2nd AFIR Colloquium 1991, 1: 267-287

Interest Rate Models for some Financial Markets Scenarios and Forecasting

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Summary

Our thinking about interest rates is often hardly structured. What determines our view of the future is often dictated by the news of the day. Because of this a more structured approach by means of simple models estimated by statistical techniques using adequate timeseries should give more reliable forecasts. This paper presents some money and capital market interest rates models for the United States, Germany and the Netherlands. These models can be used for scenario's and forecasts.

Résumé

Modèles de Taux pour Quelques Marchés Financiers; Scénarios et Prévisions

Notre réflexion sur les taux d'intérêts est souvent mal structurée. Ce qui détermine notre vision du futur est souvent dicté par les nouvelles du jour. C'est pourquoi, une approche plus structurée au moyen de modèles simples estimés par des techniques statistiques utilisant des séries chronologiques adéquates devrait donner des prévisions plus fiables. Cet article présente des modèles de taux du marché monétaire et du marché des capitaux pour les Etats-Unis, l'Allemagne et les Pays- Bas. Ces modèles peuvent être utilisés pour des scénarios et des prévisions.

Aim of the Interest Rate Model

International money and capital markets are subject to many influences. Psychological factors often play an important part, so that these markets tend very much to overreact. It is not uncommon for the market to be 'directionless' - awaiting a new impetus. For instance, the market typically waits for the weekly publication of macro-economic figures. And quite frequently, a factor which is of no importance one week appears to be crucial the next. And this is how it is that time after time we can read in reliable financial newspapers that 'Investors were dominated by fears of inflation' one day, and the next day that 'Investors are becoming convinced that inflation will be less serious than expected'.

It would therefore appear useful to introduce a structured approach to our thinking about interest rates. Precisely what factors produced what effect in the relevant past? That is the question which has to be answered, and in doing so it is important that we consistently use the same checkist of important factors so as not to vary them from time to time. Such an approach ought to enable us to introduce a little structure into our thinking, and it may even become possible to give an answer to 'what if' questions. The ultimate aim must be to design a mechanism which will allow us to say something about the future.

The first version of the model presented here was developed almost ten years ago. Over the years, the model has been refined and re-estimated, and was initially also published in several different forms.[1)] Each year, the model is used for a seminar for institutional investors in the Netherlands at which a four-quarter forecast is presented. An important limitation as regards the perfection of the theoretical framework of the model on the one hand and, on the other hand, the data used (quarterly figures instead of monthly ones) and the estimation techniques used (least squares method) is the fact that all the determinants used must be variables for which a forecast can be made and that the model must remain simple. This means that, to apply the model, it is only necessary to make use of existing external sources, if so desired. An implication of all this, however, is that all kinds of refinements which might be theoretically desirable cannot be applied.

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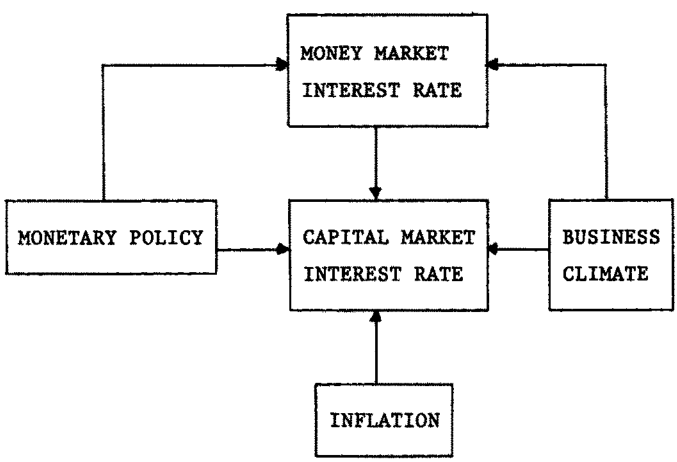
1) C.J. Prins, Enkele determinaten van de rente-ontwikkeling in Nederland (A number of determinants of interest rate movements in the Netherlands - in Dutch), Economisch Statistische Berichten, August 1983.
Id., De rente in 1986 (Interest rates in 1986 - in Dutch), Economische Statistische Berichten, February, '86.
Id., De rente in 1987 (Interest rates in 1987 - in Dutch), Economische Statistische Berichten, February, '87.

Theoretical Background

Looking into the future, in other words, does not necessarily have to rely on reading tea leaves or examining the residues of other more or less appetising products. Recourse to a simple checklist of important factors can tell us a great deal about future developments. And there is no reason why it should not be possible to make predictions about interest rates in the same way.

Let us consider what such a simple checklist of influential factors looks like in the case of the capital market interest rate. We shall not concern ourselves at this stage with the possibility of international interdependences, so as to keep things perfectly simple and transparent. In broad terms, our conceptual model might look something like this:



The influence of inflation on interest rates is well known and quite plausible. The interest rate is the price of the means of exchange -

money - and if the general level of prices rises, then the price of the means of exchange will also rise at the same rate. However, it is probable that people look beyond inflation in the current year. In other words, it will be necessary to make an estimation of future inflation.
One of the first to draw attention to this problem was Irving Fisher, who explaned the nominal interest rate (r) in terms of the expected inflation rate (E(Pc)) and the real interest rate (taken to be constant): (i).

$$r = i + E(Pc)$$

This simple expression also forms the basis of the models developed here for an number of countries.

A practical problem arises in assessing the expected inflation. It will be necessary however to estimate the inflation for the mutarity of the loan. The expected inflation is strongly related to a certain period. It is not easy to get information about the expected inflation. Information can be obtained from the past and from surveys among experts.

Two elements are of extreme importance. First the inflation of the past. We can use for this the inflation trend during a certain well defined period. It is however uncertain whether this trend will also be the future trend or not. One can be more certain about the future developments of inflation when the volatility is lower. For this reason the expected inflation uses both elements and can hence be quantified as follows:

$$E(Pc)_t = \bar{Pc}_t + \sigma Pc_t$$

The expected inflation in period "t" equals the trendvalue of inflation over a period of 10 quarters plus the volatility of this inflation measured by the standard deviation over the same period of 10 quarters.

The inflation expectation E(Pc) has a special attribute. In general the actual inflation is closely followed but only an increase of inflation is clearly visible in both trend and standard deviation. A decline in inflation however comes out in a decline in the trend value, but also in an increase of the standard deviation. This reaction to a decrease in inflation depicts clearly the wait and see attitude in the real world. Figure 1. shows this very clearly for the rise in inflation in the United States between 1978 and 1980 and afterwards for the sharp decrease in inflation. The former is closely followed by the inflation expectation the latter with a time lag.

Figure 1: Inflation as a percentage per annum and inflation expectation in the USA, 1972-1990.

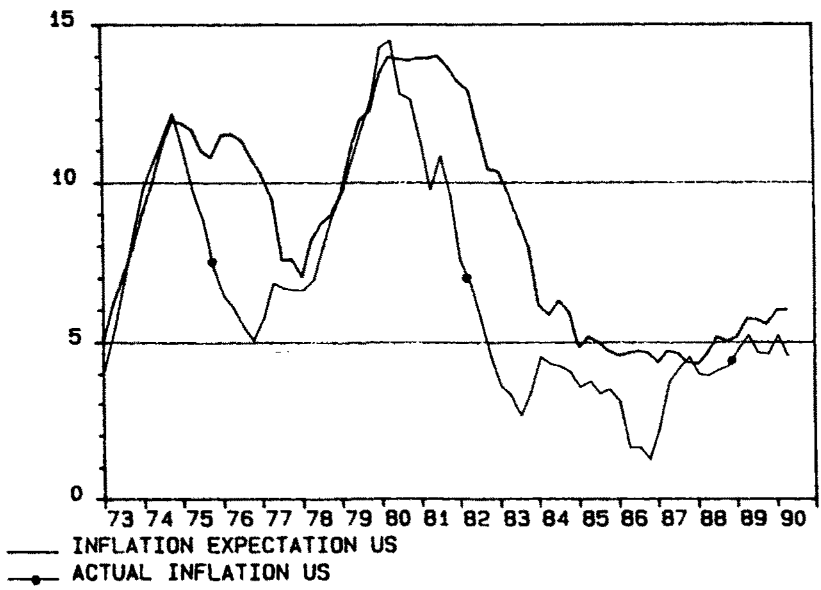
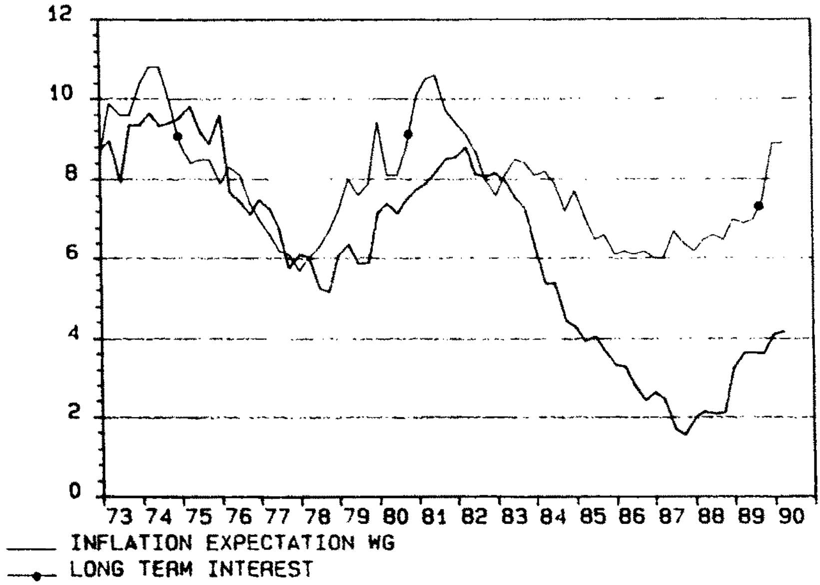


Figure 2 shows that the inflation expectation formulated in this way can provide a good explanation for the movements in the capital market interest rate. That this is particularly apparent in Germany is not strange in view of the traumatic experiences of inflation in Germany in the 1930s.

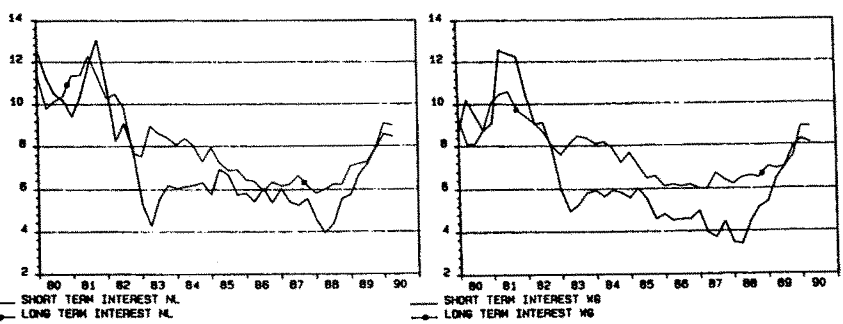
Figure 2: Capital market interest rates and inflation expectation in Germany 1972 - 1990.



The influence of monetary actions and the influence of the money market interest rate are somewhat vague and rather confused. Let us take the money market interest rate to begin with. If the short interest rate is higher than the long interest rate, then obviously many people are going to prefer to invest funds for shorter terms rather than longer terms. If we can get an attractive interest rate for a period of a few months and expect higher interest rates in the longer term, the effect will be similar. And for lower interest rates at the short end of the market and a substantial differential between long and short interest rates, the opposite will apply.

Now, the chief monetary authority in the Netherlands, De Nederlandsche Bank, is mainly able to control short term interest rates. By means of its 'small monetary policy', de Nederlandsche Bank attempts to control the value of the guilder via the money market and/or the foreign exchange market (which we have yet to consider).
Affecting the capital market directly is the 'large monetary policy', through which the Central Bank controls the growth in lending. However, this mechanism was only used to exert influence on the capital market in the years 1977 - 1981. The incidental influences arising out of the use of the interest rate weapon to moderate exchange rate fluctuations must be seen as a special influence among the various incidental influences. In countries like the USA and Germany, the monetary authorities have a variety of ways of influencing interest rates (both long and short term). The influence of the short term interest rate on the capital market interest rate is shown in figure 3 for both the Netherlands (left) and Germany (right).

Figure 3: Influence of the money market interest rates on the capital markets in the Netherlands and Germany, 1980 - 1990.



International Connections

In practice, the hypothesis that it should be possible to make projections on the basis of foreign influences cannot be substantiated. Furthermore, with the growing integration of international capital markets, interest rates in the world are becoming increasingly closely interrelated. It is possible to apply statistical tests to determine the extent to which this is so. For a dozen countries (USA, Germany, The Netherlands, Japan, UK, Australia, Sweden, Italy Canada, France Switzerland and Belgium), an analysis was made of the interrelationships on the basis of quarterly data over an extended period commencing 1970 and using Principal Components Analysis. The question was whether a common pattern could be detected in the interest rates of these countries and what degree of correlation would be found. The answer to this question was given by establishing, for each of the various subperiods, what percentage of the total variance was accounted for by the Principal Component.

The table clearly shows that the international connections have grown much stronger. For instance, the correlation between the Netherlands and Germany on the one hand and the USA on the other was particularly weak to begin with, and Japan also played hardly any part in international interest rate movements. This picture changed dramatically in the course of the 1970s. Given these changes, the obvious answer is to use a relatively short estimation period for these countries. For the USA, however, as a large independent money and capital market, this is not necessary. A study of the desirability of a simultaneous system of interest rate equations for the USA, Japan and Germany did not, incidentally, yield the desired result. Incidentally, apart from Switzerland, the odd man out in the international picture is the UK. For these two countries, the principal component is only capable of accounting for 10 - 20% of the specific variance on average.

Looking at specific correlations, the most obvious is that between Germany and the Netherlands. Less obvious is that between Japan and the Netherlands. For the whole of the period under study, out of all the countries involved, the Netherlands in fact shows the closest correlation with Japanese interest rates. And there is only a marginal change in this situation over the years. There are no fundamental reasons as to why this should be so, however.

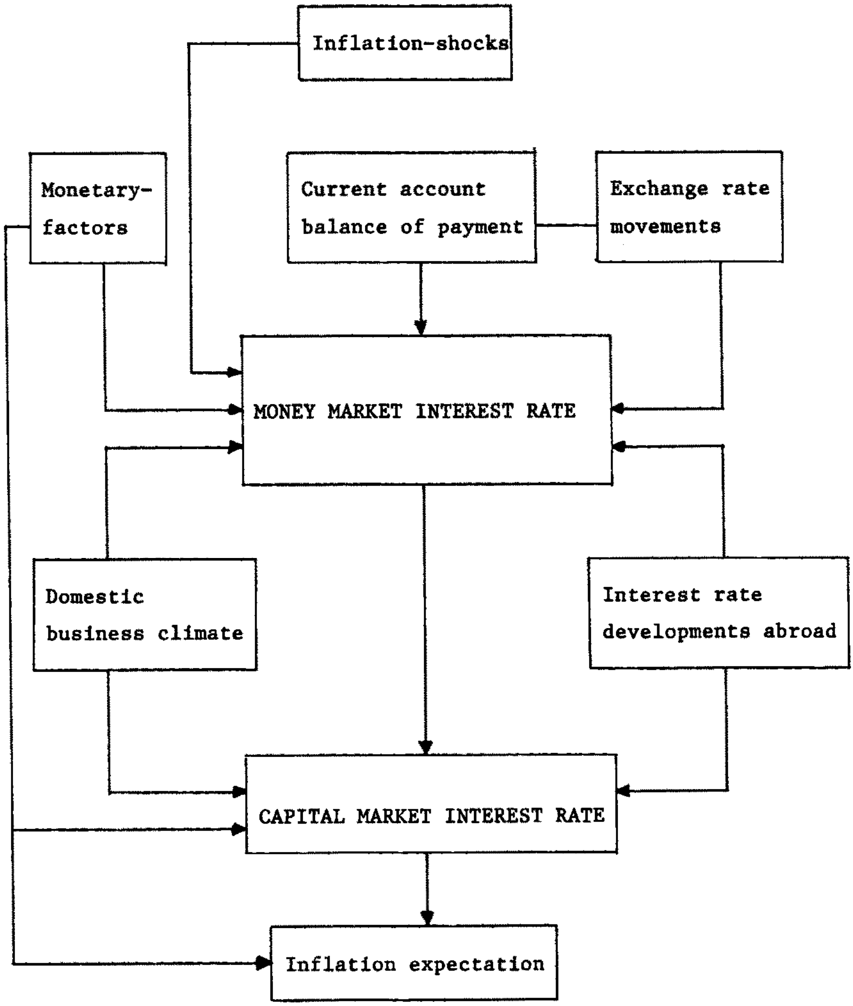
Table 1: The international connection between capital market interest rates in the twelve countries.

Period	Percentage of variance accounted for by the first principal component
1970 - 1990 (II)	55,5%
1973 - 1990 (II)	52,8%
1976 - 1990 (II)	64,3%
1978 - 1990 (II)	70,4%
1980 - 1990 (II)	74,4%

The Essentials of the Model

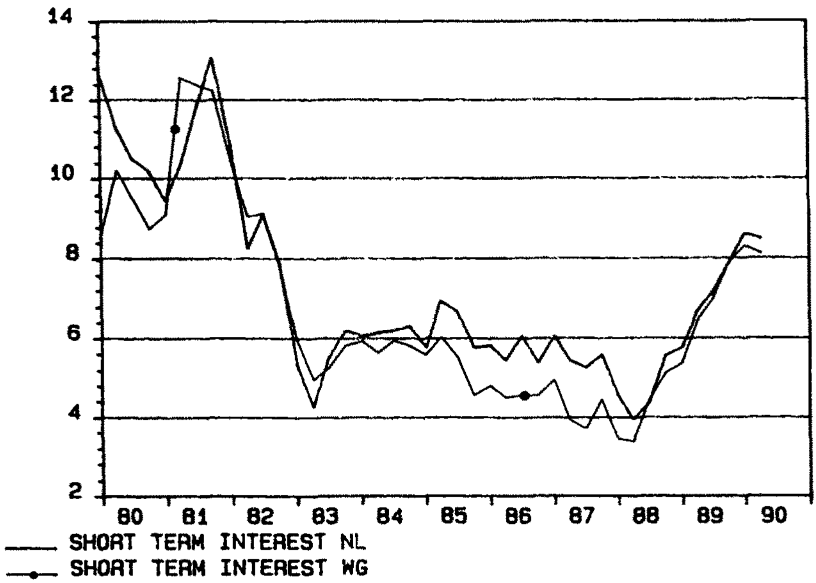
If, in addition to the national (closed) form of the model previously discussed, we also introduce the international element, we see that the whole thing becomes far more complicated. This is because the basic form of the model applies in the case of each country that is particularly exposed to developments abroad. The flow chart of the basic model takes the following form, although it should be pointed out that additional specific factors will need to be included for various countries.

Figure 4: Flow Chart of the interest rate model.



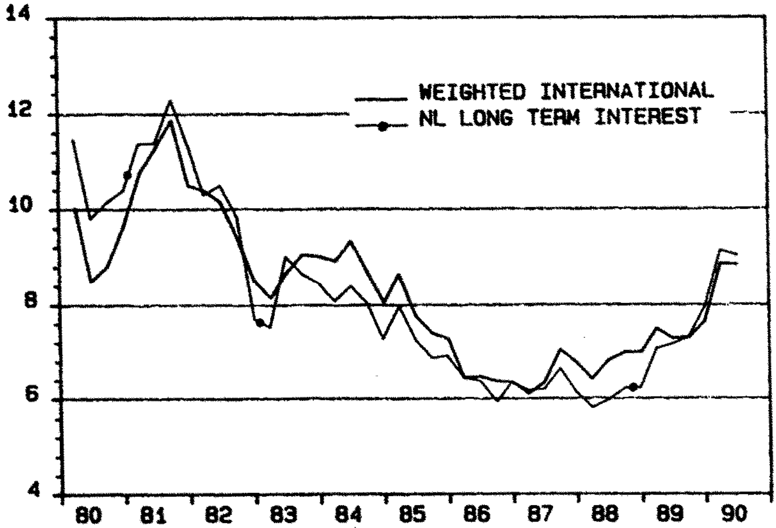
In the following graphs, we examine a number of significant relationships for the various countries in greater detail. As regards the money market interest rate, the effect of German interest rates on those in the Netherlands is shown in figure 5. The earlier conclusion concerning the connection between these two interest rates is again obvious.

Figure 5: Money market interest rates in the Netherlands and Germany.



However, figure 6, which includes foreign interest rates, made up of the German capital market interest rate (75%) and the US capital market interest rate (25%), shows that this influence extends beyond the money market. Figure 6 also shows that the influence of German interest rates on those in the Netherlands is becoming increasingly strong whilst the influence of American interest rates is becoming less and less significant.

Figure 6: Capital market interest rates in the Netherlands and foreign influences.



The Interest Rate Structure in the United States

The Money Market Interest Rate

It was found not to be a simple matter to construct an acceptable model for the money market interest rate ($R_t^{S,US}$) which was capable of giving good results over a sufficiently long period. A Koyck distributed lag was therefore introduced by using the value of the dependant variable delayed by one period as the determinant. The state of the economy is reflected in two variables, capacity utilisation (CAP_t) and the quarterly growth in GNP, G_t^{GNP}, which was annualised. Considerable importance was then also attached to the liquidity ratio (λ_t), which was included in an asymptotic relation. The constant of 0.45 was arrived at by trial and error in steps of 0.025. A dummy for the extremely tight money market policy in the fourth quarter of 1980 completes the picture:

$$R_t^{S,US} = -7{,}67 + 0{,}77\,R_{t-1}^{S,US} + 0{,}06\,CAP_t + 0{,}09\,G_t^{GNP*4} +$$
$$\quad\ (-2{,}9)\quad (9{,}6)\qquad\qquad (2{,}3)\qquad\quad (2{,}6)$$

$$+\ 0{,}71\ (1/\lambda_t - 0{,}45) + 4{,}93\ DUM_{80} \qquad R^2 = 0{,}86$$
$$(2{,}1)\qquad\qquad\qquad (4{,}9) \qquad\qquad D.W. = 2{,}22$$

The t-values are given in brackets. The sign is correct in all cases and the coefficients all have adequate significance. The overall goodness of fit is reasonable.

The Capital Market Interest Rate

The most important variable determining the capital market interest rate in the USA ($R_t^{L,US}$) is the money market interest rate with a time lag of one period ($R_{t-1}^{S,VS}$). The "twin-deficits" i.e. the budget deficit as a percentage of GNP ($BUD.DEF._t$) and the surplus/deficit on the current account of the balance of payments expressed in the same manner ($CUR.ACC._t$) play their expected parts. And again we find the previously used variable for the state of the economy, quarterly growth in GNP (G_t^{GNP}). The inflation expectation ($E(Pc_t)$ discussed earlier along with the dummy variable for the money market policy in 1980 completes the model:

$$R_t^{L,US} = 0{,}66 + 0{,}67\,R_{t-1}^{S,US} + 0{,}16\,E(Pc_t) + 0{,}08\,G_t^{GNP} +$$
$$\quad (1{,}23)\ (12{,}5)\qquad\qquad (2{,}3)\qquad\quad (3{,}0)$$

$$-0{,}29\ CUR.ACC_t - 0{,}57\ BUD.DEF._t + 1{,}63\ DUM_{80} \qquad R^2 = 0{,}86$$
$$(-3{,}8)\qquad\qquad (-2{,}9)\qquad\qquad\quad (1{,}9) \qquad\qquad D.W. = 1{,}67$$

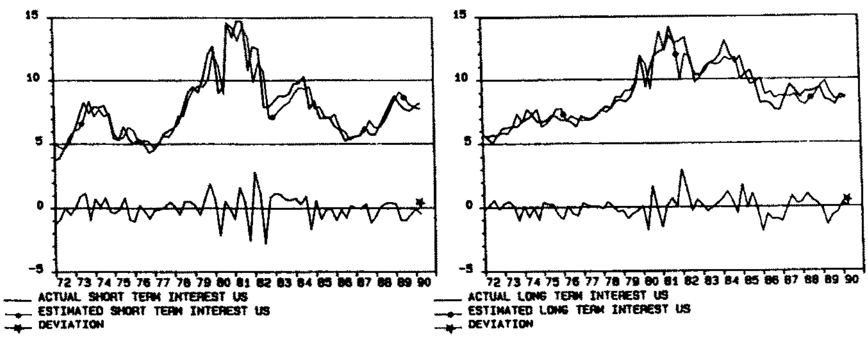
The goodness of fit achieved is again reasonable, and all coefficients have the right sign and adequate significance.

Evaluation of the Results for the USA

Correlation of the actual interest rate movements with the ex-post predictions reveals that the turning points in both the money market interest rate and the capital market interest rate are not always accurately predicted. There is a tendency for the turning points to be predicted one quarter late.

Figure 7: Correlation of model and actual interest rates for the USA

Money Market interest rate Capital Market interest rate



The graphs do show, however, that the model does not simply produce a systematic trace of the actual movements. The trend is generally well predicted. In the case of the money market interest rate, the deviation of the estimate is fairly large in relative terms, especially in the early 70s. The estimation result does not, however, improve with the shortening of the estimation period. When interest rates were at their peak (in the early 80s), the deviation of the estimate is also highest, but this is a normal phenomenon.

The Interest Rate Structure in Germany

The Money Market Interest Rate

To determine the money market interest rate ($R_t^{S,WG}$) a structure very similar to that for the United States was used. Again, a Koyck-type distributed lag system was applied. For Germany, a specific business climate index (BC_t) was constructed, made up of the standardised values for the business climate in manufacturing industry, the capacity utilisation factor, the number of unfilled job vacancies and total industrial output. The quarterly inflation figures were also included ($Pc_t^{WG,QU}$). In addition, it was assumed that the American money market interest rate had a significant effect. The ultimately preferred form taken by the model was as follows:

$$R_t^{S,WG} = \underset{(-0,6)}{-0,29} + \underset{(10,4)}{0,75}\, R_{t-1}^{S,WG} + \underset{(2,7)}{0,20}\, R_t^{S,US} + \underset{(3,1)}{0,44}\, BC_t +$$

$$+ \underset{(1,8)}{0,10}\, Pc_t^{WG,QU} \qquad R^2 = 0,93 \quad D.W. = 1,94$$

The variables again all have the correct sign and adequate significance. The overall goodness of fit is good, although the goodness of fit at the beginning of the estimation period in particular leaves something to be desired. For this reason, the whole series was re-estimated apart from the first five sets of figures. The result, measured in terms of the correlation coefficient (R^2), then showed a substantial improvement, although there was hardly any change in the value of the coefficients. The results of this shortening of the estimation period show this.

$$R_t^{S,WG} = -0,36 + 0,70\ R_{t-1}^{S,WG} + 0,24\ R_t^{K,US} + 0,49\ BC_t +$$
$$\quad (-1,3) \quad (14,9) \qquad\qquad (4,6) \qquad\qquad (6,4)$$

$$+ 0,07\ Pc_t^{WG,KW} \qquad R^2 = 0,98$$
$$(2,0) \qquad D.W. = 2,19$$

As can be seen from the above equation, there was a substantial improvement in the significance of the variables in particular. To a limited extent, however, the model continues to have a tendency to run one month behind the actual movements as regards predicting the turning points.

The Capital Market Interest Rate

In addition to the inflation expectation ($E(Pc_t)$), the short interest rate ($R_t^{S,WG}$) was also included as a potential explanatory variable. In the case of the German capital market interest rate, the influence of the quarterly movement in the dollar was also estimated ($US\$_t$). Also tested was whether the capital market interest rate in the United States plays a significant part. In the fourth quarter, German reunification had a substantial impact on the capital markets in Europe. The extent to which this aspect pushed up interest rates was tested by including a dummy variable with a declining influence over time. The steepness of this decline was determined by trial and error in steps of 0,05. The coëfficient indicates that this initial influence amounts to 1,4%. The model ultimately adopted had the following form:

$$R_t^{L,WG} = 2,64 + 0,30\ R_t^{S,WG} + 0,22\ R_{t-1/2}^{L,US} + 0,11\ E(Pc_t) +$$
$$\quad (4,9) \quad (7,1) \qquad\qquad (3,2) \qquad\qquad (2,1)$$

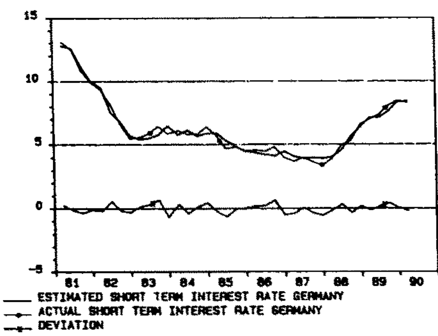
$$-0,04\ US\$_t + 1,37(0,9)^n\ DUM_n \qquad R^2 = 0,93$$
$$(-3,7) \qquad (4,3) \qquad D.W. = 1,72$$

n = 1 for 1989 fourth quarter etc.

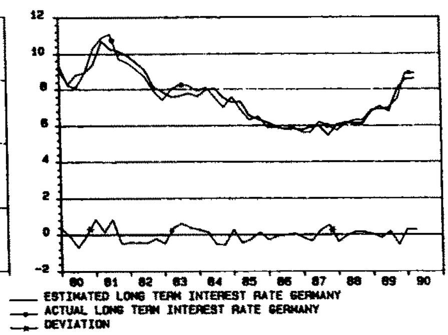
Evaluation of the Results for Germany

The two graphs for the money market interest rate and the capital market interest rate show that the goodness of fit with the actual movements is very satisfactory. Again there is no real systematic tracking of the turning points in the interest rate movements by the model either ahead of or behind the actual movements.

Money market interest rates



Capital market interest rates



In view of the good fit over the whole of the estimation period, the above results are highly satisfactory.

The Interest Rate Structure in the Netherlands

The Money Market Interest Rate

It is the policy of the Dutch central bank to link the value of the guilder to that of the D-mark. This is achieved by controlling interest rates. If the D-mark appreciates against the guilder, the interest rate is adjusted accordingly. The interest rate payable on D-mark credit balances appears to play a crucial role in this regard. Obviously, however, the state of the Dutch economy also exerts an independent influence. The money market interest rate in the Netherlands ($R_t^{S,NL}$) is accordingly made up of the money market interest rate in Germany ($R_t^{S,WG}$) with a lag of six weeks and the business climate in the Netherlands (BC_t^{NL}). This latter variable is in turn made up of four elements: capacity utilisation of capital goods, retail sales at constant prices, consumer credit at constant prices and the business climate indicator for manufacturing industry in Germany with a timelag of one period and corrected for trends. The complete model has the following form:

$$R_t^{S,NL} = \underset{(6,1)}{1,02} + \underset{(24,7)}{0,83}\, R_{t-1/2}^{S,WG} + \underset{(6,1)}{0,81}\, BC_t \qquad R^2 = 0,94 \quad D.W. = 1,43$$

The Dutch interest rate is determined almost entirely by the interest rate in Germany, the only essentially Dutch variable being the business climate indicator. And Germany even plays an important part in this indicator too.

The Capital Market Interest Rate

In the preceding versions of this model, the relationship between the capital market interest rate in the United States and that in Germany was determined by trial and error so as to create a new variable of the foreign capital market interest rate ($R_t^{L,F}$). Over the years, there has been quite a shift in these relationships. Initially, US interest rates dominated the picture whereas, today, their influence is only a third of that of Germany interest rates. As is the case with other countries, too we again find the previously defined term for the expected inflation level ($E(Pc_t)$). The model has the following form:

$$R_t^{L,NL} = 0{,}45 + 0{,}36\ R_t^{S,NL} + 0{,}53\ R_t^{L,F} + 0{,}14\ E(Pc_t) \qquad R^2 = 0{,}98$$
$$\quad (1{,}2) \quad (10{,}9) \qquad\quad (7{,}1) \qquad\quad (4{,}2) \qquad D.W. = 1{,}58$$

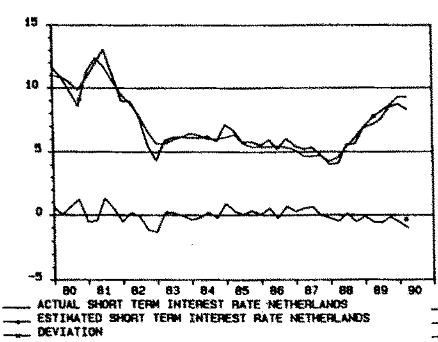
The sign of the coefficients is correct and their associated significance is more than adequate, so that the goodness of fit, at 98% is highly acceptable.

Evaluation of the Results for the Netherlands

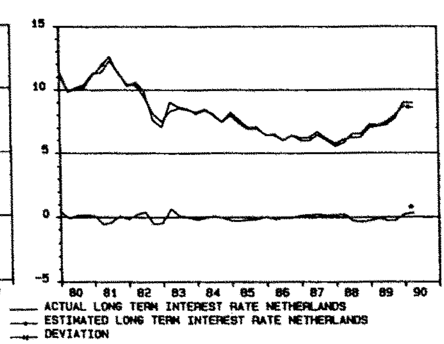
At the beginning of the period under study, owing to the close link with Germany, the money market model has difficulty in correctly estimating the peaks and troughs since, although the movement in interest rates in Germany followed the same pattern, it was far less violent. Surprisingly, according to the model, the money market interest rate should currently be somewhat higher than the already high levels we have at present. Model and realisation for the capital market interest rate correlate so closely that the goodness of fit is almost perfect. The two graphs again show this.

Model and actual for the Interest Rate Movements in the Netherlands

Money market interest rate



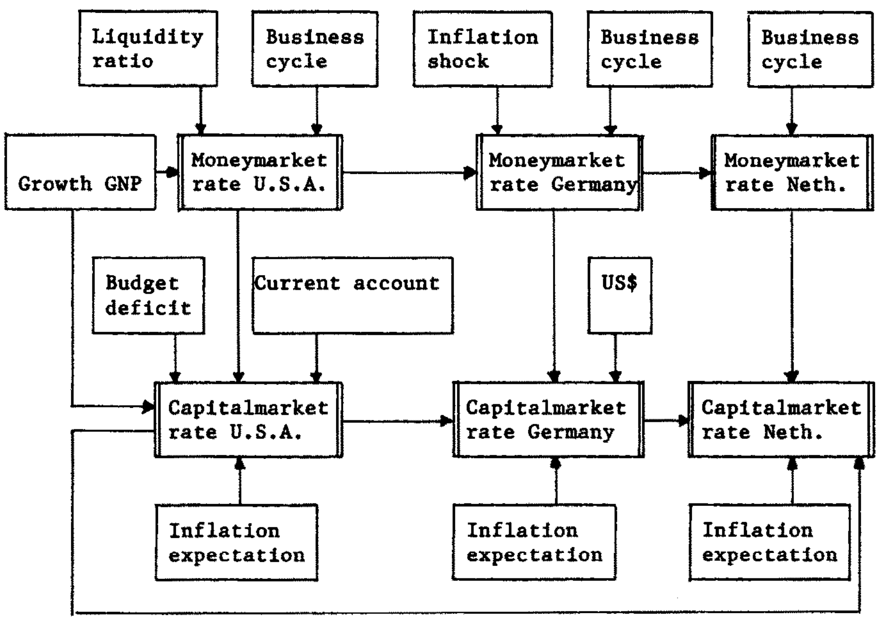
Capital market interest rate



The turning points in the interest rate movements are generally well predicted by the model.

Conclusion

It is possible to analyse interest rates in a number of countries using relatively simple methods and to develop a set of tools which are capable of answering 'what if' questions. Although the basic structure of the model in the various countries is fairly simple, the figure below shows how the underlining interdependence can nevertheless complicate matters.



By means of this instrument forecasts can be made for interest-rate developments as well as to answers what- if questions. Finally it is possible to construct scenario's.