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Inflation and Uncertainty: Does the EMS Participation Play Any Role?

Nicholas Apergis
University of Macedonia

Abstract

This paper examines whether European Monetary System (EMS) membership has affected the link between inflation and inflation uncertainty. ARCH measures of conditional inflation volatility and Granger-causality tests for nine OECD countries over the period 1980-1994 indicate that in non-EMS countries -in these countries a monetary target seems to have been closely followed- inflation seems to determine the behaviour of inflation uncertainty. By contrast, in EMS countries – these countries have geared their monetary policies to an exchange rate target – inflation seems to have no impact on inflation uncertainty. This finding is probably due first, to the absence of any institutional restriction that characterises non-EMS membership, on the manner the monetary policy is pursued, and second, to the fact that under a monetary rule, any institutional or regulatory changes in the monetary sector are expected to fall more adversely upon inflation as well as inflation uncertainty. (JEL Classification: E31)

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* Correspondence Address: Nicholas Apergis, Department of Economics, University of Macedonia, 156 Egnatia Str., 54006 Thessaloniki, Greece, (Tel) +003-031-891-785, (E-mail) apergis@macedonia.uom.gr; The author is grateful to an anonymous referee of this Journal for his/her substantial comments and suggestions. Of course, the usual disclaimer applies.

I. Introduction

Inflation has been criticised, among other reasons, for creating uncertainty about future inflation. Such uncertainty about inflation, in turn, affects both business decisions and consumer saving decisions, implying that inflation uncertainty tends to have negative effects on economic activity ⟨Ocun [1971]; Friedman [1977]; Golob [1993]⟩.

According to Ball [1990], inflation is due to the propensity of a central bank to accommodate an economic disturbance resulting in high inflation rates. Once the economy experiences such inflation rates, the central bank does not react accordingly because any drastic movements that could cut inflation they might lead the economy into a recessionary phase. Therefore, under high inflationary conditions, the public is uncertain about future inflation, since the public does not know how the monetary authorities will cope with inflation. Sauer and Bohara [1995] have shown that differentiation in the manner that monetary policy is implemented as an anti-inflation tool leads to differences in the behaviour of uncertainty. Empirical attempts in the relevant literature have shown that a positive link exists between inflation and inflation uncertainty across countries ⟨Froyen and Waud [1987]; Ball and Cecchetti [1990]; Evans [1991]; Evans and Wachtel [1993]; Brunner and Hess [1993]⟩. It is crucial for economists and policy makers to know whether inflation causes or not inflation uncertainty in order to incorporate inflation uncertainty to costs associated with inflation. Only a study, however, by Holland [1995], for the case of the US, has shown that inflation contains an information content for inflation uncertainty.

Branson [1981] and Williamson [1985] argued that a fixed exchange rate system, such as the European Monetary System (EMS), lessens uncertainty originated from monetary disturbances. The goal of this study as well as its main contribution is to extent Holland's paper to investigate whether EMS membership has a different impact on the link between inflation and inflation uncertainty. The country sample involves countries that are members of the EMS as well as non-EMS countries. In all countries under examination price stability, at least since 1980, has been widely recognised as the overriding goal of their monetary policy. However, in the former countries the achievement of price stability is to be based on exchange rate targeting, while in the latter on money stock targeting ⟨which under certain conditions a money rule could be unsuccessful, such as in the case of Canada, Racette and Raynauld [1992]⟩. Sauer and Bohara [1995] have argued that the association between inflation and inflation uncertainty differs sharply in cases of a different monetary policy targeting. The rest of the paper is organised as follows. The next section presents the empirical analysis, while section 3 provides some concluding remarks.

II. Empirical Analysis

A. Data

The empirical analysis is carried out using monthly data on prices (*P*) measured by the consumer price index, money supply (*M*) defined as M1, productivity (*PROD*) defined as the ratio of industrial production index to labour, where labour is measured as hours worked, foreign prices (*POECD*) measured by the OECD price index, and wages (*W*) defined as monthly earnings for five EMS countries, namely, Germany, France, Ireland, the UK, Italy, and 4 non-EMS countries, namely, Switzerland, Japan, Canada, and Greece over the period 1980-1994. According to Argy [1982], Japan and Canada geared monetary policy to exchange rate targets only during the 1970's, while since then a monetary rule seems to have been closely followed. Germany, France, Ireland and Italy have been continuously EMS members, while the UK joined the system on October 8, 1990. Data were obtained from the OECD Main Economic Indicators, while both the MicroFit and the R.A.T.S. software assisted with the empirical analysis. Finally, lower case letters indicate variables expressed in logarithms.

B. Error Correction Model and ARCH Estimates

Once prices were found to be cointegrated with foreign prices, wages, productivity, and money balances, it is appropriate to examine the associated error correction (EC) mechanism that describes the short-run dynamics.[1] The EC model is in the following form:

1. Stationarity tests showed that money, prices, foreign prices, productivity, and nomi-

$$\Delta p = a + \sum_{i=1}^{q_1} b_{1i}\Delta p(-i) + \sum_{i=1}^{q_2} b_{2i}\Delta w(-i) + \sum_{i=1}^{q_3} b_{3i}\Delta poecd(-i) + \sum_{i=1}^{q_4} b_{4i}\Delta prod(-i)$$
$$+ \sum_{i=1}^{q_5} b_{5i}\Delta m(-i) + fEC(-1) + \sum_{j=1}^{q} b_{6j}DUM(j) + u$$

where *EC* is the residuals from the cointegrating vector (with *f* being negative) and DUM(*j*) being a set of dummy variables for the *j* country (where applicable). The estimation of the EC model without dummies – defined below – demonstrated the presence of certain structural breaks around specific dates. Therefore, in order to capture the correct statistical framework and, in particular, the impact of certain changes in exchange rates on inflation, certain dummies were included in the EC model.[2] Having estimated the (unconditional) variance of the residuals from the EC processes, next the presence of ARCH effects was formally tested ⟨Engle [1982]⟩. The results indicated the presence of ARCH effects in all ten cases. Maximum-likelihood estimates of inflation uncertainty are reported in Table 1. The sum of the ARCH coefficients is less than one, which implies the stationarity of the h processes.[3]

nal wages are stationary only in their first differences in all cases under examination. In addition, cointegration tests by Johansen and Juselius [1990] showed that a cointegrating relationship among the variables concerned was present in all cases. The results for both the unit root and the cointegration tests are available upon request.

2. For France 6 dummies corresponding to 5 exchange rate realignments (October 1981, June 1982, March 1983, July, 1985, April 1986) and the 1992 EMS crisis were involved. For Ireland 5 dummies corresponding to 4 exchange rate realignments (March 1983, July 1985, August 1986, January 1993) and the 1992 crisis were involved. For the UK 2 dummies corresponding to the EMS participation (October 1990) and the 1992 crisis were involved. For Italy 7 dummies corresponding to 6 exchange rate realignments (March 1981, October 1981, June 1982, March 1983, July 1985, January 1990) and the 1992 crisis were involved. For Germany 1 dummy (*DUM*) with respect to the "unification" event (January 1990) was involved. For Canada 1 dummy (*DUMC*) with respect to the 1984 deregulatory monetary reforms. Finally, for Switzerland, and Greece 1 dummy (*DUMS* and *DUMG*, respectively) with respect to the 1988-1994 period, in which both the Swiss and the Greek monetary system underwent major deregulatory changes, such as reduction in reserve requirements and the introduction of a new payments system.
3. Moreover, unit root tests confirm that the h processes are characterised as I(0) variables.

Table 1
ARCH Estimates (Maximum Likelihood Estimates)

Germany

$$\underset{}{\Delta p} = \underset{(5.43)^*}{0.127}\, \Delta p(-5) + \underset{(10.4)^*}{0.381}\, \Delta poecd(-4) + \underset{(6.13)^*}{0.285}\, \Delta m(-1) + \underset{(5.77)^*}{0.102}\, \Delta m(-5)$$

$$+\underset{(5.03)^*}{0.082}\, \Delta w(-3) - \underset{(-4.52)^*}{0.232}\, EC(-1) + \underset{(3.29)^*}{0.142}\, DUM$$

$$h = \underset{(10.4)^*}{0.000321} + \underset{(4.49)^*}{0.489}\, \varepsilon^2(-1)$$

France

$$\Delta p = \underset{(16.4)^*}{0.523}\, \Delta p(-1) + \underset{(5.92)^*}{0.239}\, \Delta p(-2) + \underset{(2.34)^*}{0.153}\, \Delta m(-1) + \underset{(2.34)^*}{0.352}\, \Delta w(-1)$$

$$- \underset{(-2.74)^*}{0.097}\, \Delta prod(-4) + \underset{(13.6)^*}{0.259}\, \Delta poecd(-1) - \underset{(-2.24)^*}{0.101}\, EC(-1) -$$

$$\underset{(-2.04)^*}{0.0072}\, DUM2 - \underset{(-3.27)^*}{0.0067}\, DUM4 - \underset{(-9.96)^*}{0.002}\, DUM6$$

$$h = \underset{(11.7)^*}{0.000428} + \underset{(4.12)^*}{0.234}\, \varepsilon^2(-1)$$

Ireland

$$\Delta p = \underset{(2.13)^*}{0.371} - \underset{(-2.2)^*}{0.113}\, \Delta p(-1) - \underset{(-2.96)^*}{0.274}\, \Delta p(-2) + \underset{(4.09)^*}{0.43}\, \Delta p(-3) - \underset{(-2.17)^*}{0.171}\, \Delta p(-4)$$

$$+ \underset{(5.79)^*}{0.301}\, \Delta poecd(-2) + \underset{(2.28)^*}{0.164}\, \Delta m(-1) + \underset{(8.78)^*}{0.45}\, \Delta w(-1) - \underset{(-3.28)^*}{0.122}\, EC(-1)$$

$$-\underset{(-8.42)^*}{0.219}\, DUM7 - \underset{(-8.2)^*}{0.069}\, DUM8$$

$$h = \underset{(2.75)^*}{0.0234} + \underset{(14.3)^*}{0.246}\, \varepsilon^2(-1)$$

UK

$$\Delta p = \underset{(16.1)^*}{0.097}\, \Delta p(-3) + \underset{(2.78)^*}{0.10}\, \Delta w(-1) + \underset{(23.0)^*}{0.059}\, \Delta w(-2) + \underset{(22.1)^*}{0.15}\, \Delta m(-1) + \underset{(10.8)^*}{0.088}\, \Delta poecd(-3)$$

$$-\underset{(-13.5)^*}{0.058}\, \Delta prod(-1) - \underset{(-22.8)^*}{0.097}\, EC(-1) - \underset{(-2.51)^*}{0.0018}\, DUM12 - \underset{(-7.58)^*}{0.039}\, DUM13$$

$$h = \underset{(11.2)^*}{0.000426} + \underset{(14.9)^*}{0.214}\, \varepsilon^2(-1)$$

Table 1 (continued)

Italy

$$\Delta p = \underset{(11.6)^*}{0.025} + \underset{(4.80)^*}{0.469}\, \Delta p(-1) + \underset{(2.82)^*}{0.255}\, \Delta p(-2) + \underset{(19.9)^*}{0.312}\, \Delta m(-2) + \underset{(19.4)^*}{0.127}\, \Delta w(-3)$$

$$+ \underset{(2.07)^*}{0.091}\, \Delta poecd(-4) - \underset{(-20.1)^*}{0.249}\, \Delta prod(-1) - \underset{(-19.6)^*}{0.273}\, EC(-1) - \underset{(-2.84)^*}{0.0021}\, DUM14$$

$$-\underset{(-7.38)^*}{0.0043}\, DUM15 - \underset{(-11.6)^*}{0.0075}\, DUM17 - \underset{(-7.97)^*}{0.0065}\, DUM18$$

$$h = \underset{(9.77)^*}{0.000407} + \underset{(27.6)^*}{0.245}\, \varepsilon^2(-1)$$

Switzerland

$$\Delta p = \underset{(7.55)^*}{0.236}\, \Delta p(-1) + \underset{(4.46)^*}{0.568}\, \Delta m(-1) + \underset{(6.03)^*}{0.139}\, \Delta m(-2) + \underset{(5.41)^*}{0.142}\, \Delta poecd(-4)$$

$$+ \underset{(11.5)^*}{0.197}\, \Delta poecd(-5) - \underset{(-5.04)^*}{0.337}\, EC(-1) + \underset{(3.06)^*}{0.128}\, DUMS$$

$$h = \underset{(3.21)^*}{0.000421} + \underset{(3.25)^*}{0.361}\, \varepsilon^2(-1)$$

Japan

$$\Delta p = \underset{(2.33)^*}{0.62}\, \Delta p(-1) + \underset{(7.14)^*}{0.012}\, \Delta poecd(-2) + \underset{(3.63)^*}{0.228}\, \Delta m(-3) + \underset{(8.61)^*}{0.099}\, \Delta w(-2) - \underset{(-3.77)^*}{0.51}\, EC(-1)$$

$$h = \underset{(7.51)^*}{0.001} + \underset{(4.95)^*}{0.33}\, \varepsilon^2(-1)$$

Canada

$$\Delta p = \underset{(2.14)^*}{0.503}\, \Delta p(-2) + \underset{(2.84)^*}{0.015}\, \Delta poecd(-1) + \underset{(3.28)^*}{0.095}\, \Delta m(-1) + \underset{(3.13)^*}{0.041}\, \Delta w(-2)$$

$$- \underset{(-3.34)^*}{0.14}\, \mathrm{EC}(-1) + \underset{(3.94)^*}{0.236}\, DUMC$$

$$h = \underset{(4.78)^*}{0.0031} + \underset{(14.9)^*}{0.205}\, \varepsilon^2(-1)$$

Greece

$$\Delta p = \underset{(2.65)^*}{0.31}\, \Delta p(-2) + \underset{(7.44)^*}{0.026}\, \Delta poecd(-1) + \underset{(6.53)^*}{0.242}\, \Delta m(-1) + \underset{(2.21)^*}{0.336}\, \Delta m(-2) - \underset{(-4.28)^*}{0.066}\, EC(-1)$$

$$+ \underset{(3.14)^*}{0.233}\, DUMG$$

$$h = \underset{(7.39)^*}{0.0003} + \underset{(3.28)^*}{0.333}\, \varepsilon^2(-1)$$

Notes: * significant at 5%

D. Short-Run (Granger) Causality Tests

In this step of the empirical analysis, the Granger causality approach will examine whether lagged values of inflation help to explain the current value of conditional inflation uncertainty over and above the explanation provided by lagged values of inflation itself ⟨Holland [1995]⟩.[4] The Granger methodology involves testing jointly for the significance of the lags of the relevant explanatory variable. The fitted values of the ARCH estimates (h) and their corresponding inflation rates (Δp) are employed to test whether inflation Granger causes inflation uncertainty if, in the equation of h, the null hypothesis of zero lagged coefficients of Δp is rejected, while in the equation of Δp the null hypothesis of zero lagged coefficients of h is not rejected. Likelihood-ratio (LR) tests, proposed by Sims [1980], determined the optimal lag length for each Vector Autoregressive (VAR) model. Table 2 reports the significance levels of the F-statistic in three VAR systems with three alternative measures of lag lengths.

The results indicate that in the cases of Germany, France, Ireland, and Italy low F-test significance implies the lack of causality from inflation to inflation uncertainty. Lagged values of inflation do not have a significant effect on inflation uncertainty. In addition, the sum of the coefficients turns out to be positive, but insignificant. By contrast, in the cases of the UK (a current EMS country), Switzerland, Japan, Canada, and Greece unidirectional causality running from inflation to inflation uncertainty is detected. In addition, the sum of the coefficients of inflation, in the h equation, turns out to be positive and statistically significant. Moreover, in all cases, causality running from inflation uncertainty to inflation is not detected since the sum of lagged values of inflation uncertainty generates insignificant F-values. The sum of the coefficients remains positive, but statistically insignificant.

Since the theory of causality relies on the relevance of all past information, it is appropriate to check for the robustness of the results over alternative lag structures. The tests were performed for 2, 3, 4 and 8 lags. No difference in the results was detected. In addition, in order to check the

4. The analysis considers only short-run causality, since no cointegration between the two variables was detected. Causality is performed in the levels, even that both variables are I(0) ⟨Christiano and Ljungqvist [1988]⟩.

Table 2
Short-Run Dynamics (Granger-Causality Tests)

Dependent Variable	Tested Restrictions	F-Tests	p-values
Germany			
(Lags = 6)			
h	$\Delta p \nrightarrow h$	1.07	0.20
$R^2 = 0.20$ SEE = 0.000063	LM = 1.02[0.28]		
SUM(Δp) = 0.0131	t-statistic = 1.05[0.29]		
Δp	$h \nrightarrow \Delta \mathrm{p}$	1.23	0.29
$R^2 = 0.54$ SEE = 0.000036	LM = 4.55[0.97]		
SUM(h) = 0.264	t-statistic = 2.87[0.004]		
(Lags = 8)			
h	$\Delta p \nrightarrow h$	0.35	0.74
$R^2 = 0.24$ SEE = 0.000018	LM = 1.61[0.10]		
SUM(Δp) = 0.00907	t-statistic = 0.66[0.51]		
Δp	$h \nrightarrow \Delta p$	1.71	0.11
$R^2 = 0.11$ SEE = 0.0028	LM = 7.74[0.81]		
SUM(h) = 0.0803	t-statistic = 2.35[0.02]		
(Lags = 4)			
h	$\Delta p \nrightarrow h$	1.63	0.20
$R^2 = 0.18$ SEE = 0.000017	LM = 0.74[0.71]		
SUM(Δp) = 0.00849	t-statistic = 0.79[0.43]		
Δp	$h \nrightarrow \Delta p$	2.06	0.10
$R^2 = 0.50$ SEE = 0.0027	LM = 1.74[0.64]		
SUM(h) = 0.0613	t-statistic = 3.43[0.00]		
France			
(Lags = 5)			
h	$\Delta p \nrightarrow h$	1.78	0.295
$R^2 = 0.22$ SEE = 0.000042	LM = 2.03[0.87]		
SUM(Δp) = 0.0031	t-statistic = 1.19[0.23]		
Δp	$h \nrightarrow \Delta p$	0.85	0.55
$R^2 = 0.67$ SEE = 0.000024	LM = 1.98[0.92]		
SUM(h) = 0.0534	t-statistic = 3.45[0.00]		
(Lags = 8)			
h	$\Delta p \nrightarrow h$	1.23	0.32
$R^2 = 0.30$ SEE = 0.000016	LM = 18.3[0.11]		
SUM(Δp) = 0.019	t-statistic = 1.19[0.23]		

Table 2 (continued)

Dependent Variable	Tested Restrictions	F-Tests	p-values
Δp	$h \nrightarrow \Delta p$	0.61	0.64
$R^2 = 0.21$ SEE = 0.0019	LM = 17.9[0.12]		
SUM(h) = 0.0758	t-statistic = 2.38[0.02]		
(Lags = 3)			
h	$\Delta p \nrightarrow h$	2.15	0.18
$R^2 = 0.23$ SEE = 0.000017	LM = 1.25[0.59]		
SUM(Δp) = 0.022	t-statistic = 1.73[0.08]		
Δp	$h \nrightarrow \Delta p$	1.56	0.37
$R^2 = 0.19$ SEE = 0.000019	LM = 15.8[0.20]		
SUM(h) = 0.0777	t-statistic = 4.36[0.00]		
Ireland			
(Lags = 6)			
h	$\Delta p \nrightarrow h$	0.88	0.56
$R^2 = 0.29$ SEE = 0.000058	LM = 0.89[0.99]		
SUM(Δp) = 0.0039	t-statistic = 0.81[0.42]		
Δp	$h \nrightarrow \Delta p$	0.38	0.95
$R^2 = 0.99$ SEE = 0.000006	LM = 2.33[0.65]		
SUM(h) = 0.0793	t-statistic = 2.66[0.008]		
(Lags = 8)			
h	$\Delta p \nrightarrow h$	1.48	0.47
$R^2 = 0.40$ SEE = 0.000006	LM = 18.9[0.06]		
SUM(Δp) = 0.0029	t-statistic = 0.56[0.58]		
Δp	$h \nrightarrow \Delta p$	0.49	0.89
$R^2 = 0.60$ SEE = 0.000031	LM = 2.79[0.85]		
SUM(h) = 0.0991	t-statistic = 3.20[0.001]		
(Lags = 4)			
h	$\Delta p \nrightarrow h$	2.30	0.21
$R^2 = 0.31$ SEE = 0.000061	LM = 17.8[0.12]		
SUM(Δp) = 0.0038	t-statistic = 0.96[0.34]		
Δp	$h \nrightarrow \Delta p$	1.91	0.33
$R^2 = 0.48$ SEE = 0.000034	LM = 3.80[0.73]		
SUM(h) = 0.118	t-statistic = 4.34[0.00]		

Table 2 (continued)

Dependent Variable	Tested Restrictions	F-Tests	p-values
UK			
(Lags = 5)			
h	$\Delta p \rightarrow h$	2.48*	0.02
$R^2 = 0.37$ SEE = 0.000066	LM = 4.34[0.72]		
SUM(Δp) = 0.012	t-statistic = 6.26[0.00]		
Δp	$h \nrightarrow \Delta p$	0.93	0.50
$R^2 = 0.23$ SEE = 0.000149	LM = 5.31[0.62]		
SUM(h) = 0.0069	t-statistic = 1.04[0.22]		
(Lags = 8)			
h	$\Delta p \rightarrow h$	7.78*	0.00
$R^2 = 0.26$ SEE = 0.000012	LM = 18.8[0.06]		
SUM(Δp) = 0.0322	t-statistic = 4.43[0.00]		
Δp	$h \nrightarrow \Delta p$	1.24	0.26
$R^2 = 0.26$ SEE = 0.0048	LM = 5.29[0.64]		
SUM(h) = 0.0564	t-statistic = 1.64[0.10]		
(Lags = 3)			
h	$\Delta p \rightarrow h$	17.04*	0.00
$R^2 = 0.22$ SEE = 0.000013	LM = 3.87[0.79]		
SUM(Δp) = 0.0242	t-statistic = 5.17[0.00]		
Δp	$h \nrightarrow \Delta p$	1.18	0.31
$R^2 = 0.15$ SEE = 0.000048	LM = 5.85[0.59]		
SUM(h) = 0.0047	t-statistic = 1.01[0.39]		
Italy			
(Lags = 7)			
h	$\Delta p \nrightarrow h$	0.58	0.81
$R^2 = 0.95$ SEE = 0.000022	LM = 1.69[0.94]		
SUM((p) = 0.00611	t-statistic = 0.87[0.41]		
Δp	$h \nrightarrow \Delta p$	1.19	0.31
$R^2 = 0.64$ SEE = 0.000027	LM = 1.02[0.99]		
SUM(h) = 0.0815	t-statistic = 1.17[0.24]		
(Lags = 8)			
h	$\Delta p \nrightarrow h$	1.13	0.40
$R^2 = 0.92$ SEE = 0.000027	LM = 2.86[0.87]		
SUM(Δp) = 0.00554	t-statistic = 1.30[0.20]		

Table 2 (continued)

Dependent Variable	Tested Restrictions	F-Tests	p-values
Δp	$h \nrightarrow \Delta p$	0.85	0.61
$R^2 = 0.39$ SEE = 0.000074	LM = 16.6[0.17]		
SUM(h) = 0.0943	t-statistic = 0.57[0.57]		
(Lags = 4)			
h	$\Delta p \nrightarrow h$	1.23	0.34
$R^2 = 0.90$ SEE = 0.000029	LM = 2.63[0.90]		
SUM(Δp) = 0.00757	t-statistic = 1.18[0.28]		
Δp	$h \nrightarrow \Delta p$	1.42	0.28
$R^2 = 0.31$ SEE = 0.00074	LM = 13.1[0.36]		
SUM(h) = 0.0567	t-statistic = 1.38[0.17]		
Switzerland			
(Lags = 5)			
h	$\Delta p \rightarrow h$	3.17*	0.01
$R^2 = 0.81$ SEE = 0.000034	LM = 2.95[0.23]		
SUM(Δp) = 0.0565	t-statistic = 4.16[0.00]		
Δp	$h \nrightarrow \Delta p$	0.32	0.87
$R^2 = 0.78$ SEE = 0.000044	LM = 2.88[0.29]		
SUM(h) = 0.0094	t-statistic = 1.21[0.24]		
(Lags = 8)			
h	$\Delta p \rightarrow h$	18.85*	0.00
$R^2 = 0.62$ SEE = 0.000044	LM = 3.25[0.10]		
SUM(Δp) = 0.0024	t-statistic = 4.59[0.00]		
Δp	$h \nrightarrow \Delta p$	1.58	0.14
$R^2 = 0.15$ SEE = 0.000033	LM = 3.60[0.09]		
SUM(h) = 0.0946	t-statistic = 1.47[0.14]		
(Lags = 3)			
h	$\Delta p \rightarrow h$	16.84*	0.00
$R^2 = 0.38$ SEE = 0.000047	LM = 3.71[0.08]		
SUM(Δp) = 0.057	t-statistic = 2.94[0.01]		
Δp	$h \nrightarrow \Delta p$	0.41	0.93
$R^2 = 0.29$ SEE = 0.00033	LM = 2.99[0.24]		
SUM(h) = 0.0783	t-statistic = 0.95[0.58]		

Table 2 (continued)

Dependent Variable	Tested Restrictions	F-Tests	p-values
Japan			
(Lags = 4)			
h	$\Delta p \rightarrow h$	9.17*	0.00
$R^2 = 0.41$ SEE = 0.000005	LM = 1.16[0.49]		
SUM(Δp) = 0.0078	t-statistic = 3.03[0.00]		
Δp	$h \nrightarrow \Delta p$	0.009	0.92
$R^2 = 0.34$ SEE = 0.003087	LM = 2.14[0.29]		
SUM(h) = 0.0948	t-statistic = 0.09[0.92]		
(Lags = 8)			
h	$\Delta p \rightarrow h$	21.96*	0.00
$R^2 = 0.53$ SEE = 0.000005	LM = 0.27[0.81]		
SUM(Δp) = 0.0104	t-statistic = 2.68[0.00]		
Δp	$h \nrightarrow \Delta p$	0.63	0.43
$R^2 = 0.39$ SEE = 0.002982	LM = 1.67[0.59]		
SUM(h) = 0.0231	t-statistic = 1.18[0.24]		
(Lags = 2)			
h	$\Delta p \rightarrow h$	12.37*	0.00
$R^2 = 0.83$ SEE = 0.000004	LM = 2.55[0.10]		
SUM(Δp) = 0.059	t-statistic = 3.36[0.00]		
Δp	$h \nrightarrow \Delta p$	0.09	0.76
$R^2 = 0.37$ SEE = 0.003062	LM = 1.85[0.42]		
SUM(h) = 0.0245	t-statistic = 0.31[0.71]		
Canada			
(Lags = 5)			
h	$\Delta p \rightarrow h$	5.05*	0.00
$R^2 = 0.48$ SEE = 0.000006	LM = 0.95[0.79]		
SUM(Δp) = 0.0771	t-statistic = 2.22[0.03]		
Δp	$h \nrightarrow \Delta p$	1.19	0.28
$R^2 = 0.62$ SEE = 0.002793	LM = 1.06[0.47]		
SUM(h) = 0.0113	t-statistic = 1.49[0.14]		
(Lags = 8)			
h	$\Delta p \rightarrow h$	20.81*	0.00
$R^2 = 0.31$ SEE = 0.000007	LM = 1.00[0.49]		
SUM(Δp) = 0.0623	t-statistic = 3.56[0.00]		

Table 2 (continued)

Dependent Variable	Tested Restrictions	F-Tests	p-values
Δp	$h \nrightarrow \Delta p$	1.54	0.22
$R^2 = 0.28$ SEE = 0.002769	LM = 0.89[0.73]		
SUM(h) = 0.0022	t-statistic = 1.02[0.27]		
(Lags = 2)			
h	$\Delta p \rightarrow h$	9.06*	0.00
$R^2 = 0.26$ SEE = 0.000006	LM = 0.96[0.55]		
SUM(Δp) = 0.079	t-statistic = 3.01[0.00]		
Δp	$h \nrightarrow \Delta p$	0.53	0.47
$R^2 = 0.61$ SEE = 0.00283	LM = 1.11[0.42]		
SUM(h) = 0.0356	t-statistic = 0.73[0.46]		
Greece			
(Lags = 5)			
h	$\Delta p \rightarrow h$	11.8*	0.00
$R^2 = 0.63$ SEE = 0.000067	LM = 0.89[0.61]		
SUM(Δp) = 0.1103	t-statistic = 3.75[0.00]		
Δp	$h \nrightarrow \Delta p$	0.24	0.63
$R^2 = 0.44$ SEE = 0.010896	LM = 1.28[0.37]		
SUM(h) = 0.0017	t-statistic = 1.25[0.21]		
(Lags = 8)			
h	$\Delta p \rightarrow h$	26.71*	0.00
$R^2 = 0.31$ SEE = 0.000067	LM = 0.74[0.69]		
SUM(Δp) = 0.2651	t-statistic = 5.46[0.00]		
Δp	$h \nrightarrow \Delta p$	0.93	0.38
$R^2 = 0.58$ SEE = 0.009632	LM = 1.05[0.44]		
SUM(h) = 0.0012	t-statistic = 1.09[0.33]		
(Lags = 2)			
h	$\Delta p \rightarrow h$	10.05*	0.00
$R^2 = 0.65$ SEE = 0.000071	LM = 2.02[0.14]		
SUM(Δp) = 0.025	t-statistic = 4.11[0.00]		
Δp	$h \nrightarrow \Delta p$	0.20	0.98
$R^2 = 0.21$ SEE = 0.01253	LM = 1.83[0.25]		
SUM(h) = 0.09102	t-statistic = 0.45[0.77]		

Notes: The symbol denotes that the independent variable does not Granger-cause the dependent variable. Numbers in brackets denote p-values. LM denotes a Lagrance-Multiplier test for serial correlation. SUM(x) denotes the summation of the x lagged coefficients and their corresponding t-value.

* significant at 5%

robustness of the finding that inflation uncertainty does not cause inflation, ARCH-M models were estimated where lagged conditional variance terms (h) have been explicitly included in the inflation equation.[5] The results are shown in Table 3. In all nine cases examined, lagged *h* terms appear to be statistically insignificant, implying the empirical findings found in Table 2 about the impotency of inflation uncertainty to cause inflation.

The unidirectional causality running from inflation to inflation uncertainty observed only in the cases of the UK, Switzerland, Japan, Canada, and Greece implies that greater uncertainty is part of inflation costs ⟨Holland [1995]⟩ only in these countries. The fact that the UK joined the system in 1990 does not expiate the case from the results that hold for non-EMS countries.

Why do the causality results differ between EMS and non-EMS countries? Regrettably, no a satisfactory explanation could be given at this point, apart from that agents in these countries feel anxious that monetary policy activities are expected to create higher inflation and, thus, lower unemployment, implying higher inflation uncertainty. It is commonly accepted that non-EMS countries are not restricted to pursue a monetary policy tightly associated with an exchange rate target. Therefore, in case, say, of an adverse economic shock, monetary activities are expected to lead to more frequent monetary surprises to support output levels and, thus, to create higher uncertainty about the future path of inflation. Racette and Raynauld [1992] and Serletis and King [1993] have also argued that monetary targeting in Canada appears to be problematic due to the failure of the reserve requirements system.

Moreover, as a referee raised this issue, despite the fact that central banks in Germany as well as in Switzerland are counted among the most independent in the industrialised world, the fact is that the two central banks operate through different monetary policy targeting. Therefore, any institutional changes, as the deregulatory changes undergone both by the Swiss and the Greek central banks, are expected to contribute to higher

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5. The optimal number of lags in the new EC equations was determined through the Akaike FPE criterion. Alternative functional forms, such as square root forms, for the h terms were also attempted. The analysis provided similar results.

Table 3
Robustness tests (ARCH-M models)

Germany

$$\Delta p = \underset{(2.44)^*}{0.231}\,\Delta p(-5) + \underset{(7.39)^*}{0.011}\,\Delta poecd(-4) + \underset{(6.06)^*}{0.134}\,\Delta m(-1) + \underset{(8.61)^*}{0.153}\,\Delta m(-5)$$

$$\underset{(3.96)^*}{0.063}\,\Delta w(-3) - \underset{(-3.45)^*}{0.214}\,EC(-1) + \underset{(2.81)^*}{0.206}\,DUM + \underset{(0.13)}{0.386}\,h(-1) + \underset{(0.12)}{0.147}\,h(-2)$$

$$+\underset{(0.12)}{0.277}\,h(-3) + \underset{(0.23)}{0.086}\,h(-4) + \underset{(1.01)}{0.107}\,h(-5) + \underset{(0.45)}{0.017}\,h(-6)$$

$$h = \underset{(9.79)^*}{0.000011} + \underset{(3.21)^*}{0.333}\,\Delta 2(-1)$$

France

$$\Delta p = \underset{(16.5)^*}{0.188}\,\Delta p(-1) + \underset{(8.52)^*}{0.105}\,\Delta p(-2) + \underset{(2.95)^*}{0.365}\,\Delta m(-1) + \underset{(3.01)^*}{0.096}\,\Delta w(-1)$$

$$-\underset{(-3.24)^*}{0.164}\,\Delta prod(-4) + \underset{(11.3)^*}{0.364}\,\Delta poecd(-1) - \underset{(-2.31)^*}{0.080}\,EC(-1)$$

$$-\underset{(-3.12)^*}{0.0081}\,DUM2 - \underset{(-2.79)^*}{0.0102}\,DUM4 - \underset{(-4.43)^*}{0.013}\,DUM6 + \underset{(1.14)}{0.26}\,h(-1)$$

$$+\underset{(1.31)}{0.219}\,h(-2) + \underset{(0.46)}{0.059}\,h(-3) - \underset{(-0.35)}{0.35}\,h(-4) + \underset{(0.48)}{0.125}\,h(-5)$$

$$h = \underset{(6.98)^*}{0.000025} + \underset{(3.23)^*}{0.165}\,\varepsilon^2(-1)$$

Ireland

$$\Delta p = \underset{(2.65)^*}{0.223} - \underset{(-7.39)^*}{0.095}\,\Delta p(-1) - \underset{(-2.12)^*}{0.209}\,\Delta p(-2) + \underset{(3.43)^*}{0.164}\,\Delta p(-3) - \underset{(-3.98)^*}{0.163}\,\Delta p(-4)$$

$$+\underset{(5.54)^*}{0.214}\,\Delta poecd(-2) + \underset{(2.53)^*}{0.103}\,\Delta m(-1) + \underset{(3.25)^*}{0.321}\,\Delta w(-1) - \underset{(-2.85)^*}{0.134}\,EC(-1)$$

$$-\underset{(-2.62)^*}{0.114}\,DUM7 - \underset{(-2.34)^*}{0.105}\,DUM8 + \underset{(0.007)}{0.167}\,h(-1) + \underset{(0.53)}{0.133}\,h(-2) + \underset{(0.40)}{0.101}\,h(-3)$$

$$+\underset{(0.37)}{0.094}\,h(-4) + \underset{(1.19)}{0.1}\,h(-5) + \underset{(0.34)}{0.085}\,h(-6)$$

$$h = \underset{(3.55)^*}{0.0299} + \underset{(16.9)^*}{0.351}\,\varepsilon^2(-1)$$

Table 3 (continued)

UK

$$\Delta p = \underset{(3.27)^*}{0.289\,\Delta p(-3)} + \underset{(2.69)^*}{0.06\,\Delta w(-1)} + \underset{(6.29)^*}{0.177\,\Delta w(-2)} + \underset{(3.43)^*}{0.01\,\Delta m(-1)} + \underset{(17.6)^*}{0.014\,\Delta poecd(-3)}$$

$$- \underset{(-13.4)^*}{0.086\,\Delta prod(-1)} - \underset{(-4.84)^*}{0.047\,EC(-1)} - \underset{(-2.98)^*}{0.0066\,DUM12} - \underset{(-3.67)^*}{0.102\,DUM13} + \underset{(0.83)}{0.077\,h(-1)}$$

$$+ \underset{(1.27)}{0.226\,h(-2)} - \underset{(-0.09)}{0.01\,h(-3)} - \underset{(-1.05)}{0.117\,h(-4)}$$

$$h = \underset{(3.35)^*}{0.000071} + \underset{(3.78)^*}{0.154\,\varepsilon^2(-1)}$$

Italy

$$\Delta p = \underset{(2.77)^*}{0.132} + \underset{(2.25)^*}{0.127\,\Delta p(-1)} + \underset{(2.33)^*}{0.117\,\Delta p(-2)} + \underset{(3.49)^*}{0.085\,\Delta m(-2)} + \underset{(4.01)^*}{0.259\,\Delta w(-3)}$$

$$+ \underset{(3.06)^*}{0.079\,\Delta poecd(-4)} - \underset{(-21.6)^*}{0.057\,\Delta pr(-1)} - \underset{(-7.94)^*}{0.369\,EC(-1)} - \underset{(-3.41)^*}{0.0109\,DUM14}$$

$$- \underset{(-4.05)^*}{0.0085\,DUM15} - \underset{(-3.26)^*}{0.0036\,DUM17} - \underset{(-3.81)^*}{0.0061\,DUM18} - \underset{(0.09)}{0.234\,h(-1)}$$

$$+ \underset{(0.16)}{0.101\,h(-2)} + \underset{(0.14)}{0.358\,h(-3)} + \underset{(0.15)}{0.104\,h(-4)} - \underset{(-0.03)}{0.088\,h(-5)} + \underset{(0.17)}{0.155\,h(-6)}$$

$$+ \underset{(0.18)}{0.126\,h(-7)}$$

$$h = \underset{(9.01)^*}{0.000023} + \underset{(17.1)^*}{0.093\,\varepsilon^2(-1)}$$

Switzerland

$$\Delta p = \underset{(2.51)^*}{0.164\,\Delta p(-1)} + \underset{(3.01)^*}{0.119\,\Delta m(-1)} + \underset{(2.53)^*}{0.339\,\Delta m(-2)} + \underset{(2.39)^*}{0.152\,\Delta poecd(-4)}$$

$$+ \underset{(4.23)^*}{0.088\,\Delta poecd(-5)} - \underset{(-5.71)^*}{0.277\,EC(-1)} + \underset{(2.74)^*}{0.096\,DUMS} + \underset{(0.085)}{0.433\,h(-1)}$$

$$+ \underset{(0.86)}{0.054\,h(-2)} - \underset{(-0.083)}{0.105\,h(-3)} - \underset{(-0.32)}{0.126\,h(-4)} + \underset{(0.093)}{0.486\,h(-5)}$$

$$h = \underset{(7.66)^*}{0.000092} + \underset{(2.85)^*}{0.531\,\varepsilon^2(-1)}$$

Table 3 (continued)

Japan

$$\Delta p = \underset{(2.96)^*}{0.36}\,\Delta p(-1) + \underset{(6.02)^*}{0.011}\,\Delta poecd(-2) + \underset{(2.37)^*}{0.057}\,\Delta m(-3) + \underset{(4.33)^*}{0.021}\,\Delta w(-2) - \underset{(-3.33)^*}{0.475}\,EC(-1)$$

$$+ \underset{(0.19)}{0.114}\,h(-1) + \underset{(0.54)}{0.03}\,h(-2) + \underset{(0.31)}{0.157}\,h(-3) + \underset{(0.74)}{0.488}\,h(-4)$$

$$h = \underset{(7.74)^*}{0.00086} + \underset{(4.36)^*}{0.125}\,\varepsilon^2(-1)$$

Canada

$$\Delta p = \underset{(2.71)^*}{0.661}\,\Delta p(-2) + \underset{(2.91)^*}{0.047}\,\Delta poecd(-1) + \underset{(3.11)^*}{0.073}\,\Delta m(-1) + \underset{(7.33)^*}{0.151}\,\Delta w(-2) - \underset{(-4.50)^*}{0.15}\,EC(-1)$$

$$+ \underset{(2.75)^*}{0.239}\,DUMC + \underset{(0.12)}{0.087}\,h(-1) + \underset{(0.71)}{0.456}\,h(-2) + \underset{(0.05)}{0.361}\,h(-3) + \underset{(0.04)}{0.036}\,h(-4)$$

$$h = \underset{(2.56)^*}{0.000308} + \underset{(4.21)^*}{0.263}\,\varepsilon^2(-1)$$

Greece

$$\Delta p = \underset{(2.88)^*}{0.27}\,\Delta p(-2) + \underset{(8.31)^*}{0.026}\,\Delta poecd(-1) + \underset{(3.99)^*}{0.081}\,\Delta m(-1) + \underset{(3.60)^*}{0.092}\,\Delta m(-2)$$

$$- \underset{(-2.93)^*}{0.229}\,EC(-1) + \underset{(2.19)^*}{0.181}\,DUMG + \underset{(1.25)}{0.321}\,h(-1) + \underset{(0.52)}{0.251}\,h(-2) + \underset{(0.05)}{0.069}\,h(-3)$$

$$h = \underset{(7.13)^*}{0.00012} + \underset{(8.33)^*}{0.453}\,\varepsilon^2(-1)$$

Notes: The number of lags for the h terms was determined through the Akaike FPE criterion.

* significant at 5%

uncertainty once the public is not supposed to be completely aware about the impact of those changes on the monetary stock, and, thus, on inflation and inflation uncertainty ⟨Wasserfallen and Kursteiner [1994] and Dueker and Fisher [1996] for the case of Switzerland; Apergis *et al.* [1997] and Apergis [1997] for the case of Greece⟩. Amoako-Adu and Smith [1995] argued that certain deregulatory activities in Canada are expected to lead to higher uncertainty in the financial sector. This could lead to a lessen monetary control and therefore to higher inflation and inflation uncertainty. Finally, for the case of Japan, Hutchison and Judd [1992] argue that the information -relative to the maintenance of the monetary rule-provided by the central bank has been virtually ineffective in reducing money surprises. This limited capability by the Japanese monetary authorities to control money surprises could have contributed to higher inflation uncertainty and preventing individuals and firms from reaching the appropriate economic decisions in terms of efficiency.

III. Concluding Remarks

This study has attempted to examine the link between inflation and inflation uncertainty in five EMS countries and five non-EMS country over the period 1980 to 1994. The empirical findings indicated that for Germany, France, Ireland, and Italy, the EMS country sub-sample, inflation does not seem to determine the behaviour of inflation uncertainty, while this is not the case for the UK, Switzerland, Japan, Canada, and Greece, the non-EMS country sub-sample.

A possible explanation for the reported differentiation in the empirical findings is that for EMS countries inflation rates do not seem to contribute to inflation uncertainty because the public is not so uncertain about the course of future monetary policy, since the monetary authorities are expected to remain closely to the maintenance of an exchange rate target, i.e., thus, gaining higher credibility. This is not, however, the case for the non-EMS countries. In these cases the public feels that the central bank will not bear the cost of bringing the inflation down by creating recessionary conditions. The presence of recessionary conditions could tempt policy makers to use the exchange rate in the wrong way, for example, by depreciating the domestic currency, an action expected to aggravate domestic inflationary conditions.

A different route of investigation could also attempt to identify whether the different behaviour of inflation uncertainty seems to depend not only on monetary but also on nonmonetary factors, such as uncertainty about real shocks. This route however goes beyond the scopes of this study.

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