Monograph:
Arestis, Philip, Karoglou, Michail and Mouratidis, Kostas (2011) Monetary Policy Preferences of the European Monetary Union and the UK. Working Paper. Department of Economics, University of Sheffield ISSN 1749-8368

Sheffield Economic Research Paper Series 2011019

Sheffield Economic Research Paper Series

SERP Number: 2011019

ISSN 1749-8368

Philip Arestis
Michail Karoglou
Kostas Mouratidis

Monetary Policy Preferences of the European Monetary Union and the UK

September 2011

Department of Economics
University of Sheffield
9 Mappin Street
Sheffield
S1 4DT
United Kingdom
www.shef.ac.uk/economics

Monetary Policy Preferences of the European Monetary Union and the UK

Arestis, P.,
Cambridge Centre for
Economic and Public Policy,
Department of Land Economy,
University of Cambridge,
and Department of Applied Economics V,
University of the Basque Country.

Karoglou, M.,
Department of Economics
Aston University

Mouratidis, K.
Department of Economics
University of Sheffield

Abstract

This paper estimates central bank policy preferences in the case of the European Monetary Union and of the UK. We do so, by adopting the framework suggested by Cecchetti and Ehrmann (1999), which, however, we extent in two respects. First, we allow policy preferences to be asymmetric by assuming that inflation and output follow a Markov process. Second, following Bean (1998) we introduce dynamics in the supply and demand relationships. In doing so we estimate state-dependent policy frontiers. Empirical results from the static model show that monetary policy in the European Monetary Union and in the UK put a lot of weight on price stability. However, there is evidence of 'price puzzle' especially in the high volatility regime. The price puzzle might be the by-product of frequent realingments in the European Monetary System currency crises in 1992, 1993 and 1995 and of the more recent 2008 financial crisis. Estimates of the optimal policy frontier suggest that although the UK enjoys higher anti-inflationary credibility, it also faces a higher trade-off between inflation and output variability than the European Monetary Union.

1 Introduction

The primary objective of the European Central Bank (ECB), stated in Article 2 of its statute, is to maintain price stability (see, also, Article 3 of the Maastricht Treaty). Svensson (2001) argues that defining price stability boils down to establishing a monetary-policy loss function. Svensson (op. cit.) also argues that maintaining price stability involves minimizing the policy maker's loss function.[1] While it is easy to show that under a quadratic loss function and linear dynamic of the economic state variables, the optimal interest rate rule is a linear function of inflation and output gap, the estimated coefficients are a convolution of the parameters describing policy preferences and the underlying economic structure. Hence, the estimated policy rule is a reduced-form model, which cannot be used to address questions concerning policy evaluation. However, policy evaluation based on the observed outcomes might not reflect only policy preferences. More concretely, changes of monetary policy rule might be driven by changes of policy targets and/or changes of external shocks.

Although there is a large number of studies, which analyse the great moderation in the US, the focus of this literature was mainly the question of whether the greater stability observed in the 1990s was the outcome of an aggressive anti-inflationary policy or the lack of supply shocks. Only few authors (Cecchetti et al. 1999; Cecchetti and Ehrmann, 1999; Cecchetti, 1998; Dennis 2006; Favero and Raveli 2003) have attempted to estimate deep factors such as policy preferences which led to changes of monetary policy. To estimate changes of policy preferences, the studies above split the sample into two different periods by implementing structural break tests. One of the main disadvantages of this approach is that in a forward looking model agents form expectations accounting for possible parameter changes in the future.

Relevant literature in economics shows that macro-variables might follow a Markov regime switching process. If this is the case then the policy maker's loss function and the optimal policy rule that emerges from it become state dependent. Cukierman and Gerlach (2003) argue that the loss function of a central bank depends on the state that the economy is in. They use a loss function the implication of which is that the central bank is more reactive to inflation deviation from its target when the economy is in expansion rather than in contraction. Alternatively, central bank reacts more strongly to the output gap deviation

[1] Three alternative policies are considered, namely, commitment to a simple instrument rule such as the Taylor rule, forecast targeting (for instance inflation-forecast targeting) and intermediate targeting.

from its target level in recession than in expansion. Beck et al. (2002) generalize this framework and assume a state dependent loss function. Svensson and Williams (2005) and Blake and Zambolli (2006) examine the impact of model uncertainty on the optimal policy rule. Both of these studies assume a quadratic loss function subject to state variables, the dynamics of which follow a Markov process.

The aim of this paper is to estimate the monetary policy preferences of the EMU countries and the UK. The reason for this attempt is simply because recently the consensus on optimal monetary policy has changed within a short period of time. Evidence of high inflation and low economic growth before the collapse of Lehmann Brothers raises the question of whether the ECB and the Bank of England should focus on achieving their inflation target or helping economic growth by relaxing monetary policy. However, the latter option raises questions about the credibility of the ECB and the Bank of England concerning the objective of price stability. An alternative consideration emerges in view of the period after the collapse of Lehman Brothers, when major central banks around the world have reduced interest rates at historical low levels. The debate has now moved on to the question of whether a loose monetary policy should be coordinated with an expansionary fiscal policy. To this end we estimate the monetary policy preferences of EMU and of the UK by adopting a framework suggested by Cecchetti and Ehrmann, (1999).[2]

The contribution of this study is to estimate optimal policy preferences accounting for changes of business cycles. We do so by assuming that the dynamics of state variables follow a Markov process. In this set up the policy reaction function becomes state dependent. We assume that policy preferences are constant across the different regimes. In doing so we can estimate changes of optimal preferences driven by supply shocks. We also compute the actual and optimal policy frontier both for expansion and recession. For given policy preferences any deviation between the actual and optimal policy frontier will reflect changes in the efficiency of monetary policy across different regimes. We have adopted the same approach used by Checchetti et al. (2006), who develop a method for allocating policy performance changes to efficient monetary policy, to reduction in the variability of supply shocks and to changes in the structure of the economy.

This paper proceeds as follows. Section 2 presents a general theoretical framework of optimal monetary policy. The subsequent section describes the construction of state dependent optimal-policy frontiers.

[2]The same approach has been used by Cecchetti et al. (2006). For alternative methods of estimating policy preferences see Dennis (2006), Favero and Rovelli (2003) and Salemi (1995).

Section 4 explains the econometric methodology used to estimate monetary policy preferences. Section 5 discusses the data utilized and the empirical results of the study. Section 6 summarises and concludes.

2 Estimation of Monetary Policy Preferences

This section describes how a theoretical model concerning monetary policy preferences can be brought to data. We follow Cecchetti (1998) and derive the trade-off between inflation and output gap variability by assuming that a central bank is faced with a quadratic loss function (QLF), which is subject to linear dynamics of output and prices. We begin by minimizing the central bank's loss function as in (1):

$$L = E[\lambda(\pi - \pi^*)^2 + (1-\lambda)(y - y^*)^2] \tag{1}$$

subject to (2) and (3):

$$y_t = \gamma(i_t - d_t) + s_t, \ \gamma < 0 \tag{2}$$

$$\pi_t = -(i_t - d_t) - \theta s_t \tag{3}$$

where π is inflation, π^* is the inflation target set by a central bank, y denotes output gap, y^* is the target of output gap an i_t is the short-term nominal interest rate. The coefficient λ is the weight that the central bank attaches to inflation relative to output stabilization, γ is the inverse slope of the supply curve and θ is the slope of the aggregate demand; d_t and s_t stand for the demand and the supply shocks respectively. The combination of the quadratic loss function and the linear constrains yields a linear reaction function:

$$i_t = ad_t + bs_t \tag{4}$$

Substituting this optimal policy into (2) and (3) we obtain the respective variances σ_y^2 and σ_π^2. The can write (1) in terms of σ_y^2 and σ_π^2. Then minimisation of (1) yields:

$$a = 1 \tag{5}$$

and

$$b = \frac{\lambda(\gamma - \theta) - \gamma}{\lambda(1-\gamma^2) + \gamma^2} \tag{6}$$

The main implication of (5) and (6) is that policy makers completely offset demand shocks in terms of both output and inflation. This is so since demand shocks move output and inflation in the same direction. A trade-off between output and inflation is caused by supply shocks. Substituting (5) and (6) into σ_y^2 and σ_π^2 , it is easy to show that the ratio σ_y^2/σ_π^2 is a function of policy preferences λ, and of the inverse of the slope of the supply curve γ, as in (7):

$$\frac{\sigma_y^2}{\sigma_\pi^2} = [\frac{\lambda}{\gamma(1-\lambda)}]^2 \tag{7}$$

Using the actual values of σ_π^2 and σ_y^2 and the estimated value of γ, we can infer the policy preference parameter λ. Equation (7) has the property that for $\lambda = 0$ (the central bank only cares about output gap variability), $\sigma_y^2/\sigma_\pi^2 = 0$. Likewise, for $\lambda = 1$ (the central bank only cares about inflation variability), $\sigma_y^2/\sigma_\pi^2 = \infty$.[3] Cecchetti (1998) shows that central banks that care about the aggregate price path lose little by putting some weight on the output gap (i.e. $\lambda < 1$). Alternatively, central banks that care about output gap variability are faced with a substantially worse position if they decide to target the path of the price level.

There is empirical evidence (Hamilton et. al 1996; Ang et al. 1998) that macroeconomic variables follow a regime switching process. Thus, we can extent the loss function (1) to account for a state-depedent Philips curve:

$$E_t[L_t|S_t,\Omega_t] = p_t L_e + (1-p_t)L_R \tag{8}$$

$$E_t[L_t|S_t,\Omega_t] = p_t[\lambda_e\pi^2 + (1-\lambda_e){y_t}^2] + (1-p_t)[\lambda_R\pi^2 + (1-\lambda_R){y_t}^2] \tag{9}$$

subject to (10) and (11):

$$y_t = \gamma_{S_t}(i_t - d_t) + s_t \tag{10}$$

$$\pi_t = -(i_t - d_t) - \theta s_t \tag{11}$$

where Ω_t is the information set available at time t, S_t is an unobserved state variable at time t, p_t indicates the probability for given $\Omega_{t,}$ S_t is in expansion (i.e. $P(S = e|\Omega_t)$, the subscript e and R indicate that the relevant variables are in expansion and recession respectively. In line with the linear model we can show that optimal policy frontier become state-depedent:

$$\frac{\sigma_y^2}{\sigma_\pi^2} = \left[\frac{\lambda_{S_t}}{\gamma_{S_t}(\lambda_{S_t}-1)}\right]^2 \tag{12}$$

Equation (12) shows that for give values of σ_y^2 and σ_π^2 the policy preferences of central bank change as the slope of supply $(1/\gamma_{S_t})$ curve changes across different regime.

[3]We can trace out the entire output-inflation variability frontier by allowing λ to vary between 0 and 1.

3 Estimation of Optimal Policy Frontiers

To make the analysis more realistic we introduce dynamics in both demand and supply curves. We do so, by following Bean (1998), who uses Svensson's (1997) inflation forecast targeting model, to derive an optimal policy frontier for the UK. We also extent the work of Bean (1998) by obtaining a state dependent policy frontier using a framework suggested by Blake and Zampolli (2006) and Svensson and Williams (2005).

3.1 Optimal Policy Frontier: The Linear Case

Bean (1998) considers the problem of

$$\min_{i_t} L(\pi, y) = \frac{1}{2}(\pi_t^2 + \lambda y_t^2) \tag{13}$$

subject to

$$\pi_{t+1} = \pi_t + \alpha_1 y_t + s_{t+1} \tag{14}$$

$$y_{t+1} = \beta_1 y_t - \beta_2 i_t + d_{t+1} \tag{15}$$

In this model the best that a central bank can do is to affect inflation in two periods by choosing the optimal level of output at time $t+1$. Thus, the inflation dynamics can be written as

$$\pi_{t+2} = \pi_{t+1|t} + \alpha_1 y_{t+1|t} + s_{t+2} + s_{t+1} + \alpha_1 d_{t+1}$$

Given the linear quadratic structure, the optimal policy is given by

$$y_{t+1|t} = -\rho\pi_{t+1|t} = -\rho[\pi_t + \alpha_1 y_t] \tag{16}$$

where ρ is a positive parameter that depends on λ. We obtain the optimal reaction function from equation (16) by solving with respect to nominal interest rate:

$$i_t = \frac{[\lambda + \alpha_1\rho]y_t + \rho\pi_t}{\beta_2} \tag{17}$$

Substituting (17) into (14) and (15) and lagging the resulting equations by one period we can write the evolution of y and π as

$$\begin{bmatrix} y_t \\ \pi_t \end{bmatrix} = \begin{bmatrix} -\alpha_1\rho & -\rho \\ \alpha_1 & 1 \end{bmatrix} \begin{bmatrix} y_{t-1} \\ \pi_{t-1} \end{bmatrix} + \begin{bmatrix} d_t \\ s_t \end{bmatrix} \tag{18}$$

We compute the unconditional variances of output gap and inflation as

$$\begin{bmatrix} Var(y_t) \\ Var(\pi_t) \end{bmatrix} = \frac{1}{2-\alpha_1\rho} \begin{bmatrix} 2 & \frac{\rho}{\alpha_1} \\ \alpha_1\rho\,\frac{1}{\alpha_1\rho} & -\alpha_1\rho + 2 \end{bmatrix} \begin{bmatrix} \sigma_{d_t}^2 \\ \sigma_{s_t}^2 \end{bmatrix} \tag{19}$$

[4]Following Bean (1998) we minimize $Var(\pi_t) + \lambda Var(y_t)$ with respect to the optimal feedback coefficient ρ. Bean (1998) shows that the solution to this is

$$\rho = \frac{-\alpha_1 + \sqrt{\alpha_1^2 + 4\lambda}}{2\lambda} \tag{20}$$

(20) indicates that we can only estimate policy as an efficient policy frontier but not the policy preferences λ. By varying λ we can trace out an optimal efficient frontier that trade-offs inflation variability against output gap variability.

3.2 A state dependent Optimal Policy Frontier

We extent the work of Bean (1998) and estimate state dependent optimal policy frontiers by adopting the Markov jump linear quadratic (MJLQ) model suggested by Zampolli (2006) and Blake and Zampolli (2006).[5] Policy makers minimize an intertemporal loss function:

$$\sum_{t=0}^{\infty} \beta^t L(x_t) = x_t' R(S_t) x_t \tag{21}$$

where $0 < \beta \leq 1$ is the discount factor, $x_t = [y_t \ \pi_t]'$ is a vector of state variables and $R(S_t)$ is given by

$$R(S_t) = \begin{bmatrix} \lambda(S_t) & 0 \\ 0 & 1 \end{bmatrix}$$

The random variable S_t is assumed to form a Markov chain in $\Lambda = \{1, 2, ...N\}$ with transition probability matrix $P = (p_{ij})'_{ij \notin \Lambda}$. The transition probability p_{ij} is the probability that the economy switches from the current state i to future state j. We assume that the policy makers know the current state of the economy but they are uncertain about the future state. The minimization problem is subject to a reduced form state dependent linear dynamic of the economy

$$x_{t+1} = A(S_{t+1})x_t + B(S_{t+1})u_t + \epsilon_{t+1} \tag{22}$$

$$\epsilon \tilde{} N(0, \Sigma_\epsilon) \tag{23}$$

where

$$A(S_{t+1}) = \begin{bmatrix} \beta_1(S_{t+1}) & 0 \\ \alpha_1(S_{t+1}) & 1 \end{bmatrix}, \ B(S_{t+1}) = \begin{bmatrix} -\beta_2(S_{t+1}) \\ 0 \end{bmatrix} \text{ and } \epsilon_{t+1} = \begin{bmatrix} d_{t+1} \\ s_{t+1} \end{bmatrix} \tag{24}$$

[4]In the process of obtaining (19) we have applied the property that if $Y_t = FY_{t-1} + E$, where Y is a random vector, F is a matrix of coefficients, and E is a vector of a white noise process, then: $Vec[Var(Y)] = [I - (F \otimes F)]^{-1} Vec[Var(E)]$.

[5]Zambolli (2006) used MJLQ to study monetary policy under regime shifts without including forward-looking variables.

The matrices A and B depend on the value of the unobserved-state vector S_i, $i \in \{1, 2, ..N\}$.. Solving the problem requires jointly solving the following set of Belman equations

$$v(x_t)\widehat{\boldsymbol{\xi}}_{t|t} = \max_{r_t}\{L(x_t,)\widehat{\boldsymbol{\xi}}_{t|t} + \beta E[v(x_{t+1})\widehat{\boldsymbol{\xi}}_{t+1|t}]\} \tag{25}$$

$$v(x_t)\widehat{\boldsymbol{\xi}}_{t|t} = \max_{r_t}\{L(x_t,)\widehat{\boldsymbol{\xi}}_{t|t} + \beta E[v(x_{t+1})P\widehat{\boldsymbol{\xi}}_{t|t}]\} \tag{26}$$

$$v(x_t, i) = \max_{r_t}\{L(x_t,)\widehat{\boldsymbol{\xi}}_{t|t} + \beta \sum_{j=1}^{N} p_{ij} E[v(x_{t+1})]\},\ i = 1, 2, ...N \tag{27}$$

where $v(x)$ is the continuation value of the dynamic programing problem, $\widehat{\boldsymbol{\xi}}_{t|t}$ is a $N \times 1$ vector whose i element is the conditional expectation that the unobserved state of the world is $S_t = j$, given the information at time t and $S_{t-1} = i$ and $P = \{p_{ij}\}$. Given the linear quadratic nature of the problem and assuming further that the value function is quadratic, i.e. $v(x_t, i) = x'V_i x + d$, the first order conditions will give a set of decision rules of the following form:

$$u(x, i) = -F_i x_t \tag{28}$$

where by substituting (28) into (25) and equating the terms in the quadratic form we obtain a set of Riccati equations

$$\begin{aligned} V_i = {} & R_i + \beta G[A'VA|S = i] \\ & -\beta^2 G[A'VB|S = i](\beta[B'VB|S = i])^{-1} G[B'VA|S = i] \end{aligned} \tag{29}$$

where $i = 1, ..., N$. $G()$ is a conditional operator defined as follows:

$$G[X'VY|S = i] = [P\widehat{\boldsymbol{\xi}}_{t|t}(X'VY)] = \sum_{j=1}^{N} X_j'(p_{ij}V_j)Y_j$$

where $X = A, B$; $Y = A, B$. Having found V_i from the solution of (29) we can estimate the matrices

$$F_i = (\beta G[B'VB|S = i]^{-1} \beta G[B'VA|S = i) \tag{30}$$

Assuming $\beta = 1$ and substituting (30) into (28) and the resulting equation into (24) we obtain:

$$x_{t+1} = A(S_{t+1})x_t - B(S_{t+1})F(S_{t+1})x_t + \epsilon_{t+1} \tag{31}$$

$$= \Pi(S_{t+1})x_t + \epsilon_{t+1} \tag{32}$$

where

$$\Pi(S_{t+1}) = A(S_{t+1}) - B(S_{t+1})F(S_{t+1})$$

and (31) implies that the variance covariance matrix of the state vector x_{t+1} is regime dependent:

$$vec(\Sigma_x) = [I - \Pi(S_{t+1}) \otimes \Pi(S_{t+1})]^{-1} vec(\Sigma_\epsilon) \tag{33}$$

where $\Sigma_x = E(x_t x_t^{'})$. The diagonal element of (33) compute the regime dependent variance of the state vector x :

$$Diag[vec(\Sigma_x)] = Diag\left([I - \Pi(S_{t+1}) \otimes \Pi(S_{t+1})]^{-1} vec(\Sigma_\epsilon)\right) \tag{34}$$

However, $\Pi(S_{t+1})$ is a complicate function of $A(S_{t+1})$, $B(S_{t+1})$ and $V(S_{t+1})$. Thus, we can compute regime-depedent optimal policy frontiers by varying the values of vector $V(S_{t+1})$.[6]

4 Econometric Methodology

The next step is to identify the impact of monetary policy on output and inflation. We need to identify and estimate the impulse response functions of output and inflation to a monetary shock. Cecchetti and Ehrmann (1999) use the structural VAR approach suggested by King et al. (1991) to identify the monetary transmission mechanism. The King et al. (op. cit.) identification scheme is based on cointegrating relationships in a n-variable system. Complete identification of the n-variable system requires $[n(n-1)/2]$ restrictions.[7]

Checchetti (1998) argues that the VAR model used to estimate the responses of output and prices to interest rate changes presumes that these responses remain constant over the sample used in the estimation. Thus, the estimates of policy preferences by Checchetti and Ehrmann (1999) are based on the assumption that VAR parameters remain constant over a significant historical period. However, in the case of the EMS monetary policy, it went through different regimes. This implies that we need to adopt a statistical model which accounts for regime changes. Here, we estimate (22) by employing a structural Markov regime-switching VAR (SMRS VAR) suggested by Ehrmann et al. (2003). As another check for the use of SMRS VAR model we follow Hamilton and Lin (1996) and test for parameter stability using a test suggested by Andrews (1993).

[6] If we use $y_{t+1|t}$ as a control variable then we can obtain a state-depedent version of (19) and (20).

[7] If among the n-variable system there are r cointegrating vectors there will be k common stochastic trends, where $k = (n-r)$. To identify the k stochastic trends King et al. (1991) impose $[k(k-1)/2]$ restriction in the long-run matrix. Alternatively, to identify the r transitory shocks King et al. (op.cit.) impose $[r(r-1)/2]$ restrictions on the short-run matrix.

We also apply various tests for structural breaks.[8] Evidence of structural breaks indicates that variables went through different states rather than having a stochastic trends. Table A1 in the appendix presents results from tests of parameter stability and structural breaks. We have used the Andrews (1993) and Andrews and Ploberger (1994) methods to test for the presence of a break in the stochastic process of our macrovariables. The above tests can also be used to identify multiple breaks in a series by incorporating them in an iterative scheme (algorithm) and apply them to sub-samples of the series. In this paper, we have employed the algorithm proposed by Karoglou (2009), and explained in the Appendix, which is more robust than the basic binary division algorithm to the presence of transitional periods.

In a standard SVAR the underlying structural model is identified by imposing restrictions on the moving average representation of an unrestricted VAR. A SMRS VAR is a two-step procedure combining two important developments of VAR analysis: Markov regime-switching and identification. In the first step we estimate an MRS VAR model, where we allow all estimated parameters to be state dependent:

$$X_t = \begin{pmatrix} y_t \\ \pi_t \\ i_t \end{pmatrix}, c(s_t) = \begin{pmatrix} c_{1,s_t} \\ c_{2,s_t} \\ c_{3,s_t} \end{pmatrix}, u = \begin{pmatrix} u_{1,s_t} \\ u_{2,s_t} \\ u_{3,s_t} \end{pmatrix},$$

$$X_t = c(s_t) + \sum_{j=1}^{p} A(s_t) X_{t-j} + \Gamma(s_t)t + B(s_t)u_t \tag{35}$$

$$\Omega(s_t) = E[B(s_t)u_t u_t' B(s_t)'] = B(s_t) I_n B(s_t)' \tag{36}$$

In the second step we identify $B(s_t)$. Identification of $B(s_t)$ requires n^2 restrictions. $[n(n+1)/2]$ restrictions are imposed upon equation (36) because the variance covariance matrix of the error term is an identity matrix (i.e., $u_t u_t' = \Sigma_u = I_n$). This implies that full identification needs extra $[n(n+1)/2]$ restrictions. Sims (1980) derives these restrictions by ordering endogenous variables recursively. In this set up endogenous variables are ordered and it is assumed that the fundamental disturbances have contemporaneous effects on the variable itself and on all the other variables below it. The choice of which restriction to impose is subject to the structural VAR literature.[9] We choose the recursive form

[8] We could test for the number of states using the Hansen (1992) test. However, this test is computationally demanding and has low power when dynamics are included in the data generation process. Mitchell and Mouratidis (2004) using the Hansen (1992) test show that the growth rate of industrial production of nine EMU countries were subject to regime switching.

[9] For a detailed review of the structural VAR literature see Canova (2007).

of identification by imposing the restriction that the policy instrument does not enter into inflation and output equation contemporaneously.[10] This is consistent with the empirical model of Rudebusch and Svensson (1999) and the theoretical model of Svensson (1997). We also impose the restriction that inflation does not affect output contemporaneously.

Cecchetti (1996) argues that when we try to discern the relationship between the policy instrument and the target variables we need to add more variables to the model. His argument is based on the empirical findings of Sims (1992) and Christiano et al. (1996a; 1996b). Sims (1992) using a VAR including only prices, output and interest rate finds a positive reaction of prices to interest rate shock. This puzzling result has been called the *price puzzle*. The most commonly accepted explanation of the price puzzle is that the variables included in the VAR do not reflect the full information set of central banks. This is so because policy is likely to respond to forecast of future economic conditions. VARs may attribute the subsequent movements in output and inflation to the policy action. In other words the price puzzle is an artifact of omitted variable problem. Castelnuovo and Surico (2010) show that the omitted variable is the by-product of passive monetary policy which leads to violation of the Taylor principle and indeterminacy. Indeterminacy, as Lubic and Schorfheide (2004) underline, introduce two new elements. First, structural shocks are not uniquely identified and sunspots become important in generating business cycles fluctuations. One solution to the prize puzzle is to include commodity prices or other asset prices in the VAR. Since these prices are sensitive to changing forecasts of future inflation, they can be used as proxies of the central bank's additional information.[11]

Cecchetti and Ehrmann (1999) estimate policy preferences for the EMU countries including at least four variables. We also employ a four-variable model by introducing a long-term interest into a trivariate MRS model. We do so because a long-term interest rate is a forward-looking variable reflecting market expectations. Cecchetti and Ehrmann (1999) use dummy variables to account for institutional changes. However, our experiment with linear VAR provides evidence of non-normality and heteroscedasticity. This implies that there are structural breaks or regime

[10] The same recursive identification scheme has been used by Ehrmann et al. (2003).

[11] Barth and Ramey (2001) provide an alternative interpretation of the price puzzle. They argue that a contractionary monetary policy affects both aggregate demand and aggregate supply. For example, an increase in the rate of interest not only influences demand negatively it also raises the cost of holding inventories. This negative supply shock will increase prices and reduce output. In this interpretation, the price puzzle is due to the cost channel rather than to a misspecified VAR.

switching changes (see Canova, 2007) in line with the history of EMS.[12] We employ an MRS model because of the history of the EMS system and also, because of recent empirical evidence that macro-variables are subject to regime switching (see Ang and Bekaert, 1998).

In line with Cecchetti and Ehrmann (1999) we compute the inverse slope $1/\gamma(s_t)$ at each regime as the 12-quarter average of the impact of policy shock on output, divided by the 12-quarter average impact on inflation. The state dependent unconditional volatilities of output and inflation are measured using the smooth probabilities regarding the current economic state.

5 Data and Empirical Results

This section analyses empirical results concerning both the static and dynamic model. We focus on the case of the EMU countries and the UK. In what follows we utilize both a trivariate and a quadravariate MRS model to estimate equation (35). The trivariate MRS VAR model includes the policy instrument and the target variables. We use on a monthly basis the three-month treasury bill rate as a proxy for the policy instrument. The treasury bill is available both for all countries and for the whole period of investigation.[13] We also use monthly CPI and industrial production to construct the inflation rate and the industrial production growth rate.[14]

5.1 Estimation of Policy Preferences: The Case of the Static Model

We compute policy preferences and the slope of the supply curve for two different samples. The two samples cover the periods from March 1979 to December 1998 and from March 1979 to August 2008.[15] We choose these two periods to investigate whether the introduction of the single European currency had any impact on policy preferences.

Table 1 presents the results from the trivariate and four-variable MRS models. We distinguish each regime on the basis of their volatilities. We call regime 1, the regime with a low volatility and regime 2 the regime

[12] In the period from 1979 to 1986 the EMS experienced 11 realingments followed by a stable period up to the currency crises of the 1990s. The EMS was the subject of speculative attacks in 1993 and 1995.

[13] We could also use the short-term money market rate given by the 60b line of IFS data base. However, it is only available for the period before the introduction of the European single currency.

[14] Data for CPI and industrial production were extracted from the lines 64 and 99 of the IFS data base.

[15] We have excluded the recent financial crisis because there are not many ex-post observations.

with the high volatility.[16] The first observation is that most of the $\lambda(s_t)$s are very high. Estimated policy preferences for the full sample (i.e. March 1979 to August 2008) indicate that after the introduction of the single European currency, countries increased the weight assigned to price stability. This is so because monetary policy is conducted by a new institution, the ECB where single objective is price stability. The need to earn anti-inflationary credibility led the ECB to put emphasis on price stability. It is worth noting that both the EMU and the UK put more weight on price stability, than on output gap stability, in the regime where the slope of the supply curve (i.e. $1/\gamma$) is flatter. Countries emphasize price stability in regimes where the disinflation cost in terms of output gap is high. This might be due to the effort of EMU countries to establish anti-inflationary credibility.

Table 1: Estimated Policy Preferences

	Period $1979:03-1998:12$		*Period* $1979:03-08:2008$	
Parameters	*EMU*	*UK*	*EMU*	*UK*
3 Variables				
γ_1	-3.879	-1.550	-2.594	-38.159
γ_2	-0.729	-0.705	-2.006	-2.345
λ_1	0.951	0.777	0.928	0.988
λ_2	0.784	0.613	0.909	0.840
4 Variables				
γ_1	-2.011	-1.192	-1.049	-34.192
γ_2	-0.225	-1.156	-0.601	-10.745
λ_1	0.908	0.721	0.837	0.987
λ_2	0.525	0.715	0.747	0.959

Figure 1 shows the probability of regime 1 (i.e. low volatility regime). In line with empirical regularities the probability of regime 1 in EMU is low for the period before 1986 where eleven realignments took place in the EMS. The probability of regime 1 is also low in 1990 where the German unification and the low economic growth in EMU raised doubts about the optimality of low inflation policy pursued by the Budesbank. The probability of low volatility regime falls during the speculative attacks in 1992, 1993 and 1995.

[16] Here, in both cases, the high volatility regime coincides with the low economic growth regime.

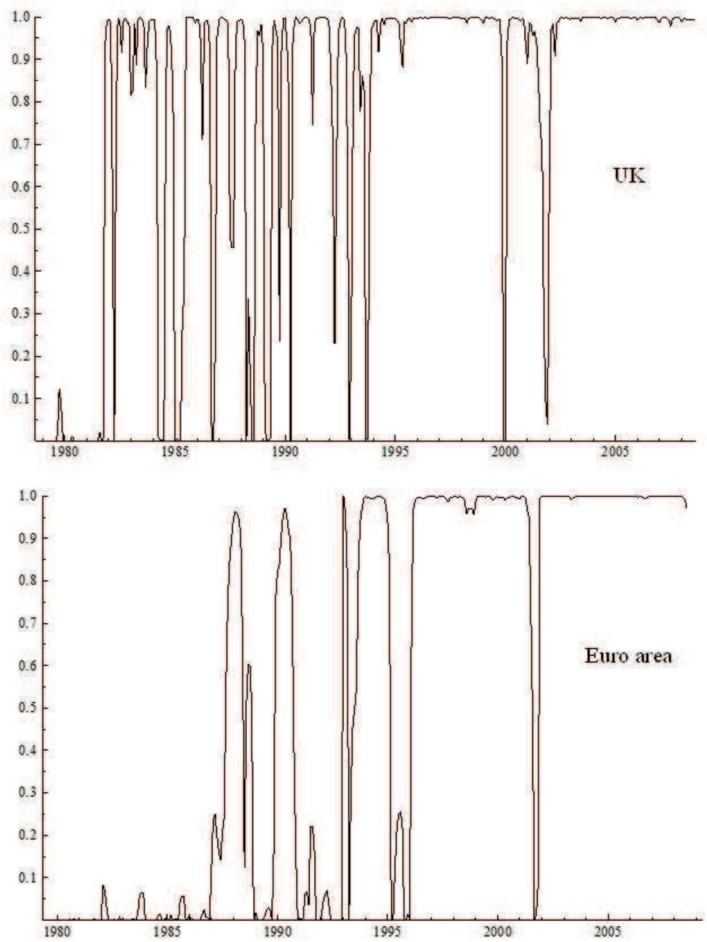

Figure 1: Smooth probabilities of regime 1 for the UK and the EMU.

Alternatively, in the UK the probability of low volatility regime is broadly in line with narrative evidence. More concretely, Benati (2008) shows that the long-run response to inflation was weaker for the period before 1979-1990 and there was a marked increase under the Margaret Thatcher administration; there was a further increase after the introduction of implicit inflation targeting in October 1992. Thus, the probability of regime 1 is low in periods where monetary policy accommodated inflationary pressure. In doing so expected inflation becomes self-fulfilling. This is so because violation of the Taylor principle will generate multiple equilibria and the expectations become self-fulfilling.[17] This implies

[17]The Taylor principle states that if the coefficient of inflation in the standard Taylor rule is smaller than one, then the rational expectations model has multiple equilibria and expectations become self-fulfilling. However, Lubik and Schorfheide (2004) show equilibrium (i.e determinacy and indeterminacy) is a system property and depends on the interaction between the parameters of the Taylor rule and of

that if the high volatility regime coincides with passive monetary policy then in regime 2 sunspots will lead to the price puzzle. Our results are consistent with Benati (2008), who using a time-varying structural VAR analysis, shows that there is violation of the Taylor principle during the 1980s, where the estimated long-run inflation coefficient fluctuates between 0.7 and 0.8. However, after the introduction of inflation targeting in October 1992 the long-run coefficient on inflation increased substantially reaching a value of 1.4. The probability of regime 1 is also low for the period between 2001 and 2003. This is in line with Groen et al. (2009) who show, by developing a multivariate extension of the CUSUM test, that the UK RPI inflation was subject to structural breaks after 2001, 2003 and 2005.[18]

Figure 2 and 3 are based on trivariate MRS-SVAR model and present the response of inflation to monetary policy shocks both for the UK and the EMU. There is a evidence of price puzzle in both regimes but it is a lot more persistent and stronger in the high volatility regime. Although this reflects that market expectations are more important in the high volatility regime than in the low volatility regime, one should bear in mind that the price puzzle might be an artifact of an omitted variable problem. Canova et al. (2006) get around the omitted variable problem by using proxies of expected inflation. Here, we use as a proxy of expected inflation the spread between the 6-year long-term interest rate and the three-month treasury bill. However, the price puzzle is still present in the augmented four-variable MRS-SVAR model.[19] Evidence of price puzzle after accounting for expected inflation indicates that either the proxy of expected inflation is not accurate or the price puzzle is due to supply shocks. This is so because the implication of the impulse response from a mis-pecified VAR is similar to the implication of the response to a supply shock. This raises some concern for policy makers in distinguishing policy shocks from supply shocks especially for regimes with high uncertainty.

---

the structural parameters. So a low inflation coefficient in policy rules should be considered as an indication of a potential indeterminacy.

[18] Groen et al. (2009) argue that there may have been temporary breaks induced by the large volatilities in housing and energy after 2000.

[19] For the sake of brevity we do not present the impulse response function of the four- variable MRS-SVAR model here. The relevant graphs are available from the authors upon request.

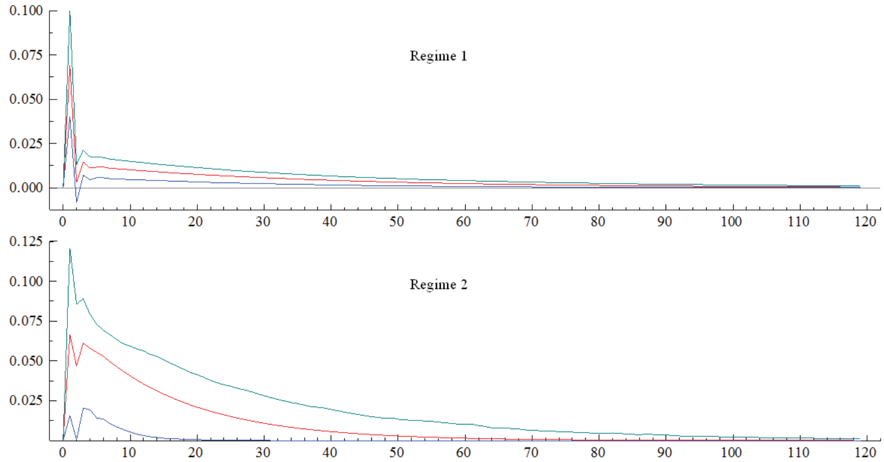

Figure 2: Impulse Response Function of Prices to Interest Rate Shock: The Case of the UK.

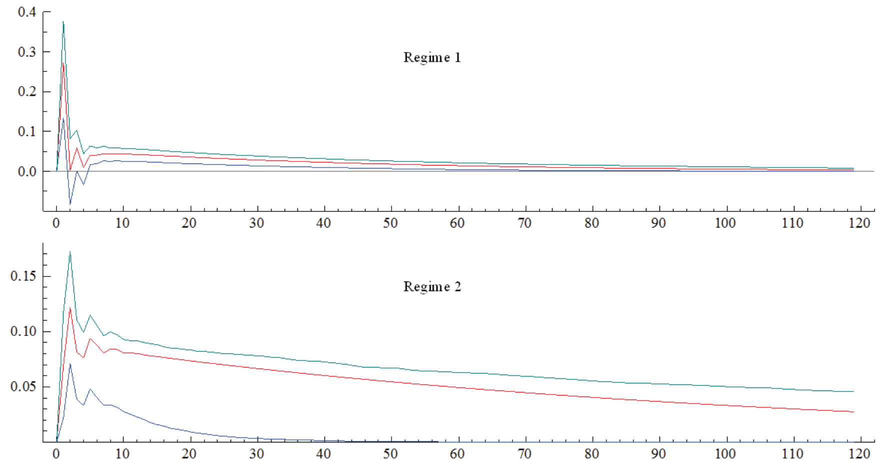

Figure 3: Impulse Response Function of Prices to Interest Rate Shock: The Case of the EMU.

It is worth noting that Castelnuovo and Surico (2006) show that the price puzzle disappears when estimation of SVAR focuses on the period between 1993 and 2006. Alternatively, Caglayan et al. (2011) show that the price puzzle is still present once the sample is extended to include the recent financial crisis. Although we exclude the recent financial crisis, our results justify those of Caglayan et al. (2011). The key element that differentiates the price puzzle before the crisis in 1992 and the price puzzle before the recent financial crises is that the latter is not the outcome of a passive monetary policy but rather the by-product of poor banking regulation. The introduction of implicit and explicit inflation targeting in 1992 and 1997 in the UK respectively, has increased the long-run response of interest rate to inflation above one. This implies that the underlying factor to price puzzle before the financial crisis in the end of 2008 was excessive lending and poor banking regulation. Haldane et al. (2007) show that UK banks increased their unsecured exposure along with UK households securing debt to figures mounting around 32% of UK banks' total lending. Haldane at al. (op. cit.) also explain that households were very sensitive to adverse shocks and there were signals of stress with the number of personal insolvencies sharply increasing before the 2007-2009 financial crises.

The UK economy went through a recession in the early 1990s. However, being a member of the ERM, the UK could not use monetary policy to boost domestic economic growth. The economic outlook of the UK deteriorated as the German unification and the subsequent contractionary policy implemented by Germany did not help unemployment in the UK. The options for the UK, at that time, were either to opt out of the ERM and achieve higher economic growth by devaluing the British pound or suffer economic recession by staying in the ERM. The markets bet in favor of the former option and in conjuction with a weak response by the Bank of England to long-run inflation, market expectations became self-fulfilling. Thus, devaluation and the subsequent inflation materialized by a passive monetary policy before the crisis in 1992. Under such circumstances, it appears that the price puzzle is the outcome of expected inflation, which is an extra state variable generated by a passive monetary policy. Our results are consistent with Castelnuovo and Surico (2006), who argue that under indeterminacy the positive relationship between inflation and interest rate appears spurious and it is due to model mis-pecification due to violation of the Taylor principle and the subsequent indeterminacy.

Evidence of price puzzle in the pre-EMU is due to the beginning of the EMS when there was high inflation differential between Germany and the rest of the EMS member countries. Thus, eleven realignments took place before inflationary convergence across the EMS member countries was achieved in the early 1990s. However, the cost of the inflationary convergence was a real exchange rate appreciation and current account deficit for countries such as Italy, the UK, Spain and Portugal. Spain and Italy experienced higher inflation rates than the EMS average during 1987-1992. During this period, without any realignment, tensions were building up for these two countries in the form of growing loss of competitiveness (see De Grauwe 1997). The choice for these countries was either to devalue or to deflate their economies but suffering further loss of competitiveness. Italy opted out of the EMS after the speculative attack in 1992 and Spain increased the band around the central parity. In 1993 the overvaluation of the currencies of the countries in the periphery was corrected but the market was left unsure in terms of the core currencies, such as the Belgian and the French francs and the Danish krone, which did not seem to provide evidence of overvaluation. Eichengreen and Wyploz (1993) and Kenen (1995) argue that the crisis in 1993 was caused by market expectations about the future stance of French policy because they thought that France and some other smaller countries were in different cyclical positions to that of Germany.[20] In 1995 the lira, peseta and the Swedish krona were under pressure because of market concerns about the ability of those countries to serve their high domestic debt.

5.2 Estimation of State Dependent Policy Frontiers: The Case of the Dynamic Model

We trace out an efficient policy frontier of a trade-off between output gap variability and inflation variability by varying $\rho(S_{t+1})$ from zero to infinity. However, in order to calculate the efficient frontier we need three pieces of information: the variance of demand shocks $\sigma^2_{d(S_{t+1})}$,the variance of supply shocks $\sigma^2_{s(S_{t+1})}$and the slope of the supply curve $\alpha_1(S_{t+1})$. We start by estimating a state dependent version of (14) and (16) using MRS models. Then we substitute the values of $\alpha_1(S_{t+1})$, $\sigma^2_{d(S_{t+1})}$ and $\sigma^2_{s(S_{t+1})}$, so obtained, into $\rho(S_{t+1})$.

Figure 4 presents the efficient policy frontiers of the UK, both in low and high volatility regimes. The striking thing with these frontiers is that they are steep and the optimal points are very close for weights in the range of [2,5]. This has an important implication concerning the credibility of the Bank of England. A rather wide range of weights on output against inflation will lead to similar points on the policy frontier. Although a steep policy frontier indicates that the Bank of England has little to loose in terms of credibility, by increasing the weight on output it also implies that emphasis on price stability is relatively expensive in terms of output.

The optimal policy frontiers for the EMU, presented in Figures 4 and 5 differ from those of the UK in two respects. First, Figure 5 also shows that the standardized policy frontier of the UK is steeper than the policy frontier of the EMU.[21] Second, the size of the trade-off between inflation variability and output gap variability is a lot lower for the EMU than for the UK. Although the UK enjoys higher credibility concerning

[20] The French and Belgian franc initially dropped by 3-4 percent leading to an increase of band around the central parity 15 per cent.

[21] For ease of exposition we have only presented the policy frontiers of the high volatility regime.

the objective of price stability than the EMU, it faces a high trade-off between inflation and output gap stability. These results are in line with evidence from the static model where the UK not only does it put less weight on inflation variability but also it has reduced this weight substantially after 2006.

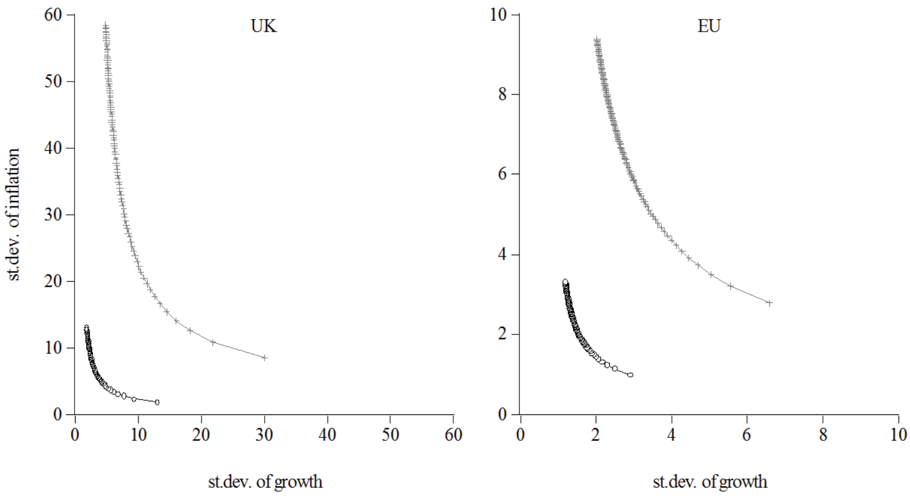

Figure 4: State dependent optimal policy frontiers. Note: the (grey) line with the crosses depicts the optimal policy frontier in the high volatility regime; the (black) line with the circles depicts the optimal policy frontier in the low volatility regime.

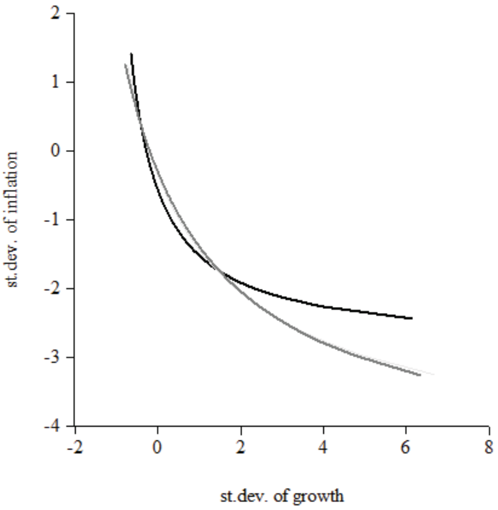

Figure 5: Standardised state dependent optimal policy frontiers in the high and low volatility regimes. Note: the black line depicts the optimal policy frontier in the high volatility regime for the UK; the grey line depicts the optimal policy frontier in the high volatility regime for the EU. It is worth mentioning that the corresponding graph for the low volatility regime is almost identical.

6 Summary and Conclusions

The aim of this paper is to estimate the monetary policy preferences of a number of EMU countries and the UK. We do so, by adopting the framework suggested by Cecchetti and Ehrmann (1999). We extent the work of Cecchetti and Ehrmann (1999) in two respects. First, we allow policy preferences to be state dependent by assuming the data generating process (DGP) of inflation and output gap to follow a Markov process. Second, we introduce dynamics into the relevant supply and demand curves. However, when introducing dynamics into the static model used by Cecchetti and Ehrmann (1999), we can only estimate an optimal policy frontier rather than policy preferences explicitly.

Empirical results from the static model show that monetary policy in the EMU and in the UK put a lot of weight on inflation variability. Alternatively, the impulse response function shows that there is price puzzle especially in the high volatility regime. Evidence of price puzzle in the EMU is the by-product of inflation differential across the EMU member countries and of currency crises caused by real exchange rate appreciation of the peripheral currencies with respect to the DM. The price puzzle in the UK was due to a passive monetary policy followed by the Bank of England prior to the speculative attack in 1992 and the excess lending before the start of the recent financial crisis in September 2008. Estimates of state dependent optimal policy frontiers show that the Bank of England enjoys higher anti-inflationary credibility and a higher trade-off between inflation and output gap variability than the ECB.

References

[1] Andrews, D. (1993). "Test for Parameter Instability and Structural Changes with Unknown Change Point" *Econometrica*, Vol. 61, pp.821-856.

[2] Andrews, D. W. K. and W. Ploberger (1994): "Optimal tests when a nuisance parameter is present only under the alternative", *Econometrica* Vol. 61, pp. 1383-1414.

[3] Ang, A. and G. Bekaert, (1998), "Regime Switches in Interest Rates", NBER *working Paper*, No 6508.

[4] Ball, L., (1997), "Efficient Rules for Monetary Policy", NBER *working Paper*, No. 5952.

[5] Barth, M. J. and Ramey, V. A. (2001), "The Cost Channel of Monetary Transmission " *NBER Macroeconomics Annuals,* Cambridge, MA: MIT Press, 199-239.

[6] Bean, C., (1998), "The New UK Monetary Arrangements: A View from the Literature", *Economic Journal,* Vol. 108, pp.1795-1809.

[7] Benati, L., 2008, The "Great Moderation" in the United Kingdom" *Journal of Money Credit and Banking*, Vol. 40, pp.121-147.

[8] Blake, A., and Zampolli, F., (2006), "Optimal Monetary Policy in Markov-switching Models with rational Expectations Agents" *Bank of England Working Paper no.* 298

[9] Frédérique Bec, Mélika Ben Salem, Fabrice Collard, (2002), "Asymmetries in Monetary Policy Reaction Function: Evidence for U.S. French and German Central Banks", *Studies in Nonlinear Dynamics and Econometrics*, Vol.6, Issue 2, Article 3.

[10] Caglayan, M., Mouratidis, K. and Saeidinezhad, E., (2011) "Monetary Policy Effects on Output and Exchange rates: Results from US, UK and Japan", *working paper*, University of Sheffield.

[11] Canova, F., (2007), Methods for Applied Macroeconomic Research, Princeton University Press.

[12] Castelnuovo, E. and Surico P., 2006, The price puzzle: fact or artifact?, working paper, No. 288, Bank of England.

[13] Castelnuovo, E. and Surico P., 2010. Monetary policy, inflation expectations, and the price puzzle. *The Economic Journal.* 120 (549), pp. 1262–1283.

[14] Cecchetti, S., Flores-Lagunes, A., and S., Krause, (2006), "Has

Monetary Policy Become more Efficient? A Cross-Country Analysis", *The Economic Journal*, Vol. 116, pp. 408-433.

[15] Cecchetti, S., (1996), "Practical Issues in Monetary Policy Targeting.", *Federal Reserve Bank of Cleveland ECONOMIC REVIEW* 32, no. 1: 2-15.

[16] Checchetti, S., (1998), "Policy Rules and Targets: Framing the Central Banker's Problem" *Economic Policy Review,* Federal Reserve Bank of New York, Vol 4, pp. 1-18.

[17] Cecchetti, S. and Ehrmann (1999), "Does Inflation Targeting Increase Output Variability? An International Comparson of Policy Maker's Preferences and Outcomes" *NBER working Paper no 7426.*

[18] Cecchetti, S. McConnel, M., and Quiros, G. P., (2002), "Policy Makers' Reveal Preferences and Output-Inflation Variability Tradeoff", *The Manchester School*, vol. 70, pp. 596-618.

[19] Clarida, R., Gali, J. and Gertler, M., (1999), "The Science of Monetary Policy: A New Keynesian Perspective", *Journal of Economic Literature*, Vol. XXXVII, pp. 1661-1707.

[20] Christiano, L. J., Eichenbaum, M. and Evans, C. L., (1996a), "The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds", *Review of Economics and Statistics*, vol. 78, pp.16-34.

[21] Christiano, L. J., Eichenbaum, M. and Evans, C. L., (1996b), "Identification and the Effects of Monetary Policy Shocks" in M. Blejer, Z Eckstein, Z. Hercowitz, and L. Leiderman (eds), Financial Factors in Economic Stabilization and Growth, Cambridge: Cambridge University Press.

[22] Cukierman, A., and Gerlach, S., (2003), "The inflation Bias Revisited: Theory and Some International Evidence", *The Manchester School*, lol. 71, pp. 541 - 565.

[23] De Grauwe, P., 1997, Economics of Monetary Union, Oxford Economic Press.

[24] Dennis, R., (2006), "The Policy Preferences of the Federal Reserve", *Journal of Applied Econometrics*, Vol. 21, pp. 55-77.

[25] Ehrmann, M., (1998), "Will EMU Generate Asymmetry? Comparing Monetary Policy Transmission Across European Countries", *European University Institute, working Paper no. 98/28.*

[26] Eichengreen, B. and Wyploz, C., (1993), The unstable EMS, Brooking Papers on Economic Activity 1, Washington, DC.

[27] Ellison, M., and Valla, N., (2001), "Learning, Uncertainty and Central Bank Activism in an Economy with Strategic Interactions", *Journal of Monetary Economics,* Vol. 48, pp. 153-171.

[28] Favero, C. and R., Rovelli, (2003), "Macroeconomic Stability and and the Preferences of Fed", *Journal of Money Credit and Banking*,

Vol. 35, pp. 545-556.

[29] Groen, J., Kapetanios, G., and S., Price, (2009), "Multivariate Methods for Monitoring Structural Change", *Bank of England,* working paper, No. 369.

[30] Haldane, A., Hall, S., and Pezzini, S., 2007, "A new approach to assesing risks to financial stability", *Bank of England, Financial Stability Paper* No. 2.

[31] Hamilton, J., and G., Lin, (1996), "Stock Market Volatility and the Business Cucles", *Journal of Applied Econometrics*, Vol. 11, pp. 573-593.

[32] Hansen, B. E. 1992. The Likelihood Ratio Test under Nonstandard Conditions: Testing the Markov Switching Model of GNP. *Journal of Applied Econometrics* 7, 61-82.

[33] Karoglou, M. (2009): "Breaking down the non-normality of stock market returns", *European Journal of Finance*, forthcoming

[34] Kenen, P. B. (1995), Economic and Monetary Union in Europe: Moving Beyoond Maastricht, Cambridge University Press, Cambridge.

[35] King, R., Plosser, C., Stock, J., and Watson, M., (1991), "Stochastic Trends and Economic Fluctuations" *American Economic Review,* Vol. 81, pp. 819-840.

[36] Lubik, T., and Schorfheide F., 2004, "Testing for indeterminacy: an application to U.S. monetary policy", *American Economic Review*, 94 (1), pp. 190–219.

[37] Mitchell, J. and K. Mouratidis (2004), "Is there a common Eurozone business cycle?". "Monographs of Official Statistics: Papers and Proceedings of the third Eurostat Colloquium on Modern Tools for Business Cycle Analysis", (ed. G.L., Mazzi and G. Savio). European Commission, 2004.

[38] Rudebusch, G.D. and Svensson, L.E.O. (1999), "Policy Rules for Inflation Targeting", in (J.B. Taylor ed.), Monetary Policy Rules, pp. 203-46, Chicago: University of Chicago Press.

[39] Salemi, M. (1995), "Revealed Preferences of the Federal Reserve: Using inverse Control Theory to Interpret the Policy Equation of Vector Autoregression", *Journal of Business Economic and Statistic*, Vol. 13, pp. 419-433.

[40] Sims, C., (1980), "Macroeconomic Policy and Reality", *Econometrica*, vol. 48, pp. 1-48.

[41] Sims, C., 1992, "Interpreting the macroeconomic time series facts: the effects of monetary policy", *European Economic Review*, vol. 36, pp. 975–1011.

[42] Svensson, L., (2001), "Price Stability as a Target for Monetary Pol-

icy: Defining and Maintaining Price Stability," in Deutsche Bundesbank, ed., The Monetary Transmission Process: Recent Developments and Lessons for Europe, Palgrave, New York, 60-102.

[43] Svensson, L., (1997), "Inflation Forecast Targeting: Implementing and Monitoring Inflation Targets", *European Economic Review,* Vol. 41, pp.1111-1147.

[44] Svensson, L.E. and Williams, N. (2005), "Monetary Policy with Model Uncertainty", manuscript, Princeton University.

[45] Zampolli, F., (2006), "Optimal Monetary Policy in a Regime-Switching Economy", *Bank of England Working Paper, No 297*

Appendix 1: Detecting structural changes

The algorithm that is used in this paper to detect the possible presence of multiple breaks comprises of the following six steps:

1. Calculate the test statistic under consideration (here the Andrews, 1994, and the Andrews and Ploberger,1994) using the available data.
2. If the statistic is above the critical value split the particular sample into two parts at the corresponding point.
3. Repeat steps 1 and 2 for the first segment until no more (earlier) change-points are found.
4. Mark this point as an estimated change-point of the whole series.
5. Remove the observations that precede this point (i.e. those that constitute the first segment).
6. Consider the remaining observations as the new sample and repeat steps 1 to 5 until no more change-points are found.

The detected breaks for each series are simply all those that have been detected after implementing this algorithm. The following table depicts the break points for each series.

Series	QA	AP	Series	QA	AP	Series	QA	AP	Series	QA	AP
Belgium rate	1985m05	1985m05	Germany rate	1982m11	1982m11	Netherlands rate	1982m09	1982m09	UK rate	1982m08	1982m08
	1994m06	-		1995m05	1995m05		1995m10	1995m10		1992m12	1992m12
	2001m12	-		2003m01	2003m01		1999m02	1999m02		2001m09	2001m09
	2006m11	-		2006m09	2006m09		2003m01	2003m01		2004m07	2004m07
	2008m10	-		2008m10	2008m10		2006m09	2006m09		2008m06	2008m06
Belgium infl	1985m05	1985m05		-	-		2008m10	-	UK infl	1980m06	1980m06
Belgium long	1985m11	1985m11	Germany infl	1982m08	1982m08	Netherlands infl	1982m05	1982m05		1990m12	1990m12
	1996m10	1996m10	Germany long	1984m11	1984m11	Netherlands long	1983m01	1983m01	UK long	1982m10	1982m10
	2002m10	2002m10		1997m08	1997m08		1996m11	1996m11		1997m06	1997m06
	2007m05	2007m05		2003m01	2003m01		2003m01	2003m01		2000m12	2000m12
Belgium growth	-	-		2004m11	2004m11		2007m05	2007m05		2002m09	2002m09
France rate	1984m11	1984m11		2006m05	2006m05		2008m11	2008m11	UK growth	-	-
	1995m12	1995m12		2008m09	2008m09	Netherlands growth	-	-	Euro rate	1984m05	1984m05
	2002m11	2002m11	Germany growth	-	-	Spain rate	1984m02	1984m02		1996m02	1996m02
	2006m09	2006m09	Italy rate	1986m06	1986m06		1996m05	1996m05		2001m12	2001m12
	2008m10	2008m10		1996m12	-		1998m06	1998m06		2006m11	2006m11
France infl	1982m06	1982m06		1998m11	-		2002m01	2002m01		2008m10	2008m10
	1986m07	1986m07		2007m02	-		2006m11	2006m11	Euro infl	1982m08	1982m08
	1992m01	1992m01	Italy infl	1983m01	1983m01		2008m10	2008m10		1994m05	1994m05
France long	1985m05	1985m05		1995m08	1995m08	Spain infl	1986m02	1983m03	Euro long	1985m01	1985m01
	1996m02	1996m02		-	-		1995m06	1992m04		1996m11	-
	2002m10	2002m10	Italy long	1985m01	1985m01	Spain long	1985m02	-		2002m10	-
	2007m05	2007m05		1996m11	-		1996m11	-		2007m05	-
	2008m11	2008m11		2002m09	-		2002m10	-		2008m11	-
France growth	-	-		2007m05	-		2007m05	-	Euro growth	-	-
				2008m06	-	Spain growth	-	-			
			Italy growth	-	-						

Table A1: Detected breaks using the Andrews-Quandt (Andrews, 1993) and the Andrews-Ploberger test (Andrews and Ploberger, 1994)