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The Slope of the Yield Curve as a Predictor of Business Cycle Fluctuations*

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Abstract

Macroeconomic models with sluggish quantity adjustment in goods markets but quick adjustment of interest rates in forward-looking bond markets suggest that the term structure of interest rates may contain valuable information about future fluctuations in real economic activity. Empirical evidence based on German macroeconomic time series shows that the slope of the yield curve is indeed a powerful predictor of future movements in various measures of real economic activity. Professional forecasts of annual real GNP growth in Germany covering the period 1968-1989 largely ignored the readily available information in the yield curve slope.

* I thank Fritz Breuss for helpful discussions.

I. Introduction

Because interest rates connect the economic future with the present, they should be sensitive to changing expectations about future economic activity. Empirical work on the term structure of interest rates has traditionally used this insight to argue that current interest rates should contain information about future movements in inflation and short-term interest rates.[1] Quite recently, a number of investigators have examined the predictive power of the slope of the yield curve or yield spread, defined as the difference between a long-term and a short-term interest rate, for future real economic activity in the U.S.[2] Invariably, this empirical work has found that the yield spread is a powerful leading indicator of real economic fluctuations in the U.S.

This paper has two purposes. First, to interpret the empirical lead-lag relationship between the yield spread and economic fluctuations in the light of macroeconomic models

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1 See Fama (1975) and a recent series of papers by Mishkin, e.g. Mishkin (1990, 1991), for work on the predictive content of interest rates for future inflation. Shiller, Campbell and Schoenholtz (1983), Campbell and Shiller (1987) and Hardouvelis (1988), among others, study the ability of the term structure to forecast future short-term interest rates.

2 See, among others, Stock and Watson (1989), Bernanke (1990) and Estrella and Hardouvalis (1991).

which assume quick adjustment of prices in forward-looking financial markets but sluggish adjustment of quantities in goods and labor markets.[3] Second, to provide empirical evidence on the predictive power of the yield spread for economic fluctuations in Germany.

There are several reasons why the relationship between yield spread and real economic activity deserves careful study. First, the yield spread can possibly provide a useful leading indicator for macroeconomic forecasting as well as macroeconomic policy making. Second, empirical evidence in support of the idea of forward-looking financial markets casts doubt on econometric model simulation results based on backward-looking expectations in bond markets. Fair (1979) demonstrated that the assumption of forward-looking bonds and stock markets in an otherwise traditional macroeconometric model can significantly affect the response of the model to unanticipated shocks in monetary or fiscal policy. Third, evidence on the relationship between the yield spread and real economic activity in Germany is of substantial relevance for a number of European countries closely tied to the German economy. Interest rates in these countries tend to move in tandem with German interest rates in the short as well as long maturity spectrum because of fixed exchange rate arrangements.

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3 See Blanchard (1981).

If interest rates in Germany respond quickly to new information about expected or unexpected movements in German fiscal and monetary policy, policy changes in Germany will exert an immediate and powerful effect on the real economies in these countries via the changed term structure of interest rates.

Section II employs a simplified version of Blanchard's (1981) model to illustrate possible lead-lag relationships between the slope of the yield curve and output in response to expansionary monetary policy. Section III examines the predictive power of the yield spread for real economic activity in Germany. Section IV considers the question whether professional forecasts of annual output growth in Germany incorporated the information in the yield spread. Section V summarizes and draws conclusions.

II. A Model

This section considers a macroeconomic model which combines slow quantity adjustment in goods markets with quick adjustment of interest rates in forward-looking bond markets. The model has a traditional IS-LM structure augmented by a relationship describing the term structure of interest rate and is a simplified version of Blanchard (1981). The model is given by the following relationships:

$$d = \alpha y - \beta R + g \qquad 0 < \alpha < 1,\ \beta > 0 \qquad (1)$$

$$r = \theta y - \phi m \qquad \theta > 0,\ \phi > 0 \qquad (2)$$

$$r = R - \dot{R}/R \qquad (3)$$

$$\dot{y} = \sigma(d - y) \qquad \sigma > 0 \qquad (4)$$

where

d = spending,

y = output,

R = long-term interest rate,

r = short-term interest rate,

g = exogenous level of spending,

m = stock of money.

Equation (1) says spending depends on output, the long-term interest rate and the level of exogenous spending. The short-term interest rate is determined by the equilibrium condition for the money market in equation (2). Equation (3) describes the term structure of interest rates. This equation is based on the convenient assumption that R is the rate of return on a perpetual bond or consol. In equilibrium, the short-term rate must equal the long-term rate plus expected capital gains on consols. Finally, equation (4) describes the adjustment of real output. If spending exceeds output, firms will first decumulate inventories and then step up production.

Inserting equation (1) in (4) and equation (2) in (3) gives after rearrangement the dynamic two-equation system:

$$\dot{y} = \sigma(g - \beta R - (1-\alpha)y) \tag{5}$$

$$\dot{R}/R = R - \Theta y + \phi m. \tag{6}$$

The dynamic behavior of the system is depicted in Figure 1. The steady state schedule for output is negatively sloped. Higher long-term interest rates reduce output in the steady state. The steady state schedule for long-term interest rates is positively sloped because a higher level of transactions balances needed to accommodate a higher level of output requires an increase in the long-term interest rate. The system exhibits saddle-point instability; stable adjustment after a shock to the system must proceed along the line AB.

The model is now used to study the reaction of output and the yield spread to an unanticipated and an anticipated monetary expansion. Consider first the effect of an unanticipated monetary expansion at time t_0 as described in Figure 2. The initial equilibrium is at E_0. The increase in the money stock shifts the steady-state schedule for the long-term interest rate to the new steady-state equilibrium at E_1. The transition to E_1 proceeds as follows: From the money market equilibrium condition, the short-term interest rate drops at t_0 in response to the increase of the money stock. The long-term interest rate also drops initially. Investors in consols expect future short-term interest rates to rise because output will increase in the future. Thus, the long-term interest rate, being an average of current and expected short-term rates, exceeds the short-term rate at t_0 and the yield curve is positively sloped. As the economy moves along the stable adjustment path to E_1, output increases and the positive yield spread disappears. Note that the positive yield spread is not causing output to increase, as an outside observer of the system might conjecture by looking at the time series patterns of interest rates and output. Both, the increase of output over time and the positive yield spread are induced by a third common force, namely the unanticipated increase in the money stock.

The response of the system to an anticipated monetary expansion announced at t_0 and taking place at t_1 is described in Figure 3. As in the case of an unanticipated monetary expansion, the steady-state schedule for the long-term interest rate is shifted to the right. At the announcement date, bond investors know that short-term interest rates will fall at t_1. The long-term rate drops immediately at t_0 to point S. Point S is determined by the requirement that the long-term interest rate and output must reach the stable adjustment path exactly at time t_1, the point in time when the stock of money is actually increased. Thus, between t_1 and t_0 the yield spread is negative with output increasing; at time t_1, the short-term rate falls in response to the increase in the money stock and the yield spread becomes positive. After time t_1, the adjustment to the steady state is similar as in the case of the unanticipated monetary expansion.

The two simple theoretical examples illustrate that a positive yield spread does not necessarily signal a future output expansion. While the positive yield spread unequivocally signalled an increase of future output in the case of an unanticipated monetary expansion, the model predicts that both a negative and a positive yield spread are consistent with a future increase in the case of the anticipated monetary expansion.

The model can also be used to examine the effects of shifts in exogenous spending which may be induced by a change in fiscal policy. It is easy to verify that an anticipated or unanticipated fiscal expansion will first be reflected in a positive yield spread followed by an increase in output over time.[4] Thus, the theoretical exercises presented in this section are suggestive of a positive but by no means tight relationship between the current yield spread and future output movements. A natural next step is to examine the empirical evidence on this relationship.

III. Empirical Evidence

The predictive power of the yield spread is examined for ten measures of real economic activity. Four of the measures,

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4 Turnovsky (1989) analyzes a model with flexible prices, stochastic shocks, and risk-averse bond holders. In his model, the fiscal expansion has to be permanent to generate a positive yield spread. A temporary fiscal expansion may generate a negative yield spread.

namely real gross national product (GNP), industrial production, capacity utilization, and the unemployment rate, are closely watched indicators of the current health of the economy. The remaining six measures, private consumption, public consumption, fixed investment, inventory investment, exports, and imports, constitute the aggregate demand components of the economy. With the exception of the capacity utilization rate and inventory investment, all series are first transformed to logarithms and then differenced. Inventory investment is expressed in percentages of real GNP. The capacity utilization rate is not transformed. The yield spread is formed by the difference between the yield on long-term government bonds and the 3-months loan rate.[5] All data series are taken from the Main Economic Indicator database maintained by the Organization of Economic Cooperation and Development (OECD). The series are measured at quarterly intervals and, with the exception of the interest rate series, seasonally adjusted. The time range is 1960.1-1989.4.

As a first step of the empirical analysis, Table 1 presents the first ten cross-correlations between GNP growth, industrial production growth, changes in the unemployment rate, and

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5 The long-term interest rate is an average over yields on government bonds with terms-to-maturity of three years or more. The reported empirical results are not affected by using long-term interest rates for more specific terms-to-maturity, for example 9-10 years, over the restricted time range 1974-1989.

capacity utilization on the one hand and the yield spread on the other hand. Using the rough rule of thumb that cross-correlations larger than 0.10 in absolute value are statistically significant,[6] the numbers show that lagged yield spreads are significantly correlated with real GNP growth up to lag six and industrial production growth up to lag 7. For capacity utilization and the change in the unemployment rate, the lead of the yield spread appears to be somewhat longer.

In the next step of the empirical analysis, Granger causality tests are used to examine the predictive power of lagged yield spreads for real economic activity in Germany. The tests for predictive power of yield spreads are based on the standard regression:

$$x_t = a + \sum_{i=1}^{n} b_i x_{t-i} + \sum_{i=1}^{n} c_i S_{t-i} + \epsilon_t, \qquad (7)$$

where x_t is an indicator of real economic activity, S_t is the yield spread defined as the difference between long-term and short-term interest rates, and ϵ_t is a regression error. Under the null hypothesis:

6 This rule of thumb is a rough approximation because it is based on the assumption that one of the two series underlying the estimated cross-correlation is serially uncorrelated.

$$H_0: c_1 = c_2 = \ldots = c_n = 0 \qquad (8)$$

lagged movements of the yield spread have no predictive power for future movements of the indicator of real economic activity. The model outlined in section II warns against committing two fallacies in the interpretation of results of the Granger causality test. First, a rejection of the null hypothesis does not imply that the yield spread is the "causal force" behind the fluctuations in economic activity. Second, non-rejection of the null hypothesis does not imply that the yield spread contains no information about future fluctuations in economic activity conditional on knowledge about the common force affecting both the yield spread and economic activity.

Before simply running Granger causality tests using the quarterly data, an important question has to be considered: What type of fluctuations in real economic activity does the yield spread help to predict? For example, it is well known that quarterly GNP fluctuations in Germany are characterized by substantial intra-year fluctuations compared with output fluctuations in other large industrialized countries.[7] Is it reasonable to expect that the yield spread predicts these short-run fluctuations, which may represent measurement errors, as well as medium-term business cycle fluctuations? Figure 4a plots the quarterly series on real GNP growth and the yield

7 See e.g. Clark (1989).

spread. While there appears to be a positive relationship between quarterly GNP growth and the yield spread for fluctuations that take more than two years, say, this relationship is severely obscured by short-run movements in the GNP growth series. Arguably, the irregular short-run fluctuations in GNP growth are of much less interest from a macroeconomic point of view than the business cycle movements.

The problem involved here can be described more succinctly by using frequency domain techniques: The coherence between two stationary time series is a measure of the linear association of the two series at different frequencies. Figure 4b plots the squared coherence between quarterly GNP growth and the yield spread. The coherences above the broken horizontal line are statistically significant at the 5 percent significance level.[8] The squared coherence is highly significant at frequencies usually associated with business cycle fluctuations, i.e. cycles in the series taking more than two years to complete. For the higher frequencies, i.e. cycles in the series that take less than two years to complete, the coherences are insignificant and vary quite irregularly across frequencies.

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8 The estimated coherences are based on a flat window of width 10. The 5 percent critical value for the null hypothesis that the squared coherence is zero is based on the fact that $20K/(1-K)$, where K is the squared coherence, has an F distribution under the null with 2 and 40 degrees of freedom, respectively. See, e.g., Brockwell and Davis (1991, p. 451).

A simple approach to remove high-frequency fluctuations is to aggregate the quarterly data to annual data.[9] Figure 4c plots the annual GNP growth rates and the yield spread. The lagged positive relationship between the yield spread and GNP growth is now easily discernable. Hence, to circumvent the problem of excessively noisy real economic indicators, the Granger causality tests were based on annual data.

The results for the Granger causality test are given in Table 2. The first column lists the different measures of real economic activity. The second column reports the lag length of the regression. The determination of lag length is based on Akaike's information criterion. The third column gives the marginal significance level of the test of the null hypothesis that lagged yield spreads have no predictive power. A small marginal significance level implies strong predictive power of the yield spread. Thus, a value of .001 means that there is only one chance in 1000 that the yield spread does not belong as a regressor in that particular regression equation. The fourth column headed by R^2_1 gives the adjusted coefficient of determination of regression (7) whereas the column headed by R^2_2 gives the adjusted coefficient of determination under the

9 A technically more demanding approach is to use the band spectrum regression framework suggested by Engle (1974). This approach allows the investigator to remove fluctuations in time series at specific frequency ranges.

null hypothesis of no Granger causality running from lagged yield spreads to the measure of real economic activity.

The regression results show that the yield spread has indeed substantial predictive power for all measures of real economic activity except public consumption. For real GNP, the marginal significance level of the test is far below 1 percent. Moreover, the adjusted R^2-statistic increases markedly from 0.133 to 0.428 as the lagged yield spread is included in the regression. Spurious regression problems are unlikely to be the source of the significant relationship between current GNP growth and the lagged yield spread because both series appear to be stationary (see Figure 4c) and the first few autocorrelations of GNP growth are small. Similar results as for GNP growth obtain for industrial production, unemployment, and capacity utilization. Not unexpectedly given these results, the two cyclically most sensitive aggregate demand components, gross fixed investment and inventory investment, are closely related to the movements in the lagged yield spread. For example, the adjusted R^2-statistic for inventory investment increases from 0.07 to 0.41 if the lagged yield spread is added to the regression.

IV. Professional Forecasts and the Information in Yield Spreads

This section asks the question: Did professional forecasts of real GNP growth in Germany incorporate the readily available information in the lagged yield spread? To shed light on this question, the following regression is used:

$$A_t = \beta_0 + \beta_1 F_t + \beta_2 S_{t-1} + u_t. \tag{8}$$

The dependent variable A_t denotes the actual annual growth rate of real GNP, F_t is a professional forecast of the growth rate, and u_t is the regression error.

Regression (8) is used to evaluate the informational content of the lagged yield spread along two dimensions. First, running the regression under the restriction $\beta_1=0$ and under the restriction $\beta_2=0$ provides two R^2-statistics, which can be compared across regressions. While one would a priori hardly expect that the yield spread contains more information than a professional forecast, the comparison is useful because it gives an idea of the relative amount of information in the two variables. Second, the two hypotheses H_1 $\beta_1=0$ and H_2 $\beta_2=0$ are tested.[10] If the lagged yield spread contains information not

10 This test strategy follows Fair and Shiller (1990).

contained in the professional forecast, β_2 should be different from zero. Similarly, if the professional forecast contains information not contained in the lagged yield spread, β_1 should be different from zero.

The professional forecasts of annual GNP growth examined in this section were issued by the OECD for the years 1968-1989 and by the German Sachverstaendigenrat (SVR) for the years 1969-1989. The OECD did not issue a one-year ahead forecast for 1972 in December 1971. Instead, the forecast issued in July 1972 is assumed to represent the one-year ahead forecast for 1972. The SVR published "range-forecasts" for GNP growth for 1979 and 1980 of 3.5-4.0 and 2.5-3.0 percent, respectively. The values 3.75 and 2.75 percent are assumed to represent the SVR forecasts for these two years.

Table 3 reports the regression results in five lines. The first line gives the results for regressing actual GNP growth on the lagged yield spread only. According to the adjusted R^2-statistic, the lagged yield spread explains 45 percent of the variation in the GNP growth rate. Moreover, the estimated coefficient is positive and suggests that growth and yield spread move almost in a one-to-one relationship. The second and third line of Table 3 report the results of regressing actual GNP growth on the OECD and SVR forecast, respectively. While the estimated coefficient β_1 is significant in both lines, the adjusted R^2-statistics are clearly below the R^2-statistic reported in the first line of the table. Thus, judged by the size of these statistics, the yield spread was a better predictor of future GNP growth than the two professional forecasts. The regression results in line four and five combine the information in the lagged yield spread and the professional forecasts. The estimated coefficients for the professional forecasts are insignificant in both cases. There appears to be negligible information in the professional forecasts which is not contained in the lagged yield spread.

V. Summary and Conclusions

This paper examined the predictive power of the slope of the yield curve for fluctuations in real economic activity in Germany. Three important empirical results emerged: First, the slope of the yield curve is a powerful predictor of economic fluctuations in Germany over the time period 1960-1989. Second, the information in the yield curve is mainly relevant for predicting business cycle fluctuations but not for high-frequency fluctuations in GNP growth. And third, professional forecasts ignored a substantial portion of the readily available information in the yield curve slope. In fact, the yield spread not only contains information ignored by the professional forecasts, but apparently also contains most of the information exploited by the professional forecasts.

Naturally, one should caution against drawing far-reaching conclusions based on empirical relationships between economic time series detected by ex-post scrutiny of the data. There is evidence suggesting that the empirical findings reported in this paper are neither robust across countries nor historical time periods. For example, Kessel (1965) observed that the cyclical comovements between yield spread and real output in the U.S. during the interwar period differ substantially from the comovements observed during other time periods. Similarly, from the point of view of forecasting, it is easy to find instances where the yield spread failed to predict cyclical turning points. For example, Watson (1991) reports that the Experimental Recession Index of the National Bureau of Economic Research did not anticipate the latest U.S. recession which started in July 1990. He traces the failure of the index to anticipate the recession to the unusual behavior of the interest rate spreads included in the index.[11] An interesting question for further empirical research is whether there are

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11 The index was suggested by Stock and Watson (1989) and contains the yield spread as well as the spread between the Commercial paper rate and another short-term interest rate.

common empirical features under which yield spreads act as reliable leading indicators of real economic activity.[12]

With due attention to the caveats just raised, the empirical findings reported in this paper suggest three further conclusions:

First, macroeconomic models which combine slow output adjustment with quick price formation in forward-looking financial markets may capture an important aspect of real-world economies. Theoretical work on models of this type has so far concentrated on the effects of monetary and fiscal policy shocks in closed economies. Models which assume an open economy framework and a richer menu of shocks including supply-side shocks may therefore provide additional useful insights.

Second, econometric model simulation results which assume backward-looking bond markets may produce misleading policy advice if bond markets are in fact forward-looking as suggested by the results in this paper. In a pioneering paper, Fair (1979) demonstrated that econometric simulations are computationally feasible given the assumption of forward-looking financial markets even in a relatively large-scale

12 The exchange rate regime, financial market regulations, and smoothing of interest rates by the central bank are likely to affect the predictive power of yield spreads for business cycle fluctuations.

macroeconometric model. More recent versions of forward-looking econometric models and their properties in response to monetary expansions are described by Taylor (1988).

Third, the results reported in this paper suggest that close inspection of interest rate movements can result in significant improvements in forecasting efficiency as well as improved interpretations of the forces shaping business cycle fluctuations. The theoretical examples discussed in section II indicate that the gains in forecasting efficiency may be even larger than suggested by the regression evidence in sections III and IV because a structural econometric model could distinguish between a multitude of different shock sources as well as take into account the possibly intricate adjustment phases in the case of anticipated policy changes.

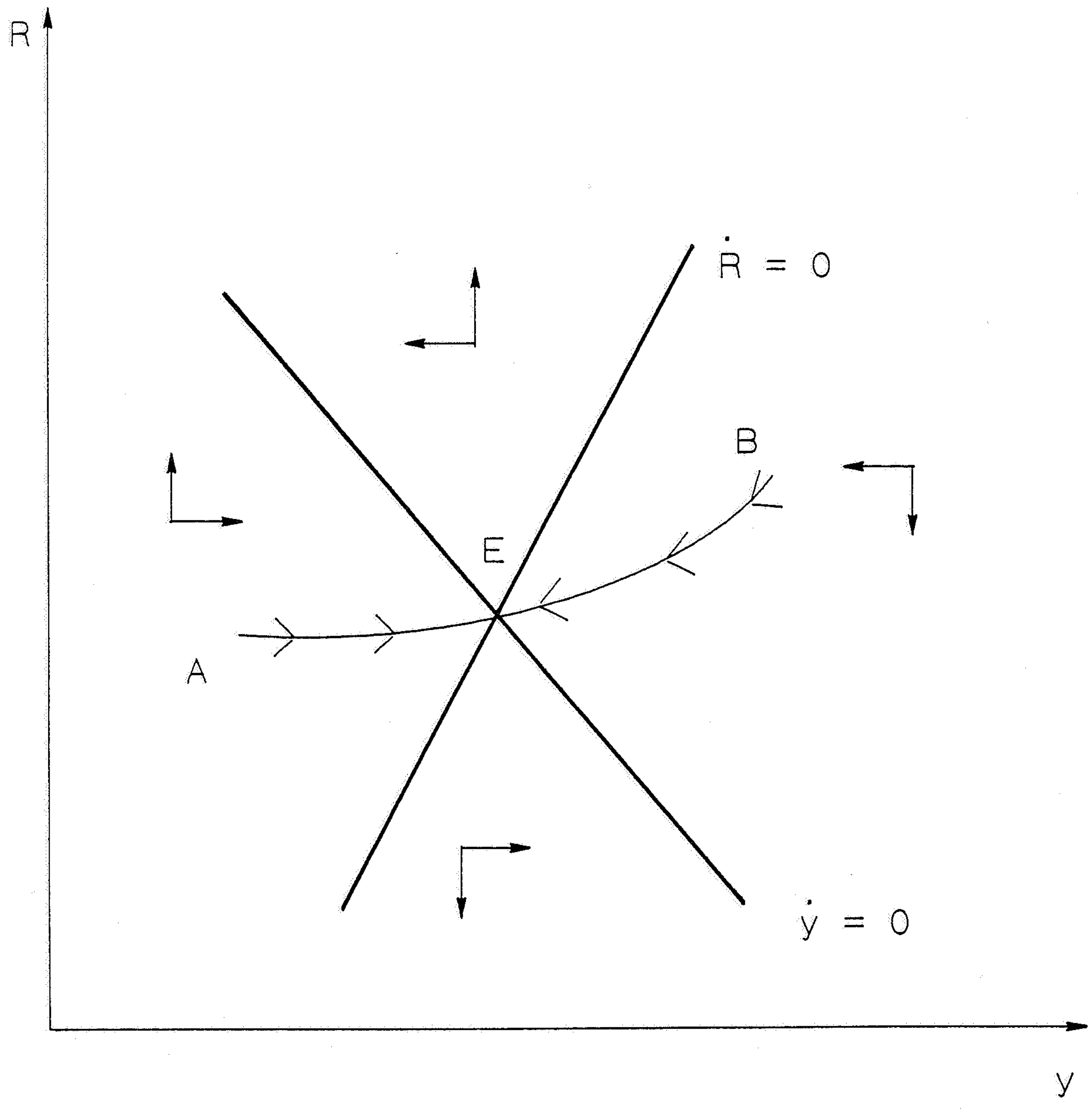


Figure 1: Steady State and Dynamic Adjustment

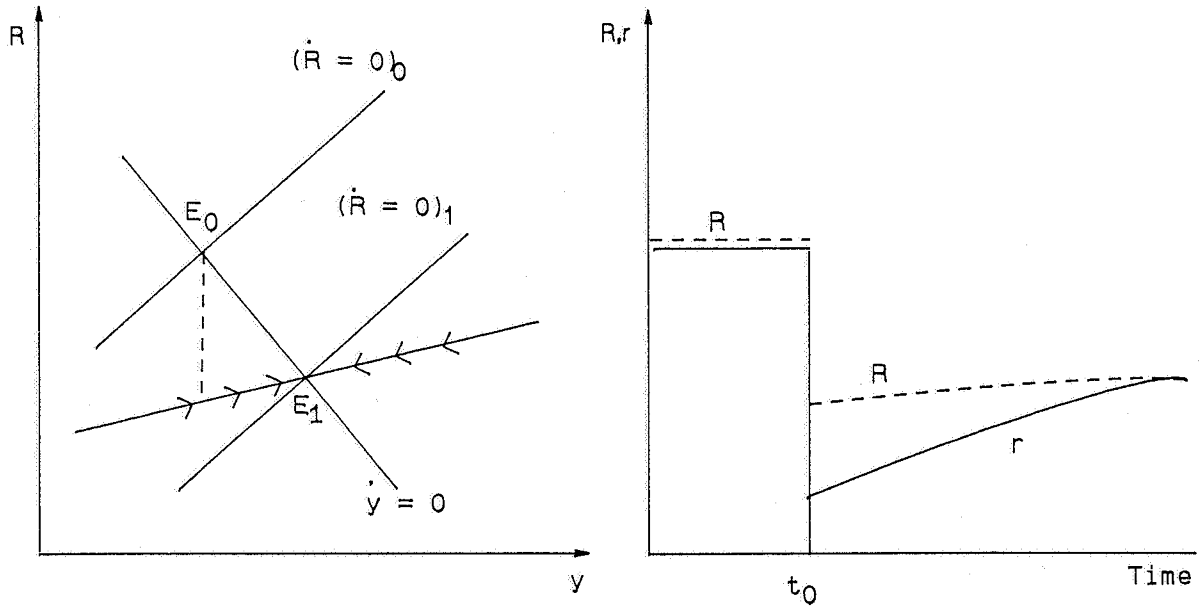


Figure 2 : An Unanticipated Monetary Expansion

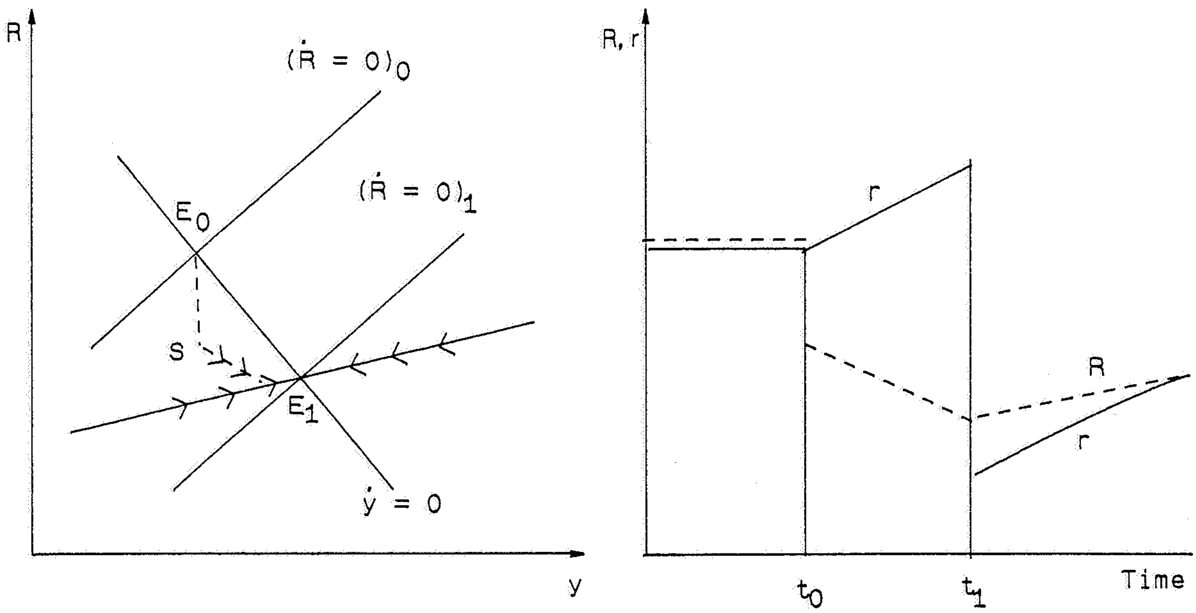
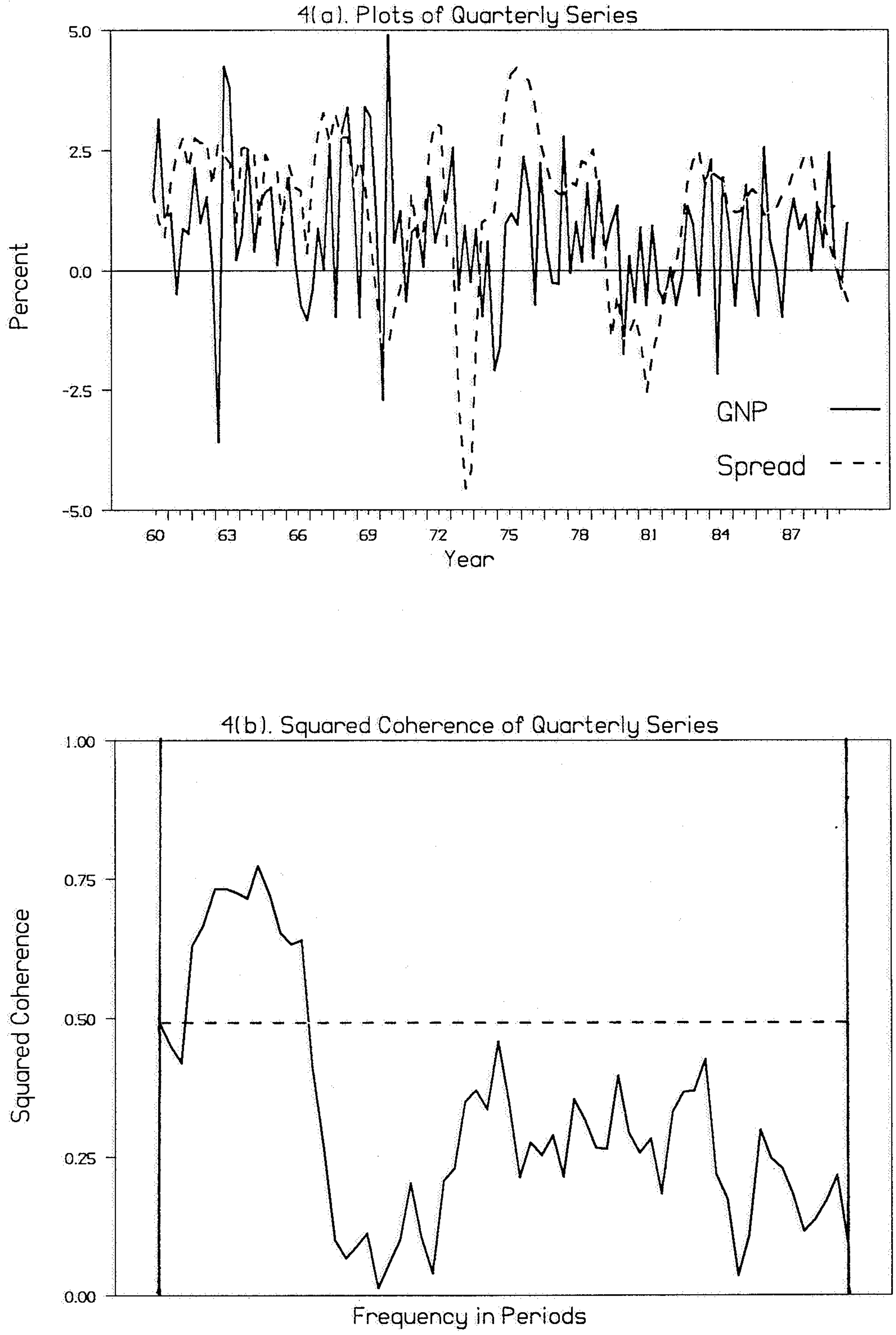


Figure 3 : An Anticipated Monetary Expansion

FIGURE 4. GNP GROWTH AND THE YIELD SPREAD



4(c). Plots of Annual Series

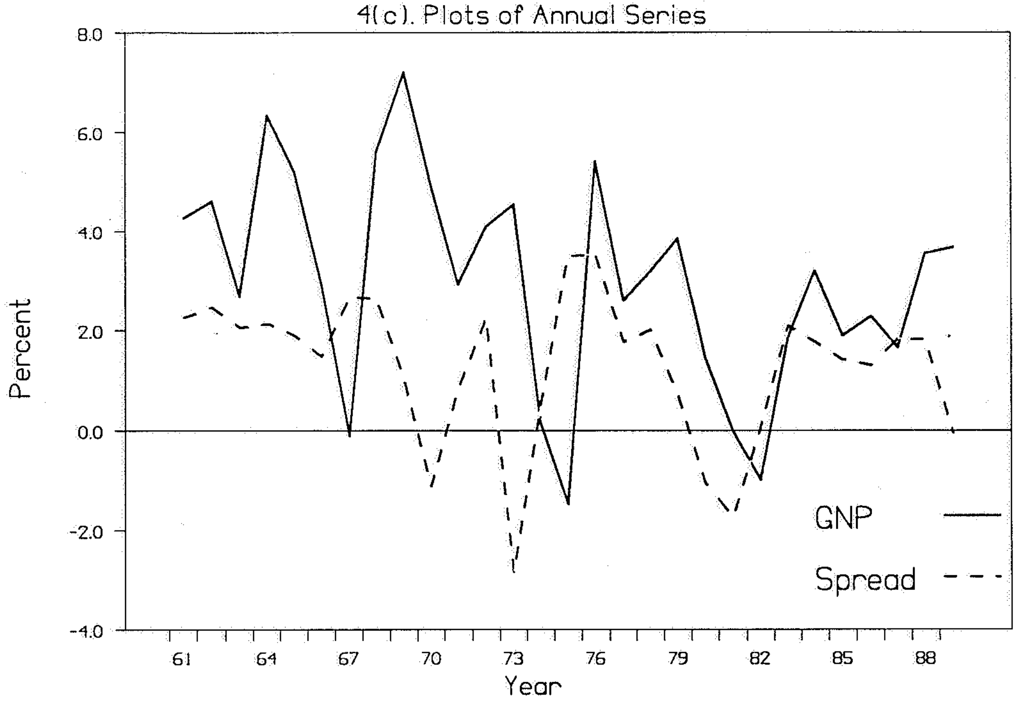


Table 1 - Cross-correlations between Measures of Real Economic Activity and the Yield Spread, Quarterly Data, 1960.1-1989.4

Variable	Cross-correlation at lag										
	0	1	2	3	4	5	6	7	8	9	10
Gross national product	0.17	0.22	0.23	0.25	0.27	0.24	0.13	0.09	0.03	0.03	-0.08
Industrial production	0.20	0.25	0.32	0.32	0.35	0.34	0.27	0.14	0.01	-0.07	-0.11
Unemployment	-0.28	-0.45	-0.57	-0.60	-0.60	-0.59	-0.55	-0.41	-0.25	-0.10	-0.02
Capacity utilization	-0.21	-0.05	0.07	0.19	0.30	0.42	0.46	0.47	0.43	0.42	0.33

Note: Cross-correlations larger than approximately 0.10 in absolute value are significant at the 5 percent significance level.

Table 2 - The Predictive Power of the Yield Spread, Granger Causality Tests, Annual Data, 1960-89

Predicted variable	Lag length	Granger causality	R^2_1	R^2_2
Gross national product	1	0.0003	0.428	0.133
Industrial production	2	0.0086	0.386	0.130
Unemployment	1	0.0000	0.591	0.130
Capacity utilization	1	0.0008	0.691	0.428
Private consumption	1	0.0155	0.474	0.358
Public consumption	2	0.6623	0.115	0.157
Gross fixed investment	1	0.0020	0.398	0.146
Inventory investment	1	0.0004	0.411	0.071
Exports Goods and Services	3	0.0176	0.231	0.018
Imports Goods and Services	1	0.0165	0.284	0.130

Notes: Lag length is determined by minimizing A.I.C.. The column headed 'Granger causality' gives the marginal significance level of the null hypothesis that the yield spread does not Granger-cause the measure of real economic activity. R^2_1 and R^2_2 are the adjusted R^2-statistics for the regression including lagged yield spreads and the regression excluding lagged yield spreads, respectively.

Table 3 - Real GNP Growth, Professional Forecasts, and Yield Spreads

Line	Forecasting Institution	Time Range	β_0	β_1	β_2	R^2	D.W.
(1)	——	1968-1989	1.81** (0.44)	——	0.93** (0.22)	0.45	1.20
(2)	OECD	1968-1989	0.36 (0.90)	0.91** (0.29)	——	0.30	1.65
(3)	SVR	1969-1989	0.11 (0.83)	0.92** (0.26)	——	0.37	1.71
(4)	OECD	1968-1989	0.58 (0.75)	0.53 (0.27)	0.73** (0.23)	0.52	1.57
(5)	SVR	1969-1989	0.51 (0.76)	0.55 (0.28)	0.61* (0.25)	0.50	1.54

Notes: Numbers in parentheses below parameter estimates are standard errors. * and ** indicate significance at the 5 precent and 1 percent level in a two-tailed test, respectively. D.W. is the Durbin-Watson statistic for first-order serial autocorrelation.

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