.
Sources: Bank of England, ECB, Federal Reserve Bank of St. Louis, Norges Bank, Reserve Bank of New Zealand, Sveriges Riksbank, Central Bank of Iceland.

large amounts of data on inflation for the year had emerged by the time that forecast was prepared. At the end of 2015, the Bank forecast inflation at 1.7%, and other forecasters' average was 1.8%. As is stated above, actual inflation averaged 1.6% in 2015.

The Central Bank's 2015 forecasts in international comparison
Finally, it can be instructive to place the Bank's forecast into international context, particularly under the current circumstances of weak global GDP growth and low global inflation, which in part have reflected the plunge in global oil prices at the beginning of the year. As Chart 11 indicates, inflation in developed countries turned out lower in 2015 than had been forecast at the end of 2014, and the overestimation in the Bank's forecast was broadly similar to that in forecasts from the US, the UK, and New Zealand, but slightly larger than in the euro area and in Norway and Sweden. Chart 12 repeats the exercise for GDP growth forecasts. Year-2015 GDP growth was overestimated in the US and the UK but underestimated in the other countries. The underestimation in Iceland was similar to that in the eurozone and Norway.[6]

6. The ECB's underforecast of GDP growth in the eurozone in 2015 is affected somewhat by a major revision of GDP growth in Ireland. Ireland's 2014-2015 GDP growth was revised upwards by more than 20 percentage points due to changes in the treatment of the operations of multinational companies operating there. As a result, 2015 GDP growth for the eurozone as a whole was revised upwards by 0.3 percentage points (see, for example, IMF, *World Economic Outlook*, October 2016, p. 21).