

Appendix 2

The Central Bank of Iceland

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 exogenous shocks. Analysing forecasting errors helps to identify the uncertainties in the forecasts and provides important information, both on possible errors in forecast preparation and on possible structural changes in the economy. Such information can be used for further development of both the Bank's models and their utilisation in forecasting.

Macroeconomic and inflation forecasts

Four times a year, the Central Bank prepares forecasts of the real economy and inflation 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 futures prices. The national accounts provide the main foundation for the assessment of the state of the real 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 identities, while others are behavioural equations that are evaluated using econometric methods. The Bank's final forecast – particularly for the recent past and immediate future – is determined not least by staff assessments and a variety of information not included in the model.

Monetary policy performance during the forecast horizon is a key factor in the preparation of each forecast. In the QMM, monetary policy is given by 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 bring 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 from a group of such rules and is considered the one that minimises the sacrifice cost in ensuring that inflation is at target.¹

1. See Á. Daniélsson, M. F. Guðmundsson, S. J. Haraldsdóttir, T. T. Ólafsson, Á. Ó. Pétursdóttir, T. G. Pétursson and R. 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>.

Central Bank inflation forecasts for 2011

At the beginning of 2011, twelve-month inflation was 2.0%, and inflation excluding indirect tax effects was 1.8%, the lowest since March 2004.² At that time, levies on fuel, carbon, alcoholic beverages, and tobacco were increased; therefore, the inflation path did not align with inflation excluding indirect tax effects during 2011. The tax hikes had a roughly 0.2 percentage point effect on CPI inflation.

Inflation forecasts early in the year assumed that inflation would be close to the 2½% inflation target throughout the year, owing to the margin of spare capacity in the economy. Chart 1 shows forecasts of developments in inflation excluding indirect tax effects from the beginning of 2011 until Q1/2012. In *Monetary Bulletin* 2011/1 and 2011/2, inflation was underforecast for the entire forecast horizon. Both of these forecasts were prepared before major centralised wage settlements were signed in May 2011. The forecasts are much closer to being accurate in the *Monetary Bulletin* issues published in the second half of the year. Inflation is overforecast in the third issue and slightly underforecast in the fourth.

In the first half of the year, inflation was driven primarily by increases in global oil prices, commodity prices, and real estate prices, and by the weak króna. This can be seen clearly in Chart 2, which shows that the February forecast in *Monetary Bulletin* assumed that the króna would be trading at 157 kr. against the euro in 2011, that import prices would rise by 2½% and wages by nearly 4%, and that house prices would fall by 3%. As 2011 progressed, the forecasts of developments in these subcomponents were adjusted upwards. Although factors other than these are considered to have contributed to higher inflation, these basic assumptions are very important. Had they been correct, the Bank's February inflation forecast would have provided for just over 3% inflation in 2011, according to the QMM.

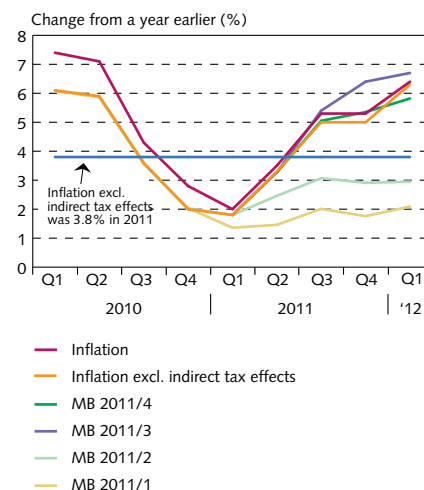
Owing to steep increases in oil and commodity prices, inflation gained pace rapidly in Q2, when annualised inflation measured 10.9%. In *Monetary Bulletin* 2011/3, however, inflation for 2011 was overforecast by 0.4 percentage points, primarily because inflationary pressures in the wake of the contractual pay increases were weaker than anticipated in the latter half of the year and the króna turned out somewhat stronger than forecast.

Table 1 Inflation forecasts in 2011

% change from prior year	MB 2011/1	MB 2011/2	MB 2011/3	MB 2011/4	Final result
Inflation	1.9	2.8	4.4	4.1	4.0
Inflation excluding indirect tax effects	1.6	2.6	4.2	3.9	3.8

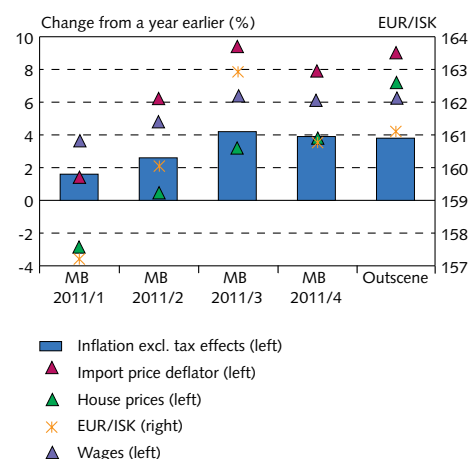
2. The change in the treatment of the broadcasting fee in the CPI had a downward effect of 0.4 percentage points in January 2011. If the change had not been made, inflation would have measured 2.2%.

Chart 1
Inflation forecasts MB in 2011 and inflation excluding tax effects



Sources: Statistics Iceland, Central Bank of Iceland.

Chart 2
Inflation forecast for 2011 and several subcomponents of the forecast



Sources: Statistics Iceland, Central Bank of Iceland.

Errors in long-term inflation forecasts

In assessing 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. This therefore 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 farther 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	-0.3	-0.8	-1.3
RMSE	0.6	1.7	2.4	2.8

Table 2 shows the mean forecast error and RMSE in the Bank's inflation forecasts up to four quarters ahead, from 1994 through August 2012 (66 forecasts). By this criterion, inflation has been underforecast two to four quarters ahead, to an increasing degree along the horizon. The mean forecast error 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 was not significant from zero, however.

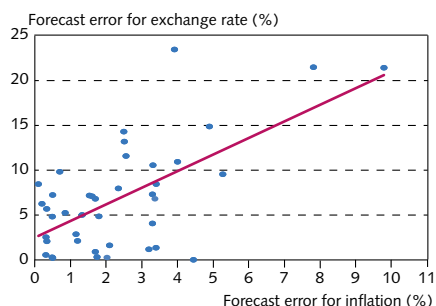
Table 3 Central Bank of Iceland inflation forecast errors since Q2/2001

	No. of measurements	Mean forecast error (%)	RMSE (%)
Four quarters ahead	40	-1.7	3.1
Eight quarters ahead	36	-2.9	4.5
Twelve quarters ahead	10	-2.4	2.8

Since adopting the inflation target in March 2001, the Central Bank has published inflation forecasts two years ahead. In March 2007, the Bank also began publishing inflation forecasts three years ahead. 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 fluctuations in inflation have increased markedly since the króna was floated.³ It should also be borne in mind that the Bank prepared no forecasts of the ISK exchange rate or Central Bank interest rates before 2007. Until that time, forecasts did not make full use of Bank staff's assessments of likely developments in these variables, as large errors in inflation forecasts in Iceland are usually linked to fluctuations in the exchange rate of the króna, as Chart 3 indicates.

Chart 3
Forecast error for inflation in *Monetary Bulletin* and deviation of average exchange rate from forecast 2001 to 2011

Forecast one year ahead



Source: Central Bank of Iceland.

3. See the discussion in the 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).

Central Bank inflation forecasts in comparison with forecasts based on simple time-series models

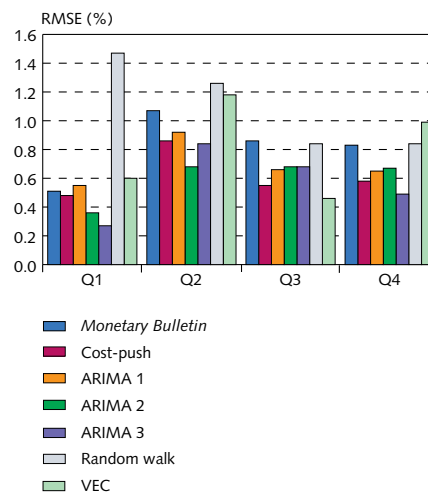
Simple time-series models that forecast inflation are also used as cross-checks in preparing the forecast. It is interesting to compare the Bank's forecasts to the results generated by such models.⁴ A review of the year 2011 shows that the ARIMA models and a simple cost-push model usually performed best.⁵ The Bank's baseline forecast varies in accuracy, however, depending on the length of the forecast horizon.

For forecasts one quarter ahead, the ARIMA 2 and 3 models performed best, followed by the cost-push model and the baseline forecast in *Monetary Bulletin*. It is noteworthy that the errors are greater in the baseline forecast two quarters ahead than in the three-quarter forecast, while the usual pattern is for forecasts to become less accurate as uncertainty increases farther along the horizon.

A comparison of the forecasts three quarters ahead reveals that the baseline forecast was least accurate, with a RMSE of 0.86%, slightly worse than a forecast using a simple random walk (RMSE equal to 0.84%), which assumes that inflation will be the same as in the previous quarter throughout the forecast horizon; i.e., that inflation is a random walk process and thus basically unpredictable. In this instance, the VEC model performed best. The VEC is a multivariate time series model that forecasts developments in inflation, import prices, output gap, and wage costs, and incorporates long-term relationships among these variables.⁶

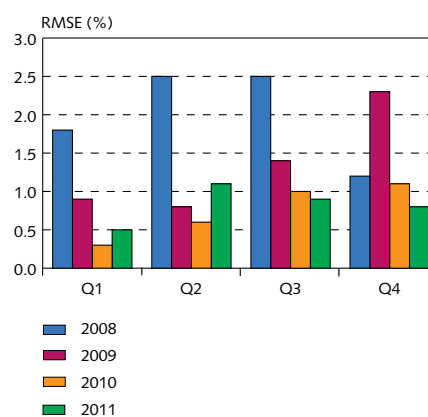
Although the performance of the baseline forecast varies depending on the length of the horizon, it is interesting to compare it with forecasts from recent years (see Chart 5). The chart shows that the error in the baseline forecasts in 2011 is generally smaller than the errors in 2008 and 2009, partly because annual inflation was around 12% or over in those two years and the pace of quarterly inflation extremely volatile in comparison with 2011. It is therefore appropriate that errors should be greater in a period of higher and more unstable inflation. Forecasts in *Monetary Bulletin* from 2011 are generally less accurate than those from 2010, at least the forecasts one to two quarters ahead. It is noteworthy that, even though the error in *Monetary Bulletin* 2011 is largest three quarters ahead in comparison with the simple time-series models (see Chart 3), it is still smaller three quarters ahead than it was during the 2008-2010 period.

Chart 4
Forecast error for inflation in *Monetary Bulletin* and from simple models in 2011¹



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
Forecast error for inflation in *Monetary Bulletin* from 2008 to 2011¹



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.

4. In all models, care is taken to ensure that they have the same information on inflation when the forecast is carried out.
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 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.
6. The VEC model was not used in *Monetary Bulletin* 2011/1.

Central Bank GDP growth forecasts for 2011

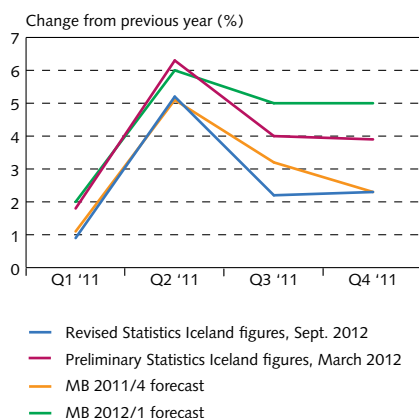
In order to obtain a clearer view of the Central Bank's success in inflation forecasting, it is necessary to examine its success in forecasting developments in the real economy. For example, the Bank is likely to underforecast inflation during periods when it underestimates growth in demand or overforecasts 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 Q4/2011 and the full year 2011 were published in March 2012, and revised figures were published in September. 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 showing the forecasts is the first quarter for which a forecast is prepared. Statistics Iceland's national accounts estimates for Q3/2010 were available in February 2011, when *Monetary Bulletin* 2011/1 was published. As a result, the Bank had to base its forecast for 2011 on the forecast for Q4/2010.

Table 4 *Monetary Bulletin* – Macroeconomic forecasts for 2011

Forecast horizon from:	Q4/ 2010	Q1/ 2011	Q2/ 2011	Q3/ 2011	Q4/ 2011	Prelim- inary figures march 2012	Revised figures Sept. 2012
% change from prior year	MB 2011/1	MB 2011/2	MB 2011/3	MB 2011/4	MB 2012/1		
Private consumption	3.1	2.7	3.8	2.9	4.5	4.0	2.7
Public consumption	-4.1	-4.1	-2.2	-0.2	-0.1	-0.6	-0.9
Gross fixed capit. formation	9.6	15.8	10.3	6.7	7.1	13.4	12.8
National expenditure	2.4	2.9	4.0	3.9	4.4	4.7	3.8
Exports	2.5	2.5	1.9	2.5	3.3	3.2	4.1
Imports	1.6	3.7	4.2	4.0	6.3	6.4	6.8
GDP growth	2.8	2.3	2.8	3.1	3.0	3.1	2.6

Chart 6
Private consumption growth: Statistics Iceland
figures and Central Bank forecasts



Sources: Statistics Iceland, Central Bank of Iceland.

The output growth forecasts in the first *Monetary Bulletin* issues from 2011 were somewhat close to the final result according to Statistics Iceland's revised figures from September 2012. If Statistics Iceland's preliminary figures from March 2012 are considered, however, the forecasts in *Monetary Bulletin* 2011/3 and 2011/4 come closest to them, which is to be expected, given that a greater part of the year had passed by the time these forecasts were prepared. Statistics Iceland's figures then underwent a major revision between the preliminary figures from March 2012 and the revised figures from September. All sub-components of national expenditure were revised downwards, particularly private consumption. The upward revision of exports counteracted this, however, and ensured that output growth did not decline in equal measure.

Some of the errors in import growth forecasts were due to unexpected imports of ships and aircraft later in 2011. Imports of ships and aircraft totalled 13.7 b.kr. in 2011, twice as much as in 2010. They are offset with counteracting entries as investment and therefore do not affect output growth; nonetheless, they pose the same problems with investment forecasting. The forecasts in the first issues of *Monetary Bulletin* 2011 assumed a 4% contraction in public consumption. Published figures for the first half of the year indicated that public

consumption had grown marginally in volume terms, and a smaller contraction, or 0.2%, was subsequently forecast. The figures were then revised downwards in September.

Chart 6 shows how quarterly growth in private consumption developed in *Monetary Bulletin* forecasts over the year, in comparison with preliminary and revised figures from Statistics Iceland. It can be seen that the forecast of developments in private consumption in the latter half of the year, published in *Monetary Bulletin* 2011/4, were quite close to the revised figures. The published figures for Q3/2011 and the first preliminary figures for the year as a whole indicated much stronger private consumption than the revised figures did. This revision stemmed in part from the reclassification of a portion of private consumption as exported services, as is discussed in Section IV.

The economic recovery and Central Bank forecasts

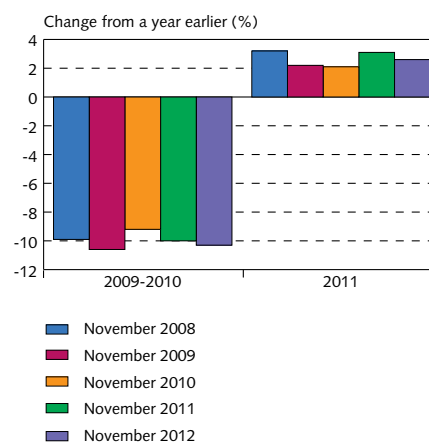
After the old banks failed in autumn 2008, it was clear that the economy would undergo a much deeper economic contraction than had previously been assumed. There was considerable uncertainty about when growth would resume and how robust it would be. Chart 7 summarises the Bank's forecasts from November 2008 through the current forecast. Box I-1 contains a more detailed discussion of the similarity between the November 2008 forecast and actual subsequent developments. It also shows that the forecast of GDP at the end of the then-current forecast horizon (Q3/2011) was virtually identical to Statistics Iceland's most recent measurement.

In the forecasts prepared between November 2008 and November 2012, it is assumed that the contraction beginning in Q4/2007 would conclude between Q4/2009 and Q2/2010, based on seasonally adjusted figures. The forecasts also assumed a contraction of 9-10½% in 2009-2010, and the actual contraction of GDP measured 10.3%. The forecasts were also quite consistent as regards the extent of the economic recovery. All of the Central Bank forecasts shown in Chart 7 assumed a slow recovery measuring 2.1-3.2% output growth in 2011. GDP grew by 2.6% according to the most recent figures from Statistics Iceland. The first forecasts after the fall of the old banks assumed that the economic recovery in 2011 would be driven by net trade, at least to some extent. The contribution from net trade was actually negative in 2011, however, and investment and private consumption were the main drivers of growth. In part, this is due to a sizeable decline in imports in 2008 and 2009, concurrent with growth in exports. After the contraction in 2008 and 2009, import growth has outpaced GDP and export growth.

Chart 8 shows the Central Bank's GDP growth forecasts for 2011, as compared with forecasts from the International Monetary Fund (IMF), Statistics Iceland, the Ministry of Finance and Economic Affairs, the Icelandic Federation of Labour, and financial institutions. All of the forecasts were prepared in the fourth quarter of the years 2008-2011. Only two were prepared in Q4/2008, those from the Central Bank and the IMF. For this reason, the difference between the highest and lowest forecast values is relatively small, although it widens in 2009, when a larger number of forecasts were prepared. It grew

Chart 7

The scale of the economic crisis and recovery: summary of Central Bank forecasts¹

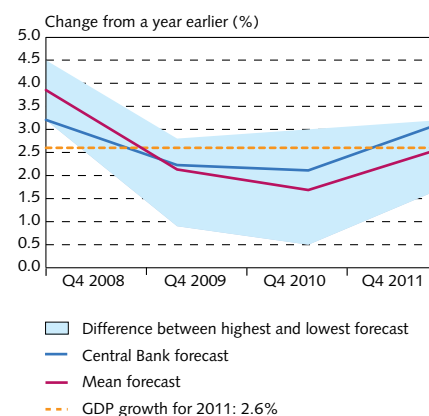


1. The economic crisis is defined as the contraction in gross domestic product (GDP) between the average of 2007-2008 and the average of 2009-2010. The scale of the recovery is the growth in GDP between 2010 and 2011.

Source: Central Bank of Iceland.

Chart 8

GDP growth forecast for 2011



Sources: Statistics Iceland, Central Bank of Iceland.

even wider in 2010 and then narrowed again in 2011. Other things being equal, economic forecasts should become more consistent with one another as the period covered by the forecast approaches and more information becomes available. Chart 8 shows clearly the magnitude of the uncertainty about the strength of the economic recovery in 2011. At the end of 2010, for instance, the Central Bank assumed that output growth in 2011 would be 2.1%, while the other forecasts averaged 1.7%. At the end of 2011, all forecasters had grown more optimistic about growth during the year: the Central Bank projected output growth at 3.1%, while the other forecasts averaged 2.6%. In its first estimates of year-2011 output growth, published in March 2012, Statistics Iceland assumed that growth for the year was 3.1%. According to the revised figures from September 2012, output growth has been revised downwards to 2.6%.