On the Information Content of the Yield Curve: Lessons for the Eurosystem?

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I. Introduction

Aimed at achieving its prime objective of price stability, which has been quantitatively defined, the monetary policy strategy of the Eurosystem[1] consists of two pillars. In its first pillar, the strategy assigns a prominent role to money, as indicated by the announcement of a quantitative reference value for the growth rate of a monetary aggregate. The information provided to the policy maker by the development of (the components of) the money stock is supplemented, in the second pillar of the strategy, by a broadly based assessment of the outlook for price developments and risks to price stability in the euro area as a whole.[2] This assessment will be based on a wide range of economic indicators, and acknowledges that, although the monetary data contain information vital to informed policy making, in isolation they do not provide sufficient information about the economy in order to gear monetary policy at the maintenance of price stability.

Central to the second element of this strategy are information variables. An important question in this respect pertains to the necessary conditions for a particular variable to be used as an information variable for monetary policy purposes. Following *Shigehara* (1996) and *Berk* (1998), we define an information variable in terms of stability, predictability and leading indicator properties with respect to non-financial

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[1] The Eurosystem comprises the ECB and the national central banks of the member states which have adopted the euro in stage three of EMU.

[2] See *Berk/Houben/Kakes* (2000) for a discussion of the monetary policy strategy of the Eurosystem.

activity. That is, the relationship between the information variable and future non-financial activity needs to be predictable. We define non-financial activity to include inflation (logically linked to the ultimate objective of monetary policy, price stability) and real economic activity. The latter is also of interest for a central bank, since monetary actions undertaken to safeguard the objective of price stability in the face of disturbances can elicit real economic effects in the short run, especially when the degree of credibility of monetary policy is insufficient (*Fuhrer,* 1997). In this paper we concentrate on one possible information variable, the term structure of interest rates. We define the term structure as the relation between the yields to maturity for different terms to maturity.[3]

The objective of this paper is to review the information content of the term structure of interest rates with respect to future movements in inflation and real output, and to investigate whether this yield curve is useful to the Eurosystem for monetary policy purposes. In the past two decades, a good deal of empirical and theoretical work has been done regarding the information contained in the term structure (see *Berk,* 1998, for a recent review of the literature). Although the empirical research has been mainly directed at G-7 countries (see *Jondeau/Ricart,* 1999, for a recent example), work by, *inter alia, Koedijk/Kool* (1995), *Bernard/Gerlach* (1996) and *Gerlach/Smets* (1997) presents evidence for other (European) countries as well. Whereas these studies primarily focus on extracting information from the yield curve, *Angeloni/Rovelli* (1999) more explictly address the issue of the usefulness of the term structure for monetary policy purposes. Like the papers presented in the latter volume, the approach in this paper is largely empirical. Using data on a large number of countries and for the euro area as a whole, we try to assess whether the yield spread contributes significantly to the predictability of both inflation and output, over-and-above simple autoregressive representations of the latter variables. We concur with *Mishkin* (1990a, 1990b) that this interpretation of information content is rather narrow, since no use is made of additional economic variables in combination with the slope of the yield curve. This criticism notwithstanding, we follow existing practice by using this interpretation. More specifically, the contribution of the paper is twofold. First, we combine results

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[3] In this paper we use the terms 'term structure' and 'yield curve' in an interchangeable fashion, which is, strictly speaking, not correct: the term structure is a particular yield curve (i.e. for zero-coupon bonds). See *Shiller* (1990), *Svensson* (1994)/*Haubrich/Dombrosky* (1996) for a discussion, and *Deacon/Derry* (1994) for details concerning the construction and estimation of various yield curves.

on the relationship between the term structure and, respectively, the future inflation rate and real economic activity. This is convenient, as both lines of inquiry have been discussed seperately in the literature. Second, and more important from a European monetary policy perspective, we conduct an empirical analysis on euro area-wide variables.

The paper is organised as follows. We first present theoretical arguments explaining why the yield curve should, in general, convey information regarding future price and output developments. The third section tries to ascertain empirically whether the yield curve contains information on future movements in the inflation rate and in output growth in the euro area and participating countries. Section IV concludes.

II. A General Discussion on the Usefulness of the Yield Curve for Monetary Policy

The theoretical basis for the information content as defined above consists of the combination of the Fisher equation and the expectations theory of the yield curve (*Modigliani/Sutch*, 1966). The (one-period) Fisher equation decomposes the one-period nominal interest rate roughly into a one-period *ex ante* real interest rate and the inflation expected one period ahead.[4] The expectations theory of the yield curve is the most prevalent explanation of the term structure, and is based on the arbitrage condition that, after adjusting for risk, the expected return from holding for one period a bond that has n periods to maturity is the same as the certain return from a one-period bond. Combining these theories gives us the following expression (for a formal derivation, see *Tzavalis/Wickens*, 1996):

(1) $$R(n,t) = E_t r(n,t) + E_t \pi(n,t) + \phi(n)$$

where $R(n,t)$ denotes the yield to maturity at t of a bond with n-periods to maturity. E is the expectations operator, and the subscript pertains to the period in which the expectation is formed, using information up to and including t. $r(n,t)$ is the average real interest rate over the current and next n-1 periods, $\pi(n,t)$ is the average inflation rate over the next n periods and $\phi(n)$ is the average risk premium on an n-period bond until

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[4] In a more general form, the Fisher equation also incorporates an inflation risk premium and the conditional variance of inflation. These factors – which are quantitatively unimportant (*Tzavalis/Wickens*, 1996, p. 105) – are omitted here for expositional ease.

it matures. This risk premium is *ex hypothesi* constant under the expectations theory of the term structure. All rates are expressed in natural logarithms, save for the inflation rate, which is defined as the first difference of two logarithms.

Equation (1) can be interpreted as an n-period Fisher equation. Subtracting from (1) the (similar) m-period Fisher equation gives the slope of the yield curve between segments n and m. For $m=1$ (the spot rate), the following equation emerges:

$$(2) \qquad R(n,t) - R(1,t) = E_t[r(n,t) - r(1,t)] + E_t[\pi(n,t) - \pi(1,t)]$$

It follows from equation (2) that the slope of the yield curve (left hand side) provides information on the expected real interest rate spread, and on the market's expected inflation path (i.e. the change in the future n-period inflation rate from the 1-period inflation rate). Hence a potential identification problem exists: if these variables are not all perfectly correlated, the yield spread is a noisy forecast of any of them.

Two extreme cases can be identified. *Mishkin* (1990b, pp. 79–80) states that the slope of the yield curve will provide an exact measure of the market's expected inflation path if and only if all the following restrictive assumptions are satisfied: (i) the expected real interest rate is constant over time (horizontal real term structure), (ii) expectations are formed rationally and (iii) risk premia are constant over time. The first assumption causes the first term on the right hand side of (2) to vanish. The second assumption implies the unpredictability of forecast errors of inflation at the moment that the expectation is formed (that is, errors in the inflation rates expected at t to occur during the life of the bond, are uncorrelated; see *Mishkin*, 1991). The third assumption justifies neglecting risk premia in equation (2). Violation of any of these assumptions makes the interpretation of the yield curve more complex and reduces its value in forecasting changes in future inflation.

On the other extreme, if prices are fixed, then nominal yield spreads are a reflection of real spreads, which contain information regarding future real economic activity (*Mishkin*, 1990a, 1991).[5] This theoretical

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[5] *Mishkin* interprets the real yield spread (long minus short) as the difference between long-run and short-run marginal productivity of capital. When the peak of the business cycle is reached, productive potential is fully used, short run capital productivity is high *vis-à-vis* capital productivity in the longer run, when activity is expected to weaken. When the trough is reached, current capital productivity is low, but the expectation of a future upswing implies higher long-run productivity. Thus the real yield spread and the future business cycle are posi-

relationship between the yield spread and real economic activity is not clear-cut, however. As can be seen from a standard IS-LM model for a small open economy (see, for example, *Dornbusch*, 1980, pp. 175–192), the nature of the relationship between the yield slope and future real activity depends on the nature of the shocks hitting the economy and the speed of price adjustment.[6] In the presence of real economic shocks and sticky prices, a positive yield spread is indicative of a future economic upswing. On the other hand, when monetary shocks dominate, a positive yield spread indicates a weakening of future economic activity. In the former case, the expected outward shift of the IS-curve raises expected future short-term rates (because the expected increase in income raises money demand), and this expectation is translated into higher current long-term rates. The information content is thus based on the expected effects of a real-economic disturbance on interest rates. In the latter case, a monetary shock such as the expectation of a future monetary tightening also raises future short-term rates and current long-term rates, but the resulting steepening of the yield curve now indicates a future decline in economic activity. The information content reflects the expected effects of monetary policy via interest rates on economic activity. When prices are flexible in the short run, the abovementioned analysis of shocks becomes more complicated because we have to take inflation expectations into account. In reaction to the monetary shock, future real short-term rates will increase, but, if monetary policy is considered to be credible, future nominal short-term rates can decline, especially for those expected to prevail in the more distant future. With a credible monetary policy, the nominal yield spread will decline and will be indicative of a future increase in economic activity: the relationship will again be positive.[7]

But, of course, inflation and real activity are not independent. The extreme positions of perfect price flexibility and complete price rigid-

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tively related. An alternative theoretical explanation of a (positive) relationship between the real yield spread and future real activity is presented by *Harvey* (1988) with the use of the CAPM.

[6] In this model, spending decisions are influenced by the long-term rate, money market equilibrium by the short-term rate, and the long-term rate by expected future short-term rates. Moreover, perfect capital mobility and fixed exchange rates are assumed to prevail. These assumptions are admittedly stringent, but in our view admissable given the illustrative character of the analysis based on the model.

[7] The analysis of fiscal shocks also becomes more complicated when price adjustments have to be taken into account. See *Blanchard/Fischer* (1989, p. 536) for a discussion.

ity reflect a debate about adjustment processes (about whether quantities or prices adjust to a change in macroeconomic conditions) and with what speeds. A synthesis is offered in the New Keynesian approach (*Blanchard/Fischer*, 1989, pp. 372–504). Using models of imperfect competition, strategic behaviour in the face of information asymmetries and search and contracting models, sluggish price adjustments in labour and product markets are explained as outcomes of rational behaviour (*Hall*, 1986; *Lindbeck/Snower*, 1987; *Layard* et al., 1991; *Cross*, 1988; *Christiano/Eichenbaum/Evans*, 1996). The approach is a synthesis as it explains phenomena that are at odds with new-classical notions (such as rigidities) from principles such as individual optimising behaviour, as new-classicals do. It thereby provides a theoretical description which subsumes both abovementioned positions as extreme cases (*Frank*, 1986). Both can occur simultaneously, depending on particular institutional and structural characteristics of the economy. The implication is that the yield curve in general possesses information content regarding both future inflation and future economic activity, but that this content could differ across countries and in time. We now take up the issue of establishing empirically the information content of the yield curve.

III. An Empirical Investigation of the Usefulness of the Yield Curve for the Eurosystem

In this section, we focus on the effectiveness of the yield curve in forecasting future movements in inflation and real output. Our objective here is not to construct the best possible forecast for inflation or real output, but to check whether the yield curve passes what we consider to be a 'minimal' test for qualifying as information variable for monetary policy. We define this minimal test as a significant marginal information content of the yield curve in forecasting inflation and real output, i.e. the yield spread should contribute significantly to the forecasting power, over-and-above the information that past patterns on inflation and output provide.

We approach this issue in a multi-country setting, with explicit attention to the euro area. To this end, we collected data from the BIS and Datastream databases on the CPI, real GDP, long-term interest rates (yields on benchmark bonds) and short-term interest rates (three month interest rates) for 12 countries: Austria, Belgium, Germany, France, Ireland, Italy, the Netherlands, Denmark, UK, Switzerland, Japan and the

US.[8] In addition we calculated euro area-wide equivalents for these variables, using the methodology of *Albers/Bijsterbosch/Vijselaar* (2000)[9], and, for the interest rates, of the *ECB* (ECB,1999). Our data base consists of quarterly data, spanning the period 1970–1998.

We start by investigating the time series properties of the data. Table 1 presents results from applying the Adjusted Dickey-Fuller unit root test on the variables involved. Table 1 shows that the inflation rate and the level of real gdp are non-stationary, as opposed to the yield spread, which is stationary.[10] First-differencing the inflation rate and calculating the growth rate of real output gdp generate stationary series (output growth in Japan being the single exception). Note that the implication that the yield spread provides information only on the change in the inflation rate is consistent with equation (2) above.

We next construct univariate autoregressive models for the stationary transformation of the inflation rate and real gdp, ie the change in the inflation rate and the growth rate of real output respectively:

$$(3) \qquad\qquad x(t) = \alpha + \sum_{i=1}^{p} x(t-i) + \varepsilon(t)$$

where x represents the variable of interest to the policy maker, ie the change in the inflation rate or the growth of real output. The maximum number of lags, p in equation (3), is chosen using the well-known Schwartz Bayesian Criterion (SBC), an information criterion similar to the AIC but with a larger penalty for additional coefficients.[11] We look for the lag length with minimal SBC, subject to the restriction that the residuals of the model should be serially uncorrelated. Whenever the minimal SBC violates this restriction, the lag length is determined based on the joint significance of the included lags, the joint insignificance of the excluded lags, and the Lagrange multiplier test for serial correlation.

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[8] *Alonso* et al. (1997) conduct an empirical experiment similar to ours for Spain.

[9] In essence, the GDP series for the euro area is constructed as a weighted average of individual countries' GDP, and the CPI series is similarly constructed, using private consumption as weights. The latter are fixed and pertain to 1995.

[10] The inflation rate is measured as the change in the CPI *vis-à-vis* the previous corresponding period. The gdp growth rate is measured in a similar fashion, and the yield spread is defined as the differential between long-term and short-term interest rates. In calculating and using the inflation rate and the growth rate of output in this way, we are side-stepping the issue of seasonal unit roots (*Hylleberg* et al., 1990).

[11] Although the SBC will always select a more parsimonious model than the AIC, we prefer the former over the latter because of its superior large-sample properties.

Table 1

Testing for nonstationarity

	Inflation rate		gdp		yield spread
	level	difference	level	growth rate	
Austria	2.78 (t,12)	5.58** (n,3)	1.95 (t,1)	3.11* (c,8)	2.62** (n,3)
Belgium	2.79 (t,12)	3.54** (n,11)	1.61 (t,6)	3.35* (c,7)	4.09** (n,1)
Germany	1.25 (t,12)	3.56** (n,11)	3.16 (t,11)	3.28* (c,12)	3.34** (n,1)
France	2.64 (t,12)	3.97*** (n,11)	3.21 (t,3)	2.98* (C,8)	3.34* (n,1)
Ireland	2.53 (t,12)	3.78*** (n,11)	1.47 (c,12)	3.22** (n,1)	3.85** (n,1)
Italy	3.16 (t,12)	3.16** (n,8)	1.66 (c,3)	4.16** (t,4)	3.88** (n,1)
Netherlands	1.86 (t,12)	3.55** (n,7)	1.95 (c,12)	3.27* (c,11)	4.31** (c,1)
Euro area	3.01 (t,5)	3.49** (n,4)	2.26 (t,2)	3.00* (c,12)	2.77** (n,1)
Denmark	3.21 (t,12)	7.18** (n,3)	2.69 (t,6)	2.06* (n,8)	4.00** (n,0)
UK	2.5 (t,12)	5.04*** (n,11)	2.56 (t,6)	3.92** (c,8)	2.52* (n,1)
Switzerland	2.49 (t,4)	3.76*** (n,7)	3.05 (t,12)	3.09** (n,12)	2.19* (n,9)
Japan	2.78 (t,12)	4.75** (n,7)	0.51 (c,12)	2.25 (t,12)	4.63** (t,6)
US	2.91 (t,12)	4.53** (n,11)	2.19 (c,12)	3.00* (c,12)	3.57* (t,12)

Notes: presented are absolute values of the ADF test. Figures within brackets represent the specification of the deterministic process and of the number of lagged terms, respectively. t = linear trend and intercept, c = intercept, n = neither. **(*) = significant at 1% (5%) level.
Sample: 1970:1–1998:4. Inflation rate and gdp growth rate are defined in terms of changes versus previous corresponding period.

As a starting point, we impose a maximum number of 12 lags, implying that the maximal lag in the monetary transmission process is 3 years, which does not seem to be unduly restrictive given the available empirical evidence (*Mishkin,* 1995, 1996). Moreover, when testing for less than the maximum number of 12 lags, we impose some standardisation in order to keep the analysis (which is based on a relatively large number of countries) tractable. That is, we considered horizons of 4, 6, 8, and 12 quarters in our models.

Table 2 presents the results of our procedure for determining the number of lags in the univariate processes for the change in the inflation rate and the growth rate of output. It follows that, for the euro area, the lag length selected in the model of the change in the inflation rate is 4 quarters. However, when comparing outcomes for individual euro area countries, it becomes clear that there exists considerable variation in the 'optimal' lag length, with Italy and Germany, for example, showing a horizon of 12 quarters. A horizon of 4 quarters seems relatively short compared to the results for the UK, Japan, and the US. In the model for output growth, a horizon of 6 quarters figures most prominently within the euro area. Apart from some serial correlation, the final AR-models show relatively few signs of misspecification.[12]

Having estimated the univariate autoregressive processes for the change in the inflation rate and the growth rate of real output, we next consider whether these processes can be improved by introducing the yield spread. That is, we estimate:

$$(4) \qquad x(t) = \alpha + \sum_{i=1}^{p} x(t-i) + \sum_{j=1}^{q} yspread(t-j) + \varepsilon(t)$$

Since all the variables considered are stationary, we need not take up the issue of cointegration here.[13, 14] Instead, we add 12 lags of the yield

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[12] Based on *Ramsey*'s RESET test for misspecification, which shows a pattern similar to the serial correlation test reported in the table. The RESET test is not reported here in order to save space, but available on request from the authors.

[13] Moreover, cointegration tests indicate that, for nearly all countries studied, the level of real GDP and the inflation rate are not cointegrated. This further validates our specification in terms of changes.

[14] A word of caution is in order here. It is well known that the power of unit root tests is low, especially in samples covering a relatively short time span (*Campbell/Perron,* 1991). If, contrary to the findings in table 1, the inflation rate and the growth rate of GDP were both non-stationary and jointly cointegrated, we need not differentiate between them when analysing their relationship with the yield curve, given the existence of a long-run equilibrium relationship between inflation and real output.

Table 2

Selection of lag length in univariate AR models

quarters	change in inflation rate					gdp growth rate				
	4	6	8	12	LM(sc)	4	6	8	12	LM(sc)
Austria	7.35*	7.27	7.22	7.06	0.99	5.81*	5.74	5.69	5.69	1.85
Belgium	7.07	7.08	7.3*	6.97	0.57	10.09	10.06	11.04*	10.94	0.53
Germany	7.58	7.55	7.5	7.44*	0.26	7.01	7.04*	6.98	6.98	1.95
France	7.39	7.38	7.42*	7.32	1.66	6.69	6.81*	6.72	6.69	1.41
Ireland	5.24*	5.18	5.13	5.02	2.58	10.09	10.04	10.59	10.8*	0.47
Italy	5.97	5.96	5.96	5.9*	4.24**	5.92	5.96*	5.9	5.75	0.5
Netherlands	7.59*	7.52	7.5	7.34	2.26	5.38	5.51*	5.45	5.31	0.99
Euro area	8.32*	8.29	8.24	8.16	0.8	6.66	6.68*	6.6	6.5	0.69
Denmark	5.94	5.85	5.91	5.89*	3.32**	4.7	4.68	4.67	4.67*	0.93
UK	5.58	5.55	5.56	5.6*	3.58***	5.86	5.87	5.92*	5.74	0.52
Switzerland	7.01*	6.95	6.92	6.78	1.84	7.12	7.23	7.19	7.31	5.4**
Japan	6.52	6.45	6.58*	6.49	3.5**	6.22	6.23*	6.15	5.86	0.64
US	7.25	7.19	7.32*	7.23	1.77	5.98*	5.95	5.86	5.85	2.24

Notes: presented are absolute values of Schwartz Information Criterium, except for the columns headed by LM(sc), which provide values for the Lagrange multiplier test for serial correlation in the residuals of the final model.
* selected lag length,** significant at 1%. All models are estimated on the longest available identical sample period. Selection of lag length based on the information criterium, remaining autocorrelations and joint (in)significance of (ex) included lags.

spread to the univariate models for the variables of interest to the policy maker, and test the joint significance of these new regressors.

Table 3 presents the results of the F-test on exclusion of the 12 lags of the yield spread. The results strongly suggest that the yield curve has only a limited value as an indicator: out of 13 countries, only in 4 (inflation rate) or even 3 (gdp) cases are the lagged yield spreads jointly significant. Only in two countries (Switzerland and the US) is the yield spread significant in predicting changes in the inflation rate as well as real output growth. Moreover, these cases are concentrated outside the euro area. No evidence is found for the euro area that the yield spread is significant in the AR-models for either the inflation rate or real output. Within the euro area, only in Belgium and Italy (inflation) and France (output) the evidence indicates significant yield spreads.

As a follow-up, we investigate in more detail the models for which the yield spread proved to be significant. For these models, we select the number of lags for the yield spread in a similar way to table 2 (note that this selection is made conditional on the number of lags for the change in the inflation rate and growth rate of output as determined earlier). The results are presented below.

Table 3

Tests of joint significance of yield spread in AR models

	change in inflation rate	gdp growth rate
Austria	0.82	1.01
Belgium	2.53*	0.45
Germany	0.67	1.05
France	1.82	2.42*
Ireland	0.23	0.89
Italy	2.35*	0.65
Netherlands	1.48	1.72
Euro area	0.4	1.38
Denmark	1.64	0.43
UK	1.23	1.3
Switzerland	2.14*	2.04*
Japan	0.43	1.28
US	2.25*	2.74*

Notes: presented are values of a F-test on the joint significance of 12 lagged yield spreads in the AR models presented in table 2.
Sample 1970:1–1998:4. * siqnificant at 5%

It follows from table 4 that the optimal lag length for the yield spread, conditional on the past history of changes in the inflation rate and the growth of real output, is 4 or 6 quarters for the change in the inflation rate and 4 quarters for the output growth model, the latter corroborating the findings of *Berk/Bikker* (1995). Again, the final AR-models showed relatively few signs of misspecification.[15]

Having constructed bivariate models for the change in the inflation rate and the growth in real output, the policy maker takes a natural interest in the performance of these models in forecasting changes in inflation and real output growth, respectively. To this end, we compare autoregressive models with and without the yield spread, and approach the forecasting performance within-sample as well as out-of-sample. The former consists of comparing RMSE of both models estimated using all available data. The latter is based on an estimation of the model using data up to and including 1989, and using this model to make forecasts for the period 1990–1998. We generate static forecasts, thereby using the information the policy maker would have had at the moment the prediction was made.

The results are presented in table 5, and are disappointing. The gain in forecasting power of adding the yield curve is fairly limited, both within-sample and out-of-sample. It is even completely absent as regards out-of-sample forecasts for real GDP. The latter implies that the policy maker, when making forecasts for the 1990's based on models estimated up to the end of the 1980's, would have been worse off when including the yield spread in simple autoregressive models for the change in real output growth.

All in all, a simple empirical exercise indicates that the value of the yield spread as an information variable with respect to future movements in inflation or real output is rather limited. This is in line with earlier findings, such as for example *Koedijk/Kool* (1995), *Sauer/Scheide* (1995), and *Tzavalis/Wickens* (1996).[16] For most countries, especially those within the euro area (and also for the euro area as a whole), the yield spread does not appear to contain information that is not already contained in the history of inflation and output. Moreover, for those cases in which some marginal information content (as defined

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[15] For details on the misspecification analysis, including testing for structural breaks, the reader is referred to the working paper version of this article, which is available from the authors on request.

[16] However, the body of empirical work on the subject is large, and the implications of this work are not clear cut. See *Berk* (1998) for a recent overview.

Table 4

Selection of lag length of yield spread in bivariate AR models

quarters	change in inflation rate					gdp growth rate				
	4	6	8	12	LM(sc)	4	6	8	12	LM(sc)
Austria										
Belgium	6.99	7.02*	6.95	6.8	0.59					
Germany										
France						6.77*	6.74	6.67	6.53	1.22
Ireland										
Italy	5.83	5.75	5.68	5.67*	1.59					
Netherlands										
Euro area										
Denmark										
UK										
Switzerland	6.84*	6.8	6.76	6.61	0.63	7.29*	7.27	7.2	7.04	1.72
Japan										
US	7.23	7.13*	7.06	7.06	1.32	5.98*	5.93	5.86	5.75	2.53

Notes: presented are absolute values of Schwartz Information Criterium, except for the columns headed by LM(sc), which provide values for the Lagrange multiplier test for serial correlation in the residuals of the final model.
* selected lag length, ** significant at 1 %. All models are estimated on the longest available identical sample period. Selection of lag length based on the information criterium, remaining autocorrelations and joint (in-)significance of ex-/in-cluded lags.

Table 5a

Comparing forecasting performance of AR models: within sample forecasts

	change in inflation rate			gdp growth rate		
	with	without	difference	with	without	difference
Austria						
Belgium	0.52	0.59	–0.07			
Germany						
France				0.64	0.68	–0.04
Ireland						
Italy	0.88	0.93	–0.05			
Netherlands						
Euro area						
Denmark						
UK						
Switzerland	0.65	0.65	0	0.43	0.46	–0.03
Japan						
US	0.47	0.5	–0.03	1	1.08	-0.08

Notes: presented are values (in %) of the RMSE of models with or without the yield spread. Difference is measured in percentage points. Sample: 1970:1–1998:4

Table 5b

Comparing forecasting performance of AR models: out-of-sample forecasts

	change in inflation rate			gdp growth rate		
	with	without	difference	with	without	difference
Austria						
Belgium	0.94	1.05	–0.11			
Germany						
France				0.91	0.74	0.17
Ireland						
Italy	1.24	0.57	0.67			
Netherlands						
Euro area						
Denmark						
UK						
Switzerland	0.68	0.71	–0.03	0.53	0.39	0.14
Japan						
US	0.72	0.79	–0.07	1.18	1.02	0.16

Notes: presented are values (in %) of the RMSE of models with or without the yield spread. The estimation period is 1970:1–1989:4, and the model is used to generate a static forecast for 1990:1–1998:4

earlier) could be established, the improvement in forecasting performance was small or even imaginary.

These results are of course subject to several caveats. To start with, our measure of the yield spread involves long-term interest rates (up to 10 years) minus short-term interest rates (3 month bonds). Our results are therefore specific for this segment of the yield curve; it could well be the case that analyses using different segments generate different results.[17] Moreover, our measure of the yield spread overshoots even the longest lags considered in the univariate autoregressive processes (i.e. 12 quarters). Our results therefore do not preclude the possibility that the yield spread reflects developments expected in the more distant future.[18] However, this possibility can be regarded as rather remote, as there is some evidence suggesting that expectations after 2–3 years are flat (*Berk/Knot*, 1997). An important further caveat pertains to the rather simplistic view of measuring the information content. It ignores, for instance, more complex interactions between the information variable and policy goal, in which the yield curve could be used in combination with other variables to predict future movements in inflation and real output. Moreover, the methodology used (single equation estimation) implies a restriction on the dynamics of the modelled relationship between information and goal variables. A topic for future research would be to allow for a richer multivariate setting, for example within the VAR-framework (see *Leeper, Sims/Zha,* 1996, for an interesting application to monetary policy). Other objections relate to the projection of the results, obtained from estimates based on pre-EMU data, to Stage Three of EMU. The start of the latter is a regime shift which is likely to give rise to Lucas (1976-)type of problems. Similarly, the structural changes induced by EMU will probably also make themselves present in European financial markets. The ensuing financial innovations could well mean that the (time series) behaviour of the 'true' euro area yield curve will be different from the historical yield curve constructed as a weighted average of national interest rates.

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[17] This could reconcile our findings with the work of others who find that the yield curve possesses significant information content, such as, for example, *Jorion/Mishkin* (1991), *Bernard/Gerlach* (1996), *Estrella/Mishkin* (1997), *Gerlach/Smets* (1997), and *Schich* (1999).

[18] *Estrella/Mishkin* (1997) circumvent this horizon mismatch between the yield spread and the dynamic specification of the model by using forward rates which can be calculated on an annual basis.

IV. Concluding Remarks

The empirical analysis suggests that the practical usefulness of the yield spread for predicting future movements in inflation and output in the euro area is limited. Moreover, it follows from the theoretical discussion that, even if a correlation could be established between these variables, this correlation may be a reflection of different economic phenomena, each warranting different policy reactions. First, a steepening can indicate an upward revision of inflationary expectations, in which case a monetary tightening is called for. Second, the steepening may reflect the expectation of an increase in capital productivity, higher real interest rates and an increase in activity. In this case, a tightening may or may not be warranted, depending on the current state of the business cycle. Third, a positive correlation may reflect the expectation of a future monetary tightening by a credible monetary policymaker. The possibility of multiple valid theoretical explanations of a single observed relationship corroborates the findings of *Turnovsky* (1989) and *McCallum* (1994), who conclude that the response of the term structure is highly sensitive to the nature of the underlying shocks impinging on the economy.

There are also other reasons why the Eurosystem should be cautious in using the yield curve for monetary policy purposes. As *Mishkin* (1991) notes, the information content is sensitive to the relative variability of expected future inflation changes and changes in real interest rates, as well as to the correlation between changes in these two variables. Any change in the conduct of monetary policy, such as using the yield curve as an information variable, i.e. a guide for monetary policy, is likely to change the correlation and relative variability of changes in expected future inflation and in real interest rates. The forecasting quality of the yield curve for the path of future inflation could therefore change dramatically, making the yield slope a poor guide for monetary policy. This is, of course, an example of the *Lucas* (1976) critique. Similar arguments can be used to explain the observed differences in the information content across countries and in time. According to *Gerlach/Smets* (1997), the information content is largest in countries where short-term interest rates are easiest to predict. Predictability can be a manifestation of a credible monetary policy. Regime shifts can destroy this credibility (especially if they occur frequently), causing the behaviour of economic agents to change, which has consequences for the empirical validity of the information content. In a similar fashion, central banks in different countries can pursue identical policies, but, because of differences in

credibility, this policy can induce different behaviour of economic agents in their countries. The implication is that the information content of the yield curve differs across countries and over time. Taken together, the outcome of the theoretical discussion and the results of our empirical experiment suggest, in our view, that considerable care should be taken in using the yield curve as information variable for the monetary policy of the Eurosystem.

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Summary

On the Information Content of the Yield Curve:
Lessons for the Eurosystem?

The focus of this paper is on the use of the yield curve in monetary policy making. Theoretical arguments and a multi-country empirical analysis with an explicit focus on the euro area suggest the need for caution in case the Eurosystem uses the yield curve as an information variable for monetary policy, because multiple theoretical explanations exist for an observed movement in the yield curve, suggesting that policy reactions cannot be prescribed unambiguously. In addition, the empirical analysis shows that, in contrast with earlier findings of, for example, *Hardouvelis* (1994) and *Bernard/Gerlach* (1996), the information content of the yield curve is fairly limited. For the individual European countries participating in the Eurosystem as well as for the euro area as a whole, the yield spread possesses only very limited information relating to future movements in the inflation rate and output growth, over-and-above the information contained in the history of the latter variables. (JEL E 43, E 58)

Zusammenfassung

Über den Informationsgehalt der Zinsertragskurve:
Lektionen für das Eurowährungssystem?

Der Schwerpunkt dieses Beitrags liegt auf der Nutzung der Zinsertragskurve für Zwecke der geldpolitischen Gestaltung. Theoretische Argumente und eine mehrere Länder umfassende, explizit auf das Eurowährungsgebiet abstellende empirische Untersuchung legen die Notwendigkeit zur Vorsicht für den Fall nahe, daß im Eurowährungssystem die Zinsertragskurve als Informationsvariable für die Gestaltung der Geldpolitik benutzt wird, da es vielfache theoretische Erklärungen für eine bei der Zinsertragskurve beobachtete Bewegung gibt, welche darauf hindeutet, daß sich Reaktionen seitens der Politik nicht eindeutig vorschreiben lassen. Darüber hinaus zeigt die empirische Untersuchung, daß im Gegensatz zu früheren Erkenntnissen von zum Beispiel *Hardouvelis* (1994) sowie *Bernard* und *Gerlach* (1996) der Informationsgehalt der Zinsertragskurve recht begrenzt ist. Für die einzelnen am Eurowährungssystem teilnehmenden Länder sowie für das Eurowährungsgebiet insgesamt beinhaltet die Zinsertragsmarge nur sehr begrenzte Informationen in bezug auf künftige Bewegungen der Inflationsrate und des Produktionswachstums, welche über die für die zuletzt genannten Variablen erwiesenermaßen vorhandenen Informationen hinausgehen.

Résumé

L'information contenue dans la courbe de rendement
a-t-elle une utilité pour le système euro?

Cet article analyse l'utilisation de la courbe de rendement dans les décisions de politique monétaire. Des arguments théoriques et une analyse empirique multi-pays se concentrant explicitement sur la zone euro incitent à la prudence dans le cas où le système euro utiliserait la courbe de rendement comme une variable d'information pour la politique monétaire. En effet, les mouvements de la courbe de rendement s'expliquent théoriquement de multiples façons, suggérant que des réactions politiques ne peuvent pas être prévues de manière inambiguë. De plus, l'analyse empirique montre qu'au contraire des résultats précédents de *Hardouvelis* (1994) et *Bernard* et *Gerlach* (1996) entre autres, la courbe de rendement ne livre que des informations assez limitées. Pour les pays européens individuels participant au système euro de même que pour la zone de l'euro comme un tout, la répartition du rendement donne seulement des informations très limitées sur les mouvements futurs du taux d'inflation et de la croissance de la production et sur les données relevant de l'histoire de ces dernières variables.