

Forecasting errors are inevitable. Some stem from errors in the models used for forecasting, others are due to inaccurate information on the economic variables on which the models are based – measurement errors, for instance – and still others can be caused by unforeseen factors. Examining errors in previous forecasts can shed light on the uncertainties in the current forecast, as well as providing important information on possible mistakes in forecast preparation and unforeseen structural changes in the economy. Both can be used for further development of the Bank's economic models, in forecast preparation, and overall improvements in analysis and forecast presentation. Finally, it should be borne in mind that the primary objective of the Central Bank's forecasts is to support monetary policy formation; therefore, it is most important to minimise the forecasting errors that complicate monetary policy implementation.

### 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 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 rule ensures that the Bank's interest rates ultimately bring inflation back to target and keep it close to target, on average, over the business cycle. The monetary policy rule in the model was selected from a group of such rules and is considered the one that minimises the sacrifice cost in ensuring that inflation is at target.<sup>1</sup>

### Central Bank inflation forecasts for 2013

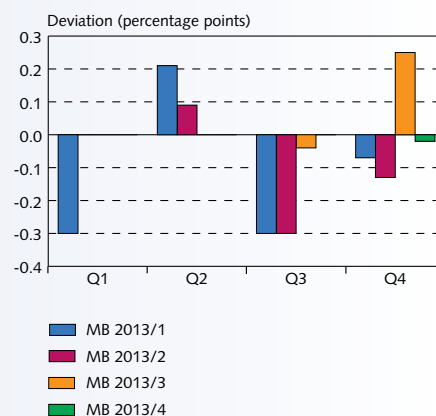
Twelve-month inflation averaged 3.9% in 2013, whereas inflation excluding the effects of indirect taxes was slightly lower, or 3.7%. The main drivers of inflation were of domestic origin: rising house prices and private services prices. Together, these items explained, on average, more than half of the rise in the CPI during the year.

Chart 1 illustrates the forecasting record for the inflation forecasts within the year. As the chart indicates, inflation was underfore-

## Box 3

### The Central Bank of Iceland forecasting record

Chart 1  
Quarterly inflation 2013 and forecasts in *Monetary Bulletin*



Source: Central Bank of Iceland.

1. See Ásgeir Danielsson, Magnús F. Gudmundsson, Svava J. Haraldsdóttir, Thorvardur Tjörvi Ólafsson, Ásgerður Ó. Pétursdóttir, Thórarinn G. Pétursson and Rósa Sveinsdóttir (2009), "QMM: A quarterly macroeconomic model of the Icelandic economy", Central Bank of Iceland, *Working Paper*, no. 41. The most recent version of the handbook for the model can be found here: <http://www.sedlabanki.is/lisalib/getfile.aspx?itemid=9132>.

cast in Q1, whereas the opposite was true in Q2. In the latter half of the year, inflation was underforecast as well. But for the year as a whole, the Bank's forecasts were quite accurate (Table 1): early on, average inflation was slightly underforecast, but the deviation was only 0.1 percentage points.

**Table 1 Inflation forecast for 2013**

Year-on-year change (%)	MB 2013/1	MB 2013/2	MB 2013/3	MB 2013/4	Final result
Inflation	3.8	3.8	3.9	3.9	3.9
Inflation excl. effects of indirect taxes	3.6	3.6	3.8	3.7	3.7

### Errors in inflation forecasts over a longer period

In assessing long-term inflation forecasts, it is important to consider the mean deviation 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 or deviation 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 quarter	Two quarters	Three quarters	Four quarters
Mean forecast error	0.0	-0.2	-0.7	-1.1
RMSE	0.6	1.6	2.3	2.6

Table 2 shows the mean forecast error and RMSE in the Bank's inflation forecasts up to four quarters ahead, from 1994 through August 2014 (74 forecasts in all). By this criterion, inflation has been underforecast two to four quarters ahead, to an increasing degree as the forecast horizon is extended. 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 0.4 percentage points for the forecasts three quarters ahead and by 0.3 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.

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

	No. of measurements	Mean forecast error (%)	RMSE (%)
Four quarters ahead	48	-1.4	2.8
Eight quarters ahead	40	-2.7	4.3
Twelve quarters ahead	18	-1.7	2.2

After adopting the inflation target in March 2001, the Central Bank published inflation forecasts two years ahead, and since March 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 introduction of the formal inflation targeting regime. The RMSE for the one-year forecasts can be seen in Tables 2 and 3. Compar-

ing these shows that the RMSE for the one-year forecast has been greater since the Bank adopted the inflation target than it was for the entire period. From the time the króna was floated until recently, fluctuations in inflation were much greater than they were under the fixed exchange rate regime of the 1990s.<sup>2</sup> It should also be borne in mind that the QMM was not used until the beginning of 2006. Furthermore, the Bank did not forecast the exchange rate or the policy interest rate until 2007; therefore, the forecasts did not make full use of Bank staff's assessments of the likely developments in these variables.<sup>3</sup> This is still the case to an extent, because 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 mean absolute errors in inflation and exchange rate forecasts is 0.64.

### Comparison of selected inflation forecasting methods

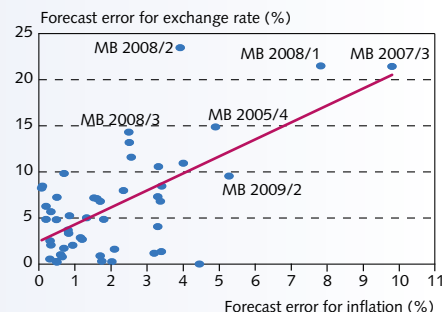
Simple time series models that forecast inflation are also used in forecast preparation. To evaluate how good the Bank's forecasts are, it is possible to compare them to the results generated by such models (Chart 3).<sup>4</sup> Three ARIMA models, a simple cost-push model, a random walk, and a VEC model are used for the comparison.<sup>5</sup> A review of 2013 shows that the Bank's forecasts had the second-smallest error, irrespective of the forecast horizon. For forecasts one quarter ahead, the cost-push model produced the smallest errors, while the ARIMA 3 model generated the smallest errors for forecasts two, three, and four quarters ahead.

It can also be informative to compare the forecasts with forecasts assuming that inflation 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 process. Simple forecasting methods of this type are often used for reference in assessing forecast quality. In the vast majority of cases, 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 forecast. For

Chart 2

Forecast error for inflation in *Monetary Bulletin* and deviation of average exchange rate from forecast 2001-2013

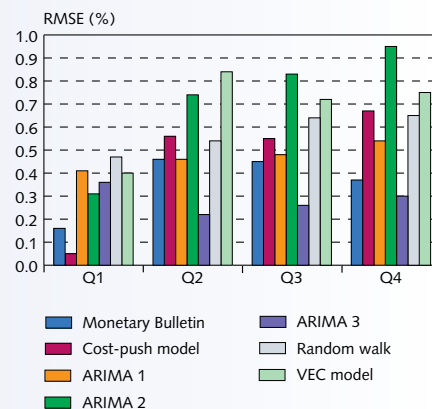
Forecast one year ahead



Source: Central Bank of Iceland.

Chart 3

Forecasting errors for inflation in *Monetary Bulletin* and from simple models in 2013<sup>1</sup>

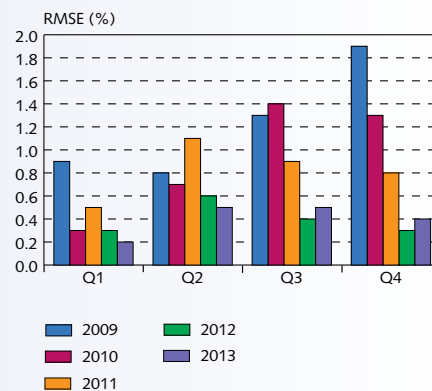


1. Q1 is the quarter in which the report is published or the first quarter forecasted; Q2 is the quarter after the report has been published; Q3 is the following quarter.

Source: Central Bank of Iceland.

Chart 4

Forecasting errors for inflation in *Monetary Bulletin* 2009-2013<sup>1</sup>

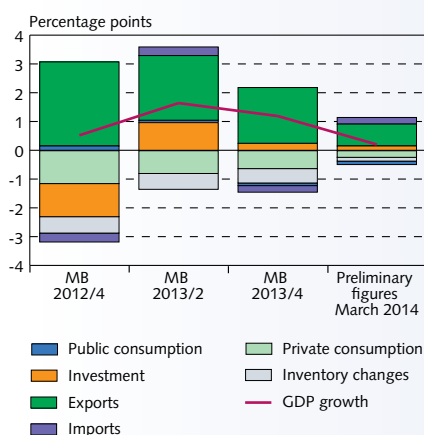


1. Q1 is the quarter in which the report is published or the first quarter forecasted; Q2 is the quarter after the report has been published; Q3 is the following quarter.

Source: Central Bank of Iceland.

2. See 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 Thorvaldur 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 unrelated, 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 5  
Contribution of expenditure items to forecast errors in GDP growth 2013<sup>1</sup>



1. Based on real figures in September 2014.  
Sources: Statistics Iceland, Central Bank of Iceland.

forecasts over a longer horizon, the Bank's baseline forecasts and the ARIMA 1 and 3 models generated smaller errors, while the results of the cost-push model were similar to the random walk results and the ARIMA 2 and VEC models were less accurate.

The Bank's forecasts in recent years are compared in Chart 4. The RMSE has declined markedly, from an average of 1.2% in 2009 to the 2013 average of 0.4%. Over the period under scrutiny, errors in forecasts one and two quarters ahead were smallest in 2013. The errors in 2013 forecasts three and four quarters ahead were also somewhat low, although the 2012 forecast errors were lower. The increased stability of the domestic economy is probably a major reason for the greater forecasting accuracy during this period.<sup>6</sup>

### Central Bank GDP growth forecasts for 2013

In order to obtain a clearer view of the Central Bank's success in inflation forecasting, it is necessary to examine the Bank's success in forecasting economic developments. 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 national accounts estimates for each quarter about two months after each quarter-end. The first estimates for Q4/2013 and the full year 2013 were published in March 2014, and revised figures were published in September. This time it is more difficult to compare the forecasts with final Statistics Iceland figures because of the changes in national accounts standards in September.<sup>7</sup> Statistics Iceland's forecasts and estimates of changes in key macroeconomic variables from the previous year can be seen in Table 4. At the top of the columns is the first quarter for which a forecast is prepared. Statistics Iceland's national accounts estimates for Q3/2012 were available in February 2013, when *Monetary Bulletin* 2013/1 was published. As a result, the Bank had to base its forecast for 2013 on the forecast for Q4/2012.

Table 4 *Monetary Bulletin* – Macroeconomic forecasts for 2013

Forecast horizon from:	2012/4	2013/1	2013/2	2013/3	2013/4	Pre-liminary figures (March 2014)	Revised figures (Sep. 2014)
% change from prior year	MB 2013/1	MB 2013/2	MB 2013/3	MB 2013/4	MB 2014/1		
Private consumption	2.5	2.2	2.0	1.9	1.6	1.2	0.8
Public consumption	0.1	0.5	1.2	1.2	1.2	1.3	0.8
Gross fixed capital formation	-1.0	-9.2	-9.4	-4.1	-4.3	-3.4	-2.2
National expenditure	1.3	0.0	0.0	0.7	0.4	0.1	-0.3
Exports	1.8	2.9	4.4	3.4	4.7	5.3	6.9
Imports	0.5	-0.2	1.2	0.8	0.3	-0.1	0.4
GDP growth	2.1	1.8	1.9	2.3	3.0	3.3	3.5

Statistics Iceland's figures underwent a considerable revision between the preliminary figures from March 2014 and the revised figures from September, primarily due to the new national accounts standards and changes in methodology. The volume change in all subcomponents of domestic demand apart from gross fixed capi-

6. A discussion of increased economic stability and the role of monetary policy in it can be found in Box I-1 in *Monetary Bulletin* 2014/2.

7. In September, Statistics Iceland published the national accounts according to the new ESA 2010 standards, which replace the previous ESA 95. National accounts will be prepared according to the new standards henceforth. Various changes in data compilation and methodology were implemented as well. The changes in Statistics Iceland's methodology are described in Box 1.



tal formation was revised downwards, and the volume change in exports and imports was revised upwards, although the revision in exports was considerably larger. This revision resulted in an increase in GDP growth for 2013.

Year-2013 GDP growth appears to have been somewhat stronger than previously forecast. The forecasts published in *Monetary Bulletin* in 2013 underestimated GDP growth by 1.2-1.6 percentage points in comparison with the national accounts figures from September. This error is due mostly to a systematic underestimation of exports by 2½-5 percentage points. In particular, exports of services and marine products exceeded the forecasts. Imports were slightly overestimated in all except the May issue of *Monetary Bulletin*. Forecasts of domestic demand in 2013 were close to the Statistics Iceland figures. Public consumption proved to be underestimated in the forecasts from the first half of 2013, while private consumption was overestimated.

Chart 5 shows the contribution of each expenditure item to the error in 2013 GDP growth forecasts based on that item's contribution to GDP growth. The chart shows that exports and gross fixed capital formation explain the lion's share of the errors. Exports always proved to have been underforecast, while forecasts of imports were relatively accurate. Gross fixed capital formation, which accounted for 15% of GDP in 2013, was underestimated in the Bank's forecasts. This was offset by the overestimation of private consumption, 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 2013, published in March, and the revised figures from September. This shows that exports were revised upwards by the largest amount, although imports and gross fixed capital formation were adjusted upwards as well. Figures for private and public consumption were revised downwards.

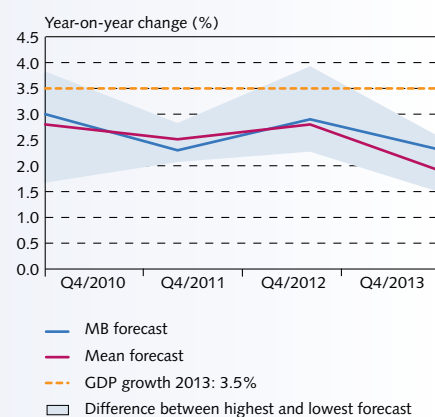
### Central Bank forecasts in comparison with other forecasters' projections

Chart 6 gives a comparison of the Central Bank's output growth forecasts for 2013 and the average of other forecasters' projections. The forecasts were all prepared in the fourth quarter of the year during the period 2010-2013, and the mean is calculated from eight forecasts from the IMF, the Icelandic Federation of Labour (ASÍ), Iceland's three large commercial banks, IFS, Statistics Iceland, and the European Commission. The range between the highest and lowest forecast values are indicated in 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 output growth forecasts are well below the revised Statistics Iceland figures for 2013, and it is particularly noteworthy that all of the forecasts were revised downwards between 2012 and 2013. Most likely, the error lies partly in the fact that the preliminary national accounts figures for the first half of the year were available by year-end 2013, but the Q1 figures have been revised upwards by nearly half a percentage point since then. In addition to this, GDP growth in H2/2013 was well above the historical average. As is mentioned above, Statistics Iceland has implemented new national accounts standards that were not taken account of during the preparation of the forecasts under examination here. A portion of the forecasting errors could be due to this.

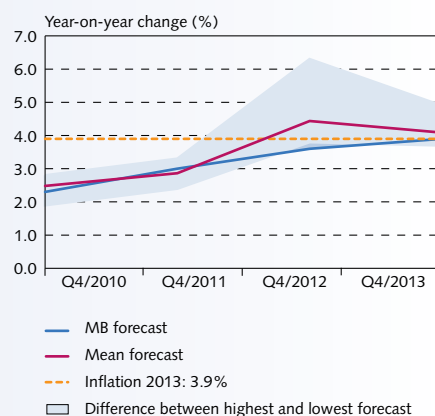
The Central Bank's inflation forecasts for 2013 were also well in line with those of other forecasters. Chart 7 shows that fore-

Chart 6  
GDP growth forecasts for 2013



Sources: Statistics Iceland, Central Bank of Iceland.

Chart 7  
Inflation forecasts for 2013



Sources: Statistics Iceland, Central Bank of Iceland.

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casted year-2013 inflation according to the projections published early in the period under consideration was somewhat below observed twelve-month inflation but was then revised upwards as time passed and new information was published. The greatest difference between Central Bank forecasts and the average of other forecasters' projections was at year-end 2012, when the Bank was the most optimistic, forecasting inflation 0.3 percentage points below the actual figure, while other forecasters projected it at an average of 0.4 percentage points above the observed measurement. The gap narrowed at year-end 2013, when the Bank's inflation forecast for 2013 was correct and the other forecasters' average was 0.2 percentage points above the observed value.

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