Appendix 2

The Central Bank of Iceland forecasting record

Forecasting errors are inevitable. They can stem from imperfect models, inadequate information on the economic variables on which the models are based, and on unforeseen shocks. It is important to examine forecast errors, as such analysis 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 the Bank's models and their utilisation in forecasting.

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 position of the economy at the time they are prepared. The assumptions concerning global economic developments are based on international forecasts and the information implied by commodity futures. The national accounts provide the main foundation for the assessment of the position of the economy. In addition, Bank staff prepare an independent assessment of the state of the economy through questionnaires and discussions with corporate executives, institutional directors, and labour market leaders; and statistical analysis of developments in key variables. The Bank's Quarterly Macroeconomic Model (QMM) is the chief tool used to process this information. It provides an assessment of the economic outlook in accordance with the economic principles on which the model is based, although the final forecast is determined equally by Bank staff's analysis and evaluation.
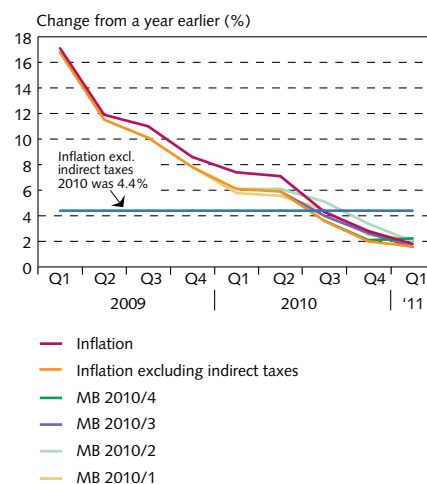
Among the key assumptions in each forecast are the projected developments in monetary policy over the forecast horizon. In forecast preparation, Bank staff use the QMM, which is based on a forward-looking monetary policy rule according to which the Central Bank's interest rates are determined by the output gap and the deviation of expected inflation from target. This policy rule ensures that the Bank's interest rates adjust so that, by the end of the forecast horizon, inflation will either be near target or approaching the target if it deviates from it. The monetary policy rule in the model is the rule that minimises the sacrifice cost in ensuring that inflation is at target.[1]

Central Bank inflation forecasts for 2010

Twelve-month inflation excluding indirect tax effects reached its 2010 peak during the month of March, when it measured 7.1%. It retreated quickly as the year progressed, however, falling to 1.7% by

Chart 1

Inflation forecasts MB in 2010
and inflation excluding tax effects

Change from a year earlier (%)

Inflation excl. indirect taxes 2010 was 4.4%

— Inflation
— Inflation excluding indirect taxes
— MB 2010/4
— MB 2010/3
— MB 2010/2
— MB 2010/1

Source: Central Bank of Iceland.

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1. See Ásgeir Daníelsson, Magnús F. Gudmundsson, Svava J. Haraldsdóttir, Thorvardur Tjörvi Ólafsson, Ásgerdur 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.

December, the lowest measurement since July 2003. Twelve-month inflation excluding tax effects averaged 4.4% in 2010, which was well in line with Central Bank forecasts (see Table 1).

Chart 1 shows forecasts of developments in inflation excluding tax effects from the beginning of 2010 until Q1/2011. In *Monetary Bulletin* 2010/1, inflation is underforecast for the first half of the horizon and overforecast for the latter half. In subsequent issues of *Monetary Bulletin*, however, there is the tendency to overforecast inflation for the entire forecast horizon, particularly in *Monetary Bulletin* 2010/2.

Table 1 Inflation forecasts in 2010

Year-on-year change (%)	MB 2010/1	MB 2010/2	MB 2010/3	MB 2010/4
Inflation	5.6	6.2	5.7	5.4
Inflation excluding tax effects	4.5	5.1	4.6	4.4

Long-term inflation forecast errors

In assessing inflation forecasts, it is standard 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	-0.7	-1.2
RMSE	0.6	1.7	2.5	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 January 2011 (60 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 based on a 5% threshold, which means that the forecasts were skewed to the downside. The forecasts one and two quarters ahead were not significantly skewed, however.

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

	No. of measurements	Mean forecast error (%)	RMSE (%)
Four quarters ahead	34	-1.6	3.2
Eight quarters ahead	30	-2.8	4.7

Since adopting the inflation target in March 2001, the Central Bank has also published inflation forecasts two years ahead. Table 3 shows the mean forecast error and the RMSE for the period since the Bank introduced inflation targeting. A comparison of Tables 2 and 3 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, as fluctuations in inflation have increased markedly since the króna was floated.[2] It should also be noted that before 2007, the Bank's forecasts assumed constant interest and exchange rates. Consequently, earlier forecasts did not make full use of Bank staff's assessments of likely developments in these variables. This probably led to larger forecasting errors – in inflation, for example – as inflation forecasts are usually influenced by errors in exchange rate forecasts.

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

Inflation forecasts based on simple time-series models are also considered during the forecasting process: It is interesting to compare the Bank's forecasts to the results generated by such models. A review of 2010 shows that the Bank's QMM always yielded the smallest forecast errors with the exception of the forecast three quarters ahead, in which case a simple cost-push model based on historical developments in wage costs and import prices and the ARIMA 1 model performed slightly better.[3] The other two ARIMA models performed less well.[4] In general, these models overestimated 2010 inflation, which tapered off quickly over the course of the year.

For forecasts one quarter ahead, however, the other models performed quite well, except for the random walk model. Forecasting errors using the cost-push model and the ARIMA models ranged from 0.41% to 0.55%, whereas the error using the random walk model was much larger, at 1.6%. The error in the Bank's forecasts, however, was 0.28%.

In recent years, these simple time-series models have been used in greater measure to improve the Bank's short-term inflation forecasts. This approach seems to have been beneficial, as short-term forecasting errors have diminished (Chart 3). Although there could be a variety of reasons for this improved performance, the possibility that the improvement is associated with the use of a greater number of models during forecast preparation cannot be excluded.

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2. See "Monetary policy in Iceland after capital controls," Central Bank of Iceland, *Special Publication* no. 4, December 2010.

3. The opposite happened in 2009, when the Bank's inflation forecasts were slightly less accurate than those obtained with simple time-series models. See Appendix 2 in *Monetary Bulletin* 2010/2.

4. The ARIMA 1 model draws on forecasts for the main 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. An interesting 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.

Chart 2

Forecast error for inflation in *Monetary Bulletin* and from simple models in 2010[1]
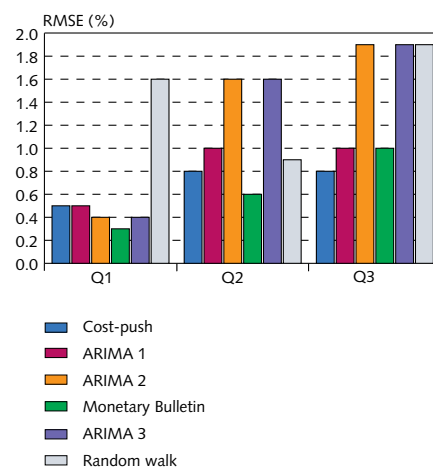
1. Q1 is the quarter in which the report is published or the first quarter forecasted; Q2 is the quarter after the report has been published; Q3 is the following quarter.
Source: Central Bank of Iceland.

Chart 3

Forecast error for inflation in *Monetary Bulletin* from 2008 to 2010[1]
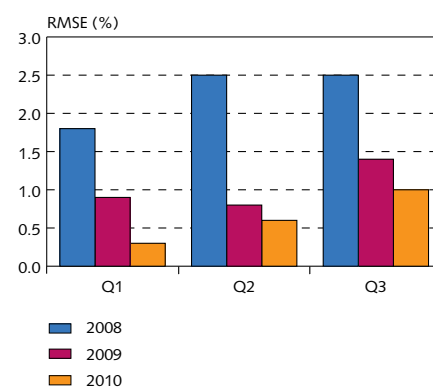
1. Q1 is the quarter in which the report is published or the first quarter forecasted; Q2 is the quarter after the report has been published; Q3 is the following quarter.
Source: Central Bank of Iceland.

Central Bank GDP growth forecasts for 2010

In order to obtain a better view of the Central Bank's success in fore-casting inflation, it is necessary to examine the Bank's success in fore-casting developments in the real economy. For example, the Bank is likely to underforecast inflation during periods when it underestimates demand growth or overestimates the slack in the economy.
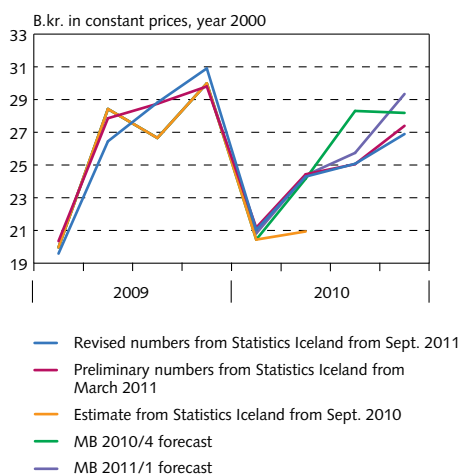
Statistics Iceland publishes national accounts figures for each quarter about two months after each quarter-end. The first estimates for Q4/2010 and the full year 2010 were published on 8 March 2011, and revised figures were published on 8 September. *Monetary Bulletin* forecasts and Statistics Iceland estimates of changes in key macroeconomic variables can be seen in Table 4. At the top of the col-umns showing the forecasts is the first quarter for which a forecast is prepared. Statistics Iceland's national accounts estimates for Q3/2009 were available on 27 January 2010, when *Monetary Bulletin* 2010/1 was published. As a result, the Bank had to base its forecast for 2010 on the forecast for Q4/2009. It is noteworthy, however, that in spite of this, the forecast published in *Monetary Bulletin* 2010/1 was the most accurate forecast of developments in domestic demand and GDP growth for the year as a whole. This is an exception, as the general rule is that forecasts tend to improve as more information is accumulated.

Table 4 *Monetary Bulletin* – Macroeconomic forecasts for 2010

Forecast horizon from:	Q4/09	Q1/10	Q2/10	Q3/10	Q4/10	Pre-liminary figures	Revised figures
Year-on-year change (%)	MB 2010/1	MB 2010/2	MB 2010/3	MB 2010/4	MB 2011/1	March 2011	Sep. 2011
Private consumption	-1.2	1.1	0.5	-0.3	-0.3	-0.2	-0.4
Public consumption	-3.2	-3.0	-3.2	-1.7	-3.5	-3.2	-3.4
Investment	-5.7	-10.2	-3.8	-3.7	-4.5	-8.1	-8.0
National expenditure	-2.8	-1.9	-0.7	-1.6	-2.4	-2.5	-2.7
Exports	1.5	0.4	-1.2	0.4	0.0	1.1	0.4
Imports	0.0	2.5	1.3	2.9	1.1	3.9	4.0
GDP growth	-3.4	-2.6	-1.9	-2.6	-2.7	-3.5	-4.0

A portion of the recent errors in forecasts of investment growth – and therefore of GDP growth – can be attributed to assumptions concerning energy-intensive development projects that were subse-quently postponed. The errors have also reflected the Bank's opinion that Statistics Iceland's preliminary figures on 2010 investment were underestimated. The Bank has based that opinion on a number of indicators, including imports of investment goods, the results of its own survey concerning planned corporate investment, and the Capacent Gallup corporate survey. Statistics Iceland's next review of 2010 figures is scheduled for March 2012. The accuracy of the Bank's forecasts of 2010 investment and GDP growth can be determined more reliably at that time.

Revision of statistics and forecasting errors

In Iceland as in other countries, historical statistics are usually revised at regular intervals, and often the final results are not available until

Chart 4

Investment: Statistics Iceland's figures and Central Bank's forecasts

B.kr. in constant prices, year 2000

— Revised numbers from Statistics Iceland from Sept. 2011
— Preliminary numbers from Statistics Iceland from March 2011
— Estimate from Statistics Iceland from Sept. 2010
— MB 2010/4 forecast
— MB 2011/1 forecast

Sources: Statistics Iceland, Central Bank of Iceland.

several years later. In Iceland, the tendency seems to be that these figures are revised upwards rather than downwards.[5] For the period 2001-2010, for example, year-on-year investment growth in Q1 was revised upwards by an average of 1 percentage point from the first figures to the final ones. Corresponding revisions for other quarters range from 3 to 6 percentage points. Chart 5 shows how the Statistics Iceland estimates of year-on-year investment growth evolved from Q1/2001 to Q2/2011. It shows that the most recent figures usually lie at the upper end of the range given by the highest and lowest values of different data vintages. Chart 6 illustrates a similar tendency in Statistics Iceland's estimates of GDP growth.

The economic crisis and Central Bank forecasts

In the wake of the 2008 banking and currency crisis and the ensuing global economic crisis, economic activity contracted sharply in Iceland as it did elsewhere, although Iceland was hit harder than most other countries (see, Section I). It is therefore interesting to determine how accurately the Bank forecasted the magnitude of the contraction in 2009-2010.

    The Central Bank published its first forecast for the year 2010 in *Monetary Bulletin* 2007/3. That forecast assumed that a 2% contraction in GDP in 2009 would give way to positive growth in 2010.[6] It reflected the unavoidable business cycle adjustment after years of overheating. The longer the adjustment predicted by the Bank was delayed, the deeper the forecasted contraction proved to be. At the beginning of 2008, the Bank's forecasts assumed a combined 4% contraction in GDP in 2009 and 2010. The financial crisis in the

Chart 5

Revision of gross investment growth

Change from a year earlier (%)

Sources: Statistics Iceland, Central Bank of Iceland.

Chart 6

Revision of GDP growth

Change from a year earlier (%)

Sources: Statistics Iceland, Central Bank of Iceland.

Table 5 GDP growth in 2009-2010 and Central Bank forecasts of the magnitude of the contraction (%)

Monetary Bulletin	GDP growth 2009	GDP growth 2010	Accumulated growth (contraction) '09-'10
MB 2007/3	-2.0	2.3	0.3
MB 2008/1	-2.5	-1.5	-4.0
MB 2008/2	-2.0	-1.9	-3.9
MB 2008/3	-8.3	-1.7	-9.9
MB 2009/1	-9.9	-0.8	-10.6
MB 2009/2	-11.0	-0.8	-11.7
MB 2009/3	-9.1	-2.2	-11.1
MB 2009/4	-8.5	-2.4	-10.7
MB 2010/1	-7.7	-3.4	-10.8
MB 2010/2	-6.5	-2.6	-8.9
MB 2010/3	-6.5	-1.9	-8.3
MB 2010/4	-6.8	-2.6	-9.2
MB 2011/1	-6.8	-2.7	-9.3
MB 2011/2	-6.9	-3.1	-9.8
MB 2011/3	-6.9	-3.1	-9.8
MB 2011/4	-6.7	-3.6	-10.1

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

6.   It should be borne in mind that, at this time, the Central Bank was the only domestic analyst to forecast that an economic contraction was in the offing. The Bank was criticised harshly for excessive pessimism (see, for example, a comparison of different forecasts in a survey of other analysts' forecasts, published regularly by the Bank in *Monetary Bulletin*).
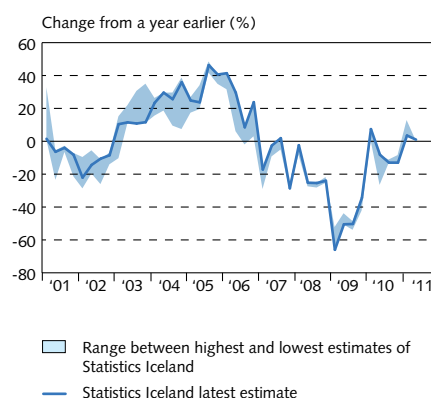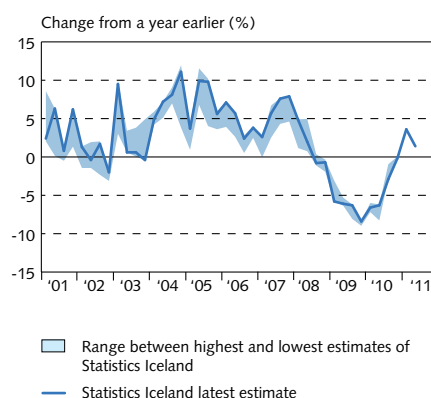
autumn of 2008 led to a major revision of the Bank's forecasts. The revised forecasts provided for an approximately 10% contraction in GDP in 2009-10, which is turning out to be very close to reality, although the distribution of the contraction between the two years has changed. It has emerged that the 2009 contraction was originally overestimated and a larger share of the downturn took place in 2010 than was assumed at the outset. The total contraction, on the other hand, was in line with original forecasts, which must be considered acceptable performance in view of the magnitude and unprecedented nature of the shock to the Icelandic economy.