

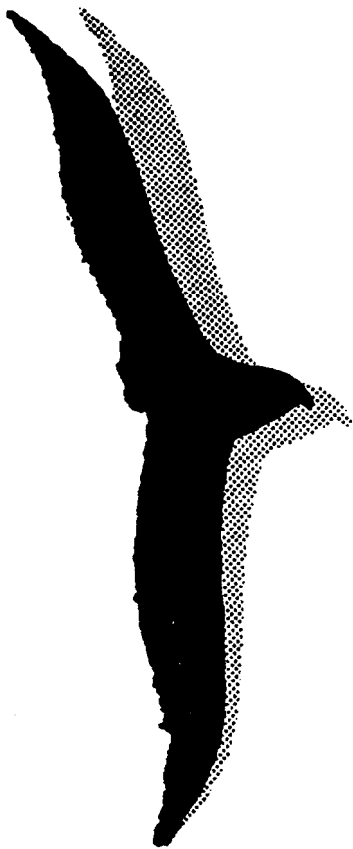
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Abstract

This paper estimates the short run and long run influences of the main determinants of the German long-term interest rate using quarterly data for the period 1982-1999. A major reason for our focus on the German interest rate is that this rate, and hence its determinants, will be dominant in explaining the developments of the long-term Euro-rate in the international capital market. The specification of our interest rate equation encompasses various theories on interest formation. The short-term German interest rate and American and Japanese bond rates appear to be the most prominent determinants of the German (and hence Euro) rate but also the business cycle and the demand for capital play a role in explaining this interest rate.

Keywords:

German interest rate, interest formation at the capital market, Euro rate, cointegration

Jel-code: E43

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1 Introduction

This paper presents an empirical model for the German interest rate which we interpret as the European long-term interest rate now that, with the introduction of the Euro in January 1999, European interest rates have been integrated. There are a number of reasons why we regard the determinants of the German interest rate as underlying determinants of the Euro rate as well. The process of integration of European interest rates started many years before the introduction of the Euro. The German interest rate always held a central position in this interest rate integration process, where it acted as a kind of "benchmark" for the other government bond yields. As January 1999 came closer and as the market got convinced about the entrance of a EU-country to the Euro-area, the interest rate of that country moved towards the German interest rate. Moreover, there is no European federal debt which could take over a benchmark position of the member states. Member states continue to carry their own debt. This implies that member states do not have the typical government risk-free advantages anymore, such as having control over monetary policy within the national borders. The governments of the member states are now competitors in the same market (see Dermine and Hillon, 1999, for a more detailed analysis). Because there is no typical European interest rate for a federal debt, an interest rate has to be chosen in the current market, to be able to conduct a research using historical time series.

For those reasons we have, in our empirical analysis, used the 10-year government bond yield (the Bund rate) as preferred indicator for the European long-term interest rate. Bonds with this German interest rate hold the largest market share in the total

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European bond market. It has a large and liquid futures market, of which futures are traded on both the Frankfurt and London futures markets. Identifying the German bond rate as the Euro rate implies that, in our empirical specification, other European long-term bond interest rates will not be used in explaining movements of the German interest rate. In other words, the relation between domestic bonds in the domestic (read: European) bond market are regarded as homogeneous products.

The contents of the remainder of the paper is as follows. Section 2 gives a short overview of 5 interest theories, which we have combined for the specification of our interest rate equation and for the selection of the explanatory variables. Section 3 summarises other empirical research on long-term interest rate movements, with a focus on the selection of variables which have been used for estimating the interest rate equations. Section 4 presents the specification of our interest rate equation for the 10 years German Bund yield and discusses the estimation results. Section 5 concludes.

2 Interest rate theory

Below we shortly discuss 5 alternative interest rate theories from the literature. Our selection of explanatory variables in the specification of the interest rate equation can be seen as encompassing all of these 5 partial theories.

Interest rate parity theory

The interest rate parity assumes integrated international capital (bond) markets. The investor has the choice between investing in the home government bond or the foreign government bond. In case there are price differences, arbitrage will cause the elimination of price differences. For this reason foreign interest rate developments can be of influence on the domestic interest rates. Also the exchange rate is of influence as it influences the net return on a foreign bond investment:

$$R_L = R_L^* - E^e$$

where: R_L = Domestic interest rate, R_L^* = Foreign interest rate, and E^e = expected appreciation of the domestic currency.

Preferred habitat theory

The preferred habitat theory (see e.g. Mishkin, 1997) shows that investments in the money market are a substitute for investments in the bond market. Returns may differ, but when the difference between returns gets out of equilibrium, it may induce capital movements to or from the money market, leading to changing bond prices. For instance, if the money market interest rate rises, it increases the attractiveness to hold short-term deposits instead of long-term deposits. Investors sell bonds (bond prices decrease, effective return increases) and buy deposits in the money market. Borrowers react in an opposite way. Their preference for long-term borrowing over short-term borrowing increases, as the short-term interest rate has risen.

The preferred habitat theory acknowledges that investors and borrowers have a preference for a certain maturity (which makes this theory differ from the expectations theory of the term structure), but that changing prices in either the money market or bond market can change the investment or borrowing decisions. Investors

are willing to change maturity when the risk premium changes. That makes movements in the money markets affect the long-term interest rate.

A positive relation between the rates at the money market and the bond market is assumed, but this does not always need to be the case in practice. For instance, a convincing response by the central bank to increase the official interest rates to fight inflation leads to a rise in short-term interest rates. Short-term inflation will be higher, while it is expected that because of the convincing central bank reaction long-term price stability is under control, which may even lead to a fall in the long term interest rate. Also, in an economy, which is just over its peak, an inverse yield curve is possible. In that case economic prospects for the longer run are sober, which depresses new investments and reduces the demand for long capital so that long-term interest rates fall. Yet the central bank has tightened monetary policy in reaction to the overheating in the recent past so that short-term interest rates are relatively high.

Classical theory of capital

In the classical capital theory the interest rate is explained by confronting demand for and supply of capital. At the demand side the main actors are companies and the government. The main supply stems from savings. On the bond market the government is the largest demanding party. Governments have historically built up large debts – particularly in our reference period. Because of the large share that governments hold in debt markets, the change in government surplus or deficit may have a considerable impact on the long-term interest rate, at least when the share of domestic bonds in the world capital market is substantial. It can strongly affect the liquidity in the market, as has been the case in Europe and especially in the United States in 2000 (see e.g. Schinasi et al., 2001 for an elaboration)

Business investments also play an important part at the demand side of the market. The investments show a strong relation with the course of business cycles. A strong (expected) economic growth leads to higher investments, production and stock building.

Fisher's interest rate theory

The classical demand and supply theory explains the real interest rate. However, an increase in inflation will cause prices to rise on the demand and supply side, moving both the demand and supply curves to the right. Fisher's interest rate theory states that investors want to be compensated for inflation. They add the expected inflation over the investment period to the market clearing real interest rate:

$$1 + R_n = (1 + R_r)(1 + \pi^e),$$

where R_n = nominal interest rate, R_r is the real interest rate and π^e is the expected inflation rate over the maturity.

Portfolio theory

Portfolio theory asserts that the difference in asset prices is caused by differences in risk, where it is assumed is that investors are risk averse and that they will only invest in higher risk assets when they are being compensated for this. For instance in Sharpe's (1964) Capital Asset Pricing Model (CAPM) the assets are priced on the degree of extra risk towards the risk free premium. Acknowledging the relation

between risky assets and risk free (government bonds) assets, movements in prices on, for instance, the stock market will effect bond prices and the interest rate. Evidence for this is probably the strongest in situations of financial turbulence on the stock market. Financial uncertainty on the stock market increases the risk of investing in shares. This leads to a capital flow towards a safe haven, for which usually highly liquid government bonds are used (German Bund and the US Treasury Bond). The capital flow from the stock market to the bond market reduces stock prices and causes a rise in the bond prices.' Higher bond prices lower the effective interest rate.

An overall interest rate theory

We will not derive a formal encompassing interest theory from these five partial theories. Our only aim is to identify from these theories explanatory variables for explaining long-term interest rate movements. Yet, in combining these theories the classical capital theory could act as core theory and could then be extended with the other theories discussed above.

Hence, the above theories lead us to use the following explanatory variables in our empirical analysis of German long-term interest rate movements (with the expected sign in parentheses):

1. Foreign long-term interest rates (+)
As earlier mentioned we see the German interest rate as an indicator for an interest rate for the Euro-zone. For this we see other European government bonds as domestic substitutes for the German bond and therefore we focus on the two largest foreign economic zones: The United States and Japan.
2. Exchange rates (-)
An expected appreciation of the domestic currency will attract foreign capital, which will lead to a fall in the domestic interest rate.
3. Short-term interest rate (+)
A positive relation is assumed between the long-term and the short-term interest, as the short-term interest rate is interpreted, in accordance with the preferred habitat theory, as an alternative investment choice.
4. Business cycle (+)
Higher economic growth gives more possibilities for investment. Usually a rising business cycle goes along with rising producer and consumer confidence.
5. Government financial balance (-)
The government held a large share in the market in our reference period. The demand for long-term credit by the government depends on the government's financial balance. A deficit on the financial balance means an additional demand for "new" capital.
6. Private savings (-)
7. Inflation rate (+)
8. Returns on assets (+)

¹ During 3 episodes of stockmarket disturbance, 1987-Q4, 1992-Q3 and 1998-Q3/Q4, the long-term interest rate on the German Bund decreased considerably. In 1987 the long-term interest rate decreased by 0,13%-point followed by 0,24%-point in the first quarter of 1988. In the third quarter of 1992 the decrease was 0,10%-point and 0,60%-point in the fourth quarter. In 1998 the interest rate decreased by 1,50%-point, of which 0,50%-point in the third quarter and 0,39%-point in the fourth quarter. These effects were not only caused by capital flows, but also by a fall in business activity and a fall in the expected inflation rate.

3 Empirical research on the long-term interest rates

Prior to presenting our own empirical research, we review a number interest rate equations from the literature. We consider both interest rate equations, which are part of larger monetary models, and equations from studies which focus specifically on the interest rates.

It appears that, in the monetary models we looked at, other interest rates are, by far, the dominant explanatory variables for the domestic long-term interest rate movement. For instance the German Bundesbank uses domestic short-term interest rates, other domestic long-term interest rates and lagged long-term government interest rates for explaining the long-term government interest rate in their 1984 model (see Bundesbank, 1986). In the 2000 MEMMOD model of the Bundesbank the Euro area long-term interest rate, the German short-term interest rate and the long-run short-term interest rate are used for explaining the German interest rate (see Bundesbank, 2000). The equation for the German long-term interest rate in the IMF MULTIMOD 11 (see Masson, Symansky and Meridith, 1990) and 111 (see Laxton e.o., 1998) as well as the FRB/US (see Brayton and Tinsley, 1996) monetary model for the United States, used by the Federal Reserve Board, has short-term interest rate expectations as explanatory variables. This is in accordance with the expectations theory² of the term structure of the interest rate. Besides the short-term interest rate expectations the IMF MULTIMOD 11 model uses the term structure at t-1 and the FRB/US model also uses the term structure at t-1 and the expected output gap to explain long-term interest rates. The OECD INTERLINK model has the short term interest rate and the term structure at t-1 as explanatory variables for the world interest rate (see Richardson, 1990).

The Bank of Canada uses in their QPM model the current short-term interest rate, the term structure at t-1 and the world long-term interest rate for explaining the Canadian long-term interest rate (see Coletti e.o., 1996). According to the Netherlands Bank foreign interest rates play an important role in explaining the domestic interest rate. In the Dutch MORKMON 1 model GDP, the domestic short-term interest rate, the German long-term interest rate, the American long-term interest rate, the dollar/guilder exchange rate and the demand of the government and private sector on the bond market are included as explanatory variables for the Dutch long-term interest rate movements (see De Nederlandsche Bank, 1985). In the MORKMON II model of the Netherlands Bank the long-term interest rate is explained by the inflation differences with Germany, the domestic short-term interest rate, the long-term German interest rate and the net foreign capital inflows.

Of the models we looked at, only the Dutch monetary models and the model of the Federal Reserve have non-interest rate variables as explanatory variables for their interest rates. Obviously, according to the Dutch models, the influence of the German interest rate is dominant over the other variables. In MORKMON 1 the coefficient of the German long-term interest rate is 0.42, as compared to 0.10 for the domestic short-term interest rate. In the Dutch short-term interest rate equation the German

² In the expectations theory the current long-term interest rate over the period N is explained by the average of the current short-term interest rate and all future expected short-term interest rates up to period N.

short-term interest rate even has a coefficient of 0.99. In MORKMON 11 the relation is even stronger, probably as a consequence of further monetary integration between the Netherlands and Germany. The coefficient of the German long-term interest rate has risen to 0.83 and the coefficient of the Dutch short-term interest rate is now estimated to be equal to 0.16. In the equation of the Dutch short-term interest rate the coefficient for the German short-term interest rate is 0.95. The strong relation between the Dutch and German interest rates leaves little room for other macro-economic variables to explain the residual interest rate movements. The coefficient of the world interest rate (specified as the US interest rate) in the Canadian QPM model is also high, as Canada is as strongly influenced by the US economy, as the Dutch economy by the German economy.

In our survey of interest equations we paid special attention to those specifications in which interest rate movements are explained by *other* macro-economic variables in addition to interest rate variables. These other variables represent the influence of the domestic economy relative to the integration of international capital markets. Knoester and Mak (1994) estimated an equation for the long-term German interest rate where the interest rate is explained by the German interest rate at $t-1$, the world interest rate, the liquidity ratio, a savings quote and the balance of payment. Caporale and Pittis (1997) also estimate an equation for the long-term German interest rate which includes non-interest rate variables, namely the German GDP and the German inflation rate. In their equation the German interest rate is, moreover, explained by the long-term interest rates of France and Switzerland and the German long-term interest rate at $t-1$. Fase and Vlaar (1998) use the German short-term interest rate, the US long-term interest rate, the German long-term interest rate at $t-1$ in explaining the long-term interest rate in Germany. In their long-term equation the change in German industrial production appears to have a significant effect in addition to these interest rate variables.

In their study of the long-term Dutch interest rate Van Els and Vlaar (1996) have, besides interest rate variables, the Dutch inflation rate and the government balance as percentage of GDP, as explanatory variables. Knot (1995) estimates an equation for the European Union long-term interest rate where he includes the real return on stocks, the short-term interest rate at $t-1$ after taxes, temporary income as percentage of national income, the expected inflation rate, investments as percentage of national income, real monetary expansion and positive and negative oil price shocks in his specification. Finally Krämer (1998) uses the short-term real interest rate, capacity utilisation and government debt for estimating the long-term interest rate for G7 countries.

All in all, these empirical studies of long-term interest equations show that short-term interest rates and foreign long-term interest rates are the main determinants. Nevertheless, some papers in the literature find significant effects of non-interest rate variables as well although the explanatory power is often limited.

4 Specification and estimation results

Specification

In our own empirical analysis of the German interest rate of the next section, we started by including all variables mentioned in section 3 in the specification but left

out those variables which did not yield plausible results either from a statistical (no contribution to explanation, test statistics indicate misspecification) or economic (wrong sign) perspective.

Chart 1 shows the time path of the interest rate on the 10-years Bund over the period 1982-1999. It is clear from the chart that this nominal rate has decreased on average over the reference period. Furthermore, the usual unit root tests indicate that the time series of this interest rate is integrated of order I(1), so that we decided to specify our equation with an error correction mechanism.



It implies that we have a long-run equilibrium equation :

$$R_{Ger} = f_1 \text{ (explanatory variables in levels),}$$

with R_{Ger} the German long -term interest rate and the short-run equation with the error correction mechanism to the long-run equilibrium where

$$\Delta R_{Ger} = f_2 \text{ (explanatory variables in first differences) } + \gamma (R_{Ger} - f_1).$$

Here γ represents the adjustment speed of the error correction.

Estimation

Our interest rate equation has been estimated over the period 1982-1999, using quarterly time series data. For the German government balance, which is only available annually, quarterly data have simply been calculated by dividing the annual movements by four.

Our preferred estimation result for the long-run equation is as follows:

$$\begin{aligned}
 GE10YR = & -7,95 + 0,18GE3M_{.1}+0,29US10YR_{.1}+0,27JP10YR_{.1}+0,01OIL_{.1}-0,35GOV_{.1}+ \\
 & (-5.43) \quad (6.71) \qquad \qquad (8.99) \qquad \qquad (6.32) \qquad \qquad (3.00) \qquad (-4.69) \\
 & 0,04IFO_{.1}+0,04REE_{.1}
 \end{aligned}$$

(4.47) (2.98)

and we arrive at the following estimation result for the short-term equation:

$$\begin{aligned} \Delta \text{GE1 OYR} = & 0,11 + 0,25 \Delta \text{GE3M} + 0,24 \Delta \text{US10YR} + 0,22 \Delta \text{JP10YR} + 0,02 \Delta \text{OIL} - \\ & (4,07) \quad (3,39) \quad (6,58) \quad (4,69) \quad (3,00) \\ & 0,31 \Delta \text{GOV} + 0,03 \Delta \text{IFO} - 0,61 (\text{LT}) \\ & (-3,56) \quad (4,47) \quad (-5,71) \end{aligned}$$

where:

GE1 OYR = German 10-years government bond yield OIL = Brent crude oil price
GE3M = 3-month German libor interest rate GOV = German government balance
US 1 OYR = United States 10-years government Bond yield IFO = German IFO-business activity indicator
JP 1 OYR = Japanese 10-years government bond yield REE = Real effective exchange rate

During our estimation procedure it appeared that not all variables we collected in section 3 for inclusion showed to be statistically significant. For instance, the German GDP did not contribute in explaining movements in the German interest rate. Instead, the IFO-business activity indicator (for West Germany) proved to be significant. The IFO indicator has strong predictive power for the business cycle and is published before the official GDP figure. Financial markets react to this early information on the stance of the business cycle and it is therefore obvious that the relation between the interest rate and the IFO indicator is stronger than the relation with the official GDP figure.

No significant effect was found from the inflation rate, which surprised us because inflation has played a dominant role on short-term and long-term nominal interest rates in the early 90's. The reason is, however, that the inflation rate is indirectly accounted for in the model through other variables, like the short-term interest rate and the oil price.

Finally, the return on shares and private savings did not show to be statistically significant in the estimated model. The real effective exchange rate appeared to be significant in the long-run equation only.

A comparison of the long-run equation and the short-run equation shows that typical short-term variables are more dominant in the short-term equation than the long term equation. The coefficients of the German short-term interest rate and the oil price are highest in the short-run equation. In the long-run equation foreign long-term interest rates and the government balance show the largest influence.

The fit of the estimated equation is depicted in chart 2. It appears that the explanatory power of the equation is rather high given the fact that the equation reproduces almost all fluctuations in the 10-years German interest rate over the period 1982- 1999. Chart 3 shows the pattern of the residuals, which forms, in addition to the usual test statistics, an eyeball test on the correct specification of the model.

Chart 2 Fit of equation, period 1982-1999

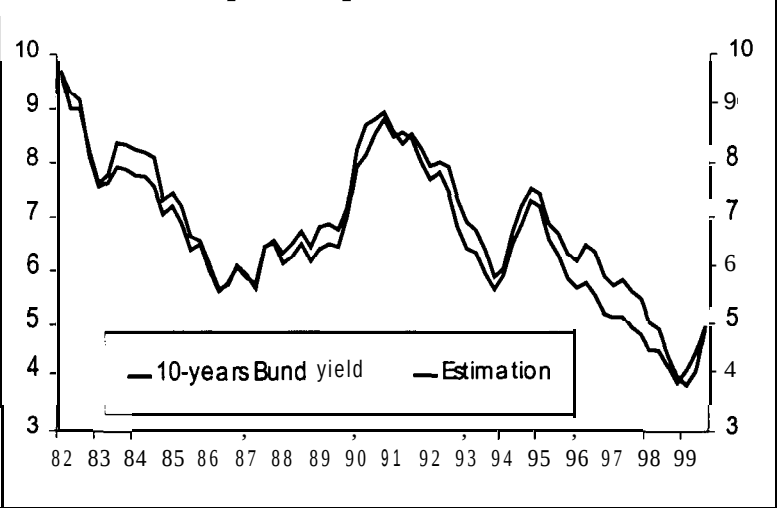
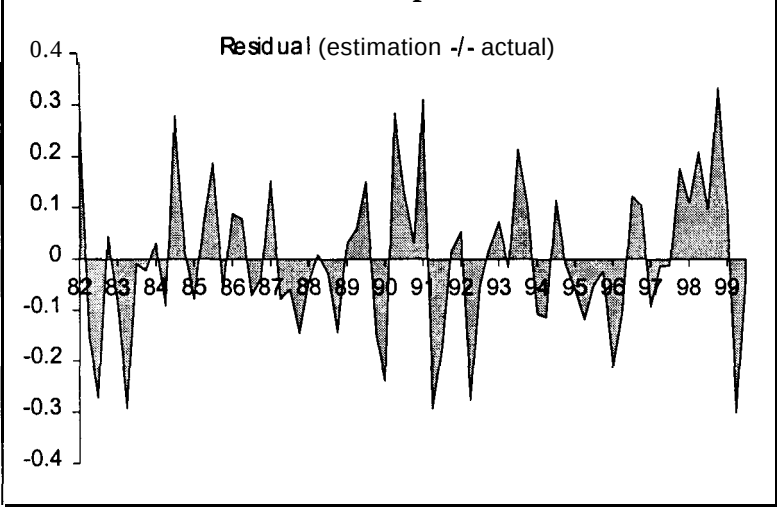


Chart 3 Estimation results, period 1982-1999



In order to gain some more insight into the empirical background of the estimation results, table 1 gives correlation coefficients between the explanatory variables in first differences. The highest correlation between the explanatory variables is 0.33, namely between the Japanese interest rate and the US interest rate. More in general, the highest correlation coefficients are found between the interest rate variables. Because the interest rate equation is estimated as $I(1)$, the correlation between the explanatory variables is not as high as when the correlation would have been measured at $I(0)$. This result leads us to conclude that there is no evidence for multicollinearity in the estimated model. Both the Wald test and the Ramsey reset test show that the coefficients are stable.

Table 1 Correlation between explanatory variables (first differences)

	GE3M	IFO	JP10YR	OIL	GOV	US10YR
GE3M	1.00	-0.02	0.24	0.13	-0.00	0.26
IFO	-0.02	1.00	0.15	0.13	0.15	0.15
JP10YR	0.24	0.15	1.00	0.24	-0.10	0.33
OILPRICE	0.13	0.13	0.24	1.00	-0.08	0.25
GOV	-0.00	0.15	-0.10	-0.08	1.00	0.06
US10YR	0.26	0.15	0.33	0.25	0.06	1.00

Interpretation of the results

The interest rate variables in the model have strong explanatory power. The sum of the coefficients of the three interest rates is 0,71 for respectively the 3-month German interest rate (0,25), the United States 10-years interest rate (0,24) and the Japanese 10-years interest rate (0,22). This is in accordance with the results of other empirical research but indicates that a change of all other interest rates with, say 1%-point, will , under the *ceteris paribus* condition, result in a change of the German bond rate of only 0.7%-points. However, the German long-term interest rate movement is not only explained by foreign long-term and domestic short-term interest rates. Also the oil price, the government balance and developments in the IFO-indicator are statistically significant and may indirectly contribute to parallel developments of the German long-term interest rate and other interest rate on the long run.

The United States long-term interest rate appears to be the most important explanatory variable. If the United States long-term interest rate is removed from the model, the adjusted R^2 drops by 12.0%-points. The second most important variable in the model is de German 3-month interest rate. Removing this interest rate causes a drop in the adjusted R^2 by 11.3%-point. These reductions of the R^2 for the other variables of our equation are respectively 6.2%-point for the Japanese long-term interest rate, 5.6%-point for the IFO-indicator, 3.6%-point for the government balance and 2.6%-point for the oil price.

In addition we have estimated a suitable ARIMA model for the German 10-years bond yield. The standard deviation of the residuals of this ARIMA model is 0.41 (measured in interest rate %-points), which is slightly higher than the standard deviation of the residuals of our fully specified model for the German interest rate (0.38). It indicates that the additional information contained in the explanatory variables is limited when the model is used for prediction on short run.

5 Conclusion

Insight into the determinants of the German long-term interest rate gains importance now that this German rate dominates the Euro bond market. This paper estimates a fully fledged error correction equation for the German Bund rate using quarterly data for the reference period 1982-1999. The determinants are derived from combining five interest rate theories. Foreign long-term interest rates and the domestic short-term interest rate appear to explain most of the fluctuations in the long-term German rate, but also the IFO indicator for the stance of the business cycle, the government balance

and the oil price contribute in explaining these fluctuations. In that sense our equation includes a richer set of explanatory variables than most other empirical studies from the literature on the (German) long-term interest rate.

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