Is M3 still a useful indicator of medium-term inflation in the EU-27?

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Abstract

The informational value of money growth for inflation policy in the European Union has been put into question. Different studies have found that money growth does not contain information that is not already present in other determinants of inflation, such as the output gap (Rudebusch and Svensson, 2002; Gerlach and Svensson, 2003, Gerlach, 2004). This paper uses the Gerlach and Svensson (2003) dataset and shows that money growth has significant informational content beyond that provided by the output gap, the real interest rate, cost shocks and other variables included in the "second pillar" of the European Central Bank's monetary strategy.

JEL Classification: E32, E52, E58

Keywords: Inflation, M3, monetary policy, European Union.

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1. Introduction

The increased process of financial globalization has the potential to undermine the effectiveness of money as a useful indicator for medium-term inflation. The increase in capital flows, the deregulation of cross-border transactions, the changing nature of money as financial intermediation internationalizes and more substitutes are created, etc. are all influences that affect the demand for money in ways that are hard to pinpoint. Indeed, as Michael Woodford has recently noted (Woodford, 2007): "It has recently become popular to argue that globalization has had or will soon have dramatic consequences for the nature of the monetary transmission mechanism."

As is well-known, the European Central Bank (ECB) has a "two pillars" monetary strategy in which money, as proxied by M3, plays a critical role as an indicator for medium-term inflation. In an important paper, Gerlach and Svensson (2003) found that the demand for broad money (M3) in the EU area has been remarkably stable in the face of the previously discussed changes, thus suggesting that there still is a role for money stock indicators in the conduct of monetary policy in the EU area. An important issue remains controversial, however, and is related to the particular treatment of the money stock indicator by the ECB in making it the "star indicator" for medium term inflation. Gerlach (2004), for example, claims that the prominence conferred by the ECB to the money stock as a predictor of medium-term inflation is unwarranted and concludes that the money stock should be treated no differently than the output gap and the rest of the indicators for inflation. Indeed, Gerlach and Svensson (2003) found that money growth contained no information that was not already contained in the output gap.

In this paper we use the Gerlach and Svensson (2003) dataset to extend the study of the connection between money and inflation in the European Union. Specifically, we pick up an issue that was not central to Gerlach and Svensson, namely the transmission lag between money and prices, and find that when the appropriate lags of the money stock are entered into the inflation rate regression specifications no other determinant of inflation (energy prices, the output gap, different interest rates, etc.) comes close to explaining as much of the variation of inflation as M3 does. Our results are in line with very recent literature on the importance of money as an indicator for medium term inflation (Christiano et al. 2007, Hafer et al., 2007), but are not in line with previous research on the subject (Rudebusch and Svensson, 2002; Gerlach and Svensson, 2003). The remainder of this paper is organized as follows. Section 2 describes the data used n this study and discusses the behavior of the data in two different subsamples: the early 1980s characterized by very high inflation and the post 1985 period characterized by the transition from moderate to low inflation. Section 3 studies the empirical relationship between money growth and inflation at medium-to-long-run horizons from a quantity-theoretic perspective. Section 4 studies the empirical medium-term relationship between money growth and inflation from an Aggregate Supply perspective. Section 5 expands the Aggregate Supply side analysis and concentrates on the influence of lagged money growth on the output gap, a connection that has been at the center of some recent studies uncovering contradictory results for the case of the US (i.e., Rudebusch and Svensson, 2002 and Hafer et al. 2007). A brief section containing some concluding remarks and suggestions for further research close the paper.

2. The data: definitions, summary statistics and subsamples

This section describes the data, summarizes its main characteristics and discusses the behavior of some of the critical variables in different sub-samples.

2. 1. The Data

The data are taken from the Gerlach and Svensson (2003) dataset (henceforth, GS). The data frequency is quarterly and spans the period 1980:1-2001:1. The data on output, money and interest rates (both short and long) stem originally from Coenen and Vega (2001) and were updated by GS using the ECB's *Monthly Bulletin*. Coenen and Vega (2001) obtained the country-specific interest rate series from the BIS database and constructed the Euro area series as weighted averages of national rates using fixed weights based on 1995 GDP at PPP rates. According to Coenen and Vega (2001), the monetary aggregate M3, as defined in December 1998 by the Governing Council of the ECB, "consists of holdings by Euro area residents of currency in circulation plus certain liabilities issued by Monetary Financial Institutions (MFIs) and, in the case of deposits, liabilities issued by some institutions which are part of the central government, such as post offices and treasuries. These include: overnight deposits, deposits with agreed maturity up to two years, deposits redeemable at notice up to three months, repurchase agreements, money market shares, money market paper, and debt securities with maturity up to two years." A detailed description of Euro area monetary aggregates can be found in ECB (1999). Regarding the data on real GDP, Coenen and Vega (2001) obtained their data from Eurostat for the period for which it is available and for earlier periods they got real GDP data from national sources and then aggregated it using fixed weights based on 1995 Real GDP at PPP rates.

Additionally, GS constructed the following Euro area measures: consumer prices, energy component of the consumer price index, and a measure of the output gap. For the period before 1995:1 the CPI and the energy component of the CPI are constructed by weighting the growth rates of national price indices using nominal GDP expressed in common currency as weights. For the post 1995:1 period, the official HICP and its energy component were used by GS. In regards to the output gap proxy, GS used a standard procedure: they filtered the real GDP series using the Hodrick-Prescott algorithm setting the smoothing parameter equal to 1600.

2. 2. Descriptive statistics and the behavior of key variables in different subsamples

Table 1 shows descriptive statistics for the GS dataset. The upper panel of Table 1 displays summary statistics for the main variables for the whole sample period 1980:1-2001:1 whereas the bottom panel displays descriptive statistics for the subsample 1985:1-2001:1. The reason for splitting the sample around the first quarter of 1985 is the substantially different behavior displayed by the rate of inflation in those two periods. Figure 1 helps to visualize the stark difference in the behavior of the inflation rate during the first half of the 1980s and the remainder of the sample. In the first half of the 1980s the annualized inflation rate reached 3 digits during 1980:3, 1980:4, 1981:1, stayed above 40% until 1982:3 and was never below 15% until 1985:1. As the bottom panel makes clear, it only fell below 10% in the second quarter of 1986. The very high inflation of the early 1980s does not seem to come together with any distinctive behavior on the part of the output gap during the same period. Indeed, as shown in Figure 2, the behavior of the output gap does not seem to differ substantially between the early and the mid 1980s. However, the distortions associated to the runaway inflation of the early 1980s are apparent in the behavior of the short-term real interest rate, as shown in the markedly negative (ex-post) real interest rates characterizing this period (please refer to Figure 3). This type of anomaly is well-known in high inflation economies but raises two related concerns: first, the problem of interpreting the behavioral meaning of such negative real interest rates. Second, the question regarding the relevance of such behavior to understand more normal periods almost poses itself for consideration.

The distortions introduced by triple digit inflation are also apparent in the behavior of income M3 velocity during the early 1980s (please refer to the top panel of Figure 4 and note how the CPI increases much faster than the money supply for a level of income that remains approximately constant during the period, a clear indication of rising velocity). This acceleration of velocity is typical of runaway episodes of high inflation in which economic agents try to find ways to economize on real money balances, but stands in sharp contrast with the behavior of M3 velocity in the remainder of the sample. In the period 1985:1-2001:1 velocity shows a slow and stable decline and the relationship between M3 and the CPI is much closer.

In light of the previous considerations we decided to drop the subsample 1980:1-1980:4 from this study. The cost paid in terms of reducing an already small sample is clear. On the other hand, we do not believe that much can be learned by pooling together data belonging to very different inflation regimes with the only purpose of expanding degrees of freedom and statistical significance (especially not if the extra statistical significance comes at the expense of economic understanding.) Retaining the period post-1985:01 still leaves enough variation in the rate of inflation, allows for an initial period of slightly negative (ex-post) real interest rates, a much more common phenomenon in "normal" times, and introduces no qualitatively different behavior in the output gap.

In the next section we turn to study the medium to long-term connection between money and prices.

3. The medium to long-term relationship between money and prices

The bottom panel of Figure 4 shows that money and prices are closely associated over the medium to long-term during moderate-to-low inflation regimes, strongly suggesting the existence of a quantity-theoretic connection in the EU over the period 1985:1 2001:1. Simple regressions of the rate of inflation on its first four lags, the first lag of the (log) change in the price of oil, the first lag of the short-term real interest rate, and lags of the (log) change of money growth strongly indicate that the lags of money growth are the most important economic and statistical determinant of the rate of inflation in the period 1985:1-2000:4 (regressions are not shown here, since very similar ones are displayed below in Table 3).

To test the connection between money and prices more formally, we followed Rudebusch and Svensson (2002, p. 433-434) and implemented a version of the P* model originally introduced by Hallman et al. (1991). The following equation was estimated by OLS (Table 2 summarizes the results):

$$\pi_{t+1} = a_1\pi_t + a_2\pi_{t-1} + a_3\pi_{t-3} + a_4\pi_{t-4} + b(m_t - m_t^*) + \varepsilon_{t+1} \quad (1)$$

Where $m_t^* = y_t^* + p_t - v_t^*$ is the long-run equilibrium level of real money balances, y^* denotes potential real GDP, and v^* is trend velocity. Potential real GDP and trend velocity were both calculated using the Hodrick-Prescott algorithm, setting the HP parameter equal to 1600, following the procedure used by GS. Additionally, m_t stands for real money balances, and π denotes the rate of CPI inflation.

Since we were especially concerned with the possibility of having pooled together data from different inflation regimes, the regressions in Table 2 are displayed for rolling samples spanning the interval 1985:1- 1988:2, so as to leave a minimum of 50 observations in the shortest sample. The estimates displayed in Table 2 show that the money gap is always significant (both economically and statistically) to explain the rate of inflation in the rolling sample regressions contained between 1985:1-2000:4 and 1988:2-2000:4. The rolling sample regressions displayed at the bottom of Table 2 indicate an important instability in the money gap coefficient toward the end of the 1987 year when the coefficient increases its size significantly. Since the standard error of the money gap coefficient did not change significantly as the sample size became smaller, this instability in the money gap coefficient does not seem to be explained by more imprecise estimates stemming from the loss of degrees of freedom as the subsamples got smaller. This issue deserves further study.

A dummy variable for the post Euro period adds no significant explanatory power to the regressions of Table 2. Furthermore, Chow breakpoint tests indicate no structural break in the estimates displayed in Table 2 after the introduction of the Euro. For instance, the F-statistic associated to structural change during the first quarter of 1999 equals 0.16, with p-value equal to 0.98.

4. Supply-side determination of medium-term inflation via Phillips curve analysis. Is M3 still important?

Gali, Gertler and Lopez Salido (2001) have shown that the traditional Phillips curve which includes four lags of the rate of inflation fits European quarterly inflation data quite well for the period 1970:I-1998-II. Similar results have been shown to hold for US quarterly inflation data for the period 1960-1999 by Rudebusch and Svensson (1999) (More technically involved analysis by Stock and Watson (1999) confirms that the many real activity variables suggested in traditional Phillips curve analysis remain helpful in forecasting inflation).

In this section, we show the results of running traditional Phillips curve regressions á la Gali et al. (2001) expanded to include lags of money growth. The estimated equations are of the following form:

$$\begin{aligned}\pi_t &= c + a_1\pi_{t-1} + a_2\pi_{t-2} + a_3\pi_{t-3} + a_4\pi_{t-4} + b\, y_{t-1} + \delta\,\Delta\ln(p\,oil)_{t-1} + \\ &\quad + e_1\,\Delta\ln(M3)_{t-1} + e_2\Delta\ln(M3)_{t-9} + u_t\end{aligned} \qquad (2)$$

Where y_{t-1} stands for the first lag of the output gap and the remaining symbols retain the meanings discussed before. Results, summarized in Table 3 for the whole sample (1985:01-2001:1), indicate that money growth exerts a significant influence on the rate of inflation both in the short and the medium run. Note that when the first lag of the (log) change in the price of oil (or an index of energy prices) is included in the regressions (to proxy for a cost shock), the influence of the first two lags of the inflation rate disappears, but the influence of the lags of money growth does not (the first lag remains statistically significant at the 7% and the 9th lag remains statistically significant at the 2% level; the two lags of money growth remain the most economically significant influences on the rate of inflation). [1]

To check for the stability of the previous results during the transition between different inflation regimes, Table 4 displays the same regression discussed in Table 3 for rolling samples spanning the periods 1985:01-2001:1 - 1988:4-2001:1 (so as to leave a minimum of 50 observations for the shortest sample). Specifications including the ninth lag of money growth are especially statistically robust, with the ninth lag of money growth being also the most important economic determinant of inflation. The statistical robustness of the first lag of money weakens significantly toward the end of the rolling sample period. However, its economic significance does not.

Chow breakpoint tests indicate no structural break in the estimates displayed in Table 4 during the post-Euro period (The F-statistic associated to a test of structural break in the first quarter of 1999, for example, equals 1.16, with p-value equal to 0.33).

Therefore, we conclude that the former analysis provides reduced-form empirical support for the claim advanced by Christiano, Motto and Rostagno (2007) that money is useful in the conduct of monetary policy amongst other reasons because of its influence on the Aggregate Supply curve (i.e., the Phillips curve).

Money growth seems to exert a significant influence on short to medium term supply-driven inflation after controlling for the influence of cost shocks and economic slack on the rate of inflation.

[1] The inclusion of variables proxying for cost-push factors has been suggested by both Gordon (1998) and Stock (1998) as a way to ameliorate the effects of structural changes in the parameters governing the structural relationship between the output gap and inflation over time.

5. The impact of M3 growth on the output gap

The analysis of the previous sections has emphasized direct effects of money on inflation, first through the quantity-theoretic links between money and prices, and then through the Phillips curve relationship, amended to include a money growth component. The focus of the present section is related to the short to medium-term inflation impact of lagged money growth on the output gap.

As a way to check for the influence of money growth on the rate of inflation in a different way, this section follows Rudebusch and Svensson (2002) and Hafer, Haslag and Jones (2007) and studies the effects of lagged money growth on the output gap. Using quarterly data spanning the period 1961:1-1996:4 for the case of the US, Rudebusch and Svensson (2002) did not find support for the hypothesis that lagged money growth affects the output gap. They concluded that "there is no support for the prominent role given to money growth in the Eurosystem's monetary policy strategy." (Rudebusch and Svensson, 2002, p. 417). Using a slightly different specification of the output gap equations, Hafer et al. (2007) found that lagged money growth did exert a significant influence on the output gap for the case of the US in the period 1961-2000. Comparative estimates for the UK are provided by Nelson (2002).

The analysis conducted below follows the specification proposed by Rudebusch and Svensson (2002). Table 5 summarizes the results. The following equation is estimated by OLS:

$$y_{gt+1} = c + a_1 y_{gt} + a_2 y_{gt-1} - a_3 r_t + a_4 \Delta \ln(M3)_{t-4} + u_{t+1} \tag{3}$$

Where y_{gt+1} is the first lead of the output gap, y_{gt} is the contemporaneous measure of the output gap, y_{gt-1} is the first lag of the output gap, r_t is the real (ex-post) short-term interest rate, $\Delta \ln(M3)_{t-4}$ stands for the fourth lag of the rate of money growth (M3 growth rate), and u_{t+1} is the disturbance term, assumed to be white noise.

Running the above regression for the sample 1985:01-2000:3 (the output gap is not available for the last quarter of the sample period, namely 2000:4, in the GS database) produces the following result (t-statistics are displayed below estimated coefficients):

$$\begin{aligned} y_{gt+1} &= 0.16 + 1.06 y_{gt} - 0.09 y_{gt-1} - 0.11\, r_t + 0.09 \Delta \ln(M3)_{t-4} \\ &\quad (0.74)\ (9.29)\quad (-0.82)\qquad (-3.84)\quad (1.00) \end{aligned} \tag{4}$$

The statistical insignificance of the money growth coefficient is due to a structural break in the relationship that occurs at the beginning of the sample period between the second and the third quarters of 1985 when the rate of inflation falls from an annualized rate of 13.54% in the second quarter to an annualized rate of 6.71% in the third. Indeed as Table 5 shows, when a dummy variable is included to control for this fact, rolling sample regressions between 1985:3 and 2000:3 and 1988:2 and 2000:3 (designed to preserve a minimum of 50 observations in the shortest sample regression) all show a significant money growth coefficient (both economically and statistically). This illustrates the peril of not properly accounting for structural change in the relationships being estimated, a danger that increases with the length of the sample and the heterogeneity of the inflation regimes being pooled together.

The inclusion of a dummy variable for the post Euro period did not change results. The dummy for the post 1999 period was invariably statistically and economically insignificant. Furthermore, Chow breakpoint tests categorically reject the hypothesis of structural changes in the relationship during the year 1999 (For example, the F-statistic associated to structural break during the first quarter of 1999 equals 0.09, with p-value equal to 0.99).

As an alternative to Rudebusch and Svensson's (2002) specification, we followed Hafer et al (2007) and estimated the equation displayed below for rolling samples starting in 1985:1 and concluding in 1988:2 (an exercise designed to preserve a minimum of 50 observations for the shortest of the samples):

$$y_{gt} = c + a_1 y_{gt-1} + a_2 y_{gt-2} - a_3 r_t + a_4 \mu_{t-5} \quad (5)$$

Results were very similar to the ones obtained under the Rudebusch and Svensson (2002) specification. We conclude that the fifth lag of money growth is highly economically and statistically significant in explaining the output gap, a result that is in line with Hafer et al. (2007), but not in line with Rudebusch and Svensson (2002).

6. Concluding remarks

Using a sample spanning the period 1980:1-2001:1, Gerlach and Svensson (2003) found that the real money gap (the difference between the real money stock and the long-run equilibrium real money stock) contains considerable information regarding future inflation in the Euro area. In contrast, they also found that the Eurosystem's money growth indicator (the difference between nominal money growth and a reference value) contains little information about future inflation and no information beyond that contained in the output and real money gaps.

Using the Gerlach-Svensson (2003) dataset, but concentrating on the sub-period 1985:1-2001:1 we are able to find a somewhat different result. Money still contains considerable information regarding future inflation, and money growth itself does provide significant information about inflation beyond that contained in the output gap and other conventional determinants of inflation. Our results are in line with very recent literature on the importance of money growth as a medium-to-long-term indicator of inflation (Christiano et al. 2007, Hafer et al. 2007).

Suggested extensions include, but are not limited to, the following: (1) Extend the GS dataset to the present time to be able to check for non-robustnesses in the results in more recent times while at the same time expanding the size of our sample in an economically meaningful way (i.e., without pooling together data from different inflation regimes); (2) Introduce BIS information on cross-border transactions to the dataset to be able to check for the effects of increased financial globalization in the Euro area on the ability of money growth to explain medium term inflation; (3) Study the inter-relations between inflation money growth, the output gap and interest rates within a VAR framework, performing cointegration analysis and Granger causality exercises within a Vector Error Correction Model. The evidence stemming from such exercises should be seen as complementary to the one presented in this paper, in our view.

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Appendix on the stationarity of the data

To check for unit roots, standard ADF tests were implemented first. All of them showed stationary series, with the exception of the one corresponding to the output gap, for which a unit root was found. Since reversing the null hypothesis is known to be useful in helping to determine the stationarity properties of the data, the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test of stationarity was also conducted. Results for the KPSS test are presented in the table below.

Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test of stationarity
H(0): Stationarity

	Inflation	Dln(LnMoney)	Dln(P Oil)	r_short	output gap
	LM Stat	LM Stat	LM Stat	LM Stat	LM Stat
	0.076762	0.116196	0.045217	0.239005	0.156924
Critical values					
1%	0.216	0.216	0.216	0.739	0.739
5%	0.146	0.146	0.146	0.463	0.463
10%	0.119	0.119	0.119	0.347	0.347

Note: all tests were initially conducted including a constant and a linear trend.
The linear trend was tested and rejected for the short term real interest rate and the output gap. Those two tests were re-ran excluding the linear trend.
That explains why the critical values differ for the last two columns.

Table 1: SUMMARY STATISTICS

SAMPLE 1980:1-2001-4

	MONEY INDEX	CPI INDEX	Energy PRICES	OIL PRICES	OUTPUT INDEX	I SHORT	I LONG	OUTPUT GAP
Mean	126.57	2281.46	113.24	93.74	101.47	8.49	9.10	-1.42
Median	128.61	2419.89	113.46	90.40	101.72	8.35	9.20	-1.78
MAX	146.07	3447.53	122.67	107.68	103.16	16.08	14.61	2.13
Min	100.00	100.00	100.00	80.37	99.98	2.64	3.99	-3.81
Std Dev	13.47	908.38	4.83	7.74	0.99	3.30	2.68	1.59
Skewness	-0.34	-0.64	-0.40	0.43	-0.08	0.12	0.04	0.75
Kurtosis	1.88	2.43	3.00	1.71	1.71	2.31	2.41	2.58
Jarque-Bera	6.01	6.79	2.24	8.40	5.96	1.79	1.17	8.05
probability	0.05	0.03	0.33	0.02	0.05	0.41	0.56	0.02
OBS	84	84	84	84	84	80	80	80

Subsample 1985:1-2001:4

	MONEY INDEX	CPI INDEX	Energy PRICES	OIL PRICES	OUTPUT INDEX	I SHORT	I LONG	OUTPUT GAP
Mean	132.21	2673.82	114.86	90.81	101.84	7.42	8.15	-1.14
Median	134.32	2804.49	114.36	89.40	101.91	7.70	8.67	-1.75
MAX	146.07	3447.53	122.67	107.68	103.12	11.86	11.01	2.13
Min	114.84	1663.07	109.09	80.37	100.40	2.64	3.99	-3.62
Std Dev	9.32	560.42	3.77	6.15	0.75	2.64	2.01	1.58
Skewness	-0.34	-0.33	0.02	1.20	-0.27	-0.13	-0.52	0.71
Kurtosis	1.87	1.66	2.07	3.83	2.15	1.80	2.10	2.29
Jarque-Bera	4.70	6.04	2.33	17.53	2.69	4.03	5.09	6.67
probability	0.10	0.05	0.31	0.00	0.26	0.13	0.08	0.04
OBS	65	65	65	65	64	64	64	64

Note: The indices take the value 100 in the second quarter of 1980.

Table 2

Equation being estimated:

$$\pi_{t+1} = a_1\pi_t + a_2\pi_{t-1} + a_3\pi_{t-2} + a_4\pi_{t-3} + b(m_t - m_t^*) + \varepsilon_{t+1}$$

	ENTIRE SAMPLE			
	Coeff.	t-stat	p-value	
a(1)	0.45	3.81	0.00	
a(2)	0.09	0.71	0.48	
a(3)	0.29	2.30	0.03	
a(4)	-0.09	-0.80	0.43	
b	0.26	3.17	0.00	
Observations	64			
R-squared	0.75			
Adjusted R-squared	0.73			
S.E. of regression	1.33			
Prob(F-statistic)	0.0000			
Durbin-Watson stat	2.17			
	ROLLING SAMPLES			
	b	t-stat	p-value	OBS
1985:2-2000:4	0.318	4.01	0.00	63
1985:3-2000:4	0.244	3.08	0.00	62
1985:4-2000:4	0.246	3.06	0.00	61
1986:1-2000:4	0.227	2.95	0.00	60
1986:2-2000:4	0.233	3.04	0.00	59
1986:3-2000:4	0.252	3.35	0.00	58
1986:4-2000:4	0.279	3.60	0.00	57
1987:1-2000:4	0.258	3.17	0.00	56
1987:2-2000:4	0.258	3.05	0.00	55
1987:3-2000:4	0.263	2.96	0.00	54
1987:4-2000:4	0.296	3.21	0.00	53
1988:1-2000:4	0.398	4.33	0.00	52
1988:2-2000:4	0.449	4.26	0.00	51
1988:3-2000:4	0.472	3.91	0.00	50

Table 3
Dependent Variable: INFLATION
Sample: 1985Q1 2001Q1
Included observations: 65

	(1)	(2)	(3)	(4)
CONSTANT	1.04	-0.77	-0.87	-1.37
t-stat	2.60	-1.22	-1.43	-1.83
p-value	0.01	0.23	0.16	0.07
INFLATION(-1)	0.47	0.32	0.15	0.20
t-stat	3.64	2.55	1.08	1.34
p-value	0.00	0.01	0.28	0.18
INFLATION(-2)	0.04	-0.02	0.08	-0.02
t-stat	0.33	-0.17	0.65	-0.17
p-value	0.75	0.87	0.52	0.87
INFLATION(-3)	0.28	0.26	0.27	0.27
t-stat	2.06	2.01	2.17	2.08
p-value	0.04	0.05	0.03	0.04
INFLATION(-4)	-0.01	-0.08	-0.04	-0.05
t-stat	-0.09	-0.69	-0.38	-0.45
p-value	0.93	0.49	0.71	0.65
OUTPUT_GAP(-1)	0.23	0.16	0.16	0.10
t-stat	1.90	1.34	1.39	0.80
p-value	0.06	0.19	0.17	0.43
CHANGE LN(MONEY)(-1)		0.84	0.80	1.10
t-stat		1.86	1.84	2.29
p-value		0.07	0.07	0.03
CHANGE LN(MONEY)(-9)		1.14	1.25	1.39
t-stat		2.64	2.98	3.01
p-value		0.01	0.00	0.00
CHANGE LN (P Oil) (-1)			0.03	
t-stat			2.29	
p-value			0.03	
CHANGE LN (Energy P) (-1)				0.17
t-stat				1.46
p-value				0.15
R-squared	0.76	0.81	0.82	0.81
Adjusted R-squared	0.74	0.78	0.80	0.79
S.E. of regression	1.43	1.31	1.27	1.30
F-statistic	37.73	33.94	32.56	30.56
Prob(F-statistic)	0.00	0.00	0.00	0.00
Durbin-Watson stat	1.99	1.94	1.77	1.90

Table 4

Equation being estimated:

$$\pi_t = c + a_1\pi_{t-1} + a_2\pi_{t-2} + a_3\pi_{t-3} + a_4\pi_{t-4} + b\,y_{t-1} + d\,\Delta\ln(p\,oil)_{t-1} +$$
$$+ e_1\,\Delta\ln(M3)_{t-1} + e_2\Delta\ln(M3)_{t-9} + u_t$$

ENTIRE SAMPLE

	Coeff.	t-stat	p-value
a(1)	0.15	1.08	0.28
a(2)	0.08	0.65	0.52
a(3)	0.27	2.17	0.03
a(4)	-0.04	-0.38	0.71
b	0.16	1.39	0.17
d	0.03	2.29	0.03
e(1)	0.80	1.84	0.07
e(2)	1.25	2.98	0.00
Observations	65		
R-squared	0.82		
Adjusted R-squared	0.80		
S.E. of regression	1.27		
Prob(F-statistic)	0.0000		
Durbin-Watson stat	1.77		

ROLLING SAMPLES

	e(1)	e(2)	p-value, e(1)	p-value, e(2)	OBS
1985:2-2001:1	0.886	1.26	0.04	0.00	64
1985:3-2001:1	0.807	1.42	0.03	0.00	63
1985:4-2001:1	0.748	1.29	0.05	0.00	62
1986:1-2001:1	0.761	1.30	0.05	0.00	61
1986:2-2001:1	0.662	1.17	0.08	0.00	60
1986:3-2001:1	0.686	1.21	0.08	0.00	59
1986:4-2001:1	0.699	1.22	0.07	0.00	58
1987:1-2001:1	0.760	1.38	0.05	0.00	57
1987:2-2001:1	0.716	1.32	0.08	0.00	56
1987:3-2001:1	0.739	1.37	0.08	0.01	55
1987:4-2001:1	0.714	1.36	0.11	0.01	54
1988:1-2001:1	0.734	1.36	0.11	0.01	53
1988:2-2001:1	0.809	1.30	0.08	0.01	52
1988:3-2001:1	0.739	1.30	0.11	0.01	51
1988:4-2001:1	0.522	1.34	0.27	0.01	50

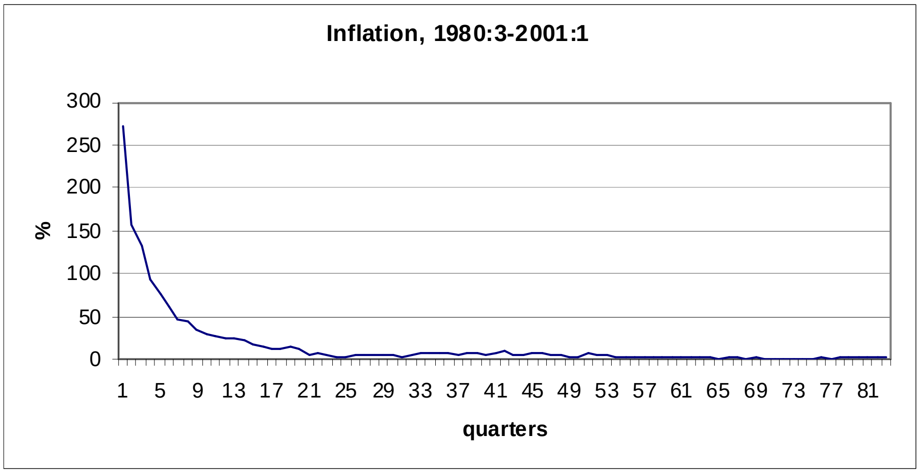
Table 5

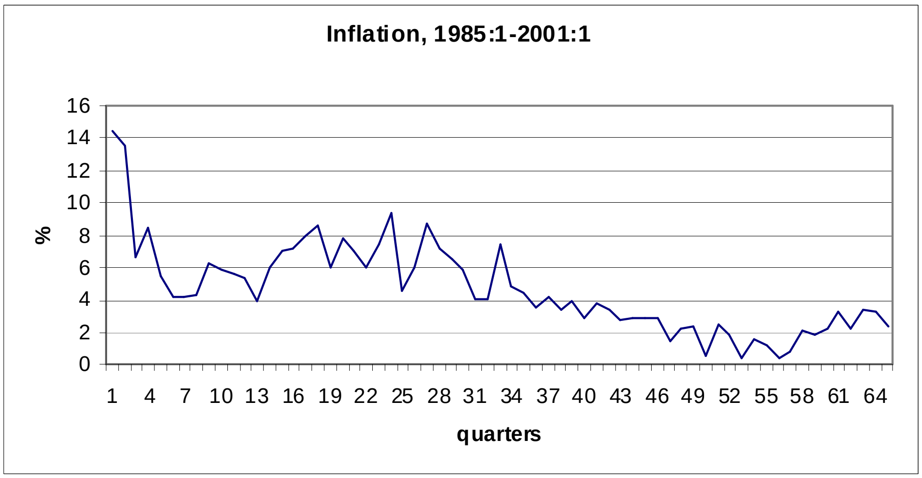
Augmented Rudebusch-Svensson (2002) equation:

$$y_{gt+1} = c + a_1 y_{gt} + a_2 y_{gt-1} - a_3 r_t + a_4 \Delta \ln(M3)_{t-4}$$

	ROLLING SAMPLE_1985:1-2000:3			
	a4	t-stat	p-value	OBS
1985:1-2000:3	0.095	1.00	0.32	63
1985:2-2000:3	0.107	1.13	0.27	62
	ROLLING SAMPLE_1985:3-2000:3			
	a4	t-stat	p-value	OBS
1985:3-2000:3	0.148	1.54	0.13	61
1985:4-2000:3	0.176	1.73	0.09	60
1986:1-2000:3	0.280	2.96	0.00	59
1986:2-2000:3	0.265	2.53	0.01	58
1986:3-2000:3	0.260	2.40	0.02	57
1986:4-2000:3	0.262	2.36	0.02	56
1987:1-2000:3	0.290	2.86	0.01	55
1987:2-2000:3	0.240	2.45	0.02	54
1987:3-2000:3	0.249	2.53	0.01	53
1987:4-2000:3	0.224	2.23	0.03	52
1988:1-2000:3	0.237	2.27	0.03	51
1988:2-2000:3	0.231	2.14	0.04	50
	ENTIRE POST 1985 SAMPLE			
	Coeff.	t-stat	p-value	
OUTPUT_GAP	0.98	8.88	0.00	
OUTPUT GAP(-1)	-0.07	-0.64	0.53	
R SHORT	-0.15	-4.98	0.00	
Money Growth (-4)	0.29	2.62	0.01	
Dummy 2 digit inflation	0.79	2.95	0.00	
Constant	-0.83	-2.13	0.04	
Observations	63			
R-squared	0.94			
Adjusted R-squared	0.94			
S.E. of regression	0.39			
Prob(F-statistic)	0.0000			
Durbin-Watson stat	2.32			

Figure 1


Inflation, 1980:3-2001:1
300
250
200
150
100
50
0
%
1 5 9 13 17 21 25 29 33 37 41 45 49 53 57 61 65 69 73 77 81
quarters


Inflation, 1985:1-2001:1
16
14
12
10
8
6
4
2
0
%
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64
quarters

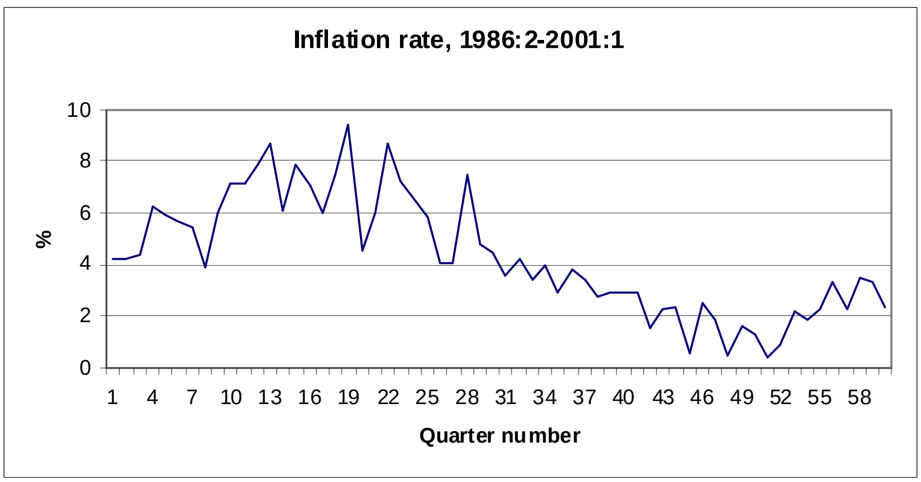
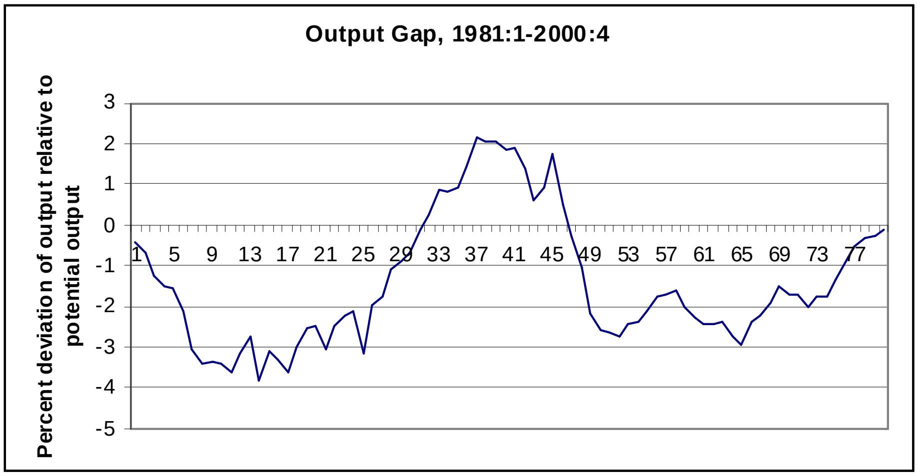
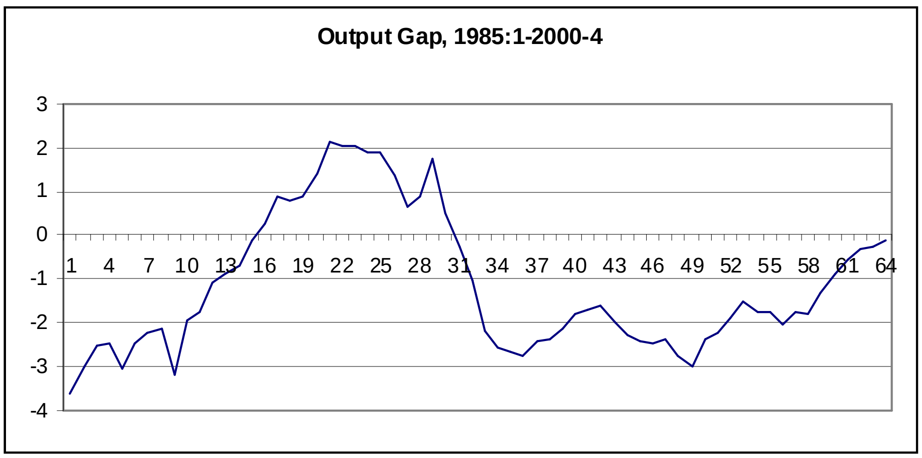

Inflation rate, 1986:2-2001:1
10
8
6
4
2
0
%
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58
Quarter number

Figure 2


Output Gap, 1981:1-2000:4
Percent deviation of output relative to potential output
3
2
1
0
-1
-2
-3
-4
-5
1 5 9 13 17 21 25 29 33 37 41 45 49 53 57 61 65 69 73 77


Output Gap, 1985:1-2000-4
3
2
1
0
-1
-2
-3
-4
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64

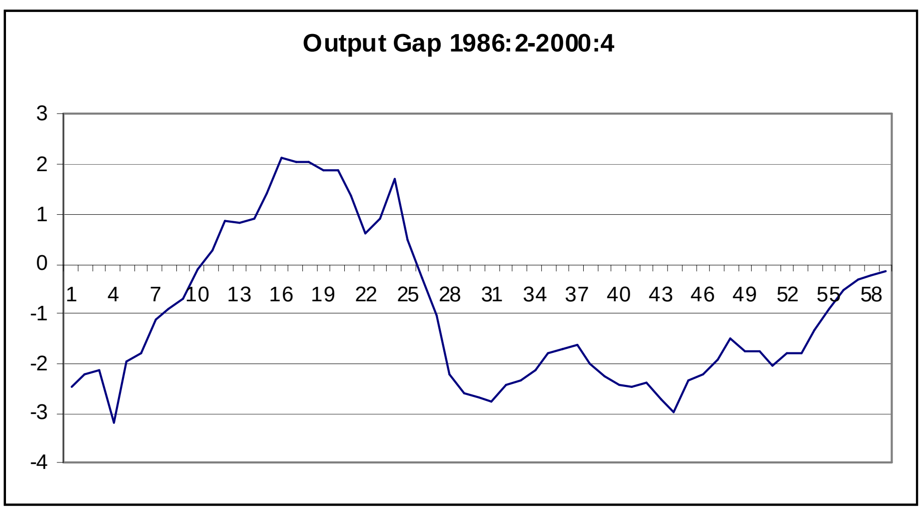
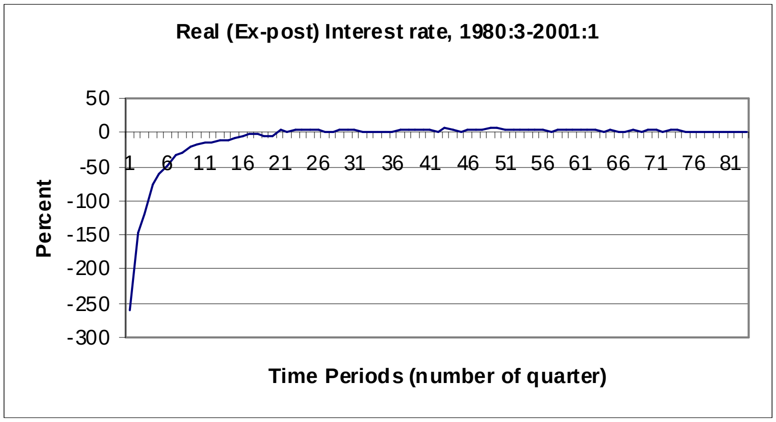
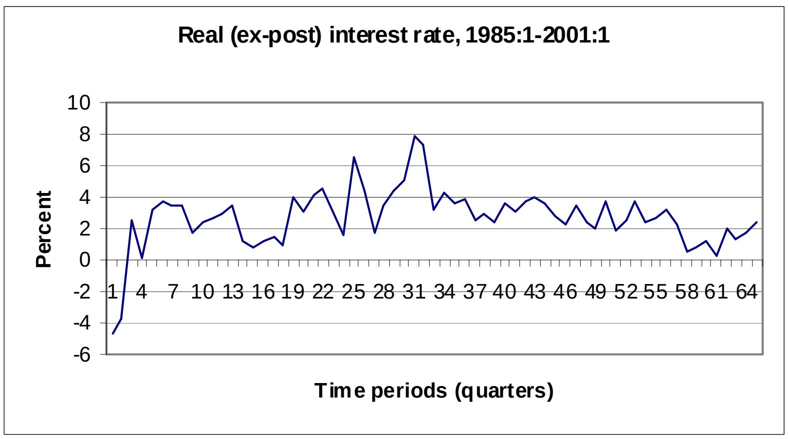

Output Gap 1986:2-2000:4
3
2
1
0
-1
-2
-3
-4
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58

Figure 3


Real (Ex-post) Interest rate, 1980:3-2001:1
Percent
50
0
-50
-100
-150
-200
-250
-300
1 6 11 16 21 26 31 36 41 46 51 56 61 66 71 76 81
Time Periods (number of quarter)


Real (ex-post) interest rate, 1985:1-2001:1
Percent
10
8
6
4
2
0
-2
-4
-6
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64
Time periods (quarters)

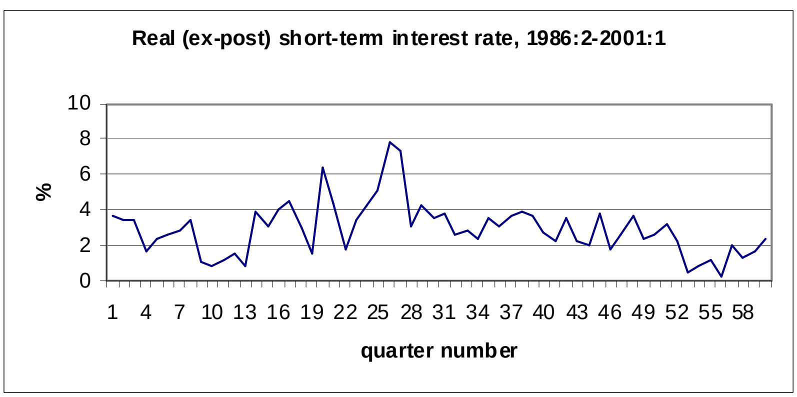
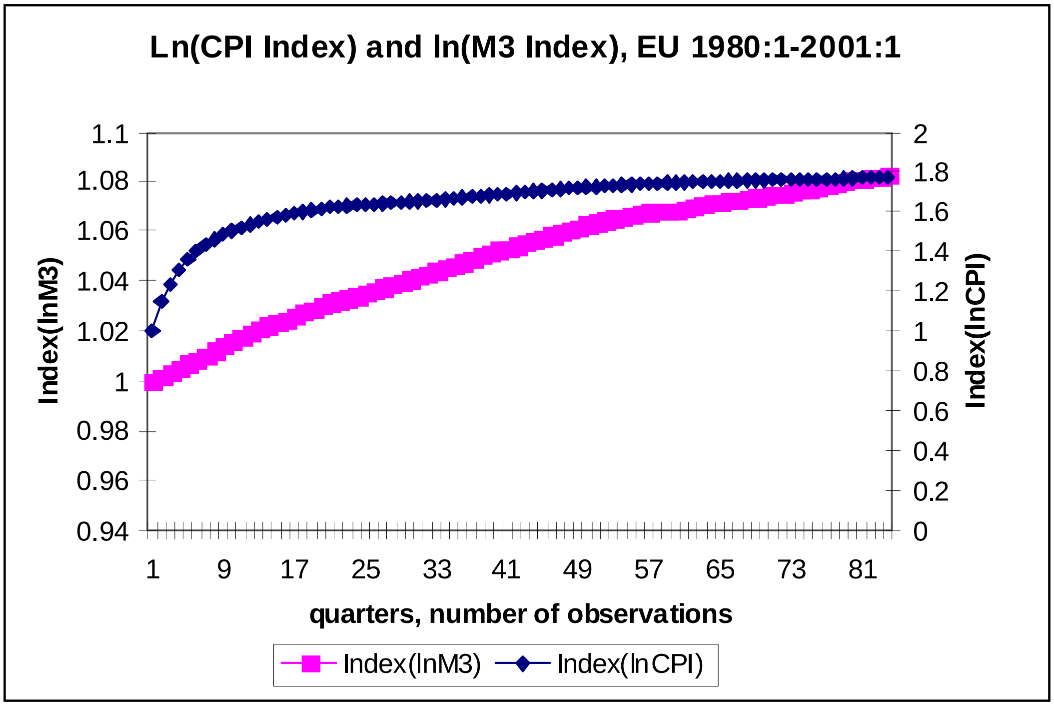
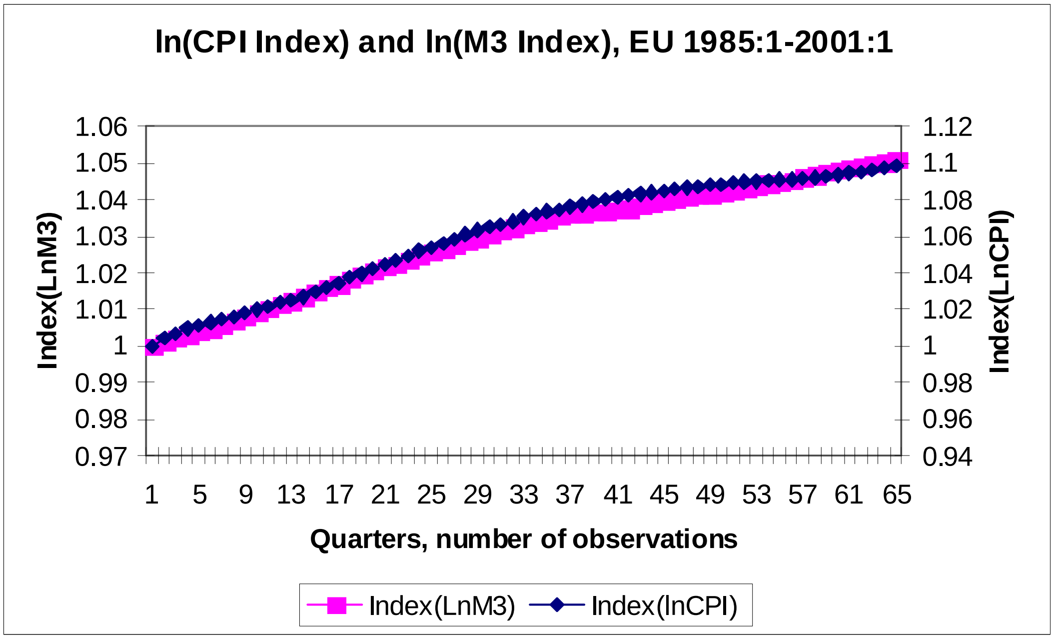

Real (ex-post) short-term interest rate, 1986:2-2001:1
%
10
8
6
4
2
0
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58
quarter number

Figure 4


Ln(CPI Index) and ln(M3 Index), EU 1980:1-2001:1
1.1
1.08
1.06
1.04
1.02
1
0.98
0.96
0.94
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Index(lnM3)
Index(lnCPI)
1 9 17 25 33 41 49 57 65 73 81
quarters, number of observations
Index(lnM3)
Index(lnCPI)


ln(CPI Index) and ln(M3 Index), EU 1985:1-2001:1
1.06
1.05
1.04
1.03
1.02
1.01
1
0.99
0.98
0.97
1.12
1.1
1.08
1.06
1.04
1.02
1
0.98
0.96
0.94
Index(LnM3)
Index(LnCPI)
1 5 9 13 17 21 25 29 33 37 41 45 49 53 57 61 65
Quarters, number of observations
Index(LnM3)
Index(lnCPI)