

Inflation measured 1.9% in April and has been at or below the Central Bank's inflation target for more than three years running. This is a lower inflation rate than Iceland has seen for quite some time, and there are signs that this increased success in controlling inflation is gradually yielding a firmer anchor for inflation expectations at the target. Deviations of inflation from target have diminished, fluctuations in inflation and inflation expectations have grown smaller, and uncertainty about future inflation has been reduced. Furthermore, short-term inflation surprises have less impact on long-term inflation expectations than before, and the effects of supply shocks on inflation appear less persistent. And finally, there are signs that the relationship between inflation and the macroeconomic variables generally considered to determine it have changed and that recent developments in inflation have been more consistent with the Bank's official 2.5% target.

These findings indicate that monetary policy has been increasingly successful in recent years and, together with favourable external conditions, contributed to lower, more stable inflation and more firmly anchored inflation expectations than Iceland has experienced for quite some time. However, the large pay increases provided for in recent wage settlements indicate that it would be premature to declare victory in the fight against inflation.

### Why does a firm anchor for inflation expectations matter?

Inflation expectations are a key determinant of inflation, in part through their impact on firms' pricing decisions and employees' wage demands. For example, workers are likelier to demand large pay increases when they expect high inflation. By the same token, firms are likelier to agree to such demands if they also expect high inflation, which will make it easier for them to pass these pay increases through to prices. Therefore, in order for it to be possible to hold inflation at target for a sustained period, it is necessary that private sector inflation expectations be consistent with the target as well.

In fact, the anchoring of inflation expectations at target reflects monetary policy's main contribution to economic stability. If inflation expectations are stable at target, real interest rates will be less volatile. This stabilises demand, employment, and GDP growth. Smaller fluctuations in inflation expectations and real interest rates also reduce exchange rate volatility, other things being equal.

A firmer anchor for inflation expectations also gives the Central Bank greater scope to look through temporary fluctuations in inflation, thereby supporting the real economy more effectively. This is because, under such conditions, the Bank has less reason to fear that a short-term increase in relative prices – such as oil prices – will affect inflation expectations and thereby have a sustained effect on inflation. The scope for monetary policy to mitigate economic fluctuations will therefore be greater than it would be otherwise. A good example of this is when a deterioration in terms of trade leads to a currency depreciation and a contraction in output. If inflation expectations are firmly anchored, the Central Bank can lower interest rates so as to provide a cushion during the downturn, even though inflation rises temporarily as a result of a lower exchange rate. If expectations lack such an anchor, there will be less scope to lower interest rates because of the risk that a temporary drop in the exchange rate will have a lasting impact on inflation expectations, which will result in higher and more persistent inflation.

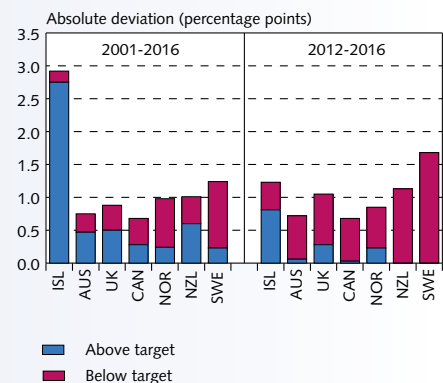
### Deviations from target have diminished ...

In recent years, inflation has fallen significantly from the level prevailing during the pre-crisis upswing and the immediate aftermath

## Box 3

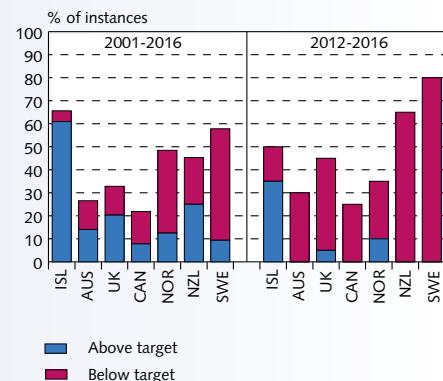
### Lower and more stable inflation and firmer anchor for inflation expectations

Chart 1  
Average deviation from the inflation target<sup>1</sup>  
Q1/2001 - Q4/2016



1. Average absolute deviation from inflation target (based on the inflation target measure used by each country) and relative contribution of above- and below-target deviations.  
Sources: Central bank websites, OECD, Central Bank of Iceland.

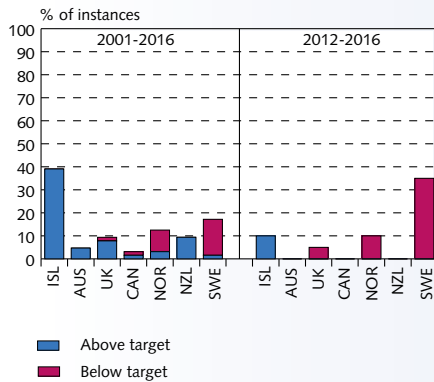
Chart 2  
Deviation of more than 1 percentage point from target<sup>1</sup>  
Q1/2001 - Q4/2016



1. Frequency of deviations of more than 1 percentage point from inflation target (based on the inflation target measure used by each country) and relative contribution of above- and below-target deviations.  
Sources: Central bank websites, OECD, Central Bank of Iceland.

Chart 3  
Deviation of more than 2 percentage points from target<sup>1</sup>

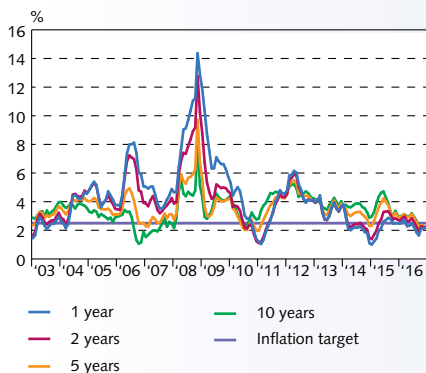
Q1/2001 – Q4/2016



1. Frequency of deviations of more than 2 percentage points from inflation target (based on the inflation target measure used by each country) and relative contribution of above- and below-target deviations.  
Sources: Central bank websites, OECD, Central Bank of Iceland.

Chart 4  
Breakeven inflation rate in the bond market<sup>1</sup>

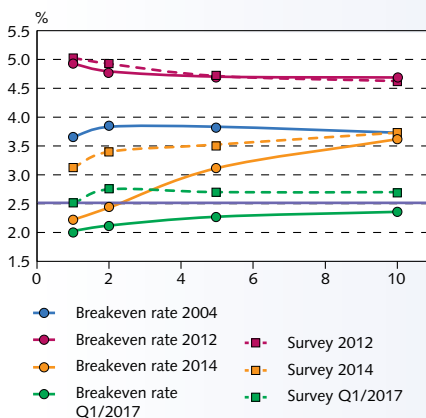
January 2003 - December 2016



1. One-, two-, five-, and ten-year breakeven inflation rate estimated from the interest rate spread between indexed and non-indexed bonds. Monthly averages.  
Source: Central Bank of Iceland.

Chart 5  
One- to ten-year inflation expectations<sup>1</sup>

Period averages



1. Inflation expectations 1, 2, 5, and 10 years ahead, estimated from the breakeven inflation rate in the bond market and market survey responses. Period averages.  
Source: Central Bank of Iceland.

of the crisis, when the effects of the collapse of the króna could still be felt. For example, inflation averaged 2.9% per year over the past five years (2012-2016), as opposed to 5.1% over the period beginning in 2001, when the monetary policy framework was changed and the 2.5% inflation target formally adopted. For the period until 2008 – i.e., excluding the high-inflation period following the crisis – it was slightly lower, averaging 4.7% per year in 2001-2007.

Therefore, inflation has been markedly above the Bank's target, on average, ever since 2001. The deviation from target averaged about 3 percentage points, as can be seen in Chart 1, and is about three times that in other relatively small, developed inflation-targeting countries (Australia, the UK, Canada, Norway, New Zealand, and Sweden). In addition, the deviations in other countries are divided more or less equally between overshooting and undershooting, while they are dominated by above-target deviations in Iceland. As Chart 2 indicates, inflation has been more than 1 percentage point above target for more than 60% of the period since 2001, and such large target misses are much more common in Iceland than in the other countries. The difference is even greater in terms of deviations of more than 2 percentage points from target: in Iceland, inflation has been more than 2 points away from target in nearly 40% of the period, whereas such large deviations are extremely rare in the other countries (Chart 3).

The economy is subjected regularly to shocks that push inflation away from the target. Deviations from target are therefore normal. Because one of the roles of monetary policy is to stabilise the real economy insofar as is consistent with price stability, it is appropriate to allow a certain flexibility in bringing inflation back to target, as business cycle volatility could be exacerbated by attempts to bring it to target very quickly. On the other hand, large and frequent departures from the target tend to erode the credibility of monetary policy, unmoor inflation expectations, and exacerbate business cycle fluctuations. Charts 1-3 indicate, however, that deviations of inflation from the target in Iceland have diminished significantly in recent years. The average deviation has been reduced by more than half, and large deviations occur much less frequently than before. The frequency of undershooting has increased as well, although overshooting is still more frequent. In the past five years, deviations have been much closer to the pattern seen in other advanced inflation-targeting countries.

### ... and inflation expectations are better aligned with the target

Inflation expectations have declined alongside falling inflation. As Chart 4 indicates, short- and long-term inflation expectations have fluctuated widely since 2003 and, like inflation, have usually been above target.<sup>1</sup> While this is particularly the case for the post-crisis period, it also applies to the period during the run-up to the crisis, when the breakeven inflation rate averaged between 3% and 4%, depending on the length of the horizon. Breakeven inflation has declined in recent years, however, and is well in line with the inflation target for all horizons. This can be seen more clearly in Chart 5, which illustrates the breakeven inflation rate and market agents' inflation expectations for up to ten years over various periods. As the chart indicates, inflation expectations were usually well above

1. The chart shows the breakeven inflation rate in the bond market; i.e., the spread between interest rates on comparable indexed and non-indexed bonds. As is discussed in Box 1 in *Monetary Bulletin 2015/2*, the breakeven inflation rate also contains a time-varying inflation risk premium and a liquidity premium (a net premium between indexed and non-indexed bonds). Data for breakeven inflation rate are available from 2003 onwards; therefore, this is the only measure of inflation expectations that extends over a long enough period.

the target before the crisis and rose steeply afterwards. As time passed, however, they were brought down towards the target – short-term expectations first and then, more recently, long-term expectations.

### Fluctuations in inflation and inflation expectations have diminished ...

As inflation and inflation expectations have fallen, fluctuations in both have also diminished (Chart 6). Fluctuations in various measures of inflation are only a fourth as large as they were in 2001-2007, and fluctuations in short- and long-term inflation expectations have receded as well. Chart 7 shows, however, inflation remains more volatile in Iceland than in other advanced inflation-targeting countries, although the difference has narrowed markedly in recent years.

### ... and uncertainty about the inflation outlook has subsided

With a stronger anchor for inflation expectations and reduced volatility of inflation and inflation expectations, it appears that uncertainty about future inflation has abated as well. As can be seen in Chart 8, households', businesses', and market agents' assessment of the inflation outlook one year ahead grew more divergent during the first years after the adoption of the inflation target, even though inflation and inflation expectations grew less volatile. Uncertainty about the inflation outlook grew even further during the aftermath of the financial crisis and the associated spike in inflation, but dispersion of inflation expectations has diminished again in the past few years and is now broadly at the level seen in the early 2000s.

### Long-term expectations more resistant to short-term fluctuations in inflation

If inflation expectations are securely anchored to the target, short-term fluctuations in inflation should not affect them, long-term expectations in particular. If the anchor is weak, however, there is the risk that surprise movements in inflation will affect expectations and give rise to stronger inflationary effects than would otherwise exist.

This can be determined by estimating the following empirical relationship using monthly data for two five-year periods (2003-2007 and 2012-2016):

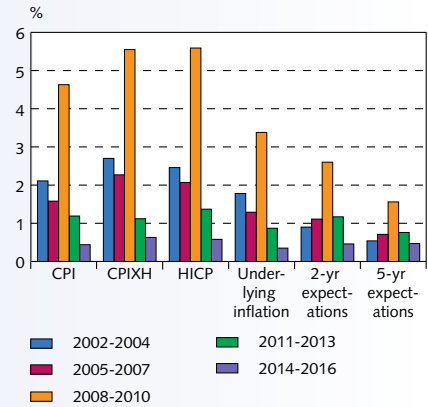
$$\Delta\pi^e = \alpha + \beta(\pi - \pi^f) + \varepsilon$$

where  $\pi$  is the monthly change in the consumer price index,  $\Delta\pi^e$  is the daily change in inflation expectations (the two-, five-, and ten-year breakeven inflation rate) following the publication of the index (from the end of the day before publication to the end of the publication day – the index is published at the beginning of the day), and  $\varepsilon$  is a residual.  $\pi^f$  is a measure of the forecasted monthly change in the consumer price index and is obtained with a simple forecasting model, where monthly changes are forecast using the monthly change of the previous month, the monthly change six months earlier, and seasonal dummies.  $(\pi - \pi^f)$  is therefore a measure of short-term surprises in inflation, and  $\beta$  is an estimation of their impact on inflation expectations. As can be seen in Chart 9, unexpected short-term fluctuations in inflation significantly affected two- and five-year inflation expectations during the former period but not during the latter.

### Fluctuations in inflation less persistent than before ...

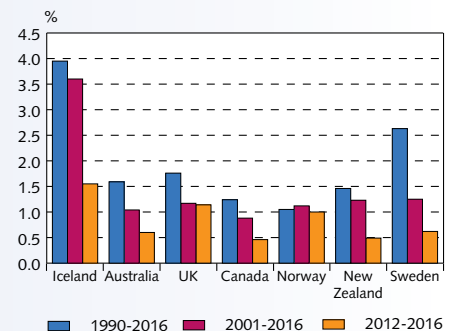
Lower and more stable inflation, a firmer anchor for inflation expectations, and reduced uncertainty about the inflation outlook also appear to have led to changes in the inflation process itself.

Chart 6  
Fluctuations in inflation and inflation expectations<sup>1</sup>  
Q1/2002 - Q4/2016



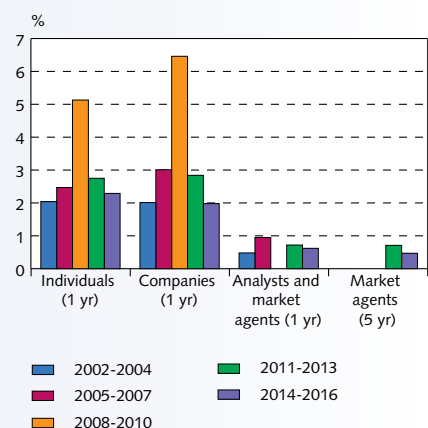
1. Standard deviation in various measures of inflation and inflation expectations for five periods of equal length. Underlying inflation is estimated from the median of five statistical measures (four trimmed means and a weighted median). The breakeven inflation rate in the bond market is used as a measure of two- and five-year inflation expectations (data only available from 2003 onwards).  
Sources: Statistics Iceland, Central Bank of Iceland.

Chart 7  
Fluctuations in inflation 1990-2016<sup>1</sup>



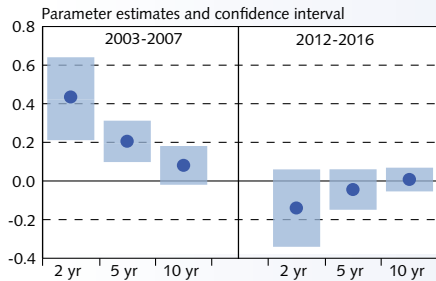
1. Standard deviation in year-on-year inflation based on quarterly averages of the CPI.  
Sources: OECD, Statistics Iceland, Central Bank of Iceland.

Chart 8  
Dispersion of inflation expectations<sup>1</sup>  
Q1/2002 - Q4/2016



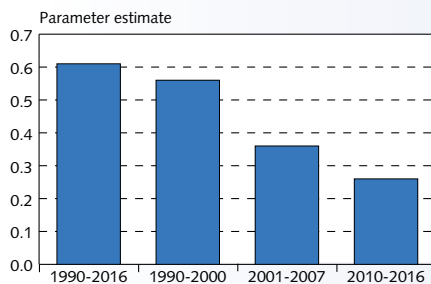
1. Standard deviation in surveys of inflation expectations for five periods of equal length (linear interpolation is used where measurements are missing). No surveys were carried out among analysts and market agents from mid-2008 until the beginning of 2012. From that time onwards, long-term inflation expectations have also been surveyed.  
Sources: Gallup, Central Bank of Iceland.

Chart 9  
Effects of unexpected changes in inflation on inflation expectations<sup>1</sup>



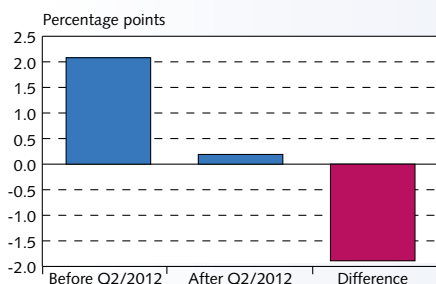
1. The dots show a parameter estimation from a regression of changes in the two-, five-, and ten-year breakeven inflation rate on unexpected changes in the consumer price index (CPI) on index publication dates for two five-year (sixty-month) periods (2003-2007 and 2012-2016). Unexpected changes in the CPI are estimated as a deviation of monthly changes in the index from the forecasted value, using a forecast equation that contains seasonal dummies and one- and six-month lags in monthly changes in the index. The shaded area shows the two-standard-deviation range of the parameter estimates.  
Source: Central Bank of Iceland.

Chart 10  
Inflation persistence<sup>1</sup>



1. Estimated using a second-order AR model for the seasonally adjusted quarterly changes in the CPI:  $\pi_t = \alpha + \gamma_1 \pi_{t-1} + \gamma_2 \pi_{t-2} + \varepsilon_t$  where  $\pi_t$  is quarterly inflation during period  $t$  and  $\varepsilon_t$  is a residual.  $\rho = \gamma_1 + \gamma_2$  gives an estimate of the level of persistence in inflation.  
Source: Central Bank of Iceland.

Chart 11  
Inflation bias according to Phillips curve<sup>1</sup>



1. The Phillips curve is of the form:  $\pi_t = \alpha + \beta \pi_{t-1} + (1-\beta) \pi_t^e + \gamma q_t + \phi q_{t-1} + \varepsilon_t$ , where  $\pi_t$  is year-on-year inflation in period  $t$ ,  $\pi_t^e$  are 10-year inflation expectations,  $q_t$  is the output gap,  $q_t$  is the year-on-year change in importers' real exchange rate, and  $\varepsilon_t$  is a residual. The inflation bias is given as:  $\pi - \pi^e = \alpha / (1-\beta)$ .  
Source: Central Bank of Iceland.

Indications of this can be obtained by estimating the amount of persistence in the inflation process. If inflation is very persistent, there is the risk that temporary supply shocks such as changes in oil prices will have a lasting impact on inflation, making it harder for monetary policy to control inflation. To measure the persistence of the inflation process, the following time series model is used for different sub-periods between 1990 and 2016:<sup>2</sup>

$$\pi_t = \alpha + \gamma_1 \pi_{t-1} + \dots + \gamma_n \pi_{t-n} + \varepsilon_t$$

where  $\pi_t$  is quarterly inflation (the seasonally adjusted quarter-on-quarter change in the consumer price index) in period  $t$ , and  $\varepsilon_t$  is a residual. Inflation persistence is then estimated as  $\rho = \gamma_1 + \dots + \gamma_n$ . As Chart 10 shows, inflation persistence has been diminishing in the past few years. The effects of supply shocks on inflation therefore appear to taper off more quickly than before, which in turn indicates a reduction in monetary authorities' tolerance of deviations in inflation from target. It also indicates that the Central Bank has had inflation under better control than before and that deviations from target call for less monetary response than was previously needed.

### ... and the relationship between inflation and its determinants appears to have changed

The last indication of changes in how inflation is determined and of improved management of inflation and inflation expectations can be found by estimating the Phillips curve (see, for instance, Box 5 in *Monetary Bulletin* 2015/2), which is a standard description of the determination of inflation, and to see whether there are signs of a structural break in the relationship between inflation and its determinants. Thus the following Phillips curve is estimated using quarterly data for the period 2003-2016:

$$\pi_t = \alpha + \beta \pi_{t-1} + (1 - \beta) \pi_t^e + \gamma q_{t-1} + \phi q_{t-1} + \varepsilon_t$$

where  $\pi_t$  is twelve-month inflation in period  $t$ ,  $\pi_t^e$  is inflation expectations (using the ten-year breakeven inflation rate),  $q$  is the output gap,  $q_t$  is the twelve-month change in importers' real exchange rate, and  $\varepsilon_t$  is a residual. The steady-state solution of the Phillips curve – i.e., where inflation is at equilibrium, output equals potential, and the real exchange rate is constant – is then given as

$$\pi = \alpha / (1 - \beta) + \pi^e$$

and the "inflation bias" as  $\pi - \pi^e$ . If inflation expectations are anchored at the Bank's target, then it should be the case that  $\pi - \pi^e = \alpha / (1 - \beta) = 0$ .

In order to determine whether and when a possible structural break has taken place in the Phillips curve and whether it means that the inflation bias has grown smaller, the Quandt-Andrews test for structural breaks at an unknown date is used, which gives a clear indication of a structural break beginning in Q2/2012 and suggests that the break stems from a fall in  $(\alpha)$ , the constant in the Phillips curve. The empirical estimates suggest that the inflation bias was about 2 percentage points before 2012 and has disappeared since then (Chart 11).<sup>3</sup> Similar results can be obtained using a two-regime

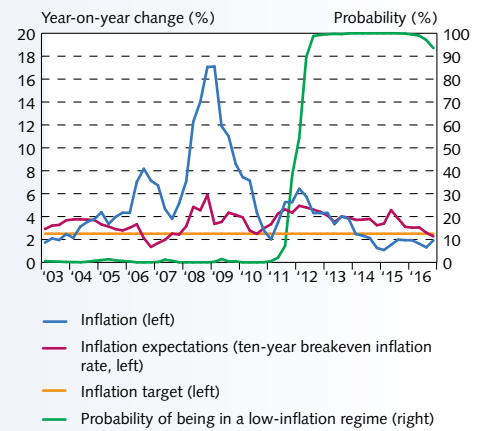
2. Statistical tests indicated that a second-order autoregressive process suffices. Further discussion of methods for estimating inflation persistence can be found in Thórarinn G. Pétursson (2008), "How hard can it be? Inflation control around the world", Central Bank of Iceland, *Working Papers*, no. 40.

3. The hypothesis that the inflation bias is zero is strongly rejected by the data before 2012 ( $p$ -value = 0.00) but not for the years thereafter ( $p$ -value = 0.59). No indications were found of other changes in the Phillips curve; i.e., there is no evidence that the slope of the Phillips curve or the pass-through of exchange rate shocks has changed.

Markov switching model to estimate the Phillips curve. According to the model inflation is either in a high-inflation regime or a low-inflation regime. The results suggest a structural break around the same time, with the probability of being in the low-inflation regime above 50% from the start of 2012 and rising to 90% or more from Q2/2012 onwards (Chart 12).

The inflation bias that seemed for a long time to be built into the determination of inflation in Iceland has therefore grown smaller in recent years and now appears to have disappeared, suggesting that inflation expectations have finally aligned with the Bank's official 2.5% inflation target.

Chart 12  
Probability of being in a low-inflation regime<sup>1</sup>  
Q1/2003 – Q4/2016



1. Smoothed probability of being in a low-inflation regime based on the Phillips curve, estimated with a two-regime Markov switching model.  
Sources: Statistics Iceland, Central Bank of Iceland.