

Appendix 2

Forecast errors in Central Bank of Iceland inflation forecasts

One of the principal roles of the Central Bank of Iceland is to promote price stability. Because of delays in monetary policy transmission, the Central Bank's forecasts of developments in inflation and other economic variables play an important role in shaping monetary policy. Analysing errors in the Bank's forecasts can provide insight into the reasons for deviations in forecasts. Such deviations can stem from insufficient information on economic variables, misinterpretation of the state of the economy, and unforeseen events, among other things. Closer scrutiny of the Bank's forecasting errors can also provide indicators of possible systemic changes in the economy, which could prove useful in further development of the Bank's economic models.

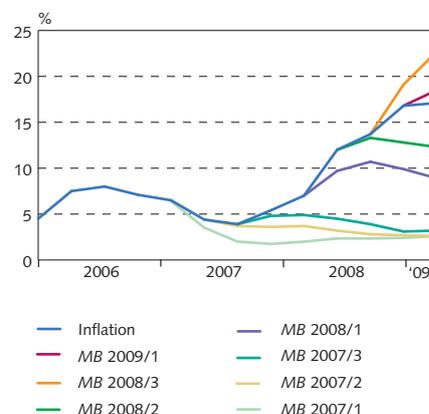
Inflation forecasts have underestimated inflation

It is clear that the transmission of monetary policy throughout the domestic economy has been ineffective in the recent past. In the first quarter of 2008, serious failures in domestic financial market operations began to emerge, leading to volatility in the exchange rate and in bond market yields. The króna depreciated by nearly 40% from Q4/2007 to Q3/2008, and the domestic policy rate was raised by over 4 percentage points. In early October, Iceland's three largest banks became insolvent. The króna plunged still further, and capital account restrictions were put in place. Thus conditions in the Icelandic financial market were extremely unusual for most of 2008 and could never have been captured satisfactorily by existing economic models.

Chart 1 shows the Central Bank's inflation forecasts as published in *Monetary Bulletin (MB)* 2007/1 through 2009/1, in comparison with actual inflation. Inflation climbed steadily during that period, and with the exception of the forecast in *MB* 2009/1, each new forecast assumed that inflation would exceed the levels in previous forecasts and that a higher policy rate would be needed to bring it down to the target. Inflation was underestimated in all of the Bank's forecasts except those prepared for *MB* 2008/3 and 2009/1. *MB* 2008/3 assumed that inflation would peak at close to 23% in the first quarter of 2009, while *MB* 2009/1 assumed a rate of 18.5%. Measured inflation proved to be 17.1%. The forecast assumed that the 30% ISK depreciation between Q3 and Q4/2008 would pass through more strongly to price levels, but this has not been the case; instead, mark-ups appear to have contracted sharply. In addition, demand and employment have declined more rapidly, and the output slack has developed sooner than expected (see Sections IV and VIII).

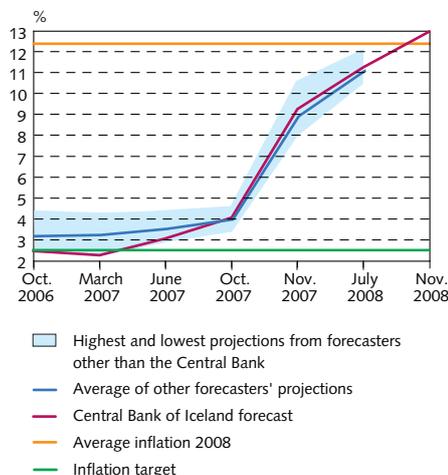
The forecasts prepared in 2007 underestimated the inflation rate ahead by a large margin. There are several reasons for this. First, economic activity was significantly underestimated for 2007. While the forecast projected GDP growth at just under 1% for the year, it

Chart 1
Inflation forecasts *Monetary Bulletin*
2007/1 - MB 2009/1 and actual inflation



Sources: Statistics Iceland, Central Bank of Iceland.

Chart 2
Projections for annual inflation in 2008
published at different times



Source: Central Bank of Iceland.

actually measured 5.5%. Furthermore, housing and wage inflation were much higher than forecasts had allowed for, especially in 2008. Moreover, the exchange rate of the króna was some 40% lower in 2008 than in 2007, while *MB 2008/1* had forecast only a 20% depreciation. Thus the errors in forecasting can be attributed in large part to overly optimistic exchange rate projections.

Chart 2 compares the forecasts by financial market analysts and the Ministry of Finance with the Central Bank's forecast for average year-on-year inflation in 2008.¹ The shaded area in Chart 2 shows the gap between the high and low values in these analysts' forecasts of average annual inflation for 2008. If the sample of forecasters were large enough, the average of the forecasts by analysts and the Ministry of Finance should be near the middle of the shaded area. The chart sheds light on whether the available information on the state of economic affairs was well utilised by forecasters. However, it is worth noting that the Central Bank did not begin to publish its own projected exchange rate and policy rate paths until 2007. Forecasts prepared for 2007 did not make full use of the Bank staff's assessment of the likely developments in these variables. Furthermore, it can be difficult to discern how well founded forecasts are by examining a single year, as developments over one year's time may be rather unpredictable. In order to gain a more accurate view of forecast quality, it is therefore necessary to examine a longer period of time and compare the primary criteria on which the forecasts are based, such as output growth, labour market conditions, and asset prices.

Early in the forecast period, the Central Bank projected that inflation would lie close to target levels in 2008, while other forecasters generally assumed that it would be somewhat higher. In 2006, forecasters projected that inflation would be in the range of 2.5-4.3%; however, they considered it more likely to be higher in 2008 than to be lower. In mid-2008, forecasters projected inflation for 2008 as a whole at 10.4-12%, and the Central Bank forecasted 11.3%. Actual inflation measured 12.4%.

Assessment of forecasting errors over a longer period

In assessing inflation forecasts, it is important to consider the mean forecast error (bias) and the root mean square error (RMSE) of the forecasts concerned. The bias shows the forecasts' mean deviation from actual inflation and thus whether inflation is being systematically over- or underforecast. A negative sign indicates that inflation has been systematically underforecast. The RMSE, on the other hand, measures how much, on average, the forecast value differs from the true value. As forecasts extend farther ahead in time, the error will increase, as the level of uncertainty about developments in the main macroeconomic variables increases.

1. The Central Bank of Iceland conducts a quarterly survey among financial analysts, in which they are asked to forecast average year-on-year inflation 2-3 years ahead. Participants in the survey were Askar Capital hf. and the research departments of Glitnir, Kaupthing Bank, and Landsbanki. The Ministry of Finance's inflation forecast can be found on the Ministry's website. The Ministry did not publish a forecast in summer 2008, however. This survey has been conducted since October 2006 but was suspended due to the collapse of the banks in the autumn of 2008.

Table 1 shows the bias and RMSE in the Bank's inflation forecasts up to four quarters ahead since 1994. By this criterion, inflation has been underforecast two, three and four quarters ahead, to an increasing degree along the horizon. In all cases except those involving forecasting errors one and two quarters ahead, the bias proved to be statistically significant in terms of the 5% tolerance level. That period was one of virtually continuous economic upswing, which could conceivably explain the underestimation of inflation, as forecasts are based to a large degree on preliminary statistics. Furthermore, because there is generally a fair amount of uncertainty surrounding economic developments, it is in a sense misleading to publish point estimates only. Examples of factors that could result in substantial deviations from point estimates include changes in the global economy and exchange rate developments.

Table 1 Central Bank of Iceland inflation forecast errors since Q1/1994

(%)	Q1	Q2	Q3	Q4
Mean forecast error	0.0	-0.3	-0.9	-1.1
RMSE	0.6	1.6	2.4	1.8

Since adopting the inflation target in March 2001, the Central Bank has also published inflation forecasts two years ahead. Table 2 shows the bias and the RMSE for the period since the Bank introduced inflation targeting. A comparison of Tables 1 and 2 shows that the standard deviation for the one-year forecast has been greater since the Bank adopted the inflation target (3.3%) than it was for the entire period (1.8%).

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

	No. of measurements	Mean forecast error (%)	RMSE (%)
Four quarters ahead	26	-1.5	3.3
Eight quarters ahead	24	-2.6	5.0

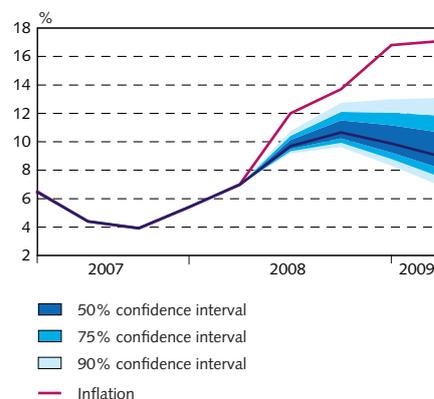
From Q2/2001 through July 2008, the Central Bank published its inflation forecast, together with the confidence intervals for the forecast. When assessing the Central Bank's inflation forecasting success, it is necessary to examine the forecast together with the confidence intervals, as the forecast for each quarter is based on uncertainties. Inflation is likely to be close to the baseline forecast, but marked divergences may be expected, particularly if key assumptions behind the forecast change.

Chart 3 compares inflation developments with the Central Bank's forecast for the first quarter of 2008, which appeared in *Monetary Bulletin* 2008/1. The chart illustrating the confidence intervals for the forecast shows the range in which inflation was 90% likely to lie. The red line shows actual inflation, which was much higher than projected and lies outside the 90% confidence interval for the entire forecast horizon.

Chart 3

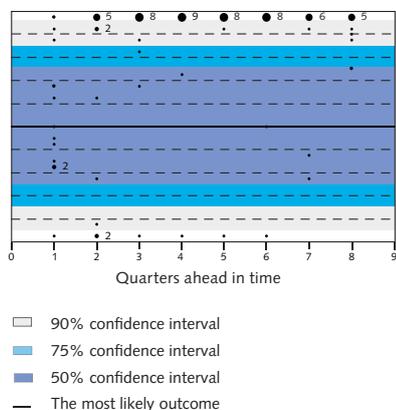
Central Bank's inflation forecast from MB 2008/1 and actual inflation

Forecasting period Q2/2008 - Q1/2009



Sources: Statistics Iceland, Central Bank of Iceland.

Chart 4
Confidence intervals of inflation forecasts
and measured inflation since MB 2005/1



Sources: Statistics Iceland, Central Bank of Iceland.

Chart 4 shows the distribution of measured inflation within the three confidence intervals (50%, 75%, and 90%); that is, where measured inflation lies with respect to the confidence intervals of the forecasts from Q1/2005 through July 2008. It can be seen that the majority of forecasts one quarter ahead are within the 50% confidence interval, and in 75% of cases they are within the 75% confidence interval. Forecasts three to six quarters ahead, however, are more often outside the upper 90% confidence interval, which indicates that in recent years the Central Bank has systematically underestimated the risk of inflation. This comes as no surprise, perhaps, in view of the fact that, in the past several years, the economy has endured a series of demand shocks that were difficult to foresee. Forecasts seven to eight quarters ahead are more accurate than those three to six quarters ahead. In 33-40% of forecasts seven to eight quarters ahead, inflation lies within the 90% confidence interval, as opposed to only 9-25% of forecasts three to six quarters ahead.

Table 3 illustrates the frequency with which inflation has been within the confidence interval of the forecast four and eight quarters ahead. With a sufficiently large sample, half of the forecasts might be expected to fall within the 50% confidence interval, three-quarters within 75%, and nine out of ten within 90%. A comparison of the distribution of forecasting errors with the assumed probability distribution reveals that the actual proportions are rather lower for forecasts four and eight quarters ahead.

Table 3 Distribution of measured inflation based on forecasts from Q2/2001²

	No. of measurements	50%	75%	90%
Four quarters ahead	24	6 (25%)	10 (42%)	13 (54%)
Eight quarters ahead	22	7 (32%)	13 (59%)	16 (73%)

Of twenty-four forecasts four quarters ahead, only six fell within the 50% confidence interval (25% of cases). Ten were within the 75% interval (42% of cases) and thirteen within the 90% interval (54% of cases). Therefore, inflation is frequently much higher than forecasts have suggested. Either the actual baseline forecast was inaccurate or the level of uncertainty was underestimated. It is appropriate to bear in mind that, for a long period of time, forecasts assumed that the policy rate and the exchange rate of the króna would remain unchanged. In some instances, however, that assumption should have resulted in overestimation of inflation rather than the reverse.

In general, it is more difficult to forecast inflation over longer horizons. This is reflected in a wider confidence interval. Of the twenty-two forecasts with a horizon of eight quarters, seven were within the 50% confidence interval (32% of cases), thirteen within the 75% interval (59% of cases), and sixteen (73%) within the 90% confidence interval. The forecasts eight quarters ahead seem to be considerably more accurate than those four quarters ahead; however,

2. In *Monetary Bulletin* 2004/1 and 2004/3, only a point estimate was published. Therefore, Table 3 includes only 24 measurements, while Table 2 includes 26.

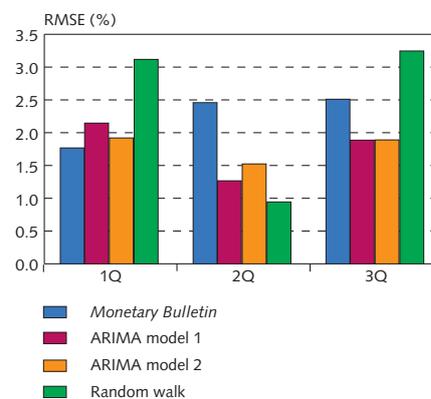
it is important to bear in mind that the confidence interval is generally twice as wide for an eight-quarter forecast than it is for a four-quarter forecast. If the forecasts allow for an endogenous monetary policy response, the effects should have more or less emerged eight quarters later. Therefore, errors in the forecasts of a central bank that is successful in operating an inflation target should not be systematic.

Performance of various models in forecasting inflation

Inflation one and two quarters ahead are very important variables in the Central Bank's macroeconomic forecast preparation because, if these are inaccurate, there is the risk that the entire inflation path will deviate from actual inflation. The Central Bank of Iceland has recently developed naive ARIMA time series models that are intended for forecasting inflation one to three quarters ahead. These models use past inflation only and, unlike the Central Bank's Quarterly Macroeconomic Model (QMM), use no other economic indicators or measures or inflation expectations. The results yielded by these models will be among the items considered by the Bank in its short-term inflation forecasting.

ARIMA models have been quite effective in forecasting short-term inflation. In 2006, for example, Norges Bank's ARIMA model was more accurate in forecasting inflation two and three quarters ahead than were the bank's published forecasts. For projections one quarter ahead, however, the bank's forecasts were slightly more accurate.³ Chart 5 compares the Central Bank's inflation forecasts one, two, and three quarters ahead for the year 2008. It compares the standard deviations (RMSE) for forecasts published in *Monetary Bulletin* with two different ARIMA models and with a simple random walk, which projects the same inflation as in the previous quarter throughout the forecast horizon. The first ARIMA model draws on forecasts for the principal subcomponents of the consumer price index and weights them together to create a single overall index.⁴ The latter ARIMA model projects the overall index directly. As can be seen, the forecasts prepared using the ARIMA models are more reliable than the *MB* forecasts two and three quarters ahead, but less accurate one quarter ahead. The forecasts using the random walk are much poorer than other forecasts one and three quarters ahead but are more reliable indicators of inflation two quarters ahead. These results indicate that the Central Bank could enhance the accuracy of its inflation forecasts by using ARIMA models together with other tools.

Chart 5
Forecast error for inflation in *MB*
and from naive models in 2008¹



1. The first quarter is the quarter in which the report is published or the first quarter forecasted; the second quarter is the quarter after the report has been published; the third is the following quarter.

Source: Central Bank of Iceland.

3. See also *Economic Bulletin 2/2007*, "Evaluation of Norges Bank's projections for 2006", pp. 77-89.

4. 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, cars and spare parts, petrol, other imported goods, alcohol and tobacco, housing, public services, and other services.