Estimating and interpreting interest rate expectations

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Expectations about future interest rates and inflation influence economic developments. For example, market expectations of higher inflation may themselves result in higher inflation, for instance through higher pay increases. Households' choice between consumption and saving is influenced by their expectations concerning future interest rates. A high level of short-term interest rates will probably have less of a contractionary effect on economic activity if the market believes this to be a transitory phenomenon than if it is expected to persist. Inflation expectations also reflect whether market participants are confident that economic policy will result in low inflation over time. One important source of information about these expectations is the market's pricing of interest-bearing securities with different maturities. This article describes the method used by Norges Bank for estimating interest rate expectations, and discusses how these estimates may be interpreted. In addition, the importance of various premia will be considered, and some alternative approaches for estimating interest rate expectations will be discussed.

Theories about the term structure of interest rates

There are several theories as to the determinants of the relationship between interest rates with varying maturities, often referred to as the term structure of interest rates. The expectations theory is probably the explanation most widely held. This theory is based on the assumption that market participants are risk-neutral and maximise the expected return without having specific preferences as to the maturity of their loans and investments. The interest rate on a long-term investment is therefore determined entirely by expected developments in short-term rates during the same period. If this were not the case, investors could achieve an expected excess return by raising long-term loans and reinvesting the funds in revolving short-term issues (or vice versa). Market participants' pursuit of this type of excess return ensures that the interest rate on long-term securities will always be an average of expected short-term rates. If the term structure of interest rates is determined by market expectations, these expectations may be inferred from the shape of the yield curve.

The liquidity preference theory is based on the assumption that market participants are averse to risk. The price of a bond with a long residual maturity will be more sensitive to interest rate changes than the price of a bond with a shorter residual maturity. The holding-period return on a bond is thus more uncertain the longer the residual maturity. Therefore, other things being equal, risk-averse investors will prefer to invest in short-term issues. To induce market participants to invest in long-term issues, they must be compensated in the form of a higher yield than the level implied by the expectations theory. This compensation, referred to as the term premium,[2] will increase with the term to maturity. Like the expectations theory, the liquidity preference theory implies that long rates are an average of expected short rates, but with the addition of a premium that depends on the term to maturity. Another complicating factor is that the term premium may not be constant over time.

The hedging pressure or preferred habitat theory assumes that market participants are highly averse to risk and that they wish to match the maturity of their investments to the maturity of their debt. Consequently, the market is split up into independent segments. Interest rates on securities of varying maturities are determined independently by supply and demand in the various market segments. According to this theory, it is meaningless to calculate market participants' interest rate expectations on the basis of the term structure of interest rates.

Implied forward rates and their interpretation

Implied forward interest rates can be calculated on the basis of observed interest rates on issues of varying maturities, ie the yield curve. Implied forward rates are interest rates between two dates in the future derived from the yield curve. If the expectations theory or the liquidity preference theory holds true, implied forward rates will reflect market expectations about interest rates, possibly adjusted for term premia. For example, the expected three-month rate three months ahead may be calculated on the basis of observations of current three-month and six-month rates. The slope of the yield curve at maturities between three and six months indicates whether the three-month rate is expected to rise or to fall. Whereas the yield curve shows the average expected interest rate in the period up to various dates, the implied forward rate expresses the expected interest rate on those dates. The reason for calculating forward rates is thus their practical interpretation rather than because they contain other information than that contained in the yield curve.

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[2] If the yield over time tends towards a "normal level", the term premium may be negative when the yield is high in relation to this "normal level". The price is then low and the probability of capital gains is high. The potential capital gain for a given rise in interest rates will then increase with the residual maturity.

There are a number of empirical studies of the expectations theory (for an overview see, for example, Browne and Manasse, 1990). Most studies reject the theory. This result is often attributed to the existence of a term premium which varies over time. In its pure form, the expectations theory poses the variation of long rates on a one-to-one basis with expected short-term rates rather than merely the existence of positive covariation between long-term and short-term rates. A number of studies find positive covariation, but must reject the theory even so. Rejection of the theory does not necessarily mean that the term structure of interest rates has no interest for monetary policy purposes. The variation in expected short rates may nevertheless explain a substantial part of the variation in long rates.

Interest rate expectations for the next few years will depend largely on the economic outlook and the market's perception of how the central bank sets its key rates. Expectations of growing pressures in the economy may, for example, generate expectations of higher interest rates – both nominal and real – if market participants are confident that the central bank will take steps to counter higher inflation. If such confidence is lacking, market participants may still expect higher nominal rates as a result of higher inflation expectations. Either way, this will be reflected in an upward sloping yield curve if the expectations theory holds true.

In order to be able to disentangle inflation expectations from nominal implied forward rates, it is necessary to assume that the expected nominal interest rate is approximately equal to the sum of the expected real rate and expected inflation (for further information see, for example, Frøyland, 1997). In the short term, interest rate expectations will be influenced by the cyclical outlook. However, in the long term, say ten years ahead, it seems unlikely that market participants have specific expectations about the cyclical situation. On this horizon it may seem reasonable to interpret the implied forward rate as the sum of the expected equilibrium values of the real interest rate and inflation, plus any risk and/or term premia.

Mishkin (1990) analysed the term structure of interest rates in the US using a model which assumed that the nominal interest rate is determined by the expected real rate and expected inflation, and that market participants have rational expectations about inflation developments. Based on observations of interest rates between 1964 and 1986, he found that the term structure for maturities of up to six months did not contain information about future inflation developments, but did provide information about the term structure of real interest rates. In the area from nine to twelve months, however, the nominal term structure started to provide information about future inflation, as well as, to a lesser extent, information about the term structure of real interest rates.

Schich (1999) used Mishkin's model to study the relationship between the term structure of interest rates and expected future inflation in the US, Germany, Canada, the UK, France, Italy and Japan. Schich found a significant relationship for the first four countries. The most informative maturity segments were further out on the yield curve than in Mishkin's study. The relationship, however, varied both across countries and over time. The variation over time was primarily attributed to shifts in the monetary policy regimes. Intuitively, it seems reasonable to assume that the information content of implied forward rates is related to monetary policy and financial markets' confidence in this policy. If monetary policy is oriented towards low inflation and has a high degree of credibility, the term structure is likely to contain little information about future inflation other than that implied by the central bank's inflation target. In this case, implied forward rates may reflect expected developments in real interest rates. Changes in the monetary policy objective may lead to changes in the information content of implied forward rates, while changes in the structure of financial markets and the degree of regulation may also change the information provided by implied forward rates over time.

If the relationship between the term structure and future inflation is not stable over time, nominal implied forward rates will not be a reliable indicator of future inflation developments. Some countries have established markets for real rate bonds where the interest rate is linked to a price index. This makes it possible to assess expected inflation by comparing yields on bonds with nominal and real returns. By comparing implied forward rates based on the two types of bond, it is possible to estimate developments in inflation expectations. No market for index-linked bonds exists in Norway. However, in a world with free capital mobility, it may be assumed that the real interest rate in equilibrium must over time show approximately the same development across countries (real interest rate parity). Differences between Norwegian and foreign long-term implied forward rates may thus be interpreted as differences in expected inflation plus any risk premium. If the risk premium does not vary to any great extent, changes in long-term implied forward rate differentials far in the future may be interpreted as changes in relative inflation expectations. The long-term implied forward rate differential may then to some extent reflect market participants' (relative) confidence in economic policy.

Since Norges Bank's December 1998 *Inflation Report*, implied forward rates have provided the basis for the technical assumption concerning developments in money market rates. This assumption influences Norges Bank's projections for economic developments in the years ahead. The projections in Norges Bank's *Inflation Report* can thus be interpreted as an assessment of the realism in the market's interest rate expectations.[3] The method used by Norges Bank for calculating implied forward rates is described in greater detail below.

[3] See the leader in Norges Bank's June 1999 *Inflation Report* for more information.

Calculation of implied forward rates

The simplest and most obvious method for calculating implied forward rates would be to calculate them directly from the observable yield curve. There are, however, a number of caveats associated with this approach. First, the yield curve consists of a limited number of observations, so that a simple calculation will not provide a continuous implied forward rate curve. It is necessary to find a method that can "fill in the gaps" in the yield curve in order to obtain a continuous curve without breaks. In addition, bonds along the yield curve pay a coupon rate, which represents a source of error if the yields are compared directly.[4] However, estimation of so-called zero-coupon yields makes comparison across different maturities possible. From a continuous function for the zero-coupon rates, it is relatively straightforward to calculate a continuous curve of implied forward interest rates. This curve always lies above the zero-coupon curve when the latter is rising, and below it when it is falling.

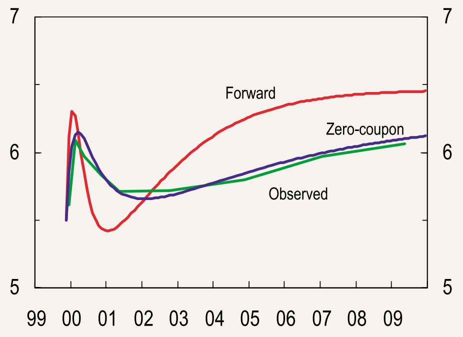
Like a number of other central banks, Norges Bank calculates implied forward rates using a parametric method developed by Nelson and Siegel (1987). This method is based on a pre-defined function. Among other things, the function is characterised by allowing for one hump or U shape along the implied forward rate curve as well as convergence towards a constant level in the long term. Svensson (1994) extended this method by adding a component in the function that allows for a second hump or U shape.[5] Norges Bank generally uses Svensson's extended model in its calculations, although both models are probably sufficiently flexible for monetary policy purposes. In the light of the interpretation of forward rates as expected interest rates, the assumption of convergence towards a constant interest rate level in the long term seems reasonable.

Svensson's function has six parameters (see Annex). Once these have been estimated, the function provides zero-coupon rates for all future points in time. The accompanying function for the implied forward rates is given by the derivative of the zero-coupon function. The implied forward rates have very short maturities and may be viewed as instantaneous rates or overnight rates.

Norges Bank uses observations of four money market rates and five government bond yields to calculate implied forward rates and zero-coupon rates for Norway. This gives a yield curve with nine points, with maturities varying from one month to approximately ten years. Chart 1 shows the observed yield curve and the calculated zero-coupon rate curve and implied forward rate curve on 22 November 1999.

In the short term, there are relatively large fluctuations in the curves, reflecting the markets' uncertainty in November 1999 about potential problems associated with the changeover to the new millennium. This uncertainty resulted in high implied forward rates around the end of the year. The chart illustrates the relationship between the zero-coupon rate and the implied forward rate. Since the zero-coupon rate is the average of the implied forward rates, the implied forward rate curve is always above the zero-coupon curve when the latter is rising, and vice versa.

Chart 1. Forward, zero-coupon and observed rates. 22 November 1999



In its inflation reports, Norges Bank uses implied forward rates as the technical assumption for the three-month money market rate. Since the calculated implied forward rates have maturities of less than three months, they are recalculated to a three-month moving average to facilitate comparison with three-month interest rates.

In some cases, the starting point for the estimated forward rate curve may deviate considerably from the observed level for the shortest money market rate. This makes it difficult to interpret the implied forward rates as expected short-term interest rates. In such cases, a restriction may be imposed in the estimation setting the starting point for the implied forward rate curve. The starting point may be set at the observed overnight rate. In Chart 1 above the starting point is set at Norges Bank's sight deposit rate.

The significance of risk and term premia

Various types of premia may cause implied forward rates to deviate from interest rate expectations. Examples of such premia include premia for the risk of exchange rate fluctuations, liquidity premia in markets with low turnover and term premia for long-term securities. Premia are often assumed to be positive and they may also vary over time. If this is the case, the implied forward rates will overestimate interest rate expectations by a factor that is not constant over time.

Term premia may be a relevant problem when measuring interest rate expectations. If the term premium is positive, the implied forward rate curve will be more

[4] Two bonds with the same maturity date but different coupon payments will not have the same redemption yield since they generate different cash flows and thus do not have the same value. This is often referred to as the coupon effect. Observed rates on coupon bonds must be expressed in a standardised manner before they can be used to calculate forward rates. This is accomplished by calculating zero-coupon rates. A zero-coupon bond is one that only provides payment on maturity, meaning that the redemption yield is determined by the bond price alone.

[5] Svensson's method is also referred to as Extended Nelson & Siegel.

upward-sloping – or less downward-sloping – than interest rate expectations would imply. On the basis of data for the US, the UK, Germany and Switzerland, Dahlquist (1997) finds evidence that there are relatively small, but positive, term premia. He also finds evidence that the term premium increases with residual maturity. This indicates that there is a positive difference between the implied forward rate and the expected interest rate and that this difference increases with maturity. Dahlquist's analysis also indicates that term premia vary over time. The variation may be explained in part by the shape and location of the yield curve. Dahlquist concludes, however, that the term premium changes fairly slowly over time, allowing changes in interest rate expectations to be reflected fairly well in the changes in implied forward rates. He also finds that term premia in different countries have a fairly strong positive correlation. This may indicate that varying term premia represent less of a problem in analyses of implied forward rate differentials between countries than when the level within one country is evaluated.

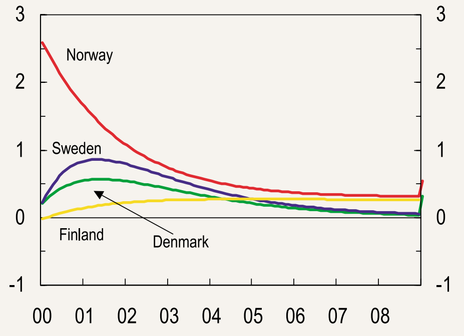
Risk premia linked to uncertainty about inflation trends may result in a premium on Norwegian interest rates in relation to foreign interest rates. For example, Norwegian long rates are generally higher than comparable German rates. This may reflect greater uncertainty about inflation trends in Norway, which, in turn, will foster uncertainty about developments in the krone exchange rate against the euro. This type of uncertainty must be compensated for by a higher yield. Liquidity factors may also be of significance: the Norwegian market is small compared with the German market, which makes it more difficult to buy or sell large blocks without affecting the market price. This also creates uncertainty that must be offset by a higher expected yield. Different degrees of credit risk will also give rise to premia. It seems unlikely, however, that credit risk is of particular significance in explaining yield differentials between Norwegian and German government bonds.

Forward rate differentials as a confidence indicator

The long-term implied forward rate differential between Norway and the euro area may be viewed as an indicator of confidence in Norway's monetary policy relative to that in the euro area. This long-term differential can be interpreted as the expected inflation differential in the long term plus a risk premium. The risk premium between Norway and Germany may reflect greater uncertainty about inflation trends in Norway than in Germany and a less liquid bond market in Norway. It is not possible to distinguish between these components in order to obtain an indication of the expected inflation differential between Norway and the euro area.[6] However, a comparison with other countries' differentials against Germany may be useful in this respect. Chart 2 shows the Nordic countries' implied forward rate differentials against Germany on 17 January 2000.

The chart shows that Norway's implied forward rate differential against Germany is substantially higher than that

Chart 2. Nordic countries' implied forward rate differentials against Germany. 17 January 2000



of the other Nordic countries in the short term. This reflects the fact that Norway was at a different stage in the business cycle and had a different monetary policy stance. Developments in the implied forward rates indicated, however, that Norway's interest rate differential was expected to approach that of the other Nordic countries within the next few years. Sweden's implied forward rate differential against Germany rose fairly markedly in the short term. This may be interpreted as expectations of higher resource utilisation and higher short-term interest rates in the Swedish economy than in the euro area. In the long term, both Sweden's and Denmark's implied forward rate differentials against Germany were close to zero. This may reflect confidence in monetary policy and possibly also expectations that these countries will join EMU within the next ten years.

Finland had a small, but positive, implied forward rate differential against Germany, except in the very short term. This may seem odd considering that both Finland and Germany are members of EMU and thus have a common currency and common monetary policy. There should therefore be no risk premium arising from expected inflation differentials[7] or exchange rate fluctuations. The differential may reflect different credit risk profiles, although the difference is probably relatively small as long as the calculations are based on government bonds. This leaves liquidity differences between the two bond markets as an important explanation for the long-term forward rate differential.

Norway's long-term implied forward rate differential versus Germany was on a par with Finland's, but higher than that in Sweden or Denmark, probably reflecting less liquid bond markets in Norway and Finland than in Sweden and Denmark. This may also be an indication

[6] Both a higher expected inflation differential and a higher inflation risk premium reflect deteriorating confidence in monetary policy. Therefore, distinguishing between these components is not crucial as long as the long-term forward rate differential is used to assess confidence in monetary policy.

[7] Although both Finland and Germany are members of EMU, the inflation differential at a given point in time may not always be zero. In the long term, however, it is likely that market participants expect the same inflation rate in the two countries.

that market participants considered it less likely that Norway will join EMU within the next ten years than they did in the case of Sweden and Denmark.

Such comparisons of implied forward rate differentials can prove useful when assessing changes over time in Norway's long-term implied forward rate differential versus Germany. If, for example, the differential for Norway should increase substantially without a corresponding increase in Sweden, Denmark or Finland, the increase might be interpreted as a sign of deteriorating confidence in Norway's monetary policy. On the other hand, an observation of contemporaneous increases in the other Nordic countries' differentials versus Germany would suggest that international developments, rather than Norwegian conditions, were the cause.

However, changes in the long-term implied forward rate differential must not be overly interpreted. The differentials are derived from estimates and there will always be a margin of error in the underlying estimates. In some cases, the shape of the function used may be ill adapted to the observed interest rates, and this may affect the long-term differential.

Evaluating the procedure for calculating forward rates

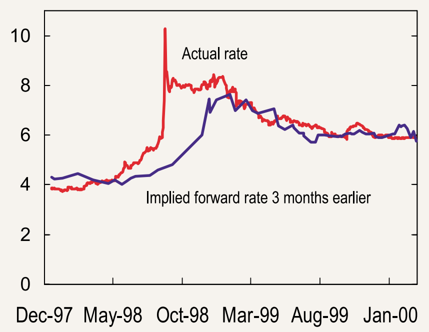
a) How well do implied forward rates reflect interest rate expectations?

When estimating expectations, it is not possible to provide a fully adequate evaluation of the estimates. Expectations cannot be observed, they are constantly changing as new information becomes available, and they can deviate substantially from the actual outcomes ex post.

Chart 3 compares actual movements in the three-month money market rate with the implied forward rate calculated on the basis of market rates observed three months earlier. For the period considered, the implied forward rate has by and large been reasonably good at predicting the evolution of the money market rate. Not surprisingly, the steep interest rate rise in short-term interest rates in the autumn of 1998, which was associated with exchange rate market turbulence, was not predicted by the implied forward rate three months earlier. If we disregard that period, and the time it took for the implied forward rate to adjust to the shock, it appears that the implied forward rate was by and large quite close to the actual rate three months later. There are no signs of the implied forward rate being systematically higher or lower than actual developments. However, this does not provide a sufficient basis for any clear-cut conclusion as to how well implied forward rates reflect interest rate expectations.

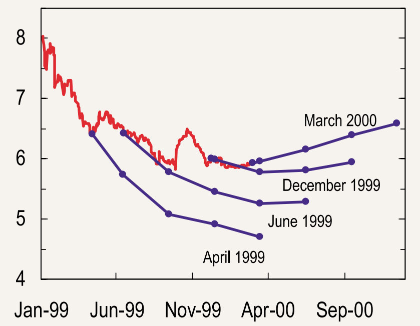
Forward rate agreements (FRAs) provide a directly observable expression of (average) market interest rate expectations. The FRA market enables agents to borrow or invest money at a given interest rate from an agreed date in the future. On the agreed date, the parties to the agreement exchange the difference between the agreed

Chart 3. "Predicted" and actual three-month money market rates. December 1997 - February 1999



interest rate and the prevailing money market rate. Hence, an FRA may be seen as a kind of wager between two parties as to the expected money market rate on the maturity date. At the same time, FRAs are a hedging instrument. The various financial institutions quote FRA rates continuously with maturities from four specific dates in the year ahead.[8] FRAs with maturities of three, six or twelve months may be concluded as of any of these dates. Chart 4 illustrates the evolution of the three-month money market rate between January 1999 and March 2000, together with some observations of three-month FRA rates in the same period.

Chart 4. Three-month money market interest rate and FRA rates. January 1999 - March 2000



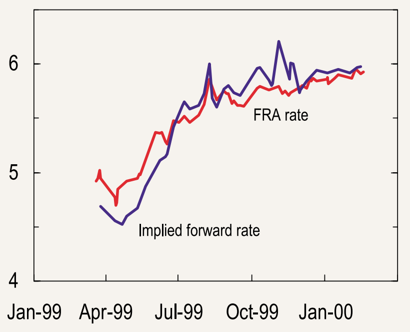
Each of these curves may be seen as expressing the anticipated movements in the three-month rate approximately one year ahead seen from the observation date. However, FRA rates are by no means a foolproof indicator of actual interest rate expectations in the market. FRAs allow market participants to hedge against interest rate fluctuations. As such, participants may be willing to pay for this insurance by borrowing at higher rates or

[8] The contracts run from the International Money Market (IMM) dates, which are international dates for the maturity of financial contracts. These dates fall on the third Wednesday of March, June, September and December each year.

investing at lower rates than the level expected. In addition, FRA rates may be affected by premia. Factors of this nature mean that the FRA rates quoted may deviate from true interest rate expectations.[9] Nevertheless, it is likely that FRA rates are normally fairly close to average market interest rate expectations on the relevant dates. If the deviations become too great, one of the parties would suffer considerable losses. This provides an incentive to "guess correctly".

The rates quoted in the FRA market can be compared to the implied forward rates calculated by Norges Bank. If the implied forward rates show consistent and substantial deviation from FRA rates, it may be a sign that the former do not give a very good indication of interest rate expectations. Since FRA quotations are only available one year ahead, the implied forward rate curve can only be checked in this way at the very short end. Chart 5 shows how the three-month rate expected to prevail in March 2000 evolved between March 1999 and January 2000, when measured on the basis of the FRA rate and the implied forward rates respectively. The two curves show fairly similar movements, indicating that expectations concerning the interest rate level in March 2000 were gradually raised through 1999. However, it may be noted that during the early part of the period, the implied forward rate remained markedly lower than the FRA rate. This was probably related to the shape of the yield curve. In the first half of 1999, the yield curve showed a steep negative slope for maturities up to two years. A steep negative slope of the yield curve is amplified in the implied forward rate curve. Throughout this period, very short-term forward rates remained higher than FRA rates, while the situation was the opposite for maturities up to one year ahead. We conclude that when there is a steep downward slope of the yield curve, there may be a tendency for implied forward rates to overestimate interest rate expectations in the very short term and to underestimate them in the slightly longer term. In the second half of 1999 the yield curve was somewhat flatter, and during this period there was closer accord between the implied forward rates and FRA rates. October and November 1999 saw considerable fluctuations in implied forward rates, and they were on occasions considerably higher than FRA rates. This may be due to the interest rate volatility associated with the transition to the new millennium, which may have influenced calculations of implied forward rates to a larger extent than the directly observed FRA rates.

Chart 5. Implied forward rate and FRA rate for March 2000. March 1999 - February 2000



b) Implied forward rates calculated on the basis of other data

The implied forward rates discussed so far were calculated on the basis of money market rates with a maturity of one to twelve months and government bond yields with a residual maturity of ½ to 9½ years. However, the credit risk in the money market is greater than that associated with government debt instruments. As a result, money market rates are normally higher than comparable yields on government securities. If the implied forward rates are to reflect interest rate expectations correctly, the credit risk along the curve underlying the calculations should be constant. Otherwise a change in the credit risk premium along the curve may be misinterpreted as a change in the expected interest rate. If the credit risk premium falls markedly at the point of transition from money market rates to government bond yields, ie when the term to maturity exceeds one year, the implied forward rate curve may display a negative slope around this point, even if market rates are expected to remain unchanged during this period. Moreover, the credit risk premium may vary over time. The difference between interest rates on loans to private borrowers and central government tends to increase in times of financial market turbulence, which will amplify the problems described above.

There are basically two possible approaches whereby the potential distortion due to different credit risk may be eliminated. The first option is to base calculations on a yield curve consisting solely of the interest private borrowers have to pay on their loans. The alternative is to use yields on government debt issues for all maturities.

A yield curve consisting entirely of private interest rates can be constructed using the fixed interest rate offered on interest rate swaps instead of government bond yields. The European Central Bank, for instance, uses these long-term private interest rates when estimating implied forward rates. Using private interest rates for all maturities makes it more natural to interpret the implied forward rates as expected money market rates. Another advantage of using this kind of data is that the number of observations along the yield curve increases, making for more accurate estimates. On the other hand, the credit risk premium component of interest rates on loans to private borrowers is probably substantial. This credit risk premium is liable to increase in line with the maturity: if there is a non-zero probability that the

[9] In order to avoid the possibility of arbitrage, FRA rates and implied forward rates in the money market must be subject to the same effects of any risk and term premia.

borrower will go bankrupt, the likelihood of this occurring during the term of the loan will be greater the longer the term to maturity. A rising credit risk premium will contribute to an upward bias in the estimates of expected interest rates obtained from implied forward rates, and the error will increase in line with the time horizon. No attempt was made to correct for this type of disturbance in the following discussion.

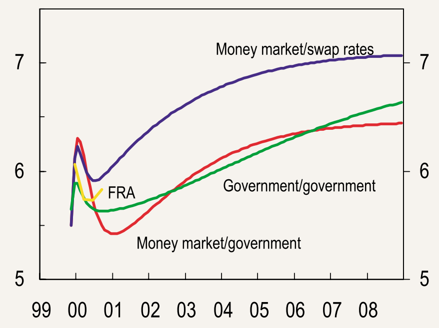
A yield curve consisting of yields on Treasury bills at the short end and government bonds further out will also have the same credit risk over the entire curve. The credit risk premium on these government debt issues is probably equal to, or very close to, zero. This implies that the problem associated with credit risk which increases with the loan's maturity is unlikely to be of any relevance. The use of government bond yields for all maturities may suggest that the implied forward rates should be interpreted as expected movements in Norges Bank's key rates, rather than money market rates. The Swedish central bank bases its implied forward rate calculations on government bond yields, and interprets the resulting rates as expected movements in its key rate (repo rate).

At any given time there are four or five outstanding Treasury bills in the Norwegian market, generating roughly the same number of observations as those used by Norges Bank in its calculations based on money market rates. Liquidity in the secondary market for Treasury bills has improved in recent years, and has probably reached a level at which these yields could viably be used as the basis for calculations. An additional advantage of using yields on Treasury bills rather than money market rates is that the prices quoted in the Treasury bill market are binding, whereas interest rates observable in the money market are indicative. This implies that observed yields on Treasury bills should provide a better picture of actual market rates. On the other hand, it is more difficult to find comparable figures for other countries on the basis of yields on Treasury bills than on the basis of money market rates. As Norges Bank uses forward rates to a large extent for international comparisons, the use of money market rates at the short end may still be preferable.

Chart 6 compares three different implied forward rate curves for 22 November 1999. The red curve is based on money market rates and government bond yields, and corresponds to that used by Norges Bank in its inflation reports. The blue curve is based on money market rates and the fixed interest rate component of interest rate swaps with maturities of up to ten years. The green curve is based on Treasury bill and government bond yields. The yellow curve shows three-month FRA rates.

All three curves rise in the very short term and fall after the end of 1999. This probably reflects that markets expected high short-term interest rates around the end of the year owing to uncertainties relating to potential problems associated with the changeover to the new

Chart 6. Implied forward rates based on various inputs. 22 November 1999



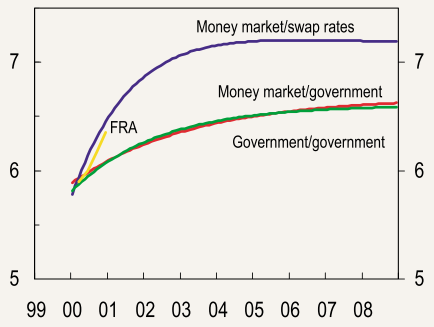
millennium (Y2K). The chart shows, however, that yields on government paper were less affected by these fears, as the green curve is flatter than the others in the short term. This probably indicates that the credit risk in the money market rose significantly as a result of Y2K concerns, while the effect on Treasury bills was relatively small. As might be expected, the blue curve, showing implied forward rates based solely on private interest rates, is higher than the others, probably reflecting higher credit risk premia.

In the short term the red curve falls much more steeply than the blue curve, despite the fact that these two curves are based on identical interest rate observations for maturities up to one year. This may indicate that the red curve falls more steeply than implied by interest rate expectations owing to the change in credit risk in the transition from money market rates to government bond yields.

At no point along the curve do the implied forward rates calculated on the basis of private interest rates drop below 5.9 per cent. This may appear somewhat high given that the three-month money market rate at that point was just over 6 per cent, and that FRA rates and market participants' interest rate forecasts indicated expectations of lower rates within a one-year horizon. This may signal that the implied forward rates based solely on private interest rates overestimated interest rate expectations.

Considering that the green and red curves in the chart are based on exactly the same observations for maturities of over one year, the difference between the end points of the two curves is quite considerable. The explanation for this is probably related to the method used. The red curve seems better in the sense that it converges towards a constant long-term level at an earlier stage than the green curve. This may be the case because the shape of the function used in the estimations (see Annex) was better suited to observations of the combination of money market rates and government bond yields than to observations of government bond yields alone. However, this only applies to the observations on that

Chart 7. Implied forward rates based on various inputs. 17 January 2000



particular day, and is not a general feature of this method (see Chart 7).

In the long term, the blue curve, based on private interest rates only, shows a considerably higher level than the other two curves. For December 2008, the difference between the implied forward rates based only on private interest rates and the ones based on a combination of money market rates and government bonds yields is 0.7 percentage point. A similar calculation based on German data produced a difference of 0.2 percentage point in the long term, giving a difference in implied forward rates between Norway and Germany when calculated on the basis of private interest rates almost twice as large as when calculated on a combination of private interest rates and government bond yields. This may be attributable to a more liquid interest rate swap market in Germany than in Norway, or to lower credit risk premia on long-term loans to private borrowers in Germany than in Norway. However, the possibility of the substantial difference in credit spread being due to factors of a purely temporary nature cannot be ruled out.

Chart 7 shows the same implied forward rate calculations, carried out on 17 January 2000. In these calculations the difference between the implied forward rates calculated on the basis of money market rates and government bond yields and the ones calculated solely on the basis of yields on government debt issues is far smaller. This may indicate that the problem of varying credit risk was particularly prominent in late 1999, in a period marked by great uncertainty associated with Y2K. As was also seen in Chart 6, the forward rates calculated on the basis of private interest rates only are much higher than the two other curves, and they probably overestimate interest rate expectations in the long term. However, Chart 7 also shows that FRA rates at this point were much closer to private forward rates than the two other curves. One possible interpretation is that the private forward rates reflected interest rate expectations more accurately in the short term than the two other forward rate curves. Alternatively, it may be that FRA rates and private forward rates are affected by the same premia, and that both overestimated interest rate expectations.

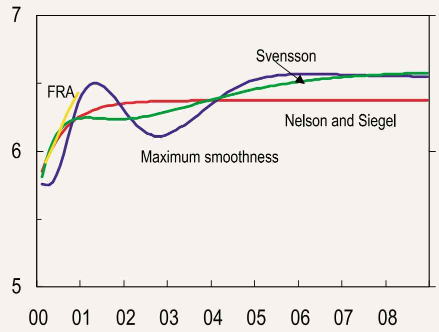
Alternative method for calculating implied forward rates

Nelson and Siegel (or Svensson) is just one of many methods developed for calculating zero-coupon rates and implied forward rates. For an overview of other methods, see for instance Deacon and Derry (1994). One method preferred by a number of market participants in Norway is the maximum smoothness method. This method is based on adapting a curve which consists of sub-functions for the various time intervals, rather than estimating a single curve as in Nelson and Siegel or Svensson. The maximum smoothness method ensures that the zero-coupon rates calculated are consistent with observed market prices for interest-bearing securities. This means that the zero-coupon rates calculated must be such that using these to discount the various bonds' cash flows results in prices (present values) which are equal to the observed market prices. At the same time, the zero-coupon curve must be as smooth as possible. For a more detailed description of this method, see for instance Bjerksund and Stensland (1996).

Using Nelson and Siegel or Svensson, the zero-coupon rates calculated will not normally be fully consistent with observed market prices. These methods are therefore less suitable for assessing market pricing of the individual securities along the yield curve. On the other hand, Nelson and Siegel or Svensson generate forward rate curves which are by and large smoother and with fewer humps than the maximum smoothness method. For monetary policy purposes, fully accurate pricing of individual securities is not required to the same extent – some precision may be exchanged for a smoother forward rate curve which captures the main features of the term structure and is easier to interpret.

The maximum smoothness method nevertheless represents a valuable supplement to Nelson and Siegel or Svensson when assessing the term structure of interest rates. Chart 8 shows forward rate curves for 14 February 2000 calculated using the three different methods. The calculations are all based on the same observations of money market rates and government bond yields. The chart illustrates how the maximum smoothness method provides information about the extent to which humps or U shapes in the term structure are "evened out" by the other two methods. Such humps may result from special supply/demand conditions in the market. For the purpose of monetary policy analysis it may be appropriate to ignore these humps and U shapes, refraining from interpreting them as interest rate expectations. On the other hand, they may be an indication of actual interest rate expectations, in which case it would be appropriate to take them into consideration. In general it is not possible to separate these cases, and assessment must therefore be based on closer examination of market conditions.

Chart 8. Implied forward rates calculated using different methods. 14 February 2000



Irrespective of whether any humps in the term structure of interest rates are attributable to particular market conditions or reflect interest rate expectations, it is important to be aware of their presence. The reason for this is that even though Nelson and Siegel or Svensson to a great extent "even out" humps of this type, the calculations can be distorted by them. Chart 8 shows that the long-term forward rate is approximately 0.2 percentage point lower in the Nelson and Siegel-based calculation than in the calculations based on Svensson and those based on the maximum smoothness method. This is probably because the Nelson and Siegel curve levels off after around two years. The entire flat portion of the curve seems to be "dragged down" by the fall which the maximum smoothness curve shows in the area between 2001 and 2003. In this respect, Nelson and Siegel may be said to produce a term structure which is too smooth, and which probably shows a long-term implied forward rate that is too low. In the absence of calculations based on other methods, this would be difficult to see. The chart also shows that Svensson's method is sufficiently flexible to avoid this problem.

It would not appear reasonable simply to interpret the fall in implied forward rates between 2001 and 2003 as expectations of falling short-term rates during this period. An alternative interpretation could be that the fall is a result of varying credit risk, since the calculations are based on a combination of money market rates and government bond yields. However, a comparable calculation based exclusively on government securities showed an implied forward rate curve with a similar shape. As such, it appears probable that the fall in forward rates is ascribable to particular supply/demand conditions linked to one or more of the bonds in the maturity segment in question. In certain countries, tax rules are linked to the size of the bond's coupon payment. Other things being equal, these tax rules make low coupon rates more favourable than high coupon rates. This can result in higher prices, and hence lower yields on bonds with a low coupon rate. The government bond maturing in 2004 has a relatively low coupon rate, and this could account in part for the shape of the implied forward rate curve.

Summary and conclusions

On the assumption that the expectations theory holds true, implied forward rates reflect market expectations concerning movements in short-term interest rates. However, most empirical studies in the literature reject the expectations theory, at least in its pure form. A widely held explanation is that positive term premia exist which increase in line with the term to maturity, and which vary over time. These premia result in a variable deviation between the implied forward rate and the expected interest rate. Despite widespread rejection of the expectations theory, evidence suggests that a considerable portion of the variation in long-term rates is attributable to expectations of developments in short-term interest rates. However, the existence of premia means that implied forward rates should be interpreted with a degree of caution, particularly with regard to the level of expected interest rates. The presence of term premia is probably less of a problem when assessing changes in implied forward rates between different points in time, or when analysing differences in implied forward rates between countries. However, it seems clear that there is potential for improving estimates of interest rate expectations by adjusting them for various types of premium. Further work is, however, necessary in this field.

Simple comparisons of implied forward rates for the near term and actual movements in interest rates do not produce clear indications that the implied forward rates calculated by Norges Bank systematically overpredict or underpredict developments in interest rates, nor is there any sign of systematic deviation in relation to FRA rates. Substantial deviation can occur, however, at certain times. Consequently, when assessing interest rate expectations, implied forward rate calculations should be supplemented by observations of FRA rates and other available information.

Implied forward rates calculated on the basis of money market rates and government bond yields will have varying credit risk for short and long maturities. Such changes in credit risk across different maturities are in danger of being misinterpreted as changes in the expected interest rate level. This problem appears to be of importance in periods of uncertainty in the markets, exemplified by the period prior to the changeover to the new millennium, whereas in more normal periods the difference in credit risk would appear to be of less significance. There is nonetheless a case for basing implied forward rate calculations exclusively on interest rates/yields with the same credit risk profile, ie to use either yields on government debt issues or interest rates on private loans, rather than a combination of the two. Calculations based solely on private interest rates would appear to generate implied forward rates which vary a good deal over time, with an accompanying tendency to overestimate interest rate expectations in the long term. One important explanation of this phenomenon is probably credit risk premia which vary across the maturity spectrum and over time. There is less of a problem associated with implied forward rates calculated on the basis of government securities alone. However, finding comparable international figures for Treasury bill yields proves more difficult than for money market rates. The use of implied forward rate calculations for international comparisons, coupled with the seemingly moderate significance of varying credit risk, tends to favour continued use of the current method. A switch to forward rates based exclusively on yields on government debt issues would necessitate a closer study of government securities markets in those countries commonly included in our comparisons.

Annex

This annex contains a brief technical description of Svensson's model for calculating implied forward rates. This description is based on Söderlind and Svensson (1996). Let *f(m)* be the instantaneous forward rate at a future date *m*. In Svensson's model the forward rate function is:

$$f(m;b) = \beta_0 + \beta_1 \exp\left(-\frac{m}{\tau_1}\right) + \beta_2 \frac{m}{\tau_1} \exp\left(-\frac{m}{\tau_1}\right) + \beta_3 \frac{m}{\tau_2} \exp\left(-\frac{m}{\tau_2}\right)$$

where $\beta = (\beta_0, \beta_1, \beta_2, \tau_1, \beta_3, \tau_2)$ is the vector of parameters to be estimated. Once the parameters have been estimated, the function gives the instantaneous implied forward rate at all future points in time m. The parameters β_0, τ_1 and τ_2 must be positive. Svensson's function is a sum of four components. The first component is a constant, β_0. This is the horizontal asymptote of the function, and may be interpreted as the constant level the implied forward rates approach in the long term (when m is high). This must consequently be positive. The second component, $\beta_1 \exp(-m/\tau_1)$, is monotonically decreasing (or increasing, if β_1 is negative) towards zero when the term to maturity *(m)* is increasing. When the term to maturity approaches zero, the forward rate approaches the constant $(\beta_0 + \beta_1)$, which must be non-negative to ensure that the instantaneous interest rate at this point (the starting point of the curve) is non-negative. The third component generates a hump on the curve (or a U shape, if β_2 is negative) as a function of the term to maturity. The fourth component is also a hump or a U shape. The function thus allows for two local humps or U shapes. The shape of the function in Nelson and Siegel's model is almost identical to Svensson's, except that it does not include the fourth component. This means that the Nelson and Siegel function can only have one hump or U shape.

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