

## Appendix 2

### The Central Bank of Iceland forecasting record

Economic developments often diverge from forecasts. Some forecasting errors can stem from errors in the models used for forecasting, others are due to inaccurate or insufficiently detailed information on the economic variables on which the models are based – measurement errors, for instance – and still others can be caused by unforeseen factors such as developments in the global economy. Moreover, forecasts are always based to a degree on forecasters' assessments, which can also give rise to errors. Studying forecasting errors helps to identify the uncertainties in the forecasts and provides important information on possible errors in forecast preparation or possible structural changes in the economy. Both can be used for further development of macroeconomic models, forecast preparation, and the procedures used during the forecasting process.

#### 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. Each forecast is based on a detailed analysis of the current state of the economy. The assumptions concerning global economic developments are based, among other things, on international forecasts and the information implied by key commodity futures. The national accounts are the primary source of data on the domestic economy, although the analysis of developments since the publication of the last national accounts also takes into consideration other variables such as turnover, lending, money supply, and interest rates. In addition to conventional empirical models, forecasts are based on information that can be extracted from a number of opinion polls, which the Bank supplements with its own surveys among executives from firms and institutions, as well as labour market participants. 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 relations, while others are behavioural equations that are estimated using econometric methods. However, the Bank's final 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.<sup>1</sup> 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 bring inflation back to target

1. Further discussion of central banks' various options concerning their underlying policy rate path can be found in 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.

no later than the end of the forecast horizon. The monetary policy rule in the model was selected from a group of such rules because it was considered the one that minimises the sacrifice cost in ensuring that inflation is at target.<sup>2</sup>

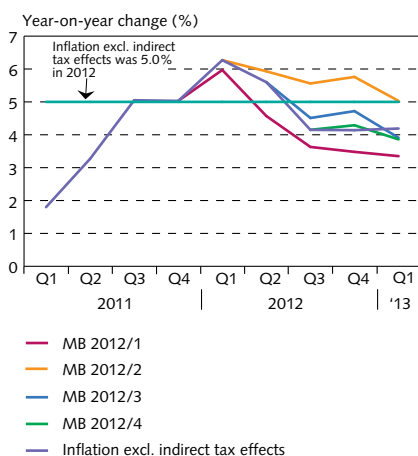
### Central Bank inflation forecasts for 2012

In January 2012, twelve-month inflation measured 6.5% after having risen somewhat from its December measurement of 5.3%. These measurements mark the beginning position of the period under scrutiny here. The spike in inflation at the beginning of 2012 was due primarily to price increases for public services and rising food and petrol prices. In Q1/2012, twelve-month inflation measured 6.4%, its highest level since Q1/2010. Table 1 gives measured inflation for 2012 as a whole (5.2%) and compares it with the forecasts in that year's issues of *Monetary Bulletin*. The first forecast for the year assumed some disinflation over the course of the year, as did its predecessor, but the first 2012 forecast had been revised upwards. Inflation declined more slowly than projected, primarily because of increased pressures from larger-than-expected wage increases and a weaker króna than had been previously assumed. Even though the previous forecast was revised, it turned out that inflation was underforecast by 0.6 percentage points for the year as a whole.

By the second quarter, inflation expectations had worsened markedly. The króna had depreciated, oil prices had risen, and the slack in the economy had proven smaller than forecasts had indicated. The inflation outlook therefore appeared to have worsened, and this was reflected in the spring issue of *Monetary Bulletin*. The forecast in the second *Monetary Bulletin* of the year proved too pessimistic about the inflation outlook, however, and inflation for the year as a whole was overforecast by about 0.8 percentage points.

The errors in the inflation forecast between 2011 and 2012 were smaller in the latter half of the year, as can be expected when the inflation rate for the first part of the year is a known quantity and the forecast for the remainder of the year extends over a shorter period of time. The previous changes in oil prices and the exchange rate reversed somewhat, and inflation began to subside once again. Market agents' inflation expectations fell as well, in line with an improved outlook. The error in the *Monetary Bulletin* 2012/3 forecast was only 0.2 percentage points from the actual outcome, and the forecast in *Monetary Bulletin* 2012/4 proved to be in line with the final outcome. As the simple average of the inflation forecasts for the year is 5.3%, the forecasts fluctuated more or less around the correct figure.

Chart 1  
*Monetary Bulletin* inflation forecasts in 2012  
and inflation excluding tax effects



Sources: Statistics Iceland, Central Bank of Iceland.

Table 1 Inflation forecasts in 2012

% change from prior year	MB 2012/1	MB 2012/2	MB 2012/3	MB 2012/4	Final result
Inflation	4.6	6.0	5.4	5.2	5.2
Inflation excl. indirect tax effects	4.4	5.9	5.3	5.1	5.0

2. See Ásgeir Daniélsson, Magnús F. Guðmundsson, Svava J. Haraldsdóttir, Thorvaldur 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.

### Errors in long-term inflation forecasts

In assessing inflation forecasts, it is helpful 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 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 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	-0.3	-0.7	-1.2
RMSE	0.6	1.6	2.3	2.7

Table 2 shows the mean forecast error and RMSE in the Bank's inflation forecasts up to four quarters ahead, from 1994 through August 2013 (70 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% critical level, which means that the forecasts were skewed to the downside and inflation consistently underforecast. The forecast errors one and two quarters ahead were not significant from zero, however.

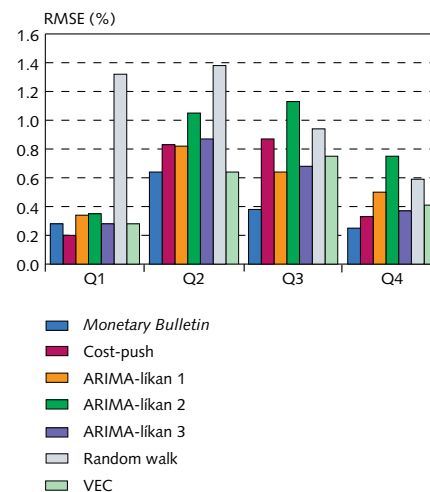
**Table 3 Central Bank of Iceland inflation forecast errors since Q2/2001**

	No. of measurements	Mean forecast error (%)	RMSE (%)
Four quarters ahead	44	-1.5	2.9
Eight quarters ahead	40	-2.7	4.3
Twelve quarters ahead	14	-2.1	2.5

After adopting an 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 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 floated the króna and adopted the inflation target than it was for the entire period.<sup>3</sup> It should also be borne in mind that the QMM was not used until the beginning of 2006. The forecasts used previously, from the National Economic Institute, were based on models that were obsolete and, in any case, were not designed for macroeconomic forecasting in support of monetary policy formation. 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. This is still true to an extent because,

3. See also 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).

**Chart 3**  
Forecasting errors for inflation in *Monetary Bulletin* and from simple models in 2012<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.

in recent years, the Bank's forecasts have been based on the technical assumption that the exchange rate will remain broadly stable at the level prevailing when the forecast was prepared (see Sections I and III). Experience shows that large errors in inflation forecasts in Iceland are usually related to unforeseen exchange rate movements, as Chart 2 indicates. Another factor, however, is that the QMM has not taken adequate account of how poorly anchored inflation expectations are, which could make attaining the inflation target seem too easy.

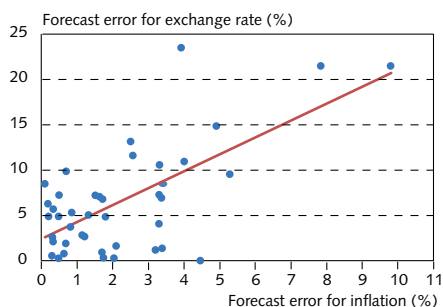
### Central Bank inflation forecasts in comparison with forecasts from simple time series models

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.<sup>4</sup> Three ARIMA models, a simple cost-push model, a random walk forecast, and a VEC model are used for the comparison.<sup>5</sup> A review of the year 2012 shows that the Bank's forecasts generally performed best. They vary in accuracy, however, depending on the length of the forecast. In general, the errors resulting from the simple models are larger and the deviations from the baseline forecast greater further out the horizon.

Examining the forecasts one quarter ahead reveals that the simple cost-push model performed best (see Chart 3). Next in line was the baseline forecast in *Monetary Bulletin*, along with the ARIMA 3 model and the VEC model. It is noteworthy that the errors are greater in the baseline forecast two quarters ahead than in the forecasts three and four quarters ahead, while the usual pattern is for forecasts to become less accurate as uncertainty increases further along the horizon. For projections two to four quarters ahead, the baseline forecast in *Monetary Bulletin* performed best, with the difference greatest in the three-quarter forecast. In that forecast, the error in the baseline forecast is 0.38%, followed by the ARIMA 1 model, with an error of 0.64%. As these figures show, the baseline forecast was far more accurate.

It can also be instructive to compare the forecasts with a random walk forecast, which assumes that changes in inflation are unpredictable. If inflation follows a random walk pattern, the best forecast is to assume that inflation will be the same in the future as in the most recent measurement. Chart 3 shows that the information from the other models is more useful for shorter forecasts (one to two quarters ahead), as the errors are much smaller than those generated by a

Chart 2  
Forecast error for inflation in *Monetary Bulletin* and deviation of average exchange rate from forecast 2001 to 2012  
Forecast one year ahead



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 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.

random walk forecast. The difference then narrows sharply, reflecting increased uncertainty further out the horizon.

It is also interesting to examine developments in the errors in the baseline forecast from year to year. As Chart 4 shows, forecasting errors have diminished considerably since 2009. It can also be seen that 2012 came out well in comparison with previous years, with inflation forecasting errors less than or equal to previous errors in all cases. The improvement is greatest for forecasts three and four quarters ahead, where the errors diminished markedly over the 2009-2012 period. The decline is probably due in large part to increasing economic stability as more time passes after the onset of the crisis, as twelve-month inflation measured 12% or over in 2008 and 2009 and the pace of quarterly inflation extremely volatile in comparison with 2011 and 2012. Most often, volatility increases as inflation rises higher.<sup>6</sup>

### Central Bank GDP growth forecasts for 2012

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 national accounts estimates for each quarter about two months after each quarter-end. The first estimates for Q4/2012 and the full year 2012 were published in March 2013, and revised figures were published last September. The Bank's forecasts and Statistics Iceland's 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 Q3/2011 were available in February 2012, when *Monetary Bulletin* 2012/1 was published. As a result, the Bank had to base its forecast for 2012 on the forecast for Q4/2011.

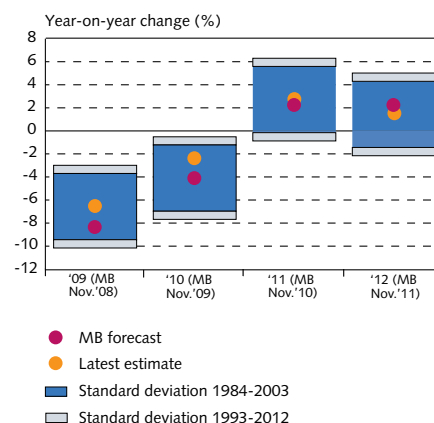
Table 4 Monetary Bulletin – Macroeconomic forecasts for 2012

Forecast horizon from:	2011/4	2012/1	2012/2	2012/3	2012/4	Pre-liminary figures (Mar 2013)	Revised figures (Sep 2013)
% change from prior year	MB 2012/1	MB 2012/2	MB 2012/3	MB 2012/4	MB 2013/1		
Private consumption	2.2	3.2	3.0	3.0	2.6	2.7	2.4
Public consumption	-1.2	-0.6	-0.1	-0.6	-1.1	-0.2	-1.4
Gross capital formation	17.5	12.4	9.0	9.2	4.9	4.4	5.0
National expenditure	3.4	3.7	3.2	2.8	2.0	1.9	1.6
Exports	1.8	3.8	5.4	4.6	3.9	3.9	3.8
Imports	3.4	5.9	6.4	5.6	3.7	4.8	4.7
GDP growth	2.5	2.6	3.1	2.5	2.2	1.6	1.4

Statistics Iceland's figures then underwent a major revision between the preliminary figures from March 2013 and the revised figures from September. All items except investment were adjusted

Chart 6

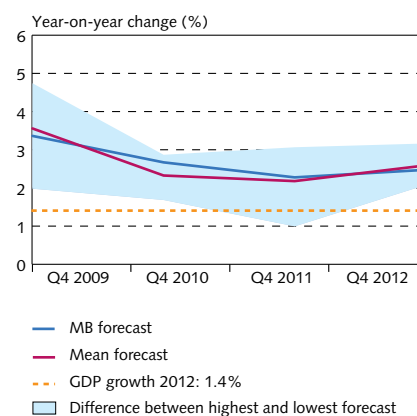
November *Monetary Bulletin* forecast for GDP growth in the following year



Sources: Statistics Iceland, Central Bank of Iceland.

Chart 7

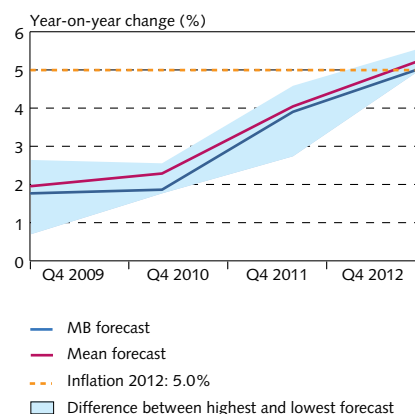
GDP growth forecast for 2012



Sources: Statistics Iceland, Central Bank of Iceland.

Chart 8

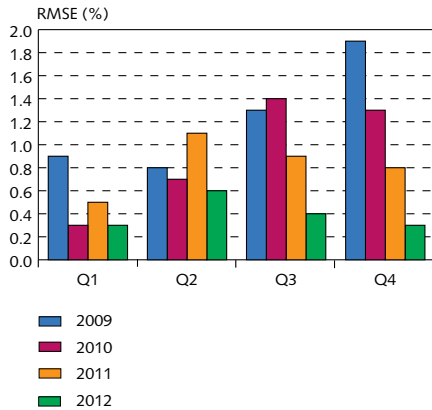
Inflation forecasts for 2012



Sources: Statistics Iceland, Central Bank of Iceland.

6. The financial crisis has tested many central banks' forecasting ability, as is discussed, for instance, in David Stockton (2012), *Review of the Monetary Policy Committee's Forecasting Capability*, October 2012.

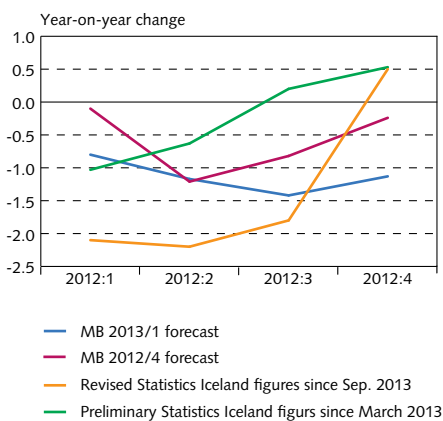
Chart 4  
Forecasting errors for inflation in  
*Monetary Bulletin* from 2009 to 2012<sup>1</sup>



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 5  
Government spending: Statistics Iceland  
and Central Bank forecasts



Sources: Statistics Iceland, Central Bank of Iceland.

downwards. The most pronounced change was in public consumption, owing primarily to a downward adjustment of municipal consumption by 1.2 percentage points from the preliminary figures. Chart 5 shows how quarterly growth in public consumption developed in *Monetary Bulletin* forecasts over the year, in comparison with the preliminary and most recent figures from Statistics Iceland. It also shows how much the September revision affected errors in the public consumption forecast. Public consumption is underforecast at first but is overforecast after the revision for the majority of the period.

The investment forecast for the period also changed significantly, due primarily to energy-intensive investment projects, which were postponed repeatedly in the Bank's forecasts and therefore caused a reduction in investment estimates between forecasts. As the year progressed, the uncertainty about investment projects understandably diminished, and in the last forecast for the period, the forecasted value according to *Monetary Bulletin* was virtually identical to the most recent figures from Statistics Iceland. Indicators of private consumption for the year also gave cause for greater optimism than is justified by the most recent measurements. Stronger private consumption growth was expected because of rising net household wealth, lower real interest rates, and the recovery of the labour market. Although the errors in the private consumption forecasts were not large in terms of percentage points, they weigh heavily in the GDP growth forecast error because of the importance of private consumption in GDP.

In addition to domestic factors, the global economic outlook deteriorated over the course of the year. As Chart I-19 in Section I shows, the International Monetary Fund's (IMF) GDP growth forecasts have been continually revised downwards, primarily due to uncertainty in the euro area. Weaker demand growth among trading partner countries eroded Iceland's terms of trade (see also Box II-1) and impeded export growth to a degree.

These factors explain in large part why year-2012 output growth was overforecast. The strength of domestic and foreign demand proved to be overestimated. Output growth forecasts were most optimistic around the middle of the period, and the error turned out greatest in *Monetary Bulletin* 2012/3, when it measured 1.7 percentage points. As can be seen in Chart 6, however, the forecasting error is well within the range defined by the historical standard deviation of output growth. The same can be said for the preceding years.<sup>7</sup>

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

Chart 7 gives a comparison of the Central Bank's output growth forecasts for 2012 and the average of other forecasters' projections. The forecasts were all prepared in the fourth quarter of the year during the period 2009-2012, and the average is calculated from eight forecasts from the IMF, the Icelandic Federation of Labour (ASÍ), the Ministry of Finance and Economic Affairs, Iceland's three large commercial banks,

7. As is discussed in Box I-1 in *Monetary Bulletin* 2012/4, the November 2008 forecast of developments in GDP through 2011 materialised almost exactly. That forecast was prepared immediately after the banks collapsed.

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.

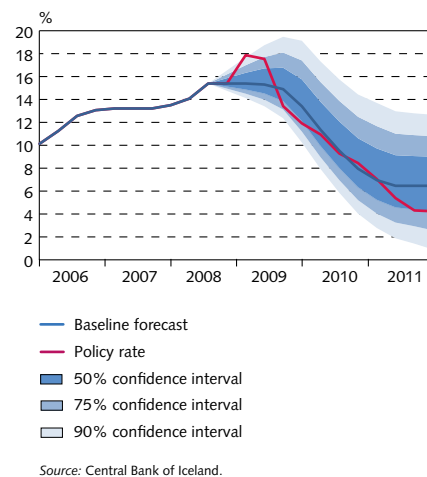
The Bank's output growth forecasts accord well with those of other forecasters. As the chart shows, the *Monetary Bulletin* forecasts published between mid-2010 and end-2011 are somewhat more upbeat – and among the most optimistic of those published in Q4/2010. Of the forecasts published at the end of 2011, two were very close to the most recent Statistics Iceland figures: ASÍ, with a forecast of 1% growth, and Landsbankinn, with 1.7%. In general, forecasters appear to have been too optimistic about the output growth outlook. Of the nine forecasts in question, eight of them, the Central Bank forecast included, were above Statistics Iceland's September measurements. As is stated above, the most likely reasons are the revision of municipal consumption, foreign demand, and the delays in energy-intensive investment, which affected forecasters more or less equally rather than distinguishing among them.

The Central Bank's inflation forecasts for 2012 were also well in line with those of other forecasters. Chart 8 shows that forecasted year-2012 inflation according to the projections published early in the period under consideration was far below observed twelve-month inflation but was then revised upwards as time passed and new information was released, in particular following new wage contracts. Because the paths are similar, it appears that changes in external factors affected the forecasting and not differences in forecasting models or forecasters' assessments. The salient difference in the inflation forecast, however, was that in all cases the baseline forecast was below the other forecasters' average. The inflation forecasts in *Monetary Bulletin* therefore appear to have been more optimistic during the period. As the range between the highest and lowest forecasts shows, however, the Bank's projection was not the lowest except for the forecast published in Q4/2012.

### Improvements in forecasting

As is stated above, it is important to draw lessons from forecasting errors and consider possible improvements to forecasting models, analytical procedures, and forecast presentation in order to reduce the magnitude of such errors – not least in the case of systematic errors – and communicate the uncertainties surrounding the forecasts more effectively. The Bank is constantly working towards improvements in these areas and has put a number of the improvements in place in recent years. Among the current points of focus are the insufficient anchoring of the inflation target and the built-in persistence of domestic inflation, and the effects of these two factors on monetary policy transmission and inflation developments in the QMM.<sup>8</sup> Other

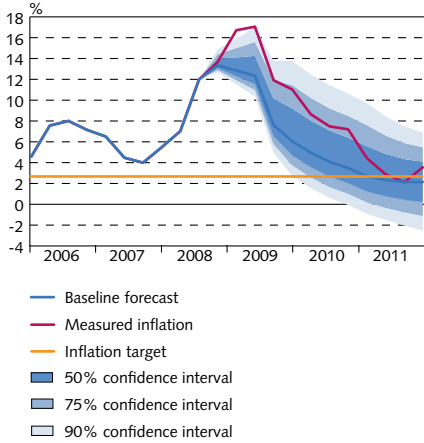
Chart 11  
*Monetary Bulletin* Policy rate forecast  
July 2008 and actual values  
Forecasting period Q3/2008 - Q2/2011



8. See, for example, Thorvardur Tjörvi Ólafsson, Ásgerdur Ó. Pétursdóttir and Karen Á Vignisdóttir (2011). "Price setting in turbulent times: Survey evidence from Icelandic firms". Central Bank of Iceland, *Working Paper*, no. 54; and 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 (Chapter 3).

Chart 9

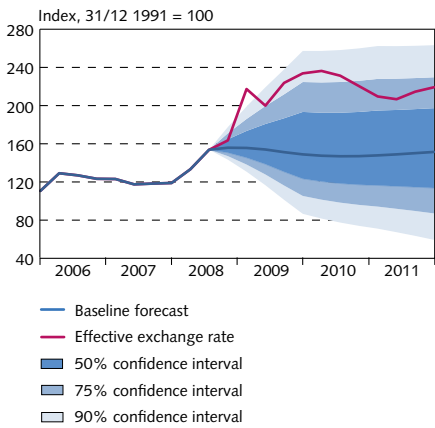
*Monetary Bulletin* inflation forecast in July 2008 and measured inflation  
 Forecasting period Q3/2008 - Q2/2011



Sources: Statistics Iceland, Central Bank of Iceland.

Chart 10

*Monetary Bulletin* exchange rate forecast in July 2008 and actual values  
 Forecasting period Q3/2008 - Q2/2011



Source: Central Bank of Iceland.

projects currently underway include a new updated version of the QMM and the development of other macroeconomic models that attempt, for instance, to capture more effectively the adjustment of the economy towards sustainable equilibrium. When the domestic economy is far from such an equilibrium path, such an adjustment can extend over a longer horizon than the three years covered by the *Monetary Bulletin* forecasts. Finally, since this May, the uncertainty surrounding the Bank's inflation forecasts has been shown more effectively through fan charts depicting the confidence intervals of the forecast. Before May, the Bank had last published such charts in July 2008, a few months before the banks failed. The fan charts for those forecasts covered a larger number of variables. As Charts 9-11 indicate, the forecasts were reasonably accurate in spite of the massive shocks sustained by the Icelandic economy shortly thereafter.