Financial market prices as monetary policy indicators

Following the emergence of new financial markets and new analysis techniques, interest in financial market prices as monetary policy indicators has increased considerably in recent years. This article deals with the use of financial market prices for measuring market expectations and as forecasting instruments for monetary policy, illustrating them by selected examples. It is found that the observation and analysis of financial market prices provide the central bank with important information on market players' assessment of current conditions in terms of, say, the outlook for interest rates, exchange rates and inflation. However, appropriate interpretation requires financial market prices to be analysed in the broad context of other indicators. They are not, on the other hand, suitable as central orientation variables, let alone target variables for monetary policy, as they in turn are determined to a large extent by expectations of future monetary policy.

The significance of indicators in monetary policy

Requirements

Like other monetary policy target variables, central bank measures influence the overall level of prices only indirectly and with long and variable time lags. To be able to identify inflationary risks at an early stage and assess the impact of its policy on an ongoing basis, the central bank therefore depends on monetary policy indicators that enable it to make a reliable analysis of market conditions. A case in point is the money stock M3, which the Bundesbank uses as a key indicator and an intermediate target for its policy. On the one hand, it enables the monetary policy stance to be assessed and, on the other, it indicates the extent to which current monetary expansion poses risks to price stability. To be able to support the monetary policy decision-making process, indicator variables must measure the relevant influences "correctly", i.e. as precisely as possible and without being distorted by other factors. Finally, up-to-date indicators should be available, to ensure a swift reaction by the central bank.

Financial market prices ideal ...

Financial market prices – such as money and capital market rates, equity quotations or exchange rates – are available on an ongoing basis and can be measured relatively simply and accurately. These "technical" characteristics alone make them appear to be ideal indicators. In economic terms, financial market prices are attractive indicator variables since, being financial variables, they are relatively closely related to monetary policy, are indicative of market agents' expectations and can also be used for forecasting purposes.

... as indicators of expectations ...

The great weight which expectations carry in price formation in the financial markets results from the fact that financial relations are invariably directed towards the future. This forces rationally-acting market players to assess the future course of the value of their assets or liabilities and consider the development of factors which are relevant to prices. For example, an investor locking in funds at long term will try to assess the future trend in inflation in order to be able to gauge the real yield to be expected and compare it with that of other assets. Financial instruments enable not only "pinpoint expectations", such as expectations of the future interest or price level, to be measured. They can also provide information on the uncertainty involved in expectations; such measures of uncertainty can be derived, in particular, from option prices.

... and for forecasting purposes

Irrespective of the crucial importance of expectations for price formation in the financial markets, interest and exchange rates play a key role in the transmission of monetary policy stimuli. Interest or exchange rate movements have an impact on aggregate demand via income, substitution and wealth effects. Price changes in the financial markets trigger changes in the transmission process of downstream variables, such as output and the price level, which is reflected in a corresponding lead. The analysis of "traditional" financial market variables, such as the interest rate level, is based on this. However, the predictive content of financial market indicators is not necessarily attributable to causal relationships but may equally well reflect correct expectations in the financial markets as to the development of other factors. For example, rising equity prices may mirror an improved outlook for industrial exports due to a changed exchange rate situation without the equity market rally being responsible for a subsequent actual export boom. Prices in relatively small financial markets, too, which tend to be insignificant for the transmission process, may therefore basically have a high predictive content.

Structural change increases interest in financial market indicators

Rapid technological progress, and market participants' changed behavioural patterns, have considerably increased interest in financial market prices as monetary policy indicators in recent years. Firstly, the advance of electronic information, trading and settlement systems has tremendously speeded up financial transactions and reduced their cost. This has led to information being available earlier, being translated into market transactions more quickly and therefore also working through to prices more quickly. Secondly, computerisation has paved the way for the emergence of efficient futures markets. Moreover, the financial markets are now dominated by institutional players for whom it is efficient, because of the lot size advantages they enjoy, to apply considerable resources to the procurement and processing of information and to convert even minor changes in expectations into market transactions. Finally, with the progress being made in financial market research and the spread of new instruments, increasingly complex variables are now being used alongside the traditional "simple" indicators.

Financial market prices as indicators of expectations

The construction of expectation indicators …

Indicators based on financial market prices can be used to measure financial market agents' expectations. In terms of monetary policy, it is particularly interesting to obtain information on interest rate expectations and the market perception of the outlook for inflation. For an indicator to have a high "expectation content" it must, for one thing, be significantly determined by market expectations, and, for another, reflect a measuring concept which makes it possible to sift out such expectations from financial market prices with sufficient accuracy or with as little distortion as possible. The interpretation of the indicator will depend on the measurement concept used, which as a rule is based on a particular theory.

… requires the identification of suitable markets and measuring concepts

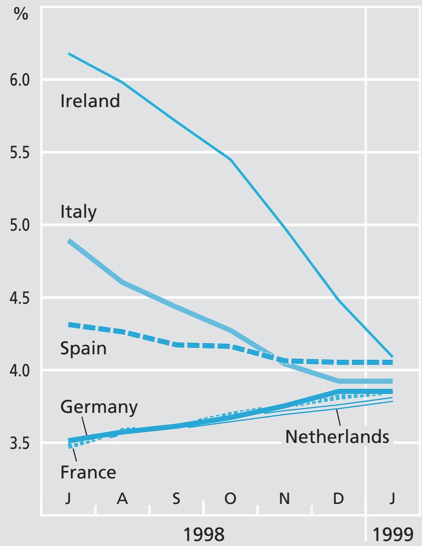
The use of expectation indicators in the implementation of monetary policy may be impeded, firstly, by the impact of expectations being reflected in prices only with distortions because of market imperfections. Admittedly, as a rule the high reaction speed, the virtual homogeneity of the goods traded and the very large number of market participants bring financial markets comparatively close to the ideal of perfect and hence frictionless markets. However, factors such as a low degree of liquidity may encourage price movements that are not attributable to changed expectations. It is therefore necessary to identify suitable market segments for deriving expectation indicators. This is made easier by the structural changes mentioned at the beginning of this article, which have led to deeper financial markets, and by the emergence of efficient futures markets. They increase the liquidity of the corresponding spot markets, too, by low transaction costs and enhanced arbitrage opportunities. This should make price formation smoother, and hence more efficient in terms of information, at least in periods of low tension.

"Direct" …

A second difficulty is the search for a suitable measurement concept. This presents few

Market expectations for three-month rates in selected countries participating in EMU *

Position: July 9, 1998



* FRA rates; for Ireland, the Netherlands and Spain implicit forward rates derived from swap rates.

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problems only in the case of futures market instruments, where financial contracts are designed in such a way that expectations themselves are directly traded, and therefore can be measured directly. For instance, in the case of Forward Rate Agreements (FRAs) the interest rate is fixed today for a money market transaction in the future. An FRA quotation for three-month funds in three months (FRA 3-6) can therefore be interpreted direct as a corresponding interest rate expectation. One example of the application of these "explicit" forward rates in the money market is presented in the chart on this page, which shows the convergence expected by the market of interest rates up to the beginning of monetary union in the countries participating in EMU. The presentation in the form of FRA rates for different dates until the beginning of 1999 can be interpreted as the expected adjustment path of money market rates.

... and "indirect" measuring of market expectations

In perfect markets, spot prices contain the same information as the corresponding quotations in the forward market. If this were not so, there would be arbitrage possibilities which would be exploited by informed market participants. Thus spot prices may be construed as a "bundle" of expectations covering the period from the present to the maturity of a financial contract; information on the expectations for particular time horizons or price components can be "extracted" only by falling back on theoretical assumptions. A relatively simple approach to this indirect measuring of expectations is to look at the prices of instruments which are similar except for one feature – say, the maturity or issuer. The analysis is based on the assumption of perfect markets which are in an arbitrage equilibrium. Price differences can then be assigned to particular features and interpreted as related expectations, for example about interest rate movements or the default risk posed by a borrower.

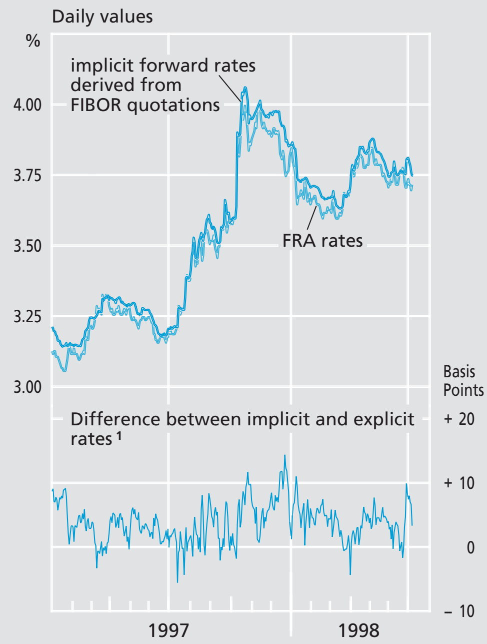
Example: forward rates in the money market ...

A standard application is the computation of implicit forward rates from spot interest rate structures in the money or capital market. It is based on the assumption that, given an arbitrage equilibrium, the interest earned on a longer-term asset must be equal to the expected return on successive short-term assets. Thus the three-month rate, for example, equals the average of the current one-month funds rate and that expected for the next two months. A comparison of the "explicit" forward rates of Deutsche Mark FRAs and the implicit forward rates in the Deutsche Mark money market suggests that arbitrage works almost perfectly here; as a rule, both indicators show only minor deviations of a few basis points (see the adjacent chart). The fact that all of the implied rates are slightly higher may be partly attributable to differences in timing and price formation procedures; thus the FRA quotations shown here are the mean of bid and offer rates, whereas FIBOR is derived from offer rates. Fluctuations in the interest rate differential may also be caused by differences in liquidity, market-specific risks, transaction costs or other institutional conditions which have a differing impact on price formation in the two market sectors.

... and in the capital market

The interpretation of the forward rates is made more difficult, however, by interest rate components which do not directly reflect interest rate expectations. These include, in particular, various risk premiums which vary over time, and may change the yield curve. Such interest rate movements also have an impact on implicit forward rates computed from spot rates; they suggest changes in expectations regarding the path of short-term interest rates and the future course of monetary policy, even though interest rate expectations may not have changed at all. A case in point is the flattening of the yield curve in the German capital market since the autumn of 1997, which has resulted in the implicit forward rates having fallen since then by about 1 percentage point (see the chart on page 54). In view of the massive capital inflows to the German bond market in the wake of the crises in east Asia, it seems obvious that this shift is due at least in part to a "risk deduction" for safe investments – i.e. lower risk premiums – and not solely to changed interest rate expectations.

Explicit and implicit forward rates for three-month funds



1 Implicit forward rates less FRA rates.

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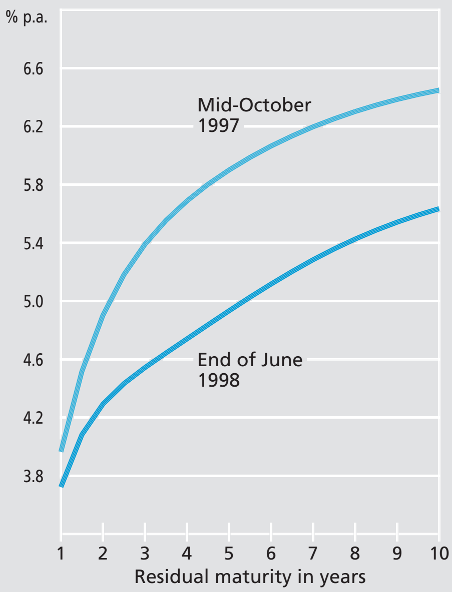
Interest rate parities in the exchange market

Simple arbitrage relationships can basically also be used to measure exchange rate expectations. Using the covered and uncovered interest rate parity – according to which the expected return on domestic assets and on foreign assets hedged against exchange rate risks or unhedged foreign assets must match – indicators of exchange rate expectations can be derived from quotations in the spot and forward exchange markets. On these assumptions, the swap rate, i.e. the percentage deviation of the forward rate from the spot rate, matches the expected exchange rate change over the period of the forward contract.

Implicit one-year forward rates in the German capital market *



* Derived from estimated yield curves.

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Measuring inflation expectations using index-linked bonds ...

The construction of expectation indicators is distinctly hampered if not only expectations regarding the indicator itself but also price-determining fundamentals are to be measured. Of particular interest in terms of monetary policy are inflation expectations. The Fisher theorem provides a simple theoretical basis for their derivation from financial market prices; according to this theorem, the nominal interest rate is derived from the expected real interest rate and a compensation for the expected inflation rate. In some countries – such as the United Kingdom and the United States – direct observation of real interest rates in the market is possible in the case of bonds hedged against inflation (index-linked); comparison with the yields of traditional bonds allows conclusions to be drawn about inflation expectations.

... or on the basis of differing assumptions about real interest rates

Without the yields of index-linked bonds, the level of the real interest rate and its future development path have to be estimated; this means that further assumptions are necessary to determine them and compute inflation expectations. These assumptions may be simplifying – say, by assuming constant real rates of interest – but they may also be based on empirical estimates. Compared with the use of variables observable in the market and simple arbitrage calculations, estimations invariably involve the problem of the price formation process having to be depicted correctly. Especially at times when structural breaks and hence basic changes in expectation and price formation processes cannot be ruled out, there is a growing risk of such model-based indicators being considerably distorted.

Indicators of price uncertainty derived from option prices

One indicator of expectations which is based on a largely standardised valuation model for options is implicit volatility. It supplements "pinpoint expectations", such as those based on the term structure of interest rates, by a measure of the strength of the price fluctuations expected over the life of an option, and hence of the uncertainty prevailing in the market. Expected volatility is a price component of the commonly used option price models; it can be calculated implicitly as the other variables used in determining the option price are known. Expected probabilities of specific events may also be determined for different option strike prices on the basis of a much more general pricing model.[1]

1 See Deutsche Bundesbank, The information content of derivatives for monetary policy, Monthly Report, November 1995, pages 17–32.

Financial market prices as forecasting variables

Predictive content

Financial market indicators may also be used to forecast the future development of particular macroeconomic variables which are of special interest to monetary policy. For example, the term structure of interest rates – measured as the simple difference between a capital market rate and a money market rate – is often used to predict the growth path of the economy, i.e. as a leading cyclical indicator. As in other cases, it is not clear here, either, on what the "predictive content" of the term structure of interest rates for economic activity is actually based. Without a plausible idea of the economic transmission channels on which the statistical lead properties are based, from the standpoint of monetary policy, predictive variables cannot be interpreted reliably, and can therefore be used to a limited extent only.

Reviewing the predictive content

Another problem is the selection of an appropriate statistical procedure for assessing the predictive content (see the adjacent box). The predictive fitness of the indicator may be over- or underrated if an unsuitable method is used. The assessment of the predictive content of an indicator or indicator system is therefore geared to the statistical description of the forecasting errors, i.e. to a comparison of the values forecast and their realisations. In this context, the degree of absolute and relative predictive accuracy is of particular interest.

The expectation content and the predictive content of a financial market indicator are

Recent approaches to reviewing the predictive content

Basically, what we understand by the predictive content of a financial market indicator is the question of whether, and how well, it predicts the future movement of one or more economic variables. As a rule, statements on predictive quality are made on the basis of statistical valuation criteria. Mostly, approaches based on regression analysis are used, whereby the statistical relationships between the indicator and the variables to be forecast are modelled and analysed. More recently, two methods in particular have come into prominence:

Multi-period regressions: Here "future" values of the variables to be forecast are combined (cumulated) over time horizons of various lengths and regressed on the "lagged" indicator value, i.e. the value originating in the previous period. If, for example, x_t is the variable to be forecast and F_t the indicator at time t, linear simple regressions of the type

$$(x_{t+1} + \ldots + x_{t+n}) = \alpha(n) + \beta(n)\, F_t + u_{t+n}$$

are computed to assess the predictive power of the indicator. $\alpha(n)$ and $\beta(n)$ represent the intercept and the slope of the equation estimated, and u_{t+n} is a stochastic disturbance which captures any other influences. Additional information is obtained if the individual "marginal contributions" x_{t+n} are used as a dependent variable, rather than the "cumulated" values. The robustness of these results can be checked by means of a multivariate regression. To this end, additional explanatory variables are added to the indicator variable, such as the lagged endogenous variable or other financial market indicators. In this case, what is to be determined is the additional (incremental) predictive contribution of a given indicator.

Vector autoregressions (VAR): Here, the indicator variable and the variable to be forecast form an interdependent dynamic system. Both variables are treated equally – unlike simple multi-period regressions – as endogenous variables. In the simplest case – with only two variables, each with only one lag – a VAR looks as follows:

$$x_{t+1} = \alpha_0 + \alpha_1 x_t + \alpha_2 F_t + u_{t+1}$$
$$F_{t+1} = \beta_0 + \beta_1 x_t + \beta_2 F_t + v_{t+1}$$

A main advantage of VARs is the possibility of forecasting over time horizons of any length without information from the forecast horizon having to be used ("unconditional" forecasts).

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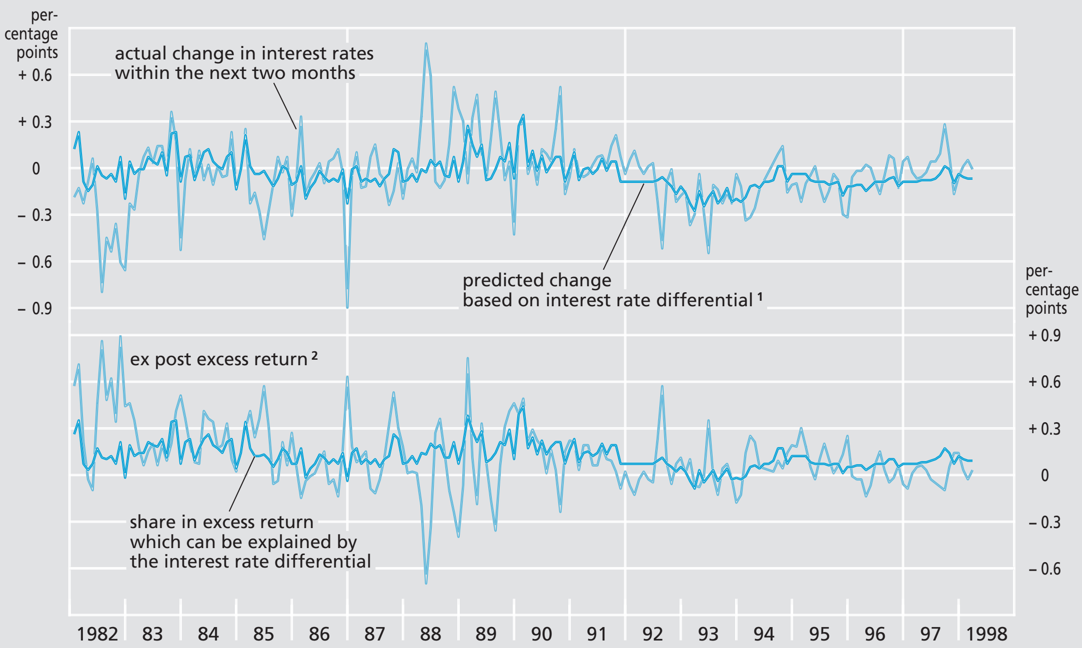
Predictive content of the interest rate differential in the money market



1 Interest rate spread between three-month funds and one-month funds. — **2** Actual excess return of three-month investment over revolving one-month investment.

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Relation between predictive and expectation content

often, but not always, closely related. Thus the predictive content of the yield curve for economic growth cannot, at least directly, be explained by a corresponding expectation content. Conversely, a good, i.e. largely undistorted, expectation indicator will not necessarily make an explanatory contribution going beyond a naive "things-will-remain-as-they-are" forecast. This is, for example, always the case if movements in a particular variable are exclusively due to unsystematic random influences and therefore do not contain any foreseeable components. By reviewing the predictive performance of an expectation indicator, it will be possible, however, to draw general conclusions about the price and expectation formation process.

Predictive content of the yield curve in the money market

The measuring and assessment of the relation between expectation and predictive content can be illustrated by the term structure of interest rates in the money market. According to the expectations theory of the term structure of interest rates, the spread between the three-month and one-month funds rates corresponds to the weighted sum of the change in the one-month rate expected over the next two months. The correctness of these expectations of interest rate changes in the past can be checked by means of corresponding regressions (see the Annex for the methodological approach).

Results...

The chart above shows the actual two-month changes in the one-month funds rate and those forecast by means of the interest rate differential. The trend movement or direction of the actual interest rate changes is as a rule predicted fairly accurately by the spread forecasts. Since, however, the scale of the relatively sharp interest rate jumps, in particular, has been predicted in isolated cases only, the coefficient of determination of the regression (which measures the share of forecast interest rate changes in overall interest rate changes), at 20 %, is comparatively low. However, such sharp interest rate shocks generally occur as a direct reaction to new unforeseen events which were not yet known at the time when expectations were formed. The comparatively weak predictive power cannot, therefore, readily be interpreted as a reflection of market participants' "irrational", inefficient expectations and a low expectation content of forward rates. The expectation content of the indicator can be questioned only if the expectation errors are of a systematic nature (see the adjacent box).

... imply the existence of risk premiums

On the assumption of rational expectations, the hypothesis of an informationally efficient market and the validity of the pure expectations theory of the term structure of interest rates are in most cases, as in the above example, rejected. However, this may also be due to false assumptions about the formation of expectations or a failure of the expectations theory of the term structure of interest rates in its pure form, which assumes that investors are risk-neutral. This is suggested by the fact that the average return on three-month investments measured *ex post* is significantly higher than that on successive one-month investments (in the example, almost 13 basis points) and, moreover, can be forecast using the term structure of interest rates

Causes of systematic expectation errors

Expectation errors are systematic if they are not purely random but are related to information available at the time the expectations are formed. Systematic expectation errors may, firstly, reflect irrational behaviour on the part of some market players who are not sufficiently informed and react to "false" signals. In such inefficient markets, with heterogeneous players, the aggregated expectations derived from prices are not representative.

Secondly, however, systematic expectation errors may also occur in informationally efficient markets if rationally-acting individuals include the possibility of past or future shifts in the structure of the economy or in economic policy ("regime changes") in their formation of expectations. In the first case, economic agents have to learn, by observation, whether they are still moving in an old system or are already in a new system. As long as this process of learning has not been completed, and as agents therefore still consider both regimes to be possible, expectation errors are *ex post* distorted in a particular direction and thus positively autocorrelated.

In the second case, such errors are observed if market players have taken due account of the possibility of a regime change, but this change has failed to occur in the periods concerned. If, in the simplest case, economic agents distinguish between only two regimes with differing prices of a particular financial asset, the market expectation of the price is the average of the two possible prices weighted with the (subjective) probability of being in the particular regime. If, for example, players in the foreign exchange market under a regime of fixed exchange rates assign a positive probability to the possibility of a massive currency devaluation, the forward rate correctly reflecting these "rational" expectations may be outside the permissible parity band even for some length of time. As long as the devaluation does not occur, the forward rate seems, *ex post*, to be a very poor predictor. If such "peso effects" occur particularly frequently during a given analysis period, a distortion of forecasting parameters is to be expected.

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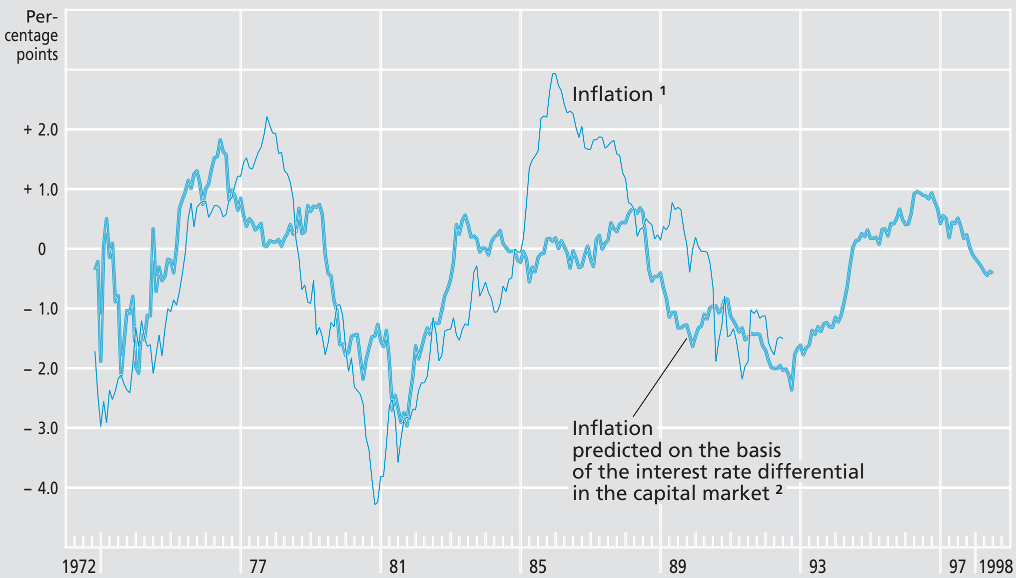
Predictive content of the yield curve in the capital market for inflation



1 Actual changes in the average inflation rate within the five-year period following the next year; shifted six years into the past. — **2** Interest rate differential between bonds with a six-year and a one-year maturity; values derived from an estimated yield curve.

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(see also the lower panel of the chart on page 56). This implies the existence of a time-variable risk premium, positively correlated with the spread, which does not exist in pure expectations theory. In addition, the average risk premium increases with the maturity of the forward contract, which is consistent with the theoretical notion that investors demand a premium which increases with the life of the asset in compensation for the liquidity loss. To that extent, it cannot be assumed that any movement in the yield curve is caused by changes in interest rate expectations; it may also reflect market participants' changed risk perceptions. This underlines the fact that implicit forward rates should be adjusted for such risk premiums in order to obtain a more accurate measure of interest rate expectations.

Swap rate and exchange rate expectations

In the exchange market, the swap rate – unlike the findings regarding the yield curve in the money market – on average fails to predict even the direction of the actual exchange rate change correctly; this applies to the majority of the major currency relationships, including the Deutsche Mark/US dollar quotation (see the table on page 59). This distorted predictive content of the forward rate may again be explained, firstly, by time-variable risk premiums. Another explanation may be provided by the systematic expectation errors already mentioned (see the box on page 57). The uncertainties about the short-term exchange rate movements are so large that a close arbitrage relationship based on expectations is likely to be less important than exchange risks.

Yield curve in the bond market, interest rate expectations ...

Studies indicate as a rule that the yield curve in the capital market has a significant and comparatively high predictive content, both regarding the future movement of short-term interest rates and regarding inflation dynamics and real growth (see the table on page 60). The predictive performance in respect of the movement of short-term interest rates can be explained by the expectations theory of the term structure of interest rates, and suggests that interest rate measures by the central bank have a systematic impact on capital market rates through market participants' expectations. The evidence also indicates, however, that expectations theory is not nearly sufficient to explain the movement of capital market rates, but must be supplemented by further elements, such as risk premiums. Against the background of the close interlinking of the German bond market with markets abroad and the high international mobility of capital, it should also be borne in mind that interest rate movements are constantly determined by a combination of domestic and foreign influences. Especially in the short term, international portfolio management operations may significantly affect interest rate movements.[2]

... and inflation forecasts

Multi-period regressions suggest that the outlook for inflation, particularly over a time horizon of about 5 years, can be fairly well assessed by economic agents (see the chart on page 58). Here, too, movements in the term structure of interest rates alone do not nearly suffice to explain the actual trend of inflation. This underlines the fact that changes in the interest rate spread can be interpreted only with reservations, and are subject to considerable uncertainty, as changed inflation expectations. Major factors which may mask the impact of inflation expectations are international interest rate influences, expectations about real interest rates and, once again, time-variable risk premiums.

Predictive content of the 3-month swap rate for future exchange rate changes

Regression 1: $\Delta W_{t+3} = \beta_0 + \beta_1 SWAP_t + u_{t+3}$

Exchange rate	β_0 3	β_1 3	R^2	$\sigma(\Delta W_{t+3})$
DEM/USD	– 1.39 (2.89)	– 0.68 (0.76)	0.009	24.32
DEM/JPY	4.27 (2.16)	– 1.58 (0.64)	0.045	22.67
DEM/CHF	0.77 (1.31)	– 0.23 (0.69)	0.001	9.91
DEM/GBP	– 5.96 (3.39)	– 1.21 (0.71)	0.028	19.72
DEM/NLG	– 0.32 (0.20)	– 0.25 (0.27)	0.012	2.20
DEM/FRF 2	– 0.35 (0.77)	– 0.10 (0.29)	0.001	4.26
DEM/ITL	– 2.64 (2.53)	0.20 (0.24)	0.004	12.81

1 Estimated using end-of-month data over the period from March 1979 (start of the EMS) to May 1998; ΔW_{t+3} is the rate of change of the exchange rate over the next three months, expressed at an annual rate, and $SWAP_t$ is the relevant swap rate, in %; β_0 and β_1 are the estimated coefficients for the constant and the slope, with standard errors in brackets (corrected according to Newey-West); u_{t+3} is the disturbance term, R^2 the coefficient of determination and $\sigma(\Delta W_{t+3})$ the standard deviation of the dependent variable. — **2** Estimation period January 1987 to March 1998. — **3** If the expectation theory of the exchange rate were valid, $b_0 = 0$ and $\beta_1 = 1$ should hold.

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Predictive content of the dividend yield

Little attention has been given, in view of the relatively minor importance of the domestic equity market, to indicators derived from equities. In addition, the "extraction" of expectations is impeded, in contrast to fixed-rate assets, by the fact that dividend payments are not pre-fixed and that equities a priori have an unlimited maturity. The predictive content of equity yields can be ascertained by means of the present dividend value

2 See Deutsche Bundesbank, The implications of international influences for capital market rates, Monthly Report, July 1997, pages 23–40.

Predictive content of the yield curve in the bond market

Coefficient of determination or coefficient	Forecasting horizon in years 1	2	3	4	5
For changes in the one-month rate 1					
R^2	0.13	0.33	0.39	0.51	0.70
α	– 0.26	– 1.09	– 1.69	– 2.06	– 2.56
	(0.34)	(0.61)	(0.75)	(0.69)	(0.49)
β	0.89	1.69	1.81	2.05	2.30
	(0.19)	(0.38)	(0.35)	(0.23)	(0.16)

Regression 2: $\sum_{i=1}^{n-1} (1-i/n)\,\Delta r_{t+i} = \alpha + \beta(Z_t^m - r_t) + u_t$

where n = 12 m months, m = 1, 2, 3, 4, 5 years.

Coefficient of determination or coefficient	1	2	3	4	5
For changes in the inflation rate 1					
R^2	.	0.04	0.12	0.20	0.31
α	.	– 0.18	– 0.44	– 0.71	– 0.99
	.	(0.12)	(0.20)	(0.26)	(0.32)
β	.	0.27	0.45	0.62	0.78
	.	(0.16)	(0.17)	(0.14)	(0.12)

Regression 2: $(\pi_{t+1}^m - \pi_{t+1}^1) = \alpha + \beta(Z_t^m - Z_t^1) + u_t$

where $\pi_{t+1}^m = \frac{100}{m}(\log CPI_{t+12m+1} - \log CPI_{t+1})$,

m = 1, 2, 3, 4, 5 years.

Coefficient of determination or coefficient	1	2	3	4	5
For growth of the real gross domestic product 3					
R^2	0.26	0.36	0.34	0.34	0.23
α	1.50	1.57	1.77	1.88	1.97
	(0.41)	(0.34)	(0.26)	(0.23)	(0.24)
β	0.53	0.48	0.38	0.32	0.22
	(0.12)	(0.08)	(0.07)	(0.08)	(0.08)

Regression 2: $\frac{100}{m}(\log GDP_{t+4m} - \log GDP_t) = \alpha + \beta(Z_t^{10} - r_t) + u_t$

m = 1, 2, 3, 4, 5 years.

1 Estimation period: September 1972 to June 1998. — **2** Definition of the variables: r: one-month or three-month rate; Z^m: interest rate on Federal bonds with m years residual maturity (zero coupon rates from estimated yield curve); π^m: average annual inflation rate for the next m years; CPI: consumer price index; GDP: real gross domestic product in western Germany. — **3** Estimation period: 3rd qtr 1972 to 1st qtr 1998.

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model; it is defined as the ratio of a dividend index and the related price index. Studies of the corresponding predictive content normally show that the dividend yield can make a significant contribution to explaining medium-term dividend growth, and also longer-term equity return rates. Falling dividend yields, such as have been observable especially in the more recent past, suggest the expectation of rising dividend payments and/or falling longer-term equity returns. The fact that investors are accepting lower equity return rates may owe something to expectations of falling opportunity costs (for example, capital market rates), but also to a higher propensity to invest in equities, and therefore to falling risk premiums.

Implications for monetary policy

Financial market prices helpful as expectation indicators ...

Financial market prices give the central bank access to information which is important for monetary policy. As indicators of expectations, they can signal the market perception of the outlook for interest rates, exchange rates and inflation. Such information is required during all stages of the monetary policy decision-making process: analysis, preparation of decisions, implementation and control. The indicators for interest rate expectations in the money market are a case in point; they invariably also constitute expectations of the future stance of monetary policy. They can provide information on precisely which monetary policy measures are expected by the market and on whether the market has responded as desired to central bank measures. In this connection it is not important whether the perception prevailing in the market turns out to have been wrong – such as the pronounced expectations of rising interest rates prior to the outbreak of the crises in east Asia (see the adjacent chart). Indicators of expectations may also facilitate decisions on the timing and gauging of the use of a monetary policy instrument, e. g. if the central bank, in periods of strong uncertainty, wishes to avoid giving the market misleading signals. There are, however, serious theoretical and practical objections to assigning financial market prices, beyond the role of information variables, a key function in the formulation and implementation of monetary policy.

... but requiring interpretation in normal circumstances ...

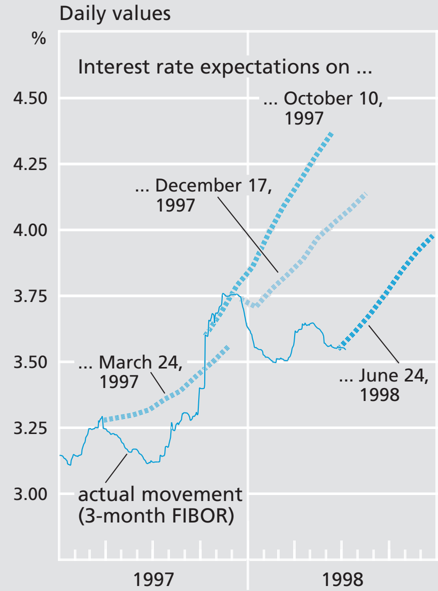
Any indicator derived from financial market prices provides fairly large scope for interpretation on account of the great variety of information and expectations it contains. A clear breakdown of the price-determining factors – say, into interest rate expectations and risk premiums – cannot, as a rule, be made, and is always subject to considerable uncertainty. For this reason it is, for instance, difficult to tell, when prices are rising sharply in the equity market, whether this rise is fundamentally warranted or constitutes a "price bubble". It is therefore always necessary to analyse financial market prices in the context of a large number of variables, historical experience and possible special factors. That applies in particular to periods when – as is now the case in the equity market – unusually dynamic price movements are being observed.

... and even more so in crisis situations

In addition, cross-border capital movements may have a strong impact of their own on domestic financial markets. Behavioural differences between domestic and foreign market agents – differences which lead to a change in price formation – cannot be ruled out, especially in periods of strong uncertainty. For one thing, the basic reassessment of risks in the international context – as in the wake of the crises in east Asia – may trigger massive portfolio shifts obscuring domestic factors. For another, a slump in prices in foreign markets may force internationally-operating investors to reduce their domestic exposure quite independently of expectations, for instance to meet a liquidity need which was caused by losses in other markets. Financial market prices must be interpreted with particular care, especially when monetary policy depends on a reliable assessment of current conditions.

Interest rate expectations for three-month funds and actual interest rate movements *

Daily values



* Interest rate expectations measured on the basis of forward rate agreements.

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Quality of forecasting indicators ...

Even the relatively good predictive qualities of financial market prices in the past do not argue in favour of giving them a major role in the monetary policy decision-making process. Firstly, the transmission mechanism on which the statistical lead of financial market indicators is based is unclear in many cases. Without at least a basic idea of the economic relationships it would, however, be risky to make particular indicators, such as the slope of the yield curve, a key monetary policy reference variable. In addition, the margins of uncertainty are considerable also for indicators with a relatively large predictive content.

... depends on the monetary policy regime

The decisive factors in a forward-looking monetary policy, after all, are not the statistical correlations which were valid in the past, but the response of economic indicator and target variables to current or future monetary policy measures. It is to be expected that especially the predictive content of financial market prices will change fundamentally if they are given major significance in the monetary policy decision-making process since the prices of, in the last analysis, all financial instruments are largely determined by expectations about monetary policy. Given rational behaviour, future losses of purchasing power must already be taken into account in prices today, and the movement of short-term interest rates has an impact on the opportunity cost of holding assets and the present value of financial assets. There is therefore a close interrelationship between monetary policy and financial market prices – a relationship which depends on the monetary policy regime.

High predictive quality an indication of stable underlying monetary conditions ...

A relatively high predictive quality of financial market prices – especially in the light of the future course of inflation – is, from the point of view of this mutual interaction, an indication of the fact that, in the past, monetary policy has succeeded in creating reliable underlying conditions for market participants' formation of expectations. It is also consistent with this picture that, for example, the predictive content of the yield curve for longer time horizons is relatively high when cyclical fluctuations or exogenous shocks are less important (see the table on page 60).

... but no argument in favour of a more prominent role of financial market prices

However, such relationships, which are quite useful for checking the "performance" of monetary policy, do not warrant a gearing to, say, yield-curve indicators. If the central bank's policy is guided by variables which, in turn, are mainly based on expectations about monetary policy, this means going round in circles. That might lead to situations in which market expectations provide no reliable indication of the stance of monetary policy and, conversely, the central bank is unable to give any guidance to the expectations of financial market players. In order to prevent such destabilisation caused by following market trends, monetary policy needs an external "anchor". Elements of such an "anchor" for the formation of expectations are an unequivocal commitment by the central bank to the goal of price stability and a transparent and credible strategy.

Annex

Subject

Using German money market interest rates, two methods by which market participants' interest rate expectations can be checked for their predictive content are illustrated in this annex. Both methods – multi-period regressions and vector autoregressions – can, on the assumption of "rational expectations", also be used for tests of financial market efficiency.

Expectations theory of the term structure of interest rates

What is known as the "pure expectations theory of the term structure of interest rates" is used to extract interest rate expectations from various forward rates in the money market. It is seen that differences in the interest rates for financial paper which is completely identical except for the contract period are explained solely by interest rate expectations; risk or forward premiums – like those according to the liquidity preference theory – are not taken into account. According to the expectations hypothesis (EH), the return on a longer-term investment – for instance in three-month funds – equals the expected return on revolving short-term transactions – in this case, three successive transactions in one-month funds. Differences in the return are eliminated immediately by corresponding arbitrage transactions; for risk-neutral agents, only the level of the expected return is important, they do not distinguish between a certain and uncertain return on an investment. With R_t being the three-month rate, r_t the one-month rate and E_t the expectations operator, the EH can be written in the form of the following equation:[3]

(1) $R_t = ⅓ (r_t + E_t r_{t+1} + E_t r_{t+2})$

If r_t is now subtracted on both sides, the following equation is obtained after a transformation:

(2) $R_t – r_t = ⅔ E_t\Delta r_{t+1} + ⅓ E_t\Delta r_{t+2}$

with $\Delta r_{t+i} = r_{t+i} – r_{t+i–1}$, the one-period interest rate change. The "spread" $S_t = (R_t – r_t)$ equals the weighted mean of the changes in the one-month rate expected over the next two months, with the expectations of interest rate changes reaching further into the future having a smaller weight. This illustrates the "expectation content", which according to the expectations theory is the simple difference between the three-month and the one-month rates.

Multi-period regressions

Rational expectations and multi-period regressions

In order to be able empirically to verify the expectations theory, an assumption needs to be made about how agents form their expectations. An operationalisation form of "rational expectations" assumes that the agents can perfectly anticipate the actual interest rate except for a purely random error ε, i.e. $r_{t+i} = E_t r_{t+i} + \varepsilon_{t+i}$. It is important in this connection that the average expectation errors are zero and (orthogonally) independent of any information available at the time when the expectations are formed. If the interest rate expectations in (2) are replaced by this form of rational expectations, after a further transformation the following equation is obtained:

(3) $⅔\Delta r_{t+1} + ⅓\Delta r_{t+2} = S_t + ⅓ (\varepsilon_{t+1} + \varepsilon_{t+2})$.

This equation can be empirically verified by means of the regression equation

3 The equation applies exactly for interest paid steadily over the life of the asset and approximately for discretionary interest payments. In the present example, the average approximation error is two basis points.

Estimation results for a bivariate vector autoregression model

Estimation period: March1982 to May 1998 (monthly values)
Endogeneous variables (demeaned):
S(t) = spread between three-month and one-month rate
Δr(t) = change in one-month rate

Equation for S(t):
R^2 = 0.30, Durbin-Watson statistic: 2.13
Standard deviation of the dependent variable: 0.18
Standard deviation of the residuals: 0.15

Variable	Coefficient	Std. error	t statistic	p value
S(t–1)	0.49	0.06	8.32	0.00
Δr(t–1)	0.13	0.04	3.62	0.00

Equation for Δr(t):
R^2 = 0.21, Durbin-Watson statistic: 1.85
Standard deviation of the dependent variable: 0.30
Standard deviation of residuals: 0.26

Variable	Coefficient	Std. error	t statistic	p value
S(t–1)	0.73	0.10	7.19	0.00
Δr(t–1)	0.05	0.06	0.79	0.43

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$$(4)\quad PFS_t = \alpha + \beta\, S_t + u_t,$$

with the left-hand side of equation (3) also being called "Perfect Foresight Spread" (PFS). If the EH is valid under rational expectations (REH), the restrictions $\alpha = 0$ and $\beta = 1$ should be met, and the residuals are composed of the independent expectation errors. As the REH permits only unsystematic excess returns which are identical with the expectation errors, these coefficient restrictions at the same time imply a test for the informational efficiency of the money market.

Results

Using end-of-month levels for the period from January 1982 to May 1998 (185 observations), the following estimation result of a least square regression (standard errors adjusted for autocorrelation and heteroscedasticity) is obtained:

$$(5)\quad PFS_t = \underset{(0.02)}{-\,0.09} + \underset{(0.07)}{0.54}\, S_t$$

R^2 is 0.20, the standard deviation of the dependent variable 0.23 and the standard deviation of the residuals 0.20. Both restrictions, and hence also the REH, must be unequivocally rejected both separately and jointly as a null hypothesis. This may be due to the existence of a time-variable risk and forward premium which systematically varies with the spread and causes a distortion of the slope of the regression. The relevant chart in the main text (see page 56) shows in the lower panel the actual and the *ex post* excess return (ER_t) of the three-month investment forecast by means of the spread. The forecast can be interpreted, neglecting other factors, as the expected risk premium. Since the *ex post* excess return equals the simple difference between the actual spread and the PFS, this regression result can also be expressed using the above estimation coefficients of the regression for the PFS (with w_t being the disturbance):

$$(6)\quad ER_t = -\,\alpha + (1 - \beta)\, S_t + w_t\,.$$

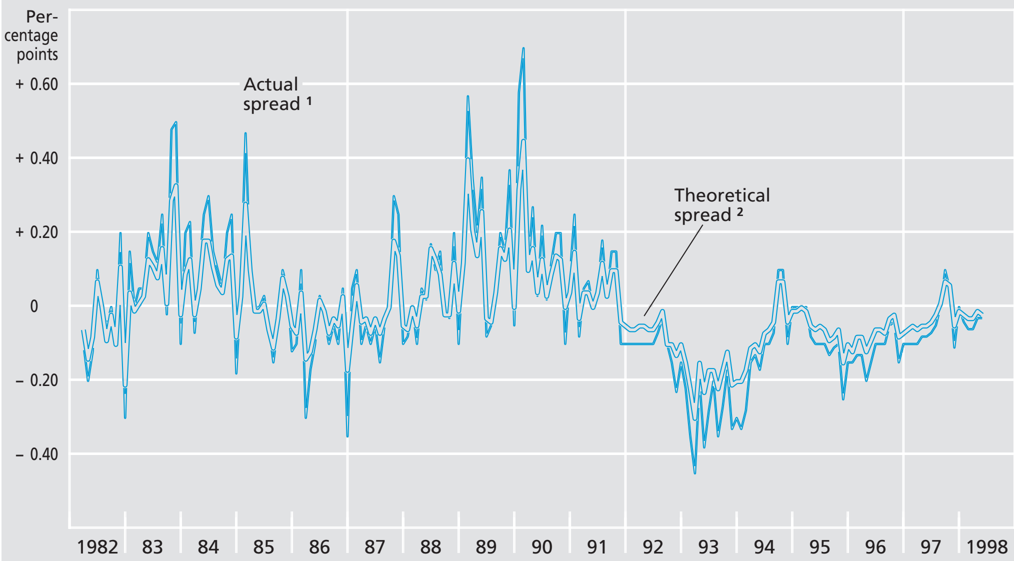
The expected excess return in the example is $E_t(ER_t) = 0.09 + (1 - 0.54)\, S_t$. Hence the more the demanded risk premium reacts to changes in the spread (in the same direction), the more the estimation coefficient β is distorted in the direction of zero.

Vector autoregressions

Model forecasts as rational expectations

As an alternative to such multi-period regressions with *ex post* realisations as rational expectations,

Actual and theoretical spread between three-month and one-month funds rates



1 Difference between three-month and one-month rates (demeaned). — **2** Weighted mean of changes in one-month rate over the next two months forecast by means of a vector autoregression model; if the expectation theory of the term structure of interest rates is valid, the theoretical spread and the actual spread should be identical.

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Campbell and Shiller (1987)[4] have developed an efficiency test which in the present application is based on a vector autoregressive representation of money market rates with theoretical cointegration restrictions between the individual interest rates.[5] It is assumed that the process which determines the joint dynamic behaviour of two money market rates can be sufficiently described by a bivariate vector autoregression (VAR) using these interest rates as the sole model variables. If the expectations theory of the term structure of interest rates is valid (constant risk premiums are permitted), the long-term and short-term interest rates are cointegrated. They are then in long-term equilibrium, which is defined by the simple difference between the two interest rates, and, if appropriate, a constant risk premium. In this case, the VAR can be transformed in such a way that the spread and the one-period change in the shorter-term interest rate result as endogenous variables. With the help of this VAR, (unconditional) forecasts can be made, covering any length of time in the future, of the changes in the short-term interest rate. In this approach, the model forecasts are equated with market participants' rational expectations. This approach is warranted by the fact that with the lagged spread all the information actually used by market agents in forming expectations is indirectly included in the forecasting model.

The "theoretical spread"

Inserting the changes in the one-month rate forecast in the individual periods in equation (2) as ex-

4 See J.Y. Campbell and R.J. Shiller, Cointegration and Tests of Present Value Models, in: Journal of Political Economy, 95 (1987), pages 1062–1088.
5 For the derivation and explanation of cointegration relationships between interest rates with the help of the expectations theory see Deutsche Bundesbank, The implications of international influences for capital market rates, Monthly Report, July 1997, pages 23-40, here page 38 ff.

pectation variables yields what is known as the "theoretical spread". If the EH is valid and given this form of rational expectations, it should be identical with the actual spread; systematic deviations would once again suggest foreseeable excess returns which are not consistent with the efficiency hypothesis.

Results

The forecast results for the three-month and one-month rates are shown in the table on page 64. All commonly used methods for determining the lag order make it seem advisable to use only the interest rates lagged by one month as an explanatory variable. The fact that in the regression equation for the monthly change in the one-month rate the lagged spread is the only significant regressor with a fairly high coefficient value is of special importance. Despite the relatively high volatility of the monthly interest rate changes (standard deviation about 30 basis points), the spread is able to explain about 21%. This "Granger causality" of the spread for the interest rate change is often already seen as a weak test of the REH.

Further information is provided in the chart on page 65, which shows the movement of the actual (demeaned) and the theoretical spread.[6] Both series show a close co-movement, it is true. However, the fact that the actual spread is far more variable than the theoretical spread (the ratio of the two standard deviations is 1.57) argues against the validity of the REH with a constant risk premium. This should not be so if solely changed interest rate expectations trigger movements in the spread. This again suggests that there are other systematic factors which have an impact on the term structure of interest rates, probably also time-variable risk or forward premiums. These other factors which cannot be observed cannot, however, be identified unequivocally and thus impede a reliable extraction of interest rate expectations from the term structure of interest rates.

6 The use of demeaned data for forecasting the VAR implies a constant risk premium of around 9 basis points (mean value of the spread over the forecast period), which must be added to the one-month rate.