Appendix 3

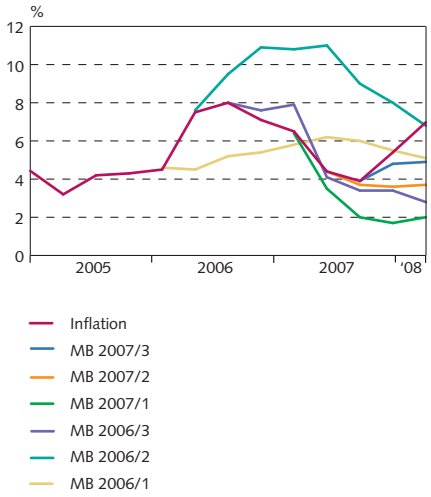
Forecast errors in Central Bank of Iceland inflation forecasts

The role of the Central Bank is to promote price stability. In order to fulfil that role satisfactorily, the Bank must follow closely the likely developments in inflation and economic affairs at all times, especially because there is a delay in monetary policy transmission. In this context, it can prove useful to examine how closely the Bank's inflation forecasts align with actual inflation and to determine, among other things, whether inflation has been systematically over- or underforecast over time.

The inflation forecast for 2007

Chart 1 shows the Central Bank inflation forecasts as published in *Monetary Bulletin*, together with actual developments in inflation from Q1/2005 to Q1/2008. It should be noted that assumptions regarding the policy rate vary in the Bank's forecasts. Policy rates were kept unchanged in forecasts until 2007, whereupon the Bank began publishing its economic forecast, together with the policy rate path that was considered most conducive to the attainment of the inflation target. The chart shows that, on two occasions during the period 2006-2007, the Bank's inflation forecast diverged markedly from actual CPI inflation. The former instance was the forecast that appeared in *Monetary Bulletin* 2006/1. The króna depreciated suddenly in the spring of 2006, triggering rising inflation and a gloomier inflation outlook. The Bank's baseline forecast at that time assumed an unchanged exchange rate. The latter instance was the forecast in *Monetary Bulletin* 2006/2, when inflation was significantly overestimated. There are two principal explanations for this. The short-term impact of the depreciation in the króna and the wage settlement review in June on wage developments was overestimated, thereby resulting in an overforecast of short-term inflation. However, it is interesting to note that, despite this divergence, the long-term effects on wage developments were forecast correctly. By year-end 2007, the entire wage drift projected by the Central Bank had surfaced – it merely emerged later than the Bank expected when it prepared its forecast in the summer of 2006. It should also be borne in mind that the Central Bank responded decisively to the inflationary effects of a falling exchange rate, thereby nullifying the assumptions lying behind the inflation forecast from *Monetary Bulletin* 2006/2. Therefore, by year-end 2006 inflation had fallen below the levels forecast in *Monetary Bulletin* 2006/2 and 2006/3. Added to this was the cut in indirect taxes – which was announced in the autumn of 2006, after the publication of the July issue of *Monetary Bulletin* – and its effect on the CPI in Q1/2007. Furthermore, the króna remained stronger than had been assumed in the Bank's forecasts. The forecasts appearing in last year's issues of *Monetary Bulletin* were much closer to actual inflation in Q4/2007, which was nonetheless underforecast.

Chart 1
Inflation forecasts MB 2006/1 - MB 2007/3 and inflation 2005 - Q1/2008



Sources: Statistics Iceland, Central Bank of Iceland.

Chart 2 compares the forecasts by financial market analysts and the Ministry of Finance for the period from September 2005 to October 2007 with the Central Bank's forecast for average year-on-year inflation in 2007.[1] The chart sheds light on whether the available information on the economy 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; therefore, the forecasts during this period are based on different models. For example, the forecasts from 2005 assumed that the exchange rate and the policy rate would remain unchanged throughout the forecast horizon. These forecasts did not make full use of the Bank staff's assessment of the likely developments in these variables. Furthermore, it can be difficult to determine how well founded forecasts are by examining only a single year, as developments over one year's time may be rather random; that is, they may be subject to unpredictable events. In order to gain a more accurate view of the quality of forecasts, it is therefore necessary to examine a longer period and compare the primary criteria on which the forecasts are based, such as output growth, labour market conditions, and asset prices.

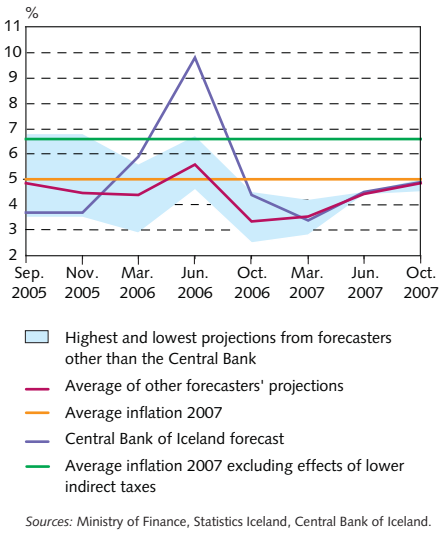
The blue area in Chart 2 reflects the highest and lowest values specified by financial market analysts and the Ministry of Finance in their forecasts of average inflation for 2007. In 2005, the estimated inflation levels for 2007 covered a broad range, but as time passed, of course, forecasters' opinions converged to a much greater degree. This is shown by a narrowing of the blue area in Chart 2. 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 blue area. In 2005, forecasters projected that inflation would be in the range of 3.5-6.8%; however, they considered inflation more likely to be lower in 2007 than higher.

Until October 2006, market participants did not know that the Government would cut consumption taxes; therefore, their inflation forecasts do not include the effects of those reductions. The green line represents average inflation without tax effects for 2007, while the yellow line shows actual average inflation for that year. In 2005, market analysts, the Ministry of Finance and the Central Bank were all far from forecasting year-2007 inflation correctly, though the Central Bank's forecast from early 2006 was not far from accurate. In mid-2006, all forecasters revised their inflation forecasts upwards following the depreciation of the króna. In the autumn of 2006, all forecasters assumed that the impact of tax cuts would be greater than it actually was, and therefore they underestimated inflation levels.

Chart 2

Projections for annual inflation in 2007 published at different times

Forecasts of Central Bank of Iceland, market analysts and Ministry of Finance



Sources: Ministry of Finance, Statistics Iceland, Central Bank of Iceland.

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 forecast error (RMSFE) of the forecasts concerned. The mean forecasting error shows the fore-

1. The Central Bank of Iceland conducts a survey three times a year among financial analysts, where 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 in the Ministry's quarterly macroeconomic forecasts.

casts' mean deviation from actual inflation and thus whether inflation is being systematically over- or underforecast. The RMSFE measures how much, on average, the forecast value differs from the true value.

In order for such measures to be significant, the forecasts must have independent forecast errors, and the number of measurements must be sufficiently large. As forecasts extend farther ahead in time, the forecast error can be expected to increase as the level of uncertainty about developments in the main macroeconomic variables increases. Conversely, the mean forecast error should become smaller as the time frame of the forecast grows shorter because of the greater availability of information on which to base the forecast.

Table 1 shows the mean forecast error and RMSFE 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 as the horizon grows longer. The mean forecast error for the forecast one, two and three quarters ahead proved not to be statistically significant. The mean forecast error four quarters ahead, however, proved to be significant, as was the mean forecast error from Table 2, which shows forecast errors in the Central Bank inflation forecasts since Q2/2001. During the period in Table 1, the economy experienced a nearly continuous upswing; therefore, it may be that inflation was underforecast because the forecasts were based largely on preliminary figures, which have tended to be revised upwards. 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. The RMSFE in Table 1 increases as the forecast horizon lengthens, as can be expected given the greater uncertainty farther ahead in time.

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

(%)	*Q1*	*Q2*	*Q3*	*Q4*
Mean forecast error	0.0	-0.3	-0.4	-0.7
RMSFE	0.4	1.2	1.5	2.0

Since adopting the inflation target in March 2001, the Central Bank has also published inflation forecasts two years ahead. Table 2 shows the mean forecast error and the RMSFE for the period since the Bank introduced inflation targeting. A comparison of Tables 1 and 2 shows that the RMSFE one year ahead for the period since the Bank adopted the inflation target (2.2%) is similar to that for the entire period (2.0%). Forecast errors have not increased despite larger variations in the exchange rate.

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

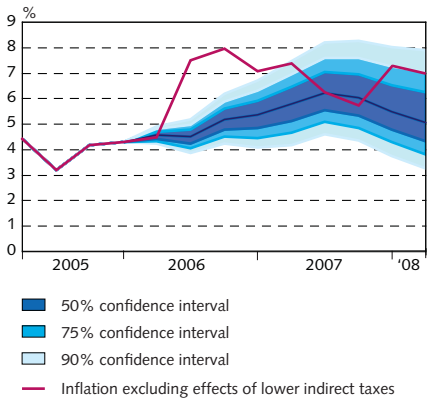
	No. of measurements	*Mean forecast error (%)*	*RMSFE (%)*
Four quarters ahead	24	-0.9	2.2
Eight quarters ahead	21	-1.2	2.0

Since Q2/2001, the Central Bank has published its inflation forecast, together with the confidence intervals for the forecast. In evaluating the Bank's inflation forecast, it is necessary to examine forecasts several quarters ahead as well as examining the confidence intervals, since the forecast for each quarter is based on various uncertainties. Inflation is likely to be close to the baseline forecast if the forecast assumptions hold, but marked divergences may be expected if key assumptions behind the forecast change. Chart 3 compares inflation developments with the Central Bank's forecast for the first quarter of 2006, which appeared in *Monetary Bulletin* 2006/1. The chart illustrating the confidence intervals for the forecast shows the range in which inflation was 90% likely to lie. The red line illustrates quarterly inflation excluding tax effects. The chart shows that it is more difficult to forecast short-term inflation developments. The forecast 2-4 quarters ahead is therefore outside the 90% confidence interval, while later in the forecast horizon it moves within the confidence interval.

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 the first quarter of 2005. It can be seen that the majority of forecasts one quarter ahead are within the 50% confidence interval, and in 90% of cases they are within the 90% 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 underestimated the risk of inflation. This comes as no surprise, perhaps, in view of the fact that since 2004 and 2005 the economy has endured a series of demand shocks that were difficult to evaluate in advance. Forecasts seven to eight quarters ahead are more accurate than those three to six quarters ahead. In 50-67% of forecasts seven to eight quarters ahead, inflation lies within the 90% confidence interval, as opposed to only 11-33% of forecasts three to six quarters ahead.

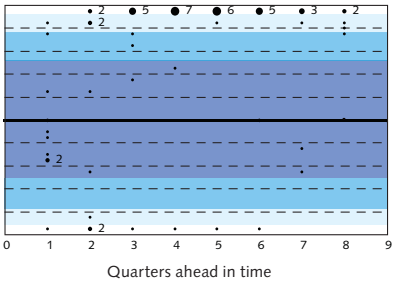
Table 3 illustrates the frequency with which inflation has been within the confidence interval of the forecast four and eight quarters ahead. With a sufficiently large sample, half of the forecasts might be expected to fall within the 50% confidence interval, three-quarters within 75%, and nine out of 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.

Chart 3
Central Bank's inflation forecast from MB 2006/1 and quarterly inflation excluding the effects of lower indirect taxes
Forecasting period: Q1/2006 - Q1/2008



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.

Table 3 Distribution of measured inflation based on forecasts from Q2/2001[2]

	No. of measurements	*50%*	*75%*	*90%*
Four quarters ahead	22	6 (27%)	10 (45%)	13 (59%)
Eight quarters ahead	19	7 (37%)	13 (68%)	16 (84%)

2. In *Monetary Bulletin* 2004/1 and 2004/3, only a point estimate was published. Therefore, Table 3 includes only 22 measurements, while Table 2 includes 24.

Of twenty-two forecasts four quarters ahead, only six fell within the 50% confidence interval (27% of cases). Ten were within the 75% interval (45% of cases) and thirteen within the 90% interval (59% of cases). Therefore, inflation is frequently much higher than forecasts have suggested. Either the actual baseline forecast was inaccurate or the level of uncertainty 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 broader confidence interval. Of the nineteen forecasts with a horizon of eight quarters, seven were within the 50% confidence interval (37% of cases), thirteen within the 75% interval (68% of cases), and sixteen (84%) within the 90% confidence interval. The forecasts eight quarters ahead seem to be considerably more accurate than those four quarters ahead; however, it is important to bear in mind that the confidence interval is generally twice as wide for a forecast eight quarters ahead than it is for a forecast four quarters ahead. 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.