Uncertainty regarding future interest rate movements

This box presents methods to illustrate the uncertainty of interest rate movements based on implied forward rates. An important conclusion is that, even if the Riksbank at a particular point in time were to judge that the implied forward rate curve used as the basis for the forecasts in its Inflation Reports broadly speaking reflected a reasonable future development of the repo rate, there is considerable uncertainty regarding economic development, which may cause the actual repo rate path to deviate from the expected path.

In the past, the Riksbank based its forecasts in the main scenario on the assumption that the repo rate would remain unchanged throughout the forecast period. Since the October Inflation Report last year, the forecasts are instead based on the assumption that the repo rate develops in line with market expectations regarding the future repo rate, as expressed in the implied forward rates.

Monetary policy has a direct effect on the shortest interest rates in the economy. Consequently, expectations regarding future monetary policy also affect expectations regarding future short-term interest rates. It is these expectations that are captured in the implied forward rates. The implied forward rates can, in other words, be interpreted as the financial markets' forecast regarding the future repo rate. The Riksbank derives the implied forward rates from the interest rates for government securities with different maturities.[8] If, for example, the annual yield on interest-bearing government securities is higher for long maturities than it is for short maturities, this could be interpreted as meaning that the market is expecting the repo rate to be raised.

Implied forward rates normally include premiums for maturity, credit risk and liquidity. Accordingly, they do not represent an exact measure of the market's expectations regarding the repo rate. Since the Riksbank estimates implied forward rates on the basis of the interest rates for government securities, the premiums for liquidity and credit risk should, however, be negligible. In the following outline, term premiums have, for the sake of simplicity, also been disregarded, but it is important to remember that these can sometimes arise.

In the long term, the implied forward rates normally provide a more reasonable assessment of future interest rate movements than the assumption that the repo rate remains unchanged. This improves the conditions for making forecasts as well as the possibilities for evaluating them.

Another effect of the new interest rate assumption is that it to a certain extent makes it easier for businesses, consumers and other market participants to form a reasonable opinion of future interest rate movements on the one hand, and the link between interest rate movements and the Riksbank's forecasts regarding inflation, GDP, etc. on the other. The Riksbank can, by being clear about its view on economic development, including the monetary policy associated with such a development, affect the general public's expectations regarding future interest rate movements. At the same time, it is important to point out that there is significant uncertainty regarding future economic developments and accordingly interest rate movements. This uncertainty means that the Riksbank cannot in advance tie its monetary policy to a particular interest rate path, that is then slavishly followed. Even if the implied forward rates at the time of a decision are felt to reflect a reasonable future development of the repo rate based on the information available at the time, the economic development – and accordingly also the interest rate path – could be different to that expected. It is important that the Riksbank clarifies this in various ways.

Several different methods may be used to illustrate the uncertainty regarding future interest rate movements. In the following section, two different methods have been used to calculate uncertainty intervals regarding the implied forward rate curve on which the forecasts in

8 The implied forward rate curve used refers to a 15-day average and has been derived from interest rates on T-bills and government bonds.

the Inflation Report have been based. Firstly, uncertainty is estimated on the basis of historical deviations between the repo rate and implied forward rates. Secondly, it is estimated with the help of option prices. Both methods serve to illustrate the uncertainty regarding future interest rate movements, but it is important to note that they do not measure uncertainty in exactly the same way.[9] The methods also have their respective advantages and disadvantages. The methods and applications selected here are intended to serve as illustrative examples.

Uncertainty regarding the implied forward rate curve based on historical outcomes

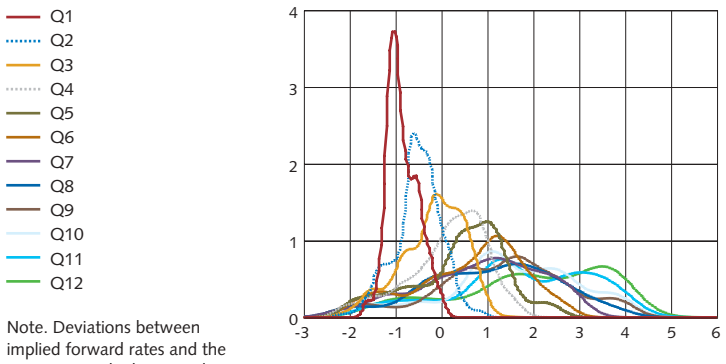
One method for illustrating uncertainty is to calculate implied forward rate curves for different points in time in the past and to then study how well they have predicted the actual outcome for the repo rate. Based on interest-bearing government securities with varying maturities, the daily implied forward rates have been calculated for time horizons ranging from 1 to 12 quarters for the period 1998–2005. Then, for each of the respective time horizons, the differences between the implied forward rates and the (actual) repo rate have been calculated.

Table B2 illustrates the average deviations between the implied forward rate and the repo rate as well as the standard deviations for different time horizons. Figure B4 shows the distribution of these individual deviations when centred around the average deviation for each of the respective time horizons.[10] For example, the red curve shows the difference between what the market at various points in the past has believed the repo rate would be one quarter into the future and the actual outcome. The broken blue curve shows the corresponding information for two quarters into the future, etc.

The longer the forecast horizon, the greater on average the deviations between the implied forward rate and the actual outcome of the repo rate are (see Table B2 and Figure B4). The average deviation is 0.2 percentage points for "forecasts" one quarter into the future. For "forecasts" 12 quarters into the future, the average deviation is 2.1 percentage points. In other words, the implied forward rates do not contain so much useful information about the future development of the key policy rate in the longer term.

The spread (standard deviation) also increases for longer time horizons. This illustrates that the probability of unexpected disturbances arising in the economy and provoking monetary policy reactions becomes greater the longer the forecast horizon. The economy is constantly exposed to unexpected disturbances with the

Figure B4. Deviations between the implied forward rate and the repo rate for different time horizons during the period 1998-2005.
Per cent



Note. Deviations between implied forward rates and the repo rate on the horizontal axis (percentage points). Frequency on the vertical axis (per cent).

Source: The Riksbank.

Table B2. Average deviation between the implied forward rate and the repo rate and standard deviations for different time horizons during the period 1998 to 2005.
Percentage points

	Time horizon (quarters)											
	1	2	3	4	5	6	7	8	9	10	11	12
Average	0.2	0.4	0.6	0.9	1.0	1.2	1.4	1.5	1.7	1.8	2.0	2.1
Standard deviation	0.2	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.0	1.0	1.0	1.1

Source: The Riksbank.

9 See the box "Uncertainty surrounding future interest rate developments", in *Inflation Report 3/2005*, Norges Bank, for a similar study.
10 The distribution's histogram has been evened out using "kernel estimation".

result that the actual repo rate will deviate from the expected repo rate.

Historical deviations between implied forward rates and the repo rate during 1998–2005, as illustrated in Figure B4, thus show that the repo rate can deviate significantly from market expectations. This illustrates that there is considerable uncertainty regarding interest rate movements.

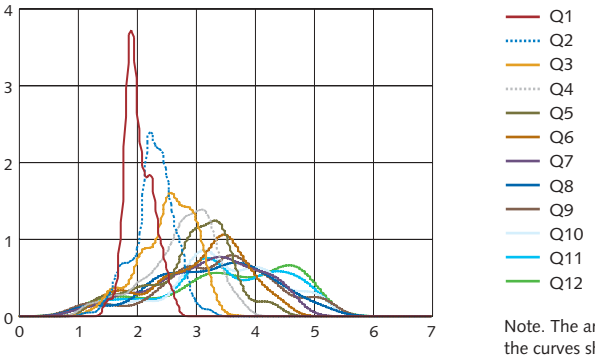
If certain conditions are met, the historical deviations may also be used to make an estimate today of the probability that the repo rate will fall within a certain interval at a certain point in time in the future. Firstly, the deviations between the implied forward rate and the repo rate during the period 1998–2005 must be deemed to be representative, even for future deviations. Secondly, it requires that the term premiums are zero. In practice, term premiums are not zero. Moreover, it is difficult to separate term premiums from other factors that also contribute to systematic deviations between the implied forward rates and the repo rate.[11] The probability distributions calculated under such conditions should therefore be interpreted with caution. On the other hand, the uncertainty that arises as the result of these problems should be relatively slight in relation to the uncertainty regarding interest rate movements that the probability distributions aim to illustrate.

The probability distributions calculated are illustrated in Figure B5. The figure shows exactly the same distributions as Figure B4, with the only difference being that they are now centred around the average implied forward rates and not around the average historical "forecasting errors". For example the red distribution in Figure B5 illustrates the probability of the repo rate falling within a certain interval one quarter into the future. The broken blue distribution shows the probability of the repo rate falling within a certain interval two quarters into the future, etc.

On the basis of these distributions, for each of the time horizons, a 25, 50 and 75 per cent uncertainty interval has been calculated for the implied forward rate curve (see Figure B6). It is clear that the market, with 75 per cent probability, expects the repo rate to fall somewhere within the interval 1.75–3.5 per cent one year into the future. The probability is 50 per cent that the repo rate within one year will be somewhere in the interval 2.25–3.25 and 25 per cent that it will be 2.5–3.0 per cent. As is also shown, the uncertainty interval increases sharply if the time horizon is extended to three years. This shows that there is considerable uncertainty in the implied forward rates.

One can naturally question how historical deviations between implied forward rates and the repo rate during a given period are representative for the future. If one has access to data over a very long period of time, the method should work reasonably well, since unusual (period-specific) deviations between the implied forward rate and the repo rate in such cases are lightly weighted. The calculations here have, however, been based on a relatively short period of time. The reason is that the shift in stabilisation policy regime and other examples of major turbulence in the first half of the 1990s mean that a longer period of time would risk generating misleading results. This is one more reason why the calculations presented should be interpreted with some caution.

Figure B5. Probability distributions for the repo rate based on historical deviations between the implied forward rate and the repo rate.
Per cent

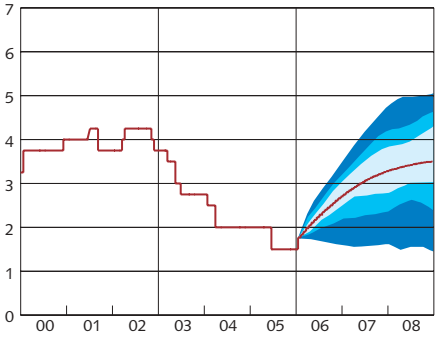


Note. The area under each of the curves shows the probability of the repo rate falling within a certain interval.

Source: The Riksbank.

11 See Alsterlind, J. & Dillén, H., "Monetary policy expectations and forward premia", *Sveriges Riksbank Economic Review* 2, 2005, for a description of methods on how the size of term premiums can be estimated.

Figure B6. Uncertainty intervals regarding the implied forward rate curve based on historical deviations between the implied forward rate and the repo rate. Per cent



Note. The widest interval (dark blue field) shows the 75 per cent uncertainty interval. The narrowest interval (light blue field) shows the 25 per cent uncertainty interval and the field in between (medium blue field) shows the 50 per cent uncertainty interval.

Source: The Riksbank.

Uncertainty regarding the implied forward rate curve based on option prices

Trade in interest rate derivatives also provides an opportunity to highlight the uncertainty regarding future interest rate movements. There are several types of interest rate derivative, for example forward contracts, swaps and interest rate options. An interest rate option grants a right to buy or sell a certain interest-bearing asset at some point in the future, for example a government bond, at a predetermined exercise price. The exercise price is determined by the market's perception of uncertainty in the future price (or returns). At any given point in time, the exercise price of similar interest rate derivatives can vary. This variation in the exercise price reflects the market's assessment of the uncertainty in the future price of the interest rate derivative's underlying asset. By observing this variation, different methods can be used to estimate an implied probability distribution that constitutes an appreciation of the market's assessment of the probability that the price will fall within a certain interval at a certain point in time in the future.[12] From this estimate of the probability distribution, it is possible to construct an uncertainty interval which illustrates the uncertainty regarding the implied forward rate curve.

One advantage of an uncertainty interval based on option prices compared with those that are based on historical deviations between the implied forward rate and the actual outcome of the repo rate is that they immediately show the market's assessment of the uncertainty in future interest rate movements. Another advantage is that they are not in the same way dependent on economic developments during a certain period in the past. However, these uncertainty intervals could reasonably be affected by historical developments, albeit more indirectly.

The Riksbank uses government securities with different maturities to arrive at the implied forward rate curve in the Inflation Report. Unfortunately, the statistical basis regarding interest rate derivatives with government securities as an underlying asset is not sufficiently broad to offer a viable basis for calculating the uncertainty interval, and this is one clear disadvantage of this method. To illustrate how interest rate derivatives can be used to estimate uncertainty intervals regarding implied forward rates, these intervals have instead been derived from UK price statistics for Swedish interest rate caps using three–month bank securities as the underlying asset.[13] The interest rate cap is an interest rate derivative that is used by market players looking to fix a certain maximum interest paid. If the market rate exceeds a certain limit, one is guaranteed, or has the right, to pay only a certain predetermined maximum interest. This type of interest rate derivative can accordingly be regarded as a interest rate option. A number of Swedish mortgage institutions already offer customers variable rates with an interest rate cap, for which they charge a certain premium on the interest rate during the contractual period.

Figure B7 shows the probability distributions based on option prices (i.e. the corresponding data for the distributions shown in Figure B5). For example, the red distribution

12 See for example Aguilar, J. & Hördahl, P.,"Option prices and market expectations", *Sveriges Riksbank Economic Review*, No. 1, 1999, for a more technical description of how to proceed in principle when estimating such probability distributions.

13 The calculations have been derived from the prices of Swedish interest rate caps set by ICAP, a brokers' firm based in London, and are based on the *average* volatility ("flat volatility") for the relevant period of maturity (in this case 90 days).

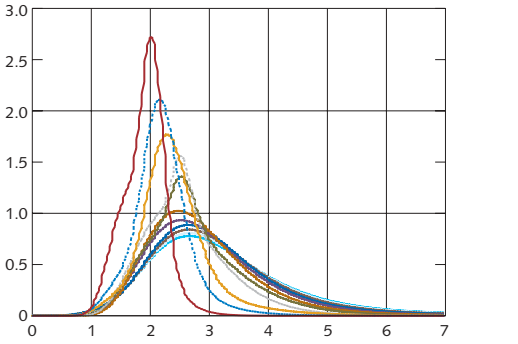
(subject to the effect of term premiums) shows the market's assessment of the probability that the repo rate will fall within a certain interval two quarters into the future (*on average* during the second quarter).[14]

These distributions, in a similar fashion as in the distributions shown in Figure B5, have subsequently been converted to uncertainty intervals that illustrate the uncertainty regarding the future interest rate path as perceived by the market (see Figure B8). It should be pointed out that this information primarily reflects the image which those market players who enter into such agreements have regarding uncertainty about future interest rate movements. It is thus not necessarily representative of the market as a whole.

When uncertainty regarding the implied forward rate curve has been calculated in this way, it is clear that the market, with 75 per cent probability, expects the repo rate to fall somewhere within the interval 2.0–3.5 per cent one year into the future. The 50 per cent interval has the range 2.25–3.25 per cent, while the 25 per cent interval is 2.5–3.0 per cent.[15]

The uncertainty interval regarding the implied forward rate curve from a one-year perspective, estimated with the help of interest rate options, is broadly the same size as those intervals derived from historical deviations between implied forward rates and the repo rate. The uncertainty intervals for two years and three years are also broadly the same.

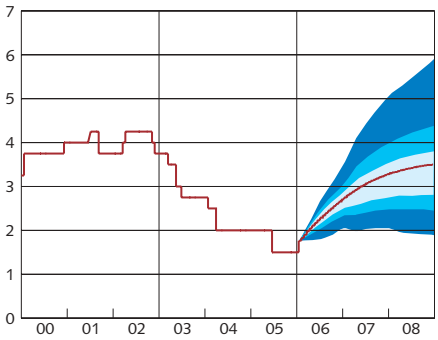
Figure B7. Probability distributions for the repo rate based on option prices.
Per cent



Note. The area under each of the curves shows the probability of the repo rate falling within a certain interval.

Source: The Riksbank.

Figure B8. Uncertainty interval regarding the implied forward rate curve based on option prices.
Per cent



Note. The widest interval (dark blue field) shows the 75 per cent uncertainty interval. The narrowest interval (light blue field) shows the 25 per cent uncertainty interval and the field in between (medium blue field) shows the 50 per cent uncertainty interval.

Source: The Riksbank.

Summary

An important message in this box is that even if the Riksbank at a particular point in time were to judge that the implied forward rate curve used as the basis for the forecasts in the Inflation Report broadly speaking reflected a reasonable future development of the repo rate, there is still considerable uncertainty regarding economic development which means that actual developments in the repo rate could deviate from expectations. This box presents two different methods that attempt to quantify how uncertain future interest rate movements are.

The uncertainty interval regarding the implied forward rate curve used as the basis for the inflation forecast has in this Inflation Report been derived with the help of historical deviations between implied forward rates and the repo rate on the one hand, and option prices on the other. Both methods paint a similar picture; the uncertainty is already considerable for a time horizon ("forecast") of one year. For example, those uncertainty intervals based on option prices indicate that the market believes that the repo rate, with 50 per cent probability, will be somewhere in the interval 2.25–3.25 per cent one year into the future. The uncertainty interval rises noticeably as the time horizon increases.

14 As these estimates have been made on the basis of three–month interest rates, the spot rate for the first quarter is known.
15 It is important to remember that these uncertainty intervals, unlike the implied forward rate curve, have been derived from interest rates on bank securities and not government securities and that they moreover apply to three–month rates and not the overnight rate. However, these discrepancies should not have any material bearing on what the uncertainty intervals serve to illustrate here.