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# Nonlinear monetary policy in Europe: fact or myth?

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**Abstract**

We hold the fort for linear specification of monetary policy and economic activity in Europe. Using data on the last two and a half decades, we cannot reject the hypothesis that monetary policy is a linear process and we find mixed results regarding economic activity.


*Keywords:* Time series model specification; Linearity tests; Nonlinear models

*JEL classification:* C51

## 1. Introduction

Nonlinear monetary policy is well documented in the theoretical literature. The phases of the business cycle are argued to influence monetary policy in a different way. For instance Cukierman (1999) assumes that policymakers fear failures that cause recession more than failures that cause expansion. In such setting, monetary authorities may be tougher on inflation during economic upturns, whereas output stabilization receives a relatively larger weight in downturns (see e.g., Dolado et al., 2000; Bec et al., 2002, for empirical evidence). Economic theory also suggests that the impact of monetary policy on economic activity may be nonlinear (cf. Ball and Mankiw, 1994), with asymmetric effects of monetary expansion and contraction (see e.g., Cover, 1992; Karras, 1996; Sensier et al., 2002, for empirical

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evidence) or asymmetric effects in booms and recessions (see e.g., Kakes, 1998; Peersman and Smets, 2001; Sensier et al., 2002, for empirical evidence).

Even if this idea is supported for the US, it is challenged for countries constituting the core of the euro-area (of which we examine Germany, France, Italy, and the Netherlands).

Since the start of the Exchange Rate Mechanism (ERM) in 1979, European countries have increasingly committed to independent monetary authorities with goals separated from political or business cycle considerations. Within the current European Monetary Union (EMU), there is little room for discretion in monetary policy and a priori little reason to expect nonlinear influence of economic activity on monetary policy. Nevertheless, the commitment to reach EMU has not been the same for all countries at all times during the process of European monetary integration. We therefore additionally consider Denmark and the UK, who both abandoned the road towards EMU at some stage. Particularly for the UK, the desire for discretion in monetary affairs contributed to their decision to distance from further monetary integration. Thus, for these two non-euro economies, nonlinear effects of economic activity on monetary policy decisions remain conceivable a priori.

This paper tests the relevance of nonlinear monetary policy in Europe. It relies on the Lagrange-multiplier test of linearity proposed by Luukkonen et al. (1988), which tests smooth transition nonlinearity against the linear benchmark. Section 2 presents the test while Section 3 discusses the empirical application. Section 4 concludes.

## 2. Testing for smooth transition nonlinearity

Consider the logistic smooth transition autoregressive (LSTAR) model

$$y_t = x_t'\,\phi + (x_t'\,\theta)G(\gamma, c; s_t) + u_t \qquad (t = 1,\ldots T), \tag{1}$$

where $y_t$ alternately indicates monetary policy (term spread of interest rates or growth of real balances) or economic activity (real output growth) and $x_t$=(1, $x_{k,t-1},\ldots, x_{k,t-1-m}$) with $m$ lags of variable vector $k$ (containing real output growth, term spread of interest rates, and growth of real balances). The transition function $G(\cdot)$ is continuous, bounded between [0,1], follows $G(\gamma, c; s_t)=(1+\exp(-\gamma(s_t-c)))^{-1}$ with $\gamma>0$ and increases monotonically in the transition variable $s_t$ (cf. Teräsvirta, 1998). $u_t$ is a white noise residual with variance $\sigma^2$, $\gamma$ indicates the speed of transition between 0 and 1, and $c$ the switch-point between regimes.

This LSTAR model tends to a linear model for $\gamma\rightarrow 0$ . The major challenge associated with a formal linearity test is how to cope with the different numbers of nuisance parameters under the null of linearity and the alternative of LSTAR nonlinearity. Luukkonen et al. (1988) tackle this issue by building an LM-type statistic using the third-order Taylor approximation of the transition function $G(\gamma, c; s_t)\equiv \delta_0+\delta_1 s_t+\delta_2 s_t^2+\delta_3 s_t^3+R(\gamma, c; s_t)$ where $R$ is a remainder and $\delta_j$, $j$=0,1,2,3 are constant. Substituting back into Eq. (1) gives

$$y_t = x_t'\,\phi + (x_t s_t)'\,\beta_1 + \left(x_t s_t^2\right)'\,\beta_2 + \left(x_t s_t^3\right)'\,\beta_3 + u_t^* \qquad (t = 1,\ldots, T), \tag{2}$$

where $u_t^*=u_t+(x_t'\,\theta)R(\gamma, c; s_t)$. The LM test of linearity assesses $H_0$; $\beta_j=0$, $j$=1,2,3 against $H_1$: at least one $\beta_j\neq 0$. The statistic ($\xi$) associated with this test has the following form:

$$\xi = \sigma^2\left(\sum_{t=1}^{T}\hat{u}_t w_t\right)'\left(\hat{M}_{11} - \hat{M}_{10}\hat{M}_{00}^{-1}\hat{M}_{01}\right)^{-1}\left(\sum_{t=1}^{T} w_t\hat{u}_t\right), \tag{3}$$

where $w_t = (x_t s_t, x_t s_t^2, x_t s_t^3)'$, $\hat{M}_{00} = \sum_{t=1}^{T} \hat{x}_t x_t'$, $\hat{M}_{01} = \sum_{t=1}^{T} \hat{x}_t w_t'$, $\hat{M}_{10} = \sum_{t=1}^{T} \hat{w}_t x_t'$ and $\hat{M}_{11} = \sum_{t=1}^{T} \hat{w}_t w_t'$. Luukkonen et al. (1988) show that under the null $\xi \rightarrow \chi^2(3p)$ where $p = k \times (m+1) + 1$ indicates the number of explanatory variables.

## 3. Test results for European countries

We use quarterly series on GDP, consumer prices (CPI), long- and short-term interest rates, and the money supply (M3). German, French, Italian, Dutch and UK data is obtained from De Nederlandsche Bank while Danish data is taken from Engsted and Nyholm (2000). We analyse the period 1979:1–2002:1, which covers the entire process of monetary integration in Europe. We include the turbulent first years of monetary integration to stack the deck against linear monetary policy.

For each country, LSTAR nonlinearity in economic activity (quarterly growth of GDP, denoted for simplicity as $\Delta GDP$) and monetary policy is assessed. We use the monetary policy reaction model developed by McCallum (1994), which is based on the observation that central banks adjust short-term rates in order to influence the term spread (the difference between long- and short -term interest rates, denoted *Spr*). In addition, we capture the tightness or ease of monetary policy with the growth rate of real balances (denoted $\Delta M/P$).[1] Table 1 reports the test results. The optimal lag length in each individual case is selected using the SBIC criterion, which is the most conservative model selection criterion and therefore penalizes linear specifications.

In columns (1)–(3) LSTAR nonlinearity in economic activity is explored, using alternately lagged $\Delta GDP$, *Spr* and $\Delta M/P$ as the transition variable. The linearity test results show that there is little evidence of nonlinear economic activity in the EMU countries when using lagged $\Delta GDP$ or *Spr* as the transition variable. When lagged $\Delta M/P$ is used as the transition variable, nonlinear $\Delta GDP$ in the euro area still remains limited to Germany. These findings agree with Kakes (1998), who concludes that there are $\Delta GDP$ regimes in monetary policy effectiveness in Germany while Dutch monetary policy is ineffective in both recessions and booms. Peersman and Smets (2001) share these findings, but also report $\Delta GDP$ regimes for France and Italy. They do not, however, justify their nonlinear models with the rejection of formal linearity tests. Regarding the non-euro economies, for the UK there is evidence of distinct nonlinearities in economic activity (in line with Kakes, 1998; Sensier et al., 2002), while for Denmark $\Delta GDP$ regimes associate only with lagged $\Delta M/P$ and economic activity. Knowledge of economic activity regimes is useful for example for the purpose of improving recession probability predictions (see e.g., Anderson and Vahid, 2001).

The relevance of monetary policy regimes driven by economic activity is explored in columns (4) and (5). There, term spread and growth of real balances are modelled as LSTAR nonlinear processes using lagged economic activity as the transition variable. The linearity test results are such that linear monetary policy is accepted for all countries that we consider. For the EMU countries such finding confirms our economic arguments: monetary policy on the way to EMU has been focused on business cycle independence since its incipience. It also agrees with Dolado et al. (2000) who find no asymmetric behaviour of German and French monetary policy with respect to business cycle

[1] Cointegration relationships between level of output and real balances are rejected by the Johansen (1991) test. We thus consider in the system the growth rate of output and real balances.

Table 1
Monetary policy and economic activity in Europe: linearity test results

| Transition variable | $\Delta GDP$ | | | $Spr$ | $\Delta M/P$ |
|---|---|---|---|---|---|
| | $\Delta GDP_{-1}$ | $Spr$ | $\Delta M/P_{-1}$ | $\Delta GDP_{-1}$ | $\Delta GDP_{-1}$ |
| *Denmark* | | | | | |
| Lags | **1** | 1 | **1** | 1 | 1 |
| Linearity | **0.05** | 0.38 | **0.01** | 0.59 | 0.47 |
| *France* | | | | | |
| Lags | 1 | 1 | 1 | 1 | 5 |
| Linearity | 0.73 | 0.63 | 0.18 | 0.09 | 0.73 |
| *Germany* | | | | | |
| Lags | 4 | 4 | **4** | 1 | 4 |
| Linearity | 0.42 | 0.95 | **0.00** | 0.94 | 0.19 |
| *Italy* | | | | | |
| Lags | 1 | 1 | 1 | 1 | 4 |
| Linearity | 0.06 | 0.55 | 0.13 | 0.14 | 0.20 |
| *Netherlands* | | | | | |
| Lags | 1 | 1 | 1 | 1 | 2 |
| Linearity | 0.10 | 0.37 | 0.07 | 0.68 | 0.18 |
| *United Kingdom* | | | | | |
| Lags | **1** | **1** | **1** | 1 | 1 |
| Linearity | **0.00** | **0.01** | **−0.01** | 0.23 | 0.11 |

Sample period is 1979:1–2002:1. Each model includes the indicated number of lags for $\Delta GDP$, $Spr$ and $\Delta M/P$. The optimal number of lags for the models presented has been selected using the SBIC information criterion, refer to the appendix for the SBIC model selection results. The linearity test uses an F-approximation to $\xi$ (Eq. (3)) with $3p$ and $T$-$4p$-1 degrees of freedom; concomitant $p$-values are reported in the table. The Dutch models additionally include the German term spread. For Germany, a dummy for reunification is used in the $\Delta GDP$ and $\Delta M/P$ models. Bold characters indicate the rejection of the null hypothesis of linearity at the 5% significance level.

considerations. Bec et al. (2002) reject linearity for Germany. For Denmark the linear monetary policy result can also be explained as the Danes, although they rejected the single European currency, closely follow ECB monetary policy. The UK, however, has ever been reluctant to commit to straitjacket its monetary policy and is unattached to EMU monetary measures. Yet we find that UK monetary authorities seem not to have exerted the discretion they have available as British monetary policy is best characterized by a simple linear reaction function.

## 4. Conclusions

Formal tests fail to accept nonlinear monetary policy for the European economies that we analyze. While for the euro economies this result relates to the very foundation of the European Monetary Union—which considers price stability of paramount importance with disregard for the business cycle—

our findings are similar regarding monetary policy in Denmark and the UK, both of which stopped their pursuit of monetary integration short of monetary union.

For the EMU economies save Germany, similar conclusions follow for economic activity: linear economic activity is accepted for France, Italy and the Netherlands. For Germany, Denmark and distinctly for the UK, we do reject the null of linear economic activity. For these economies, business cycle forecasts using nonlinear techniques should outperform forecasts using linear techniques.

The limited evidence of nonlinearity in European monetary policy and economic activity leads us to emphasize once more that formal linearity testing should precede any nonlinear modelling.

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