Is There A Trade-Off Between Inflation Variability And Output-Gap Variability in The EMU Countries?

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ABSTRACT

This paper examines two issues. First, we compare, based on the ratio of output-gap variability to inflation variability, the monetary policy performance of eleven EMU countries for the whole period of the EMS. Second, we examine whether the introduction of an implicit inflation-targeting by the EMU member countries after the Maastricht Treaty changed the trade-off between inflation variability and output-gap variability. We employ a stochastic volatility model for the whole period of the EMS and for two sub-periods (i.e., before and after the Maastricht Treaty). We find that for the whole period the trade-off ratio varies among EMU countries, especially in the case where industrial production is utilized to construct the output-gap variable. The results also vary from the point of view of how the trade-off variabilities change for each country before and after the Maastricht Treaty. The implication of these findings is that asymmetries exist in the euro area as a result of either different monetary policy preferences or different economic structures among the EMU's member countries.

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). Much economic theory suggests that unanticipated inflation has much stronger effects on output than anticipated inflation (see, for example, Gros and Thygesen, 1998). This argument clearly suggests that the costs of unanticipated inflation imply that price stability should be taken to mean that inflation should be close to zero and should also be predictable. Building on these theoretical propositions, a number of countries have assigned monetary policy the task of achieving the objective of stable and low inflation using the rate of interest as the policy instrument, and in some of these cases through adopting explicit inflation targets. The ECB pursues the price stability objective in the form of a 0-2 per cent target for the annual increase in the Harmonised Index of Consumer Prices (HICP) for the euro area.

An important criticism of inflation targeting, explicit or implicit, is that it may lead to higher output variability (see, for example, Cecchetti and Ehrmann 1999). Another objection to inflation targeting is that it tends to ignore other objectives of policy, such as economic activity. We also suggest that monetary policy through manipulating the rate of interest may be ineffective in achieving inflation targets. However, inflation targeting need not exclude the achievement of other objectives, such as, for example, stabilization of output-gap. Indeed, some studies argue that inflation targeting leads also to output-gap stabilization when the source of shocks come from the demand side (Svensson 1998, Cecchetti and Ehrmann 1999, Clarida et. al., 1999). In the case of supply shocks, however, targeting inflation destabilizes output-gap (Arestis et al. 2002, Bofinger 1999, Clarida et al. op. cit.).

The aim of this paper is twofold. First, we compare the monetary policy performance of eleven Economic and Monetary Union (EMU) countries for the whole European Monetary System (EMS) period.[1] We evaluate the monetary policy performance of each country based on the trade-off between inflation variability and output-gap variability. Second, we examine whether the adoption of implicit inflation targets by the EMU member countries immediately after the Maastricht Treaty in 1992, changed the trade-off between inflation variability and output-gap variability. The data chosen to split the sample is consistent with the work of Cecchetti and Ehrmann (1999). They demonstrate that since the early 1990s, and for nine European Union countries, the coefficient of policy aversion against inflation has increased

[1] Luxembourg is the only EMU country that is excluded from our sample, in view of data unavailability.

in the same manner as in the case of inflation targeting countries. So that in preparation to join the EMU, the countries of EU were forced to behave like inflation targeting countries throughout the 1990s. We employ structural stability tests to examine whether the cross-period comparisons are warranted. The econometric technique utilized for our purposes is based on stochastic volatility specification for the output-gap and inflation. The paper is organized as follows. Section 2 reviews the literature that relates to the inflation and output-gap variability trade-off in an attempt to provide the theoretical underpinnings of this study. Section 3 explains the econometric methodology adopted to investigate the existence of this trade-off. In particular we discuss the stochastic volatility method specification of output-gap and price inflation. Section 4 discusses the data utilized and our empirical findings. Section 5 summarizes and concludes the paper.

THEORETICAL UNDERPINNINGS

Theoretical research on monetary policy rules over the last two decades, has demonstrated the possibility of a trade-off between output-gap variability and inflation variability (for example, Phelps and Taylor 1977, Taylor 1979, 1980, and 1993). In fact, Taylor (1980, 1994) shows that the short-run trade-off between the level of inflation and output-gap implies a long-run trade-off between their respective variances. This indicates that it is essential to examine the question of whether inflation targeting (implicit or explicit) induces excessive output-gap variability.

Cecchetti (1998), and Cecchetti and Ehrmann (1999), among others, show that a trade-off between inflation variability and output-gap variability arises only in the case of supply shocks (i.e. cost-push shocks). In particular, an efficient frontier between output-gap variability σ_y^2 and inflation variability σ_y^2 is constructed, based on a central bank optimization model. The policy problem for the central bank is to minimize a quadratic loss function subject to the dynamics of the structure of the economy (i.e. output and inflation) as a function of the policy instrument (i.e. the rate of interest). That is, minimize (1) subject to (2) and (3) below:

$$L=E_t[\sum_{i=0}^{m}\beta^i \{\alpha[p_{t+i}-p^*_{t+i}]^2+(1-\alpha)[y_{t+i}-y^*_{t+i}]^2\}] \qquad (1)$$

$$y_t=\gamma(r_t-d_t)+s_t,\ \gamma<0 \qquad (2)$$

$$\pi_t=-(r_t-d_t)-\varphi s_t \qquad (3)$$

where y_t is the log of output, p_t is the log of price level, y^* and p^* are the target level for y and p, α is the relative weight the monetary authorities attach to price deviation from its target level, β is a discount factor and m is the horizon. The parameter γ is the inverse of the slope of the aggregate supply curve and φ is the slope of the aggregate demand curve. In equations (2) and (3) d and s denote aggregate demand and supply shocks, and r is the rate of interest.

Equations (2) and (3) indicate that aggregate demand shocks move output and inflation in the same direction, while supply shocks move output and inflation in the opposite direction. Cecchetti (1998) normalizes the variance of demand shocks to unity; as a result the variance of supply shocks, given by σ_S^2, measures the variance of supply shocks relative to demand shocks.

Combining the linear constraints (2) and (3) can yield an equivalent policy rule that is a linear function of demand and supply shocks:

$$r_t=\delta d_t+bs_t \qquad (4)$$

Substituting (4) into (2) and (3) we obtain the variances σ_y^2 and σ_π^2:

$$\sigma_y^2=(\delta-1)^2\gamma^2+(1+\gamma b)^2\sigma_s^2 \qquad (5)$$

$$\sigma_\pi^2=(1-\delta)^2+(\varphi+b)^2\sigma_s^2 \qquad (6)$$

Substituting (5) and (6) into (1), and minimizing the resulting loss function with respect to δ and b, gives us the following results: for horizon $m=0$, and under discretion, the solution of the minimization exercise yields (see Cecchetti et. al. 2002, pp. 607-608, for more details):

$$\delta=1 \qquad (7)$$

and

$$b=\delta(\gamma-\phi)-\gamma/\ \delta(1-\gamma^2)+\gamma^2 \qquad (8)$$

The solution in equation (7) indicates that policymakers completely offset demand shocks on both output and inflation. Substituting the expressions for δ and b into (5) and (6), we may obtain the ratio of output-gap variability to inflation variability as in (9):

$$\sigma_y^2/\sigma_\pi^2 = [\alpha/\gamma(\alpha - 1)] \qquad (9)$$

Equation (9) indicates that the trade-off between inflation variability and output-gap variability depends on monetary policy preferences and the structure of the economy (i.e. aggregate supply and demand curves). Allowing α to vary between zero and one, we can derive the output-inflation variability frontier, the shape of which depends on the slope of the aggregate supply curve ($1/\gamma$). The implication is that if the value of γ is high (i.e. a flat aggregate supply curve) then any reduction in inflation variability leads to a relatively large increase in output-gap variability, making inflation targeting more difficult.[2] In what follows we do not use (9) to measure the trade-off ratio between inflation variability and output-gap variability because it is based on unconditional volatilities; this paper concentrates instead on conditional volatilities. Moreover, the construction of (9) requires estimating γ which involves the level of the series rather than their variabilities. We use instead the ratio of the impact that a supply shock has on output-gap variability to the impact that the same shock has on the inflation variability; in other words, this ratio measures the unit cost of output-gap variability in terms of inflation variability. More concretely, we use a bivariate stochastic volatility model that includes the output-gap variability and the inflation variability. We postulate a statistical model based on theoretical priors: shocks that move both variabilities in the same direction are identified as demand shocks. When variabilities move in the opposite direction they are characterised as supply shocks.

Turning to the empirical aspects of the trade-off under investigation we note that over the past several years there has only been a small number of empirical studies that attempt to estimate a long-run trade-off between inflation variability and output-gap variability (see, for example, Taylor 1980, 1994; Further and Moore 1995; and Further 1997). These studies conclude that any attempt to stabilize inflation leads to higher output-gap variability. More recently, Chechetti and Ehrman (1999) using the model to which we referred above, estimate the changes in the preferences of monetary policy makers in 23 industrialized and developing

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[2] Recent contributions utilizing intertemporal general equilibrium models with staggered price setting and completely flexible wages, have called into question the possibility of a variability trade-off. These models consist of asymmetric demand and supply equations derived from the dynamic optimizing behavior of firms and households (Yun, 1996; Bernanke, Gertler and Gilchrist, 1998; and Erceg et al., 1998). Furthermore, they include an explicit monetary policy rule (an interest rate policy rule) and its transition mechanism. Within this framework (see, for example, Goodfriend and King, 1997), monetary policy rules that keep inflation constant also minimize output-gap variability. All of these studies imply that monetary authorities have to adopt a strict inflation targeting. Erceg et. al. (1998), however, demonstrate in an optimizing-agent model with staggered nominal wage and price contracts, that the trade-off between inflation variability and output-gap variability is absent only in the special case of sticky prices and perfectly flexible wages. Erceg et. al. (op. cit.) show that

economies including nine that adopted inflation targeting. They find that inflation targeting countries together with nine European Union (EU) countries, attach a higher weight to inflation variability. In preparing for monetary union, the EU countries were forced to behave more like inflation targeting countries. As such they also increased their aversion to inflation volatility, but by slightly less than the inflation-targeting countries. Cecchetti and Ehrmann (op. cit.) compare the late 1980s with the mid-1990s. They observe that since the variability in both output and inflation fell in all countries (targeting and non-targeting) in their sample, the 1990s were relatively shock-free. Therefore, it may be difficult to assess whether the better performance during the 1990s was due to an inflation targeting regime, or mainly to shocks with lower standard deviation hitting the economy (see, also, Bernanke et al. 1999).

In what follows we attempt to tackle these issues by concentrating on 'implicit targeting' countries in the case of eleven EMU members. This is made possible by scaling to unity the variances of both structural shocks. In particular, we identify a bivariate stochastic volatility model by restricting the variance-covariance matrix of the transition equation to an identity matrix for all periods. This implies that the degree of severity of shocks does not vary over the period of investigation, thereby overcoming the problem identified by Cecchetti and Ehrmann (1999); we return to this issue in the section on empirical methodology. We undertake this exercise for yet another reason. As the analysis relating to equations (1)-(9) above shows, the response of monetary authorities to supply shocks (i.e. shocks that induce a trade-off between inflation variability and output-gap variability) that buffet the economy, depends on two factors. First, on the economic structure as measured by the slopes of aggregate demand and supply curves; and second, on the preferences of monetary authorities regarding the stabilisation of output-gap variability and inflation variability. Evidence of differences in the trade-off in each of the EMU countries in the two sub-periods under investigation, implies either the existence of asymmetries in the euro area, or different preferences among the member countries of the EMU concerning ECB monetary policy. Consequently, asymmetric shocks can put strong pressures on the ECB's conduct and stance of monetary policy, thereby undermining its credibility.[3]

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when the model is calibrated to exhibit nominal wage inertia, strict inflation targeting induces substantial output-gap variability.

[3] Credibility may be defined for the purposes of this contribution in the sense of Blinder (1999), that 'deeds are expected to match words', so that economic agents believe that the central bank 'will do what it says'; provided, of course, there is general belief that what the central bank says is sensible.

EMPIRICAL METHODOLOGY

The theoretical and empirical focus of the studies just reviewed is on the relationship between the unconditional standard deviation of the output-gap and inflation. In other words, the focus is on the long-run variability trade-off. We suggest that an explicit model of the transitional (short-run) dynamics can yield useful information on the long-run relationship between the output-gap and inflation variability. For this purpose we focus on an empirical model of the conditional volatilities. To the best of our knowledge, Lee (1999) is the only attempt to analyze the presence of a variability trade-off in the short-run. This study uses a BEKK parameterization of a bivariate linear Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model to US historical data over the period 1960-1997.

We argue that although the BEKK model easily imposes the necessary restrictions to ensure that the matrix of time-varying conditional variances is positive definite, it is inappropriate for estimating and testing for the presence of a variability trade-off. Specifically, the BEKK specification for the bivariate GARCH (1, 1) model uses the following quadratic form:

$$H = K_0^{'} K_0 + A_1^{'} \varepsilon_{t-1} \varepsilon_{t-1}^{'} A_1 + \Delta_1^{'} H_{t-1} \Delta_1 \qquad (10)$$

where K_0 is a (2×1) vector of constants, A_1 and Δ_1 are (2×2) matrices. Suppresing the time subscripts, the (1,1) element of H is given as in (11):

$$h_{11} = c_{11} + \alpha_{11}^2 \varepsilon_1^2 + 2\alpha_{11}\alpha_{21}\varepsilon_1\varepsilon_2 + \alpha_{21}^2\varepsilon_2^2 + \delta_{11}^2 h_1^2 + 2\delta_{11}\delta_{21}h_1 h_2 + \delta_{21}^2 h_2^2 \qquad (11)$$

The coefficients of ε_2^2 and h_2^2 are positive and, therefore, the relationship between variabilities is not measured by the off-diagonal elements of Δ_1 but by the off-diagonal elements of $\Delta_1\Delta_1$'. The latter are always positive and any possible trade-off is automatically ruled out. As an alternative, it is possible to use either an exponential GARCH (EGARCH) or a stochastic volatility model. These methods avoid non-negative restrictions by allowing an exponential specification of the conditional variance. The difference is that in stochastic volatility models the conditional variance is treated as an unobserved component. We experimented with a bivariate EGARCH model between inflation and output-gap, which produced a maximum likelihood function that did not converge to an optimal point (local or global since different starting values were used).[4] Therefore, we choose to estimate a stochastic volatility model for practical reasons (see also, Arestis et. al. 2002).

In the case of a two variable system, a multivariate stochastic volatility model specification is in order. This may be represented as in (12) and (13):

$$w_t = \Theta h_t + \xi_t \quad (12)$$

$$h_t = h_{t-1} + \eta_t \quad (13)$$

where w_t is a 2×1 vector of (de-meaned) stochastic volatilities, h_t is a 2×1 vector of unobservable factors whose dynamics is given by the state equation (13). Θ is a 2×2 matrix of factor loadings, ξ_t is a 2×1 vector of disturbances with mean zero and with variance-covariance matrix $\Sigma_{\xi t}$, and η is a 2×1 vector of normally distributed disturbances with zero mean and variance-covariance matrix $\Sigma\eta$.

The model given by (12) and (13) is not identified. For any non-singular matrix H, the matrix of factor loadings and the trend component could be redefined as $\Theta^* = \Theta H^{-1}$ and $h_t^* = Hh_t$, so that:

$$w_t = \Theta^* h_t^* + \xi_t \quad (14)$$

$$h_t^* = h_{t-1}^* + \eta_t^* \quad (15)$$

where $\eta_t^* = H\eta_t$ and the relationship between the covariance matrices of η and η^* is given by $\Sigma_{\eta*} = H\Sigma_\eta H'$. Then, the model given by (12) and (13) is observationally equivalent to the one given by (14) and (15).

An identifiable model may be set up by requiring that the elements of Θ are such that $\Theta_{ij} = 0$ for $j > i$, i *and* $j = 1, 2$, while Σ_η is an identity matrix. Restricting the variance-covariance matrix Σ_η to an identity matrix, avoids the problem mentioned by Cecchetti and Ehrmann (1999) that there are periods when the economy is hit by less severe shocks than in other periods. This is so because the matrix of structural-factor shocks is restricted in all periods to be equal to the identity matrix. Therefore, we are able to make an assessment concerning the impact of the introduction of inflation targeting (implicit or explicit) on output-gap variability, regardless of the magnitude of the shock hitting the economy. These restrictions are easily imposed and the model may be estimated by the Quasi Maximum

[4] For the optimisation of the maximum likelihood function, we employed the BFGS and BHHH algorithms.

Likelihood (QLM) method, using the Kalman filter. The restrictions on the Θ matrix imply a recursive identifying scheme: the first series is influenced only by the first shock η_{1t}, whereas the second series is influenced by both shocks η_{1t} and η_{2t}. However, this identification scheme is arbitrary and to get a model with useful interpretation we consider a factor rotation matrix (Harvey, 1989). For this reason, a factor rotation is carried out with respect to a frequency ω by post-multiplying Θ by the transpose of the orthogonal matrix H:

$$H = \begin{bmatrix} cos\omega & sin\omega \\ -sin\omega & cos\omega \end{bmatrix} \qquad (16)$$

and the factors $h^*_t = Hh_t$ are still driven by mutually uncorrelated disturbances with unit variances, while the factor loading matrix becomes $\Theta^* = \Theta H'$. Factor rotation can help to interpret the two permanent shocks η_{1t} and η_{2t} according to our prior. In this paper we use 'rotating factors' that are theory consistent. More specifically, we rotate factors in such a way that if a shock moves the two volatilities in the same direction, it is then identified as a demand shock. If, instead, it moves them in the opposite direction, it is identified as a supply shock.

Having estimated the loading factor, we evaluate the trade-off between inflation variability and output-gap variability for the eleven EMU countries for the whole EMS period. Following Arestis et al., (2002), we assess the trade-off between inflation variability and output-gap variability based on the ratio of the impact that supply shocks have on output-gap variability in relation to the impact on inflation variability. This ratio measures the cost of one-unit decrease of inflation in terms of output-gap.[5] Countries where this ratio is lower than that of the other countries in our sample, imply a better monetary policy performance regarding the trade-off between inflation variability and output-gap variability. This might be due to these countries being able to enjoy higher credibility concerning their announcement of a future course of monetary policy. In a second stage we test whether the introduction of an implicit inflation target after the Maastricht Treaty in 1992, changed the ratio of output-gap variability to inflation variability. Given that we have normalised the variance-covariance matrix of shocks to an identity matrix for each sub-sample, a decrease of this ratio suggests an improvement in monetary policy performance unequivocably. More precisely, we examine how this ratio changes from one sub-sample to the next, rather than compare this ratio between countries in each sub-sample.

EMPIRICAL MATTERS AND RESULTS

The empirical analysis has been carried out for eleven EMU member countries. We use quarterly data for the Consumer Price Index (CPI) and for Gross Domestic Product (GDP). All data are from *International Financial Statistics*—*CD ROM* data base. GDP is taken from line 99B and CPI from line 64. However, lack of consistent GDP data for Italy, Belgium and Greece, forced us to repeat the whole exercise using Industrial Production (IP) to measure the output-gap variable—the data for this variable are from the same source as above, line 66. We estimate the model using IP for all countries and not only for the countries where there are not available data for GDP. This is so because the variability of IP is higher than the variability of GDP. Under such circumstances, it is possible for the trade-off ratio in these countries to be higher than in other countries where GDP was used to construct the ouput-gap variable.

Data are used for three periods. The first period covers the EMS era throughout its life, i.e. 1979:Q1 to 1998:Q4. The second period starts from the first quarter of 1979 with the commencement of the EMS, through to the last quarter of 1991, when the Maastricht Treaty was inaugurated. The third period starts from the first quarter of 1992 and terminates in the fourth quarter of 1998, just before the introduction of the EMU and the euro. The reason that we have not extended the period beyond 1998 is that the introduction of the EMU starts a new inflation targeting regime which differs from the one of the pre-1998 period in that it is a great deal more explicit than previously. Indeed, monetary policy since 1999 is conducted by the ECB, while prior to 1999 it had been the responsibility of the national Central Banks.

We perform structural stability tests based on the likelihood ratio to examine whether the selection of the periods under consideration is warranted (Lee 1999). A drawback of this test is that we have chosen the date of the structural break. Other tests where the breakpoint is identified endogenously might be appropriate (Andrews 1993). However, these tests are computationally demanding. Moreover, in the case of more than one break in the whole EMS period, we would have to examine a trade-off between output-gap and inflation variabilities

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[5] We cannot interpret this ratio as the inverse of the supply curve because the slope of the inverse of this curve is the ratio of the impact of policy innovations on output level to the impact on inflation level. Supply shocks in our model explain the reaction of the variabilities of target variables and not of the level.

in a relatively small sub-period. Under such circumstances, and given that we use quarterly data, we do not expect a significant autoregressive pattern in volatilities. The only way to overcome this difficulty is to employ a Markov-regime switching model (MRS) for the whole period (Hamilton 1988, 1989). Although this would be an interesting exercise to undertake, there may be the difficulty that since MRS are reduced-form models, the problem of regime identification could very well arise.

In a state-space model where the transition equation follows a stationary autoregressive process, testing the hypothesis of constancy of regression coefficients is not valid (Hamilton, 1994). In particular, under such circumstances $h_t=\bar{h}$ and $\Sigma_\xi=0$, where $\bar{h}$ is the steady-state value of the state vector h. However, such a specification violates two of the conditions for asymptotic normality to hold. First, under the null hypothesis Σ_ξ falls on the boundary of the parameter space. Second, the elements of the autoregressive matrix of the state equation are unidentified under the null hypothesis. In our specification, however, none of these restrictions hold because the state equation (13) follows a random walk. Therefore, $\Sigma_\xi \neq 0$, $h_t \neq \bar{h}$, and the autoregressive matrix is an identity matrix. This indicates that the Σ_ξ does not fall on the boundary of parameter space and the autoregressive matrix of the state variable is identified. We are, thus, fully justified in examining the constancy of regression coefficients.

The output-gap series have been generated by assuming that the trend is the log of a random walk without drift. We have actually experimented in this by assuming that the trend follows the following two processes: (i) a smooth stochastic process uncorrelated with the cyclical component (Hodrick-Prescott detrending); and (ii) a deterministic linear process uncorrelated with the cyclical component.[6] We selected the random walk process as a measure of the potential output, since only in this way could a sufficient degree of smoothing in the output-gap series be achieved. The annualised inflation is measured by (CPI – CPI_4)/CPI_4, where the subscript denotes the lag order. We do not use the first order difference simply because it leads to high variability in the series, and as a result the variance-covariance matrix of the stochastic volatility model is singular. Therefore, the estimation of the structural factor loading matrix obtained by the Choleski decomposition of the reduced form variance-covariance matrix was not possible.

[6]Canova (1993) explains and describes clearly the application and computation of the filters referred to in the text.

Tables 1 and 2 report estimates of the loading factor matrix Θ in each country.[7] In these tables, SV-GAP and SV-INFL stand for the stochastic volatility of output-gap and inflation respectively. In each table, the two entries in the first column associated with each country, measure the effect of demand shocks on both variabilities. The effect of supply shocks on both variabilities, associated with each country in both tables, is cited on the second column. In what follows we concentrate only on supply shocks, since this is the only case of possible trade-off.[8] In each table RTO stands for the ratio of the trade-off. This is the ratio of the two elements of the second column for each country associated with supply shocks. Finally, in each table logLF, logLF1 and logLF2 denote the likelihood value for the periods 1979:Q1-1998:Q3, 1979:Q1-1991:Q3, and 1992:Q1-1998:Q3 respectively. LRT is the likelihood ratio stability test constructed as follows: LRT=-2[logLF-(logLF1+logLF2)].

The results reported in Table 1 for the whole period, suggest that the ratio used to measure the trade-off for eight EMU member countries ranges from 0.2 for Austria and Ireland to 0.8 for Germany. In the case of Finland, France, the Netherlands, Portugal and Spain this ratio is on average 0.4. These results are consistent with those of Checchetti and Ehrmann (1999) regarding the ratio that measures the cumulative percentage loss of output for one percentage point reduction of inflation. Estimates for each sub-sample indicate that the trade-off between inflation variability and output-gap variability has deteriorated in the period after the Maastricht Treaty for Finland, France Germany, Ireland and Spain. In Ireland the deterioration is not as large as in the other four countries just cited. There is an improvement of the trade-off in the case of Austria, the Netherlands and Portugal.

In Table 2 we repeat our estimation for the eleven EMU countries, utilising IP rather than GDP (we add Belgium, Greece and Italy to the list of countries reported in Table 1; there are consistent quarterly industrial production data for these countries but not GDP). It is important to note that the ratio used to measure the trade-off is expected to be higher compared to the same ratio cited in Table 1. This is so since GDP is less volatile than industrial production (Cecchetti et al. 2002). Indeed, Table 2 indicates that this ratio increases for all countries and for all periods when industrial production is utilised in relation

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[7] In Tables 1-2 the estimated parameters are not accompanied by their standard errors, because the package we employ, STAMP (version 6.2; see Koopman et. al. 2000), does not provide standard errors for the loading factor matrix. To our knowledge empirical applications of multivariate stochastic volatility models do not normally provide standard errors (see, for instance, Harvey et al., 1994).

to when GDP is used. Table 2 also shows that there are three groups of countries. The first group comprises countries with a trade-off ratio lower than 0.2. This group includes Austria, Germany and the Netherlands. The second group includes Belgium, Ireland and Italy where the trade-off ratio is on average 0.9. The third group includes countries with a ratio higher than one (i.e. Finland, France, Greece, Portugal, and Spain). Moreover, Table 2 indicates that in the second sub-period there is an improvement of the trade-off in the cases of Austria, Germany, Ireland and Portugal. The trade-off deteriorates in Belgium, Finland, France, Greece, Italy, the Netherlands and Spain.

As mentioned earlier in this section, we split the sample into two sub-periods and perform a structural stability test based on the likelihood ratio. The bottom row of Table 1 shows that the likelihood ratio test rejects parameter constancy for all countries. The exception to this result is the Netherlands and Ireland. Similarly, the bottom row of Table 2 indicates that the likelihood ratio test rejects the hypothesis of parameter constancy for all countries, with the exception of Austria, Ireland and Spain.

The results in Tables 1 and 2 regarding the two sub-periods (i.e. before and after Maastricht Treaty) are consistent with each other, with the exception of Germany, Ireland and the Netherlands. In Germany there is a deterioration of the trade-off in Table 1 and an improvement in Table 2. We rely more on the results obtained in Table 1 for two reasons. The first is that during the period between 1979 and 1992 the interest rate differential between Germany and the other EMS member countries was high, although Austria and the Netherlands were the exception. Germany was the anchor country to transmit 'deflationary credibility' to the rest of the countries in the EMS. Under these circumstances it may be argued that German monetary policy enjoyed more flexibility since the other EMS countries followed it. In the second period, interest rates in most of the EMS member countries had almost converged to the German interest rate level (Caporale et al. 1996). Consequently, flexibility in the use of monetary policy to stabilise supply shocks for the German monetary authorities was rather limited. The second factor that might explain the deterioration of the trade-off is the German unification in 1990. Although the German unification happened in the first sub-period, it had long-run effects that led to the currency crises in 1992 and 1993.

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[8]Svensson (1998) shows that in the context of an open economy, demand and productivity shocks produce similar effects and it is, therefore, difficult to differentiate between different types of shocks. More recently Walsh (1999) has argued that in the open economy case a trade-off arises regardless of the type of shock. The EMU, however, is much closer to a closed economy, and consequently we concentrate on those shocks that could potentially generate a trade-off between inflation and output-gap variability.

The needs of unification required an expansionary fiscal policy, which put a high inflationary pressure leading to substantial increases in interest rates (De Grauwe 1997).

In the case of Ireland as in Germany there is a deterioration of the trade-off in Table 1 and an improvement in Table 2. However, results of structural stability tests accept the hypothesis of parameter constancy for the case of Ireland in both Tables. Therefore, any evidence of deterioration or improvement is misleading.

In the Netherlands there is improvement of the trade-off in Table 1 and deterioration of it in Table 2. The latter result is rather strange, since the credibility of monetary policy in the Netherlands regarding stabilisation of inflation, was high over the whole period. Under such circumstances a central bank can stabilise inflation at a low cost in terms of the output-gap variability. Monetary policy performance in the Netherlands is, thus, more attuned to the results obtained in Table 1 where GDP is utilised rather than IP.

The overall conclusion of the results reported in both tables, and our discussion on them, clearly support our contention that it is imperative to examine the trade-off for each country for both the whole EMS period and the two sub-periods before and after the Maastricht Treaty.

SUMMARY AND CONCLUSIONS

This paper has investigated the monetary policy performance of EMS member countries, based on a trade-off ratio between output-gap variability and inflation variability for the whole period of the EMS. It also examined whether the adoption of an implicit inflation targeting by EMS countries after the Maasticht Treaty in 1992 changed the trade-off between output-gap variability and inflation variability. A stochastic volatility model was employed throughout the study. GDP and IP were used to construct the output-gap variable. For the whole period of the EMS, our empirical findings show that the trade-off ratio varies amongst the countries included in the sample. Evidence for each sub-period shows that there is improvement of the trade-off ratio in some cases and deterioration in others. The implication of these findings is that they point to the existence of asymmetries in the euro area, in view of different preferences concerning monetary policy and different economic structures amongst the EMU member countries. Under such circumstances asymmetric shocks can put a strong pressure on the ECB, potentially undermining its credibility.

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Table 1: Loading Factor Matrix for eight EMU countries (GDP)

Period 1979:Q1-1998:Q4

	AUS		**FIL**		**FRN**		**GER**	
SV-GAP	0.34	-0.10	0.55	-0.16	0.47	-0.13	0.23	-0.36
SV-INFL	0.24	0.50	0.18	0.41	0.04	0.28	0.58	0.42
RTO		0.20		0.39		0.46		0.85
-2LogLF	-105		-219.48		-294.03		168.87	

	IRL		**NET**		**POR**		**SPN**	
SV-GAP	0.34	-0.11	0.70	-0.20	0.09	-0.04	0.24	-0.07
SV-INFL	0.15	0.50	0.26	0.48	0.28	0.10	0.10	0.17
RTO		0.22		0.41		0.40		0.41
-2LogLF	-80.66		-62.28		-307.51		-476.9	

Period 1979:Q1- 1991:Q4

	AUS		**FIL**		**FRN**		**GER**	
SV-GAP	0.37	-0.11	0.33	-0.09	0.21	-0.07	0.41	-0.12
SV-INFL	0.31	0.57	0.11	0.21	0.08	0.22	0.16	0.70
RTO		0.19		0.42		0.31		0.17
-2LogLF1	-108.80		-231.3		-284.52		203.38	

	IRL		**NET**		**POR**		**SPN**	
SV-GAP	0.83	-0.24	0.56	-0.22	0.24	-0.07	0.19	-0.05
SV-INFL	0.11	0.30	0.47	0.57	0.07	0.21	0.09	0.18
RTO		0.80		0.38		0.33		0.27
-2LogLF1	-54.44		-5.38		-243.77		-321.5	

Period 1991:Q4- 1998:Q4

	AUS		**FIL**		**FRN**		**GER**	
SV-GAP	0.19	-0.05	0.38	-0.11	0.17	-0.06	0.41	-0.12
SV-INFL	0.49	0.73	0.17	0.19	0.11	0.09	0.03	0.22
RTO		0.06		0.57		0.66		0.54
LogLF2	-53.64		-106.2		-181.65		35.65	

	IRL		**NET**		**POR**		**SPN**	
SV-GAP	0.69	-0.20	0.30	-0.08	0.09	-0.02	0.12	-0.03
SV-INFL	0.15	0.24	0.12	0.26	0.24	0.07	0.10	0.05
RTO		0.83		0.30		0.28		0.60
-2LogLF2	-33.64		-60.15		-104.23		-208.3	

Stability Likelihood Ratio Test (LRT)

	AUS	**FIL**	**FRN**	**GER**	**IRL**	**NET**	**POR**	**SPN**
LRT	55.9*	118.12*	172.14*	70.15*	7.42	3.40	41.25*	52.9*

Notes: RTO is the ratio of the trade-off in absolute terms. logLF, logLF1 and logLF2 denote the likelihood value for the periods 1979:Q1-1998:Q3, 1979:Q1-1991:Q3, and 1992:Q1-1998:Q3 respectively. LRT is the likelihood ratio stability test constructed as follows: LRT=-2[logLF-(logLF1+logLF2)]. The likelihood ratio test (LRT) has a $\chi^2(7)$ distribution. One star and two stars denote rejection of the null hypothesis at the 1% and 5% levels of significance, where the critical values are 18.5 and 14.1 respectively. The country codes are: AUS, Austria; BEL, Belgium; FIL, Finland; FRN, France; IRL, Ireland; ITL, Italy; GER, Germany; GR, Greece; NET, the Netherlands; POR, Portugal; SPN, Spain. The entries in the two columns for each country measure the effect of demand shocks (first column) and supply shocks (second column) on both volatilities.

Table 2: Loading Factor Matrix for eleven countries (IP)

Period 1979:Q1-1998:Q4

	AUS		BEL		FIL		FRN		GER	
SV-GAP	0.40	-0.11	0.95	-0.27	1.09	-0.56	0.82	-0.42	0.042	-0.06
SV-INFL	0.50	0.81	0.31	0.30	0.25	0.51	0.004	0.29	0.005	0.35
RTO		0.13		0.90		1.09		1.44		0.17
-2LogLF	-21.5		-33.65		-54.69		-132.70		164.74	

	GR		IRL		ITL		NET		POR		SPN	
SV-GAP	0.90	-0.26	0.99	-0.28	0.59	-0.17	0.12	0.05	1.38	-0.40	0.65	-0.32
SV-INFL	0.03	0.06	0.13	0.35	0.04	0.18	0.54	-0.26	0.05	0.29	0.002	0.19
RTO		4.33		0.80		0.94		0.19		1.39		1.68
-2LogLF	-196.8		-80.66		-38.15		19.26		-74.56		-166.8	

Period 1979:Q1-1991:Q4

	AUS		BEL		FIL		FRN		GER	
SV-GAP	0.46	-0.13	1.14	-0.33	1.16	-0.33	0.57	-0.16	0.75	-0.21
SV-INFL	0.70	0.86	0.41	0.26	0.08	0.18	0.01	0.24	0.09	0.45
RTO		0.15		1.26		1.83		0.66		0.46
-2LogLF1	3.68		-29.29		-144.83		-111.69		100.35	

	GR		IRL		ITL		NET		POR		SPN	
SV-GAP	0.60	-0.17	0.97	-0.28	0.64	-0.18	0.32	-0.23	1.36	-0.39	0.33	-0.24
SV-INFL	0.05	0.07	0.04	0.33	0.07	0.21	0.76	0.61	0.06	0.21	0.02	0.20
RTO		2.42		0.84		0.88		0.37		1.85		1.20
-2LogLF	-177		-54.44		-91.38		33.43		-87.23		-107.6	

Period 1992:Q1-1998:Q4

	AUS		BEL		FIL		FRN		GER	
SV-GAP	0.30	-0.09	1.29	-0.37	0.97	-0.28	0.53	-0.15	0.06	-0.01
SV-INFL	0.03	0.72	0.63	0.26	0.10	0.13	0.01	0.15	0.34	0.10
RTO		0.12		1.42		2.15		1.00		0.10
-2LogLF2	-29.8		-18.34		-93.33		-75.13		81.69	

	GR		IRL		ITL		NET		POR		SPN	
SV-GAP	0.78	-0.22	0.26	-0.07	0.93	-0.24	0.58	0.58	0.87	-0.25	0.25	-0.18
SV-INFL	0.05	0.09	0.25	0.18	0.12	0.25	0.03	0.3	0.13	0.22	0.13	0.09
RTO		2.44		0.38		0.98		1.93		1.13		2.00
-2LogLF	-64.3		-33.64		-51.61		24.20		-64.62		-66.21	

Stability Likelihood Ratio Test (LRT)

	AUS	BEL	FIL	FRN	GER	GR	IRL	ITL	NET	POR	SPN
LRT	4.62	14.6**	183.7*	54.1*	17.2**	44.5*	7.42	104.8*	38.3*	76.7*	7.00

Notes: RTO is the ratio of the trade-off in absolute terms. logLF, logLF1 and logLF2 denote the likelihood value for the periods 1979:Q1-1998:Q3, 1979:Q1-1991:Q3, and 1992:Q1-1998:Q3 respectively. LRT is the likelihood ratio stability test constructed as follows: LRT=-2[logLF-(logLF1+logLF2)]. The likelihood ratio test (LRT) has a $\chi^2(7)$ distribution. One star and two stars denote rejection of the null hypothesis at the 1% and 5% levels of significance, where the critical values are 18.5 and 14.1 respectively. The country codes are: AUS, Austria; BEL, Belgium; FIL, Finland; FRN, France; IRL, Ireland; ITL, Italy; GER, Germany; GR, Greece; NET, the Netherlands; POR, Portugal; SPN, Spain. The entries in the two columns for each country measure the effect of demand shocks (first column) and supply shocks (second column) on both volatilities.