The implications of international influences for capital market rates

In Germany capital market rates play an important role in the overall economic funding process and in the transmission of monetary policy stimuli. This raises the question of the extent to which external factors influence German capital market rates and of whether these factors have changed significantly during the past few years. This empirical analysis is confined to the interest rate relationship between Germany and the United States, as the world's largest capital market. It emerges that the linkage between interest rates in Germany and those in the United States became markedly closer at the beginning of the eighties. Over the longer term, domestic interest rate movements, and therefore also Germany's capital market rate, continue to be determined by domestic factors; in the shorter term, by contrast, the movement of German rates generally follows US market trends. In these circumstances the central bank has to try to mitigate external disruptive influences from the outset by means of a consistent anti-inflationary stance. This is all the more important now that the susceptibility of the domestic market to such disturbances is tending to increase as a result of the sharp rise in international interdependence since the beginning of the nineties.

Interest rates in open economies

Transmission channels of international influences

It is only in a closed economy, completely cut off from external influences, that capital market rates are determined by domestic factors alone. However, it is characteristic of industrialised nations, as well as of a growing number of emerging economies, that their goods and financial markets are closely linked internationally in a variety of ways. In such an environment, external influences can be transmitted to the domestic bond market through a number of direct and indirect channels. The domestic capital market is exposed to direct external influences owing to cross-border portfolio management. International stimuli may also be imported indirectly through the goods markets, an example being an increase in real interest rates at home due to a sharp rise in exports. Irrespective of cross-border flows of capital or goods, a similar change in the expectations of most market participants at home and abroad – following, for example, the publication of major economic indicators – may be enough to bring about a similar change in domestic and foreign capital market rates.

Interest rate trends in Germany and the United States

1 Yield on ten-year public bonds outstanding. — **2** Three-month rate for interbank money (Germany) and Treasury bills (United States).

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Approaches to assessing external influences

All direct and indirect foreign influences ultimately affect the term structure between domestic and foreign capital markets. To obtain information on the extent of foreign influence, it is essential to have a theoretical framework which enables one to filter out systematic interest rate relationships from interest rate movements at home and abroad. Certain macroeconomic and theoretical exchange rate approaches provide suitable reference systems. Nominal domestic and foreign interest rates are always identical if interest rates are fixed and on the ideal assumptions of perfect capital mobility, perfect goods markets and perfect information; in that case, domestic interest rates respond only to changes in the global supply of, and demand for, funds. If some of the assumed conditions – particularly that of perfect capital mobility – are realistically mitigated, and if floating exchange rates are introduced, these

approaches help to provide indications as to the cause of the observed deviations from that strict international interest rate relationship.

International capital mobility and financial market integration

Problem of measuring international capital mobility

The degree of international capital mobility – in a narrower sense of the term – depends on the institutionally imposed restrictions on the extent to which market players may invest or raise financial assets without hindrance either at home or abroad. Cross-border capital transfers may be impeded, for example, by government controls or by tax regulations at home or abroad. In a wider sense, capital mobility is also determined by the willingness of individual players to conduct international financial transactions even in the face of uncertainty; it is therefore also dependent on the preferences of market players, and especially on their propensity to run risks. Hence, perfect or complete capital mobility, in this broader definition of the term, calls not only for completely free capital movements but also for investors who are risk-neutral, because only then are securities which are denominated in different currencies but otherwise are homogeneous treated as perfect substitutes.

Various approaches to measuring international capital mobility

When formulating theoretical relationships to help determine empirically the degree of international capital mobility, it is assumed that there is perfect capital mobility. A distinction can be made between approaches which either are based on international interest rate relationships or deal with the implications for cross-border capital flows. So-called interest rate parities, which describe the arbitrage equilibria between domestic and foreign interest rates, belong to the first category. Tests (for example, that by Feldstein and Horioka[1]), as well as surveys of the international diversification of portfolios, are based on the quantitative dimension of international capital movements.

Covered interest rate parity

Interest rate parities are based on a comparison of the returns on domestic and foreign assets. If an investor hedges in advance against the currency risk posed by a foreign investment by means of an appropriate forward contract, he must consider the hedging costs – the difference between the forward and the spot rate (swap rate). In the case of unrestricted capital movements the covered interest rate parity determines the market equilibrium: the domestic interest rate must correspond to the sum of the swap rate and the foreign interest rate; otherwise riskless arbitrage gains may be achieved. Major deviations from the covered interest rate parity imply a low degree of integration between the financial market segments concerned at home and abroad. This lack of integration may be due in the main to existing or expected capital controls, transaction costs and differing risks of default.[2]

1 See Feldstein, M. and Horioka, C., Domestic Saving and International Capital Flows, in The Economic Journal, 90 (1980), pages 314–329.
2 Unless the deviations stem from measurement errors or from inhomogeneities in the assets on which they are based.

In contrast to the situation in the money market, at the long end of the bond market it is not usually possible to hedge against the entire currency risk posed by an external commitment through the foreign exchange forward market. However, this risk can be covered, for example, through a combination of currency and interest rate swaps, with the result that an arbitrage condition exists for long-term bonds, too. Empirical studies show that, in terms of the covered interest rate parity, mobility is very high both in the money market and in the capital market in Germany and the United States.[3] Consequently, differences between the two countries in capital market rates cannot be explained by impediments to capital movements. This is not surprising, in that there have been virtually no restrictions on capital movements between Germany and the United States since the abolition of coupon tax in 1984.

Uncovered interest rate parity

Provided the players are risk-neutral, the uncovered interest rate parity defines a further arbitrage equilibrium. As long as the covered interest rate parity exists (that is to say, there are no restrictions on capital movements), the interest rate differential must be offset by the expected change in exchange rates. An interest rate advantage at home (abroad) therefore has to exactly match the expected depreciation (appreciation) rate of the domestic currency. The empirical evidence definitely argues against the uncovered interest rate parity in this form. That is due to the unrealistic assumption that investors are prepared to assume additional risks – in this case, the currency risk – without compensation. Investors who are averse to taking risks regard domestic and foreign assets as no more than imperfect substitutes, and the uncovered interest rate parity must be augmented in this case by a risk premium.[4] The complexity of such a risk premium – which reflects, in reality, not only uncertainties about future exchange rate movements but also other economic risks – interacting with the likewise unobservable expectations regarding exchange rates, weakens the arbitrage relationship between domestic and foreign interest rates, which is based on expectations. The variations in risk premia and exchange rate expectations therefore constitute a major reason why interest rates develop along different lines in different countries.

Real interest rate parity

The uncovered interest rate parity can also be formulated for real variables. In this case the real interest rate differential corresponds to the expected change in the real exchange rate (real interest rate parity). If – beyond the nominal interest rate parities – the (relative) purchasing power parity always applies, real interest rates are evened out internationally. If this is to happen, the expected exchange rate change must exactly match the expected inflation differential between two countries. Empirical evidence suggests, however, that purchasing power parity generally does not

3 See Popper, H., Long-Term Covered Interest Parity: Evidence from Currency Swaps, in Journal of International Money and Finance, 12 (1993), pages 439–448.
4 Theoretical statements on determinants, plus or minus signs and the further shape of risk premia are provided by, for example, the portfolio theory of the exchange rate and the International Capital Asset Pricing Model (ICAPM). See Adler, M. and Dumas, B., International Portfolio Choice and Corporation Finance: a Synthesis, in Journal of Finance, 38 (1983), pages 925–984.

come into play in the short run.[5] Real interest rate differences which persist for a lengthy period may be accompanied by changes in the real exchange rate, which in turn may be due to sluggishness in the adjustment of the prices of goods (and thus to imperfectly integrated goods markets) and other factors. Hence different real interest rates do not reflect merely premia for currency risk and therefore imperfect capital market integration (in the narrower sense of the term).

Feldstein/ Horioka test

The assumption of perfect capital mobility implies the existence of a global capital market. From the point of view of a single (small) country, this means that national savings are supplied to the global capital market and capital is obtained there for investment purposes. If that is so, the perfect correlation between savings and investment in a closed economy completely disappears. Empirical analyses based on the work of Felstein and Horioka, however, regularly identify a significantly positive connection between the two variables, and such a connection has also been shown to exist for western Germany during the period from 1960 to 1994 and – albeit to a lesser extent – from 1974 to 1994.[6] However, this finding can be interpreted only with reservations as evidence against a high degree of international capital mobility. The main reason for this is the assumption that there is a uniform real global interest rate, not to mention the fact that various estimation problems are inherent in that simple regression model.

Another indication that capital mobility is imperfect is the generally low international dispersion of securities portfolios. The diversification of capital investment over different countries and currencies makes it possible – at least where earnings prospects are similar – to reduce portfolio risk by combining different and imperfectly correlated risks.[7] Hence there can be no talk of perfect integration of the markets until this scope for further diversification has been fully exhausted. However, it can be said of foreign investors, just as much as of German investor groups, that their portfolio structures are still characterised by a preponderance of domestic securities ("home bias").

Portfolio structure biased towards domestic securities

Extent of the "home bias"

The extent of this "home bias" can be reliably determined only by comparing actual bond holdings with an (estimated) optimum portfolio. Studies in which such comparisons have been attempted generally support the hypothesis of a pronounced preference for domestic bonds and notes. A simple analysis of German investors' holdings of domestic and foreign bonds confirms the fact that international diversification has not made all that much progress so far; this owes something to investment regulations for institutional investors. Domestic bonds accounted for about 96 % of the bond portfolios of insurance enterprises at the end of 1995, while in the case of individuals and investment

5 See Deutsche Bundesbank, Overall determinants of the trends in the real external value of the Deutsche Mark, Monthly Report, August 1995, pages 17–37.
6 The result for the entire period from 1960 to 1994 is as follows (standard errors are in brackets): $I/Y = 0.14\ (0.01) + 0.69\ (0.05)\ S/Y$, where I/Y and S/Y are the overall investment ratio and saving ratio, respectively. The result for the shorter period from 1974 to 1994 is: $I/Y = 0.18\ (0.01) + 0.30\ (0.14)\ S/Y$.
7 Experience shows that this improvement in portfolio deployment occurs irrespective of whether currency risks are hedged or not.

funds they accounted for 87 % and 77 % of the total, respectively. By contrast, the German bond market accounted for only 11 % of global market capitalisation. Even if, from the point of view of a German investor, this percentage does not represent an optimum portfolio share of German paper (which is likely to be significantly higher), it does reflect a discrepancy between the diversification potential and actual cross-border investment.

Openness of the German bond market

Regardless of the analytical approaches to measuring the international integration of the German bond market, a purely descriptive statistical analysis shows that there is now greater international interdependence, and that this has greatly accelerated, especially since the beginning of the nineties. But the legal conditions for the liberal commitment of foreign investors in the Deutsche Mark bond market and for the acquisition of foreign bonds and notes by German residents were created quite early: the Deutsche Mark was fully convertible as early as the end of 1958, and when the Foreign Trade and Payments Act came into force in 1961, the principle of fundamental freedom in external trade and payments was established. During the final period of the Bretton Woods system, measures to ward off undesirable capital inflows – notably the cash deposit requirement – repeatedly stood in the way of free capital movements. Until 1984 coupon tax hampered the acquisition of German bonds and notes by non-residents, a situation which resulted in most foreign investment being made via foreign Deutsche Mark bonds and German borrowers' notes, which were exempt from coupon tax.

The presence of foreign investors in the domestic market has grown massively since reunification, when Germany's capital requirements rose steeply and the bond market greatly increased in depth as a result of extensive public sector borrowing. At the end of 1996, approximately 40 % of the public bonds outstanding were held by foreign investors. The greater influence of foreign market players on capital market operations is impressively reflected in the annual volume of cross-border transactions, which since 1993 has amounted to roughly 1.4 times the total of German bonds and notes outstanding, compared with a ratio of 0.4 in the second half of the eighties and 0.1 before that.

Foreign investment and susceptibility to disruption

This relatively strong international penetration of the German capital market does not necessarily affect ongoing interest rate formation. That is changed only if foreign investors show different patterns of behaviour from German ones. Differences could be attributable, in particular, to the key role of foreign institutional investors in cross-border financial transactions, since such investors typically restructure their portfolios quickly and relatively often, and may therefore trigger off considerable price fluctuations. More frequent periods of high volatility in the nineties might suggest that this has enhanced the susceptibility of the German bond market to disruption, even if no increase in the trend of volatility has been detected.

Interest rate formation as a mixture of German and foreign influences

Analyses of international capital mobility and the international penetration of the German bond market have so far suggested that interest rate formation is always determined by a

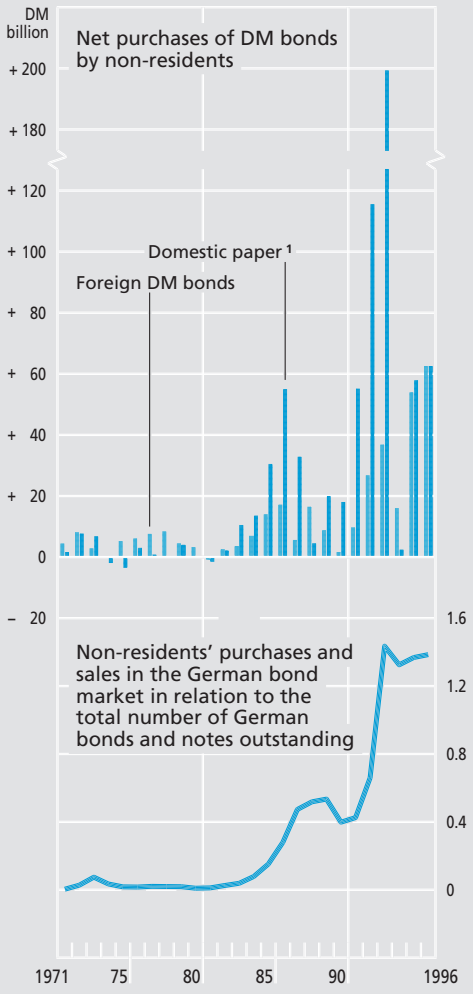
mixture of domestic and foreign influences on account of admittedly imperfect, but for all that high, capital mobility. External influences have to be singled out if a more accurate idea is to be gained of the extent to which German capital market rates are influenced by external factors. Interest rate movements in the United States – as the world's largest economy and most important capital market – are of paramount significance here.

The linkage between German and US interest rates in the capital market

Concept and dimensions of international interest rate links

The trend in capital market rates in Germany and the United States is characterised by a synchronous movement which is generally referred to as an "international interest rate linkage" (in the narrower sense of the term). Particularly since the beginning of the nineties, a distinct convergence of interest rate levels in the two countries has also been evident. Whether these phenomena reflect the great extent to which German capital market rates depend on external factors, and have done so increasingly during the past few years, can only be assessed by identifying the relevant causes and effects. All three dimensions of the international interest rate relationship – synchronisation, convergence and causality – require different measurement and test concepts, but they do not have to be analysed separately. There are some econometric models which provide a unified analytical framework for examining these three questions.

Foreign investment in the bond market



1 Excluding German foreign currency bonds.

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Measuring synchronisation

The degree of synchronisation between interest rates is usually measured by means of simple correlation coefficients. As a rule, the changes in the interest rates are correlated with each other in order to ascertain common movements. The yields on public bonds outstanding with residual maturities of approximately ten years are chosen as representative and easily comparable variables for German and US capital market rates. The analysis

Correlations of monthly interest rate changes for various periods

Correlation [1] between ...	1974–1996	1974–1979	1980–1989	1990–1996
R(G) and R(US) [2]	0.47	0.30	0.54	0.48
r(G) and r(US) [2]	0.14	0.29	0.11	– 0.07
R(G) and r(G)	0.44	0.36	0.53	0.32
R(US) and r(US)	0.63	0.61	0.65	0.50
Significance level	0.12	0.23	0.18	0.22

1 The correlation coefficients are significantly different from zero when they are above the significance level. — **2** R(j): yield on public bonds outstanding with a residual maturity of ten years; r(j): three-month rate in the interbank money market in the case of Germany and three-month Treasury bill rate in the case of the United States where j = G (Germany), US.

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covers the period from February 1974 to December 1996. That period provides fairly homogeneous institutional conditions for comparing interest rates in Germany and the United States because it is characterised by a uniform exchange rate regime (floating exchange rate of the Deutsche Mark against the US dollar) and a low level of restrictions on capital movements.

Interest rate linkage in the bond market

Apart from cyclical interest rate movements, the German-US yield differential has been comparatively small since the beginning of the nineties. The analysis of the correlation, however, cannot identify any increase in the degree of synchronisation during the nineties: the correlation coefficient of the monthly changes in yields is 0.54 for the eighties and 0.48 for the nineties; it was distinctly lower only in the seventies, at 0.30. Hence the closeness of the international interest rate linkage seems to be largely independent of the relative yield levels at which the synchronous movements take place.

Interest rate linkage and volatility

Moving correlations over a 36-month window provide a more accurate picture of the temporal development of the international interest rate linkage. According to this approach, the German-US interest rate linkage developed rapidly at the beginning of the eighties and has remained at a comparatively high average level ever since.[8] However, the linkage is subject to pronounced episodic fluctuations, with the correlations increasing particularly fast whenever there is worldwide financial market turmoil as a result of symmetrical shocks (for example, the oil price shock of 1979-80, the stock market crash of October 1987 and the bond market turbulence at the beginning of 1994). Such episodes are characterised by sharp changes in interest rates which, as a rule, are not confined to a single country, but rather spread internationally. This suggests that there is a positive correlation between bond market volatility and the international interest rate

8 For extended periods during the seventies, interest rate movements in Germany and the United States tended to be independent of each other. This pattern is closely associated with the differing responses of monetary policy and domestic price movements to the first oil price shock. The correspondingly weak interest rate correlation strengthened significantly at the beginning of the eighties, once these effects had gradually worn off and a sharp worldwide increase in interest rates had been brought about by the second oil price shock. The tendency for the interest rate linkage to increase is, however, also associated with the growing liberalisation of international capital movements and the multitude of financial innovations.

linkage.[9] On the other hand, disturbances which are regionally confined – such as the turmoil in the European Monetary System in 1992 and 1993 – give rise to less close synchrony between German and US yields.[10]

Interest rate linkage in the money market

The degree of synchonisation of interest rate movements declines as maturities become shorter. This is reflected particularly clearly in the fact that short-term interest rates in Germany and the United States – represented here by the three-month rate for interbank funds and the interest rate for three-month Treasury bills – are much less closely correlated than the respective capital market rates. During the entire observation period, the correlation coefficient is 0.14, and thus weakly, but significantly, positive. The moving correlations are always appreciably lower than in the case of long-term interest rates, and their fluctuations are much more pronounced. Over some periods they actually show negative values because short-term rates in Germany and in the United States moved in opposite directions, even over longer periods (notably from the end of 1988 to the beginning of 1994). Since the money market rates are within the central bank's area of direct influence, and are therefore closely linked to central bank rates, the weak correlations suggest, in principle, that the scope for action by monetary policy makers in both countries is fairly wide.

Interest rate linkage and structural dependence…

The causal and temporal dimensions of the structural relationships underlying the international interest rate linkage are particularly interesting from a monetary policy point of view because they make it possible to assess

Linkages between German/US interest rates in the money and capital markets *

Quarterly averages

* Moving correlations over a 36-month window.

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the extent to which the central bank's room for manoeuvre is affected by international influences. To ascertain whether in this case US influences are able to change the German interest rate level temporarily or permanently, one first has to establish the dynamic effects of independent (exogenous) interest rate changes abroad. Simple correlation coefficients provide only very limited information on such relationships. They are derived without making any assumptions about causal

9 With respect to the transmission of daily fluctuations in US yields to the German bond market, see also Deutsche Bundesbank, Financial market volatility and its implications for monetary policy, Monthly Report, April 1996, page 60 f.

10 See Deutsche Bundesbank, Capital market rate movements since the beginning of the nineties, Monthly Report, November 1996, page 24.

relationships,[11] and since they measure only unadjusted (linear) relationships between two variables, there is a considerable risk that a change in the coefficients may be due to the influence of omitted variables, rather than to a structural break.

... can be estimated more reliably by an econometric model

In principle, it is possible to obtain information on the fundamentals underlying the international linkage of capital market rates and on their direction of impact through econometric models, which provide a theoretically persuasive and statistically correct approximation to the unknown "true" structural relationships. To achieve this, these models must capture the major determinants of interest rates and provide suitable relationships between all variables considered. In this way the influence of the domestic fundamentals and the foreign interest rates can be singled out as well, with the result that the problem of omitted variables (which hamper a reliable interpretation of the simple correlation coefficients) is duly mitigated.

Interest rates without a constant long-term equilibrium level

The main results of an econometric analysis of the relationship between German and US yields are presented below. The mutual influences of the two interest rate variables are captured by means of a vector error correction model (VECM), which is a special form of the vector autoregressive approach.[12] This type of model is chosen because, according to the relevant test criteria, the interest rate levels have to be treated as non-stationary variables, at least during the observation period (from the beginning of 1974 to the end of 1996). This means that they have no tendency to converge towards a long-term equilibrium level that remains constant during the period concerned ("mean reversion"). Such an equilibrium "mean" could serve market players as a guideline for the long-term interest rates to be expected. According to the test results, however, the interest rates show (stochastic) trends which can be presented in their determinants as the weighted aggregate of unforeseeable shocks (innovations). This means that not even the direction of the long-term trend in interest rates can be predicted.

Theoretical framework: expectations theory of the term structure of interest rates...

The estimation model should encompass not only the German and US capital market rates but also the influence of the respective major domestic fundamentals. Under certain conditions, it is sufficient to include only the money market rates of both countries in the VECM as supplementary variables. This approach is warranted by the expectations theory of the term structure of interest rates, which is sufficiently validated by the empirical evidence to date. According to an extended interpretation of expectations theory, the long-term interest rate in arbitrage equilibrium is equal to the weighted sum of optimum forecasts (expectations) of the short-term interest rate, supplemented by a risk premium or forward

11 Simple correlation coefficients must not be confused with elasticities or other response measurements. Correlation coefficients have no physical dimensions and, owing to their construction, are limited to the value interval [– 1, + 1]. If, by contrast, one regresses, for example, the change in the German yield to the change in the US yield, one obtains a coefficient which shows the number of basis points the German yield rises or falls when the US yield has increased by 100 basis points. It is assumed here that the US interest rate is independent. For this example see Deutsche Bundesbank, Capital market rate movements since the beginning of the nineties, Monthly Report, November 1996, page 24.

12 The structure and estimation of the VECM are explained in more detail in the annex to this article.

premium, with the forecast horizon corresponding to the maturity of the long-term paper. The relationship between the capital market rate and the money market rate invariably reflects the total amount of information used by market players when forming their expectations, and substantiates a dynamic relationship between the two interest rate variables.

Since short and long-term interest rates are both included in the VECM as endogenous variables, this market-related information can be used indirectly for the model, and the *a priori* unspecified dynamic relationships can be explicitly estimated.[13] As a central bank gears its ongoing interest rate policy to inflation trends and general economic developments in accordance with its objectives and preferences, fundamentals such as inflation, the money stock and real economic activity are also integral parts of this stock of information and therefore do not need to be captured explicitly. Moreover, the expectations hypothesis substantiates a long-term equilibrium relationship ("cointegration") between the yield levels and the money market rate levels in a given country, with the result that the two interest rates should follow a common trend or should be continually converging.

... and uncovered interest rate parity

In theory, the international interest rate relationship is created through the uncovered interest rate parity, extended to include aspects of risk. In the light of the choice of variables, the model simultaneously estimates the international linkages for short and long-term interest rates. The respective interest rate differential is equal to the corresponding change expected in exchange rates plus a risk premium; to enable a long-term equilibrium relationship to exist between the domestic and foreign interest rates, it must be assumed that these two components are stationary.

No international interest rate convergence, but long-term equilibria between national interest rate levels

The test results show, however, that a long-term equilibrium relationship which could exert international pressure to converge exists neither between the money market rates nor between the capital market rates of the two countries. Yet such cointegration relationships have been identified between the national short-term and long-term interest rates. Such equilibrium relationships do not require complete convergence but rather are compatible with an interest rate advantage on the part of the capital market, and this advantage is to be interpreted as a premium for the capital risk associated with a long-term bond market investment. The cointegration between the money market and capital market rates implies that both interest rates follow a common (stochastic) trend, with the result that, over the longer term, they always move in the same, albeit unforeseeable, direction. The trend-setting domestic and foreign interest rate shocks in the model ultimately reflect changes in the fundamental domestic determinants of general interest rate movements, such as inflation, economic growth and public sector deficits. However, these specific influences are not rendered explicit in the model.

13 These relationships were first elaborated by J. Y. Campbell and R. J. Shiller, Cointegration and Tests of Present Value Models, in Journal of Political Economy, 95 (1987), pages 1062–1088.

Interest rate influence from the United States strong, all the same

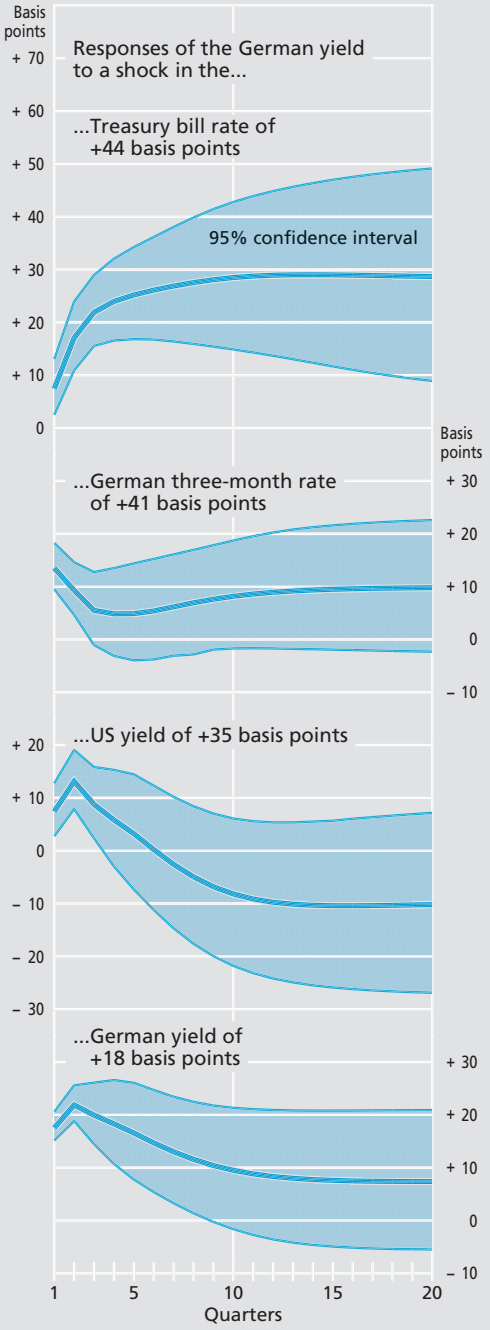
The US money market rate is at the same time, and also in the long term, independent of other interest rates; it therefore largely determines the general interest rate trend. This situation is also reflected in what are known as "impulse response functions", which mirror the dynamic course of the responses of an interest rate to a one-off independent shock in another interest rate variable.[14] Firstly, it is only the auto-shocks, but not the changes in other variables, that permanently alter the money market interest rate level in the United States. Secondly, movements in short-term US interest rates result in permanent changes in the levels of other interest rates.[15]

German capital market rates have the following response patterns: positive shocks in US yields can distinctly and significantly increase the German yield level only for a comparatively short time (about three quarters); the effects of this are not permanent. Auto-shocks and innovations in the German money market rate, by contrast, result in sustained changes in German yields. Conversely, the German capital market rate has no significant effects on US interest rates. Only shocks in the German money market rate may temporarily trigger a response in the opposite direction among US interest rates.

Heavy dependence on interest rates abroad owing to transmission of interest rate shocks

Because of the lack of any pressure to converge, US interest rates do not clearly dictate the German interest rate level; through the

Impulse response functions for German yields *



* Impulse response functions from the VECM with two lags estimated over the period from the third quarter of 1975 to the fourth quarter of 1996. The extent of the shocks concerned corresponds to its estimated average value (a standard deviation) during the period observed.

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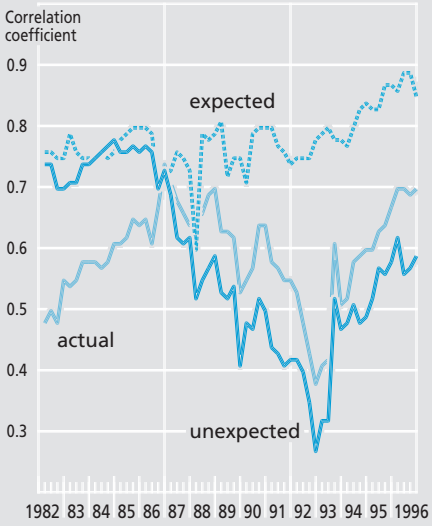
14 Impulse response functions capture all direct and indirect, simultaneous and lagged, mutual influences of the four interest rates.

15 These permanent effects are a reflection of non-stationary interest rates.

ripple effect of interest rate shocks from the US capital and money markets, however, temporary and even permanent shifts in the German interest rate level may occur. Notably the German long-term interest rate reflects interest rate movements in the US capital market through this transmission channel; US interest rate movements, for their part, are largely determined by US monetary policy. The German yield level, however, is dominated, at least over the longer term, by the domestic interest rate conditions reflected in the German money market rate. Furthermore, there are no signs of lasting structural breaks in the estimated relationships with the result that, particularly in the nineties, it is unlikely that there has been any increase in the dependence of German yields on US interest rates.

Correlations of actual, expected and unexpected yield changes *



* German and US yield; breakdown of the actual yield change by means of one-step model forecasts; moving correlation over a 24-quarter window.

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Degree of synchronisation reflects periods of turbulence

Finally, with the aid of the VECM, the actual quarterly changes in German and US yields can be broken down into an anticipated part and an unanticipated part.[16] If the expected and the unexpected components of German and US capital market rates are correlated through a moving window (in this case over 24 quarters), the correlations of the unexpected interest rate shocks show a time path in much the same way as in the case of the actual total interest rate changes. The correlations of the expected part are all higher and are stable over time. Since sharp interest rate changes generally reflect unanticipated events and since a positive relationship between bond market volatility and interest rate linkage is likely, it can be inferred from this that changes in the interest rate linkage (measured by means of simple correlations) indicate economically relevant structural breaks to only a limited extent. Instead, they indicate periods in which interest rate movements in both countries are marked either by strong symmetrical shocks (close interest rate linkage) or, more likely, by small, disconnected interest rate movements (loose interest rate linkage).

No universally valid information on structural dependence obtainable

However, the information on the German-US interest rate relationship collated by means of the impulse response functions can provide no definitive indication of the precise structure of the international interest rate linkage.

16 Since the VECM only includes the lagged interest rates as explanatory variables, the estimated value for each individual variable corresponds to a one-step forecast which can be interpreted as an expected value. The residual correspondingly contains the expectation error (the unexpected component).

Firstly, the results achieved inevitably depend on the theoretical and statistical assumptions on which the model specification is based. Secondly, it is probable that the estimated relationships include many expectation effects, which are more likely to constitute responses to one-off events and less likely to reflect systematic recurring relationships. This is suggested by the marked variability of interest rate movements, which is reflected, for example, in the large confidence intervals among the impulse response functions.

Monetary policy implications

Linkage between capital market rate and monetary policy

The domestic factors reflected in Germany's money market rate determine nominal capital market rates in the long run; at times, however, they may be obscured by strong international influences. The parallelism which can normally be observed between changes in short-term and changes in long-term interest rates is not surprising in that both – through the reaction function of the central bank and the expectations of market players – reflect the same fundamental influences. However, this empirical finding definitely does not imply that the central bank can manage the capital market rate mechanistically.

Stability-oriented monetary policy…

The potential impact of monetary policy on the capital market rate is of a long-term nature and is restricted to its monetary components, namely inflation expectations and the inflation risk premium. From the point of view of the central bank, it is desirable to keep both interest rate components as small as possible, with the result that the expectations which they enshrine are in line with the lasting achievement of price stability. This can only be accomplished if the shaping of interest rate conditions in the money market is an integral part of a consistent and credible monetary policy strategy. If it is, the central bank is making an enormous contribution to reducing uncertainty about longer-term interest rate movements.

… without short-term action for its own sake…

The inference is that the central bank, in principle, should not try to offset undesirable external influences on the capital market rate by taking short-term counteraction. Changes in the money market rate due to such action might lead to a reappraisal of the monetary policy regime and undermine the stable relationships hitherto obtaining. There is a danger of the long-term anchoring of market expectations becoming less stable or even being forfeited, with the result that the undesirable external influences are actually reinforced, instead of being reduced. This has to be borne in mind all the more carefully, given the fact that the susceptibility of the bond market to swings in expectations has increased, not least on account of the enormous rise in the presence of foreign investors.

… makes it possible to decouple Germany from unwelcome trends abroad

Conversely, consistently adhering to a stability-oriented policy paves the way optimally for containing disruptive external influences from the outset. This is underlined, for example, by the movement of German capital market rates during the bond market upheaval of 1994. Although Germany could not entirely escape the worldwide rise in interest rates in the bond markets, the increase in yields in this country was noticeably lower than in

other economies, and receded again relatively quickly.[17] Such a policy ultimately helps to ensure that existing scope for decoupling German interest rate movements from international interest rate trends deriving from differences in economic developments is actually exploited, and not reduced as a result of uncertainty.

Long-term interest rate as a monetary policy indicator

Where the interest rate trend in the capital market, as marked out by the fundamentals, is obscured in the short run not only by technical market influences (such as the arbitrage or hedging strategies of institutional investors) but above all by the transmission of interest rate shocks from abroad, the observed capital market rate cannot readily act as an indicator of the current stance of monetary policy. Instead, what appears necessary is an analysis of its determinants in the light of the given situation and in the context of a greater range of indicators tailored to the ruling monetary policy strategy and providing a comprehensive picture of the monetary setting in which that monetary policy is being pursued.

17 See Deutsche Bundesbank, The economic scene in Germany in summer 1994, Monthly Report, September 1994, pages 12–14.

Annex

Interest rate linkages in the vector error correction model

Cointegration as a long-term equilibrium relationship

The influences of short-term and long-term interest rates in Germany and in the United States on each other can be captured by means of a vector autoregressive approach. The non-stationarity of the interest rates raises the economically significant question of whether cointegration relationships exist between them. Cointegration between two or more non-stationary variables occurs if there is a linear combination of these variables which is stationary. The parameters of this linear combination form the so-called cointegration vector. Once these relationships are identified, they can be interpreted economically as a long-term equilibrium. Cointegrated interest rates have a common stochastic trend, with the result that they cannot diverge from each other indefinitely. The equilibrium errors affect the short-term interest rate dynamics in such a way that they are self-adjusting over time. To that extent, cointegration always implies the existence of an error correction model, which for the multivariate case is represented by the VECM:

$$\Delta z_t = \Gamma_1 \Delta z_{t-1} + \ldots + \Gamma_{p-1} \Delta z_{t-p+1} + \Pi \begin{pmatrix} z_{t-1} \\ 1 \end{pmatrix} + \Psi D_t + \epsilon_t ,$$

with $z_t^T = (z_{1t}, \ldots, z_{nt})$ – (nx1) vector of the endogenous variables; Γ_i – (nxn) coefficient matrices, where i = 1, ..., p–1; Π – (nxn+1) matrix; D_t – vector of deterministic variables (e. g. dummies); Ψ – coefficient matrix for the deterministic part; ϵ_t – (nx1) vector of independently, identically and normally distributed error variables, where $\epsilon_t \sim$ NIID(0, Σ); $z_0, \ldots, z_{-p+1}$ fixed starting values. The influence of the constants is restricted to the cointegration relationship in this case because the interest rates do not show any deterministic time trends. The maximum likelihood estimation of the VECM is made by the so-called Johansen procedure for

quarterly averages from the first quarter of 1975 to the fourth quarter of 1996.[18] The cointegration hypotheses are verified with the aid of a special test procedure based on matrix Π. If $0 < r < n$ cointegration relationships are found, Π can be decomposed into: $\Pi = \alpha\beta^T$. Matrix α is designated as a "loading matrix", and matrix β contains the r cointegration vectors β_i in columns. The parameters of the loading matrix show how the system variables (the first differences) respond to the lagged equilibrium errors $\beta_i^T (z_{t-1}^T, 1)^T$. The loading coefficients therefore represent a yardstick of the "speed of adjustment" to the equilibrium.

Interest rate relationships in the VECM

A VECM can be used to examine the three dimensions of the international interest rate relationship discussed above – convergence, causality and synchronisation – in a uniform framework. Domestic and foreign interest rates converge when a cointegration relationship exists between them. Statements on (statistical) causality can be obtained with the aid of impulse response functions. The average degree of synchronisation is reflected in the co-variances of the residuals; decomposing the actual changes in interest rates into an anticipated part and an unanticipated part provides, in addition, information on features of periods with different degrees of interest rate synchronisation.

Theoretical cointegration relationships

The theoretical framework of the model was presented in the main article. The expectations theory of the term structure of interest rates implies the following relationship between the long-term interest rate (R_t), the short-term interest rate (r_t) and the expected changes in the short-term rate:

$$R_t - r_t - \phi = \sum_{i=0}^{n-1} w_i E_t \Delta r_{t+i}\,.$$

A long-term, constant and positive risk premium ϕ is assumed. The weights w_i diminish geometrically in the case of yields on coupon bonds and add up to one. If a stationary risk premium is assumed, the short-term and long-term interest rates must be cointegrated because the first interest rate differences (and thus the right-hand side of the equation) are stationary. The simple spread – extended to include the risk premium – forms the long-term equilibrium relationship with the cointegration vector $\beta = (1, -1, -\phi)$.

The uncovered interest rate parity, augmented in each case by a risk premium φ, is for a single-period investment or for long-term securities with a maturity of n periods:

$$r_t^D - r_t^{US} = E_t \Delta e_{t+1} + \varphi_t^{(1)},$$

$$R_t^D - R_t^{US} = \frac{1}{n}\sum_{i=1}^{n} E_t \Delta e_{t+i} + \varphi_t^{(n)}.$$

If the expected exchange rate changes ($E_t\Delta e_{t+i}$) and the currency risk premium are stationary, the simple interest rate differentials constitute the theoretical cointegration relationships.

The two national term structures and the two uncovered interest rate parities define, independently of each other, four cointegration relationships. In fact, it is the case that, where the expectations theory and the interest rate parity are valid simultaneously, all interest rates must be cointegrated pairwise. In a system where n interest rates are cointegrated pairwise, however, there can only be n–1 cointegration vectors that are linearly inde-

18 A comprehensive representation and explanation of the multivariate cointegration analysis appears in Johansen, S., Likelihood-Based Inference in Cointegrated Vector Autoregressive Models, Oxford et al., 1995.

pendent.[19] In the present case, therefore, not more than three cointegrating relationships can be found. This makes the task of identification easier because it must be possible to reduce the resultant cointegration relationships to individual interest rate differentials.

Specification

The VECM is estimated with two lags. Particular attention is paid to the fact that the properties of the residuals are consistent with the model assumptions. Problems are posed by the exceptionally erratic behaviour of the Treasury bill rate at the beginning of the eighties.[20] These problems can be controlled, firstly, by jump dummies for individual quarters with very large leaps in interest rates and, secondly, by estimating a partial VECM in which the short-term US interest rate no longer appears as an endogenous, but simply as an exogenous, variable. The results described in this article relate to the dummy version of the VECM.[21]

Cointegration results

Tests indicate two cointegration relationships, but categorically refute the idea of there being three. Each of the two cointegration vectors can be restricted as a relationship between the national short-term and long-term interest rates, and therefore can be identified; all hypothesis tests which assume at least one international interest rate relationship among the cointegration relationships must be definitely rejected.

Interpretation of the loading coefficients

The loading coefficients indicate how the variables react to the lagged equilibrium errors. Only the Treasury bill rate is weakly exogenous, with the result that the two loadings of the short-term US interest rate can be restricted to zero. The short-term US interest rate is therefore the driving force in US interest rate movements, and adjustment to disequilibria in the US term structure all occurs through the long-term interest rate. This finding does not necessarily argue against the validity of expectations theory; it simply implies that the US spread does not make any significant contribution to forecasting US short-term interest rates.

In the case of Germany, in line with expectations theory, the term structure contains useful information for anticipating the future course of the German money market rate. Moreover, the German long-term interest rate responds significantly to disequilibria in the spread in the United States. The following is a possible interpretation of this fact: if – for example, as a result of an unexpected rise in the money market rate – an equilibrium situation in the United States changes into a narrowing of the spread (resulting in this case in a negative equilibrium error in the US term structure), financial market players expect a rise in the yield on US bonds outstanding. This expected rise in the US interest rate entails increasing German yield expectations, which is reflected in the lagged US spread in the German yield equation.

No structural breaks

Structural break tests reveal no structural changes in the system. There are occasionally individual interest rate leaps of exceptional size, but these have no lasting effects. Consequently, it can be assumed on the strength of these results that the

19 See A. D. Hall, H. M. Anderson and C. W. J. Granger, A Cointegration Analysis of Treasury Bill Yields, in The Review of Economics and Statistics, 74 (1992), pages 116–126.
20 Firstly, the properties of the residuals deteriorate dramatically and, secondly, implausible coefficient estimations arise. The erratic behaviour of the short-term US interest rate is due to an operative realignment of monetary policy (change of regime), which was in force from the end of 1979 to 1982, and to a few administrative interventions in the United States.
21 This is possible because weak exogeneity can be ascertained for the Treasury bill rate. Although the partial VECM shows more favourable statistical properties, it cannot be used for decomposing the actual yield changes into an expected component and an unexpected component owing to the simultaneous influence of the exogenous Treasury bill rate.

Cointegration vectors and loading coefficients for the vector error correction model (VECM)

The VECM establishes the following connection between the quarterly interest rate changes and the long-term equilibrium relationships:

$$\Delta z_t = \alpha\beta^T \begin{pmatrix} z_{t-1} \\ 1 \end{pmatrix} + (...).$$

The vector of the endogenous variables z_t contains the short-term (r_t) and long-term (R_t) interest rates of the United States and Germany in the following order: $z_t^T = [r(US)_t, R(US)_t, r(G)_t, R(G)_t]^T$. The coefficients of the two cointegration relationships stand in the two columns of the (5x2) matrix β, with the result that the (2x1) product $\beta^T(z_{t-1}^T, 1)^T$ contains the two equilibrium errors in its rows. When weighted with the corresponding element from the (4x2) loading matrix α, each equilibrium error brings about a lagged adjustment of the various interest rates. The estimate [1] gives the following long-term relationships [2], while the t-values (for the loadings) and the standard errors (for the cointegration coefficients) are shown next to the estimated values in brackets, without a plus or minus in each case:

$$\begin{pmatrix} \Delta r_t^{US} \\ \Delta R_t^{US} \\ \Delta r_t^{G} \\ \Delta R_t^{G} \end{pmatrix} = \begin{pmatrix} 0 & 0 \\ -0.127\ (2.56) & -0.029\ (0.48) \\ -0.086\ (1.79) & +0.145\ (2.31) \\ -0.086\ (2.84) & -0.058\ (1.48) \end{pmatrix} \begin{pmatrix} R_{t-1}^{US} - 1.038\ (0.11) r_{t-1}^{US} - 1.548\ (0.79) \\ R_{t-1}^{G} - 0.431\ (0.08) r_{t-1}^{G} - 4.613\ (0.53) \end{pmatrix} + (...).$$

1 Estimate of the VECM with two lags for the period from the third quarter of 1975 to the fourth quarter of 1996 with jump dummies for the monetary policy regime change in the United States (fourth quarter of 1979, the first, second and fourth quarters of 1980, the first and fourth quarters of 1981 and the third and first quarters of 1982) as well as for the German yield shock in connection with German unification (the first quarter of 1990). — **2** Cointegration vectors restricted as national term structure relationships and US short-term interest rates as weakly exogenous (likelihood ratio test statistic = 1.94 with a p-value of 0.75).

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structural relationships between German and US interest rates have remained quite stable over time. The one qualification is that the short-term relationships, in particular, are estimated imprecisely on account of the comparatively strong variability of interest rates.