MONETARY UNION OF SMALL OPEN ECONOMIES: THE ROLE OF TRANSPARENCY MISPERCEPTIONS*

1. Introduction

The literature on optimal monetary policy in currency unions postulates that the public is fully knowledgeable about the policymakers' preferences. This contrasts with the practice of monetary policy, which is characterized by imperfect transparency and market misperceptions surrounding interest rate announcements. One example is the pervasive lack of numeric output targets, which contrasts with a more precise quantification of inflation targets (Cukierman, 2002). A realistic approach to monetary unions should explicitly model the difficulties faced by private agents in assessing central bank preferences.

The present paper aims at filling this gap by explicitly introducing unobservable policy targets into a monetary union environment. We do so in order to assess whether monetary transparency considerations affect the balance of costs and benefits facing small open economies choosing to join a currency union. Our framework allows for a number of cross-country structural differences (involving country size and macroeconomic shocks). Transmission channels would also be affected by different possible values for structural features (such as supply slopes, the degree of exchange-rate pass-through, etc.). The development of our theoretical setup is preceeded by an empirical evaluation aimed at uncovering patterns in transparency, country size and supply slopes in a broad international context. Finally, we investigate the model's welfare implications carrying out a sensitivity analysis with respect to key parameter values.

This paper is mostly devoted to extending the analysis of a multi-country currency union to the case in which the private sector

* Comments from Javier Reyes are gratefully acknowledged. The views expressed in this paper are those of the author and need not reflect those of the ECB. The usual disclaimer applies.

is unsure about the degree of monetary policy transparency. Unlike Sánchez (2009), who introduces monetary uncertainty in a model of two countries hit by supply shocks, the present extension allows for a large (but finite) number of small open economies to be impacted by a wider array of shocks[1]. We also draw on Geraats' (2007) analysis of transparency misperceptions for a closed economy, whereby it is optimal for the monetary authority to create the perception of transparency about inflation while giving the impression of ambiguity about the output target. Such mix of transparency and opacity helps the central bank reach the policy targets while constraining expected inflation volatility. This analysis relates to models that postulate uncertainty about central bank preferences (Sørensen, 1991; Eijffinger *et al.*, 2000) and look at how information flows impact inflation expectations (Cukierman, 2001; Hahn, 2009)[2].

The rest of the paper is as follows. Section 2 discusses data on transparency, country size and supply slopes. Section 3 sets up the basic model. We then turn to study policy under monetary autonomy (Section 4) and monetary union (Section 5). Section 6 presents our welfare analysis. Section 7 concludes.

2. Evidence on transparency, country size and Phillips curves

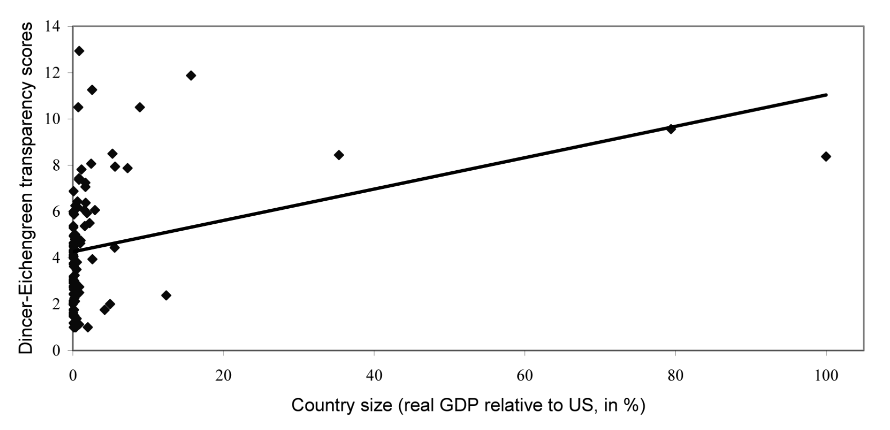
Transparency imperfections are likely to introduce complications into monetary union analysis. We thus attempt to get a sense of whether the scope of such implications can be narrowed down by looking at the empirical relations between transparency, country size and supply slopes – the latter two structural features being known to matter for monetary union. Table 1 reports transparency scores

[1] We look at supply, demand and risk premium shocks, as in Sánchez (2008b). Our treatment of small open economies draws on Ball (1999, 2002) and Svensson (2000). Sánchez (2006) applies a simpler currency union framework to emerging East Asia. In dealing with a finite number of unequally-sized members, we depart from the study of infinitesimal economies of Galí and Monacelli (2008).

[2] While the former branch of the literature mentioned finds that transparency lowers volatility in private-sector expectations and overall economic uncertainty, for the latter information imperfections have the opposite effects. Here, we do not address incentive considerations raised by modelling transparency either as a discipline device for monetary authorities (Faust and Svensson, 2002) or as involving a coordination failure associated with the transmission of public signals (Morris and Shin, 2002).

alongside estimates for supply slopes and country size for a subset of advanced economies, while Figure 1 relates transparency to country size for the largest available sample of 96 economies. Overall, the sample encompasses countries from the euro area (an existing currency union) and euro area candidates Sweden and the UK, on top of – in the case of Figure 1 – many more countries currently participating in, or considering joining, the euro area and other

FIGURE 1 - *Transparency Scores and Country Size*



Sources: Dincer-Eichengreen (2007), IMF's World Economic Outlook and OECD's Economic Outlook.

Note: Data are available for 96 economies (taking 12-country euro area as one single economy). Dincer-Eichengreen transparency scores range from 0 to 15, with a higher value meaning higher transparency (see main text for details). The scores are here reported as averages for the period 1998-2005. Country size is measured as real GDP relative to the US (averages over 1991-2005).

monetary union arrangements. In all cases, country size is measured as real GDP relative to the US starting only in 1991 (due to the mostly recent samples for the other indicators as well as the German reunification). Supply slopes are taken from the Phillips curve results reported in Ihrig *et al*. (2007). Transparency indicators come from three different datasets. Fry *et al*.'s (2000) data measure the quality of 'policy explanations' concerning policy decisions, forecasts and risks to the latter, as well as published assessments and research. Fry *et al*.'s (2000) indices are constructed using survey responses from central banks. In contrast, Dincer and Eichengreen's (2007) and Crowe and Meade's (2008) (henceforth DE and CM, respectively) data cover a wider variety of transparency aspects (including so-called

TABLE 1 - *Transparency Scores, Supply Slopes and Country Size*

	Transparency			Supply slopes (Ihrig *et al.*, 2007)							Country size
	Crowe and Meade (2008)	Dincer and Eichengreen (2007)	Fry *et al.* (2000)	CPI minus trend core inflation*				CPI inflation; foreign output gap#		CPI inflation; tax dummies$	Real GDP relative to US
				No foreign output gap		Foreign output gap		No speed effects	Speed effects		
				BIS	FRB	BIS	FRB	BIS	FRB	FRB	
A) Data											
Euro area	*0.51*	9.6	*0.45*	*0.29*	*0.25*	*0.04*	*0.29*	*0.01*	*0.02*	*0.00*	*10.4*
Austria	0.40	na	0.27	0.45	0.42	0.14	0.43	na	na	Na	2.4
Belgium	0.45	na	0.68	0.41	0.31	-0.03	0.36	-0.13	-0.04	-0.11	3.0
France	0.50	na	0.53	0.25	0.25	-0.01	0.25	0.09	0.06	0.08	16.0
Germany	0.48	na	0.70	0.25	0.13	0.26	0.16	na	na	na	22.4
Italy	0.60	na	0.81	0.34	0.34	0.11	0.44	-0.01	-0.04	-0.06	15.4
Netherlands	0.65	na	0.79	0.16	0.14	-0.01	0.16	0.10	0.12	0.09	4.7
Spain	0.48	na	0.59	0.20	0.19	-0.16	0.25	na	na	na	8.9
Non-euro area countries	*0.74*	*9.8*	*0.75*	*0.24*	*0.21*	*0.04*	*0.13*	*0.11*	*0.11*	*0.01*	*24.3*
Australia	0.50	8.5	0.78	0.26	0.15	0.02	0.17	-0.19	-0.19	-0.03	5.2
Canada	0.68	10.5	0.79	0.15	0.14	0.05	0.14	0.27	0.31	0.01	8.9
Japan	0.85	8.4	0.89	0.20	0.19	0.12	0.19	0.05	0.07	0.17	35.3
Sweden	0.90	11.3	0.95	0.14	0.14	0.05	0.04	0.03	0.03	0.02	2.6
Switzerland	0.55	8.1	0.86	0.48	0.36	0.19	0.24	0.02	0.06	-0.15	2.4
UK	0.95	11.9	0.94	0.24	0.24	0.00	0.18	0.47	0.34	-0.10	15.7
US	0.83	8.4	0.95	0.22	0.23	-0.13	-0.03	0.14	0.17	0.13	100.0

TABLE 1 - *Continued*

Transparency				Supply slopes (Ihrig *et al.*, 2007)							Country size
	Crowe and Meade (2008)	Dincer and Eichengreen (2007)	Fry *et al.* (2000)	CPI minus trend core inflation*				CPI inflation; foreign output gap#		CPI inflation; tax dummies$	Real GDP relative to US
				No foreign output gap		Foreign output gap		No speed effects	Speed effects		
				BIS	FRB	BIS	FRB	BIS	FRB	FRB	
B) Correletions with transparency											
Crowe and Meade (2008)	1.00	0.53	0.79	-0.55	-0.35	0.16	-0.62	0.65	0.59	0.35	0.40
Dincer and Eichengreen (2007)	0.53	1.00	0.13	-0.51	-0.36	-0.17	-0.11	0.66	0.55	-0.24	- 0.35
Fry *et al.* (2000)	0.79	0.13	1.00	-0.42	-0.43	-0.08	-0.64	0.33	0.32	0.04	0.36

Sources: Crowde and Meade (2008), Dincer and Eichengreen (2007), Fry *et al.* (2000), Ihrig *et al.* (2007) and OECD's Economic Outlook.

Notes: Countries are classified according to whether they belong to the euro area or not. We calculate means for the different groupings as unweighted averages whenever data for all countries are available. For transparency scores, Fry *et al.* (2000) only covers year 1998, while the values given for Dincer and Eichengreen and Crowe and Meade data are averages over the years available (1998 through 2005, and 1998 plus 2006, respectively). Moreover, Crowe and Meade data for Japan are only available for 2006. In all cases, a higher value indicates more monetary policy transparency. Supply slopes are measured in terms of the coefficient of the domestic output gap in a regression of consumer price inflation, with the variants described in the Table. All supply slope results are from Ihrig *et al.* (2007). BIS refers to results in turn taken from Borio and Filardo (2007), while FRB are those produced by Ihrig *et al.* (2007) themselves.

The estimation periods are as follows: * 1985-2005; # 1985-2005 except Australia (1991-2005); and $ 1991-2005. Country size is measured as real GDP relative to the US (averages over 1991-2005), in PPP US dollars of 1995.

political, economic, procedural, policy and operational dimensions) and are derived from information available publicly on central bank's websites and publications.

In Table 1, transparency scores display high correlation (0.80) with each other only in the case of the pair (CM, Fry *et al.*, 2000). The results for the full set of countries (not shown) indicate more consistent comovements between any pair of transparency data, with correlations in the range of 0.58 to 0.72 among 61 to 88 economies. With regard to the transparency/size nexus, for the subset of advanced countries in Table 1, correlations are low. Again, there is some disagreement between transparency measures – the link with size being positive for CM and Fry *et al.*'s (2000), and negative in the DE case. This discrepancy does not however hold for the full set of countries. As shown in Figure 1, the correlation between DE transparency and size is positive, with the correlation coefficient (0.34) being fully comparable to those resulting from using CM or Fry *et al*. (2000) data (at 0.34 and 0.33, respectively). Such low correlations can be traced to rather diverse experiences at the country level. For instance, in Table 1, among small economies Sweden tends to exhibit high transparency while the opposite is the case for Austria. Among the larger countries, some show high transparency (Japan, UK and the US) whereas euro area member states have tended to be less transparent – with DE scores being on average more benign for the grouping in this regard.

Turning to the evidence on supply slopes, there appears to be a disagreement between the various available estimates. The correlation is negative when slopes are computed on the basis of inflation minus its core trend, positive when headline inflation is used alongside foreign output gap as a regressor, and ambiguous when controlling for tax dummies. In some cases, the correlations are as high as 0.5 to 0.65, but associations are mostly relatively weak. An illustration of this is that, among countries that possess steep supply curves, some tend to exhibit high transparency scores (such as Italy and the Netherlands) while others (such as Austria and to some extent Switzerland) appear to overall be less transparent[3].

Overall, the existing evidence points to identifiable cross-country

[3] Concerning exchange-rate pass-through, existing studies tend to uncover cross-country differences as considerable as those earlier reported for supply slopes. See e.g. Ca' Zorzi *et al*. (2007), Bussiere and Peltuonen (2008) and – for the narrower set of EU new member states – Beirne and Bijsterbosch (2008) and María-Dolores (2008).

differences in country size in an international context. No clear pattern emerges between country sizes and transparency scores, in part as a result of rather diverse experiences across the countries considered and over time. It is worth mentioning that the unclear size/transparency nexus has also been affected – even if to a limited extent – by discrepancies across data sources available for transparency scores. Moreover, a similar uncertainty affects our knowledge of supply slopes, with estimates of the latter appearing to be largely affected by the specific dataset used and/or econometric specification attempted. The inconclusive patterns detected here suggest that, in order to better understand the role of transparency in a monetary union, it is advisable to set up a general framework that can then be applied to specific cases in more detailed analyses. In particular, our model will allow for country-specific transparency misperceptions and country sizes, while in the case of other structural characteristics (such as supply slopes and the degree of exchange-rate pass-through) we study changes that are for simplicity constrained to be the same across economies. An effort in this direction is attempted in what follows.

3. A simple model

For each country $i=1,2,...,n$ of country size φ_i, four equations describe the economy:

$$\pi_i = \pi_i^e + a y_i - y q_i + \varepsilon_i \tag{1}$$

$$y_i = \beta_i r_i - \delta_i q_i + d_i \tag{2}$$

$$r_i = q_i - q_{i,+1}^e + f_i \tag{3}$$

$$r_i = R_i - \pi_{i,+1}^e \tag{4}$$

where all variables, with the exception of the inflation rate (π_i) , are expressed in deviations from steady state values. Output (y_i) and the real exchange rate (q_i) are in logs. All parameters are positive. All shocks are i.i.d. white noise errors (with zero mean and constant variance)[4] and uncorrelated with each other for economy i, but allowed to be correlated across countries.

In supply equation (1), inflation in deviations from its expected value (π_i^e) responds positively to output, while also reacting to exchange rate movements (an increase in q_i denotes a real appreciation).

[4] Variances of supply, demand and risk premium shocks are, respectively, $\sigma_{\varepsilon i}^2$, σ_{di}^2 and σ_{fi}^2 .

Equation (2) states that aggregate demand is decreasing in the (short-term) real interest rate r_i. Output also depends negatively on q_i. Equation (3) is an uncovered-interest-parity condition relating the interest rate to expected changes in the exchange rate. Finally, (4) is the Fisher equation defining the real interest rate as a short-term interest rate R_i (R in the currency union) minus expected inflation, $\pi^e_{i,+1}$[5]. Positive values for ε_i and d_i represent favorable supply and 'real demand' (henceforth, simply 'demand') shocks, respectively; a positive value of f_i captures an adverse risk premium shock.

Supply schedule (1) deserves further discussion. A steeper supply curve (higher a) is known to raise monetary stabilization costs under supply shocks, with the deviation of inflation from target becoming larger for a given change in output. The responsiveness of inflation to the exchange rate, γ, captures a direct (supply-side) component of the total corresponding pass-through. In the following, we take γ to be positively related to trade openness[6]. Furthermore, we aim at reaching some conclusions concerning the case of countries exhibiting both small size and a high degree of trade openness, given the evidence that openness is inversely related to country size (Alesina and Spolaore, 2003; Alesina *et al.,* 2005).

4. Autonomous monetary policy

In this case monetary authorities choose policy at the country level, minimizing the loss function

$$L_i = \frac{1}{2}[(y_i - \kappa_i)^2 + \chi(\pi_i - \theta_i)^2] \tag{5}$$

which penalizes inflation and output deviations from their respective targets, θ_i and κ_i. Parameter χ is the weight of inflation aversion relative to output stability. Inflation and output targets are both

[5] We model financial markets as being forward-looking, but assume for tractability backward-looking inflation expectations. In an environment also of monetary policy uncertainty, Orphanides' (2003) and Geraats' (2007) asymmetric information results are found to be robust to expectational assumptions about inflation.

[6] Trade openness may also make the supply slope steeper since, for a given real exchange rate depreciation associated with output expansion, the inflationary effect is larger the higher the degree of openness. See Sánchez (2007, 2008a) for monetary union applications of such approach.

stochastic, with $\theta_i \sim N\left(\bar{\theta}_i, \sigma^2_{\theta_i}\right)$ and $\kappa_i \sim N\left(\bar{\kappa}_i, \sigma^2_{\kappa_i}\right)$, and θ_i and κ_i independent.

The private sector has an informational disadvantage *vis-à-vis* the monetary authority as it does not observe the inflation target θ_i and output target κ_i. Instead, it receives public signals

$$\xi_i^\theta = \theta_i + \varsigma_i \tag{6}$$

$$\xi_i^\kappa = \kappa_i + \eta_i \tag{7}$$

where ς_i and η_i are i.i.d. white noise. Noise terms ς_i and η_i capture errors made by the private sector in interpreting the monetary authority's communication. The central bank observes these terms' actual distributions $\varsigma_i \sim N\left(\bar{\theta}_i, \sigma^2_{\varsigma_i}\right)$ and $\eta_i \sim N\left(\bar{\kappa}_i, \sigma^2_{\eta_i}\right)$. From this point of view, the degree of transparency associated with signals ξ_i^θ and ξ_i^κ can be described by

$$\tau_i^\theta \equiv \frac{\sigma^2_{\theta_i}}{\sigma^2_{\theta_i} + \sigma^2_{\varsigma_i}}; \text{ and } \tau_i^\kappa \equiv \frac{\sigma^2_{\kappa_i}}{\sigma^2_{\kappa_i} + \sigma^2_{\eta_i}} \tag{8}$$

respectively, where $0 \leq \tau_i^\theta, \tau_i^\kappa \leq 1$. This measure of accuracy is analogous to that introduced by Faust and Svensson (2002). When $\sigma_{\varsigma i} = \sigma_{\eta i} = 0$, the signals ξ_i^θ and ξ_i^κ transmit θ_i and κ_i without any noise. Thus, there is perfect actual transparency about the central bank's targets.

Unlike the central bank, the public does not know the actual stochastic distributions of θ_i, κ_i, ς_i and η_i. Instead, the public uses the perceived distributions $\theta_i \sim N\left(\bar{\theta}_i, \tilde{\sigma}^2_{\theta_i}\right)$, $\kappa_i \sim N\left(\bar{\kappa}_i, \tilde{\sigma}^2_{\kappa_i}\right)$, $\varsigma_i \sim N\left(\bar{\theta}_i, \tilde{\sigma}^2_{\varsigma_i}\right)$ and $\eta_i \sim N\left(\bar{\kappa}_i, \tilde{\sigma}^2_{\eta_i}\right)$. As a result, the perceived degrees of transparency are given by

$$\tilde{\tau}_i^\theta = \frac{\tilde{\sigma}^2_{\theta_i}}{\tilde{\sigma}^2_{\theta_i} + \tilde{\sigma}^2_{\varsigma_i}}; \text{ and } \tilde{\tau}_i^\kappa = \frac{\tilde{\sigma}^2_{\kappa_i}}{\tilde{\sigma}^2_{\kappa_i} + \tilde{\sigma}^2_{\eta_i}} \tag{9}$$

where $0 \leq \tilde{\tau}_i^\theta, \tilde{\tau}_i^\kappa \leq 1$.

Monetary policy is assumed to be conducted under discretion. Events unfold as follows. First, the inflation target θ_i and output target κ_i are realized and observed by the monetary authority. Then, the public receives the signals ξ_i^θ and ξ_i^κ, which are an input to π_i^e, the private-sector rational expectations about inflation. Next, aggregate supply shock ε_i, demand shock d_i and risk premium shock f_i are realized and observed by the central bank. Finally, the central bank chooses interest rate R_i, with implications for the levels of inflation π_i and output y_i.

The central bank aims at selecting the interest rate so as to stabilize inflation and output. The equilibrium can be obtained by solving the model backwards. That is, given expectations about inflation and the real exchange rate, the central bank solves its optimization problem, implying solutions for π_i^e, $\pi_{i,+1}^e$ and $q_{i,+1}^e$. However, since the monetary policy reaction function is found to be linear in the shocks, for simplicity we impose the result that expected inflation equals the targeted level (also assumed to be credible), implying $\pi_i^e = \pi_{i,+1}^e$. Moreover, given the stability of forward solution in light of $\omega \in (0,1)$, it is possible to show that $q_{i,+1}^e = 0$. Minimization of the expected value of loss function (5) with respect to R_i, taking into account (1)-(4) and given private-sector inflation expectations π_i^e, yields inflation and output levels

$$\pi_i = \phi\left(\pi_i^{\,e} + \frac{\chi}{\alpha^2}\theta_i + \frac{\kappa_i}{\alpha} + \varepsilon_i - \gamma\vartheta d_i + \gamma\omega f_i\right) \tag{10}$$

$$y_i = (1-\phi)\alpha\left(-\pi_i^{\,e} + \theta_i + \frac{\alpha_i}{\chi}\kappa_i - \varepsilon_i + \gamma\vartheta d_i - \gamma\omega f_i\right) \tag{11}$$

where $\alpha \equiv 1/(a + \gamma\vartheta)$, $\vartheta \equiv 1/(\beta + \delta)$, $\omega \equiv \beta\vartheta$, and $\phi \equiv \alpha 2/(\alpha 2 + \chi)$. Composite coefficient α, whose definition encompasses both supply and demand parameters, can be regarded as an overall inflation-output tradeoff. In (10) and (11), factors ϕ and $1-\phi$ indicate how optimal monetary policy splits the cost of the supply shock between output and inflation. In equation (10) inflation is increasing in the inflation target θ_i, the output target κ_i and private-sector inflation expectations π_i^e, and decreasing in the aggregate supply disturbance ε_i.

Private-sector inflation expectations depend on perceptions regarding the inflation target θ_i and output target κ_i. By allowing for asymmetric information about the degree of accuracy of monetary policy signals, private-sector transparency misperceptions (that is, deviations between perceived and actual stochastic volatility) are introduced. Using public signals (6) and (7), alongside (9), private-sector rational expectations of policy targets amount to[7]

[7] We use the property that, if x and z are jointly normal, $\mathrm{E}[x\,|\,z] = \mathrm{E}[x] + \dfrac{\mathrm{Cov}[x,z]}{\mathrm{Var}[z]}(z - \mathrm{E}[z])$.

$$\tilde{E}\left[\theta_i \mid \xi_i^{\theta}\right] = \tilde{\tau}_i^{\theta}\, \xi_i^{\theta} + 1 \quad \tilde{\tau}_i^{\theta}\, \bar{\theta}_i \tag{12}$$

$$\tilde{E}\left[\kappa_i \mid \xi_i^{\kappa}\right] = \tilde{\tau}_i^{\kappa}\, \xi_i^{\kappa} + \left(1 - \tilde{\tau}_i^{\kappa}\right)\bar{\kappa}_i \tag{13}$$

Transparency perceptions $\tilde{\tau}_i^{\theta}$ and $\tilde{\tau}_i^{\kappa}$ thus impact the updating of private-sector expectations. As a result, private-sector inflation expectations are found to be

$$\pi_i^e = \bar{\theta}_i + \tilde{\tau}_i^{\theta}\left(\theta_i - \bar{\theta}_i\right) + \tilde{\tau}_i^{\theta}\, \varsigma_i + \frac{\alpha}{\chi}\left[\bar{\kappa}_i + \tilde{\tau}_i^{\kappa}\left(\kappa_i - \bar{\kappa}_i\right) + \tilde{\tau}_i^{\kappa}\, \eta_i\right] \tag{14}$$

In the absence of policy shocks (that is, $\theta_i = \bar{\theta}_i$, $\kappa_i = \bar{\kappa}_i$ and $\varsigma_i = \eta_i = 0$), expected inflation amounts to $\bar{\theta}_i + (\theta/\chi)\bar{\kappa}_i$, a constant.

Substituting (14) into (10) and (11) yields levels of inflation and output involving perceived transparency:

$$\pi_i = \bar{\theta}_i + \phi\left(\frac{\chi}{\alpha^2} + \tilde{\tau}_i^{\theta}\right)\left(\theta_i - \bar{\theta}_i\right) + \phi\tilde{\tau}_i^{\theta}\, \varsigma_i + \frac{\alpha}{\chi}\bar{\kappa}_i + \phi\left(\frac{1}{\alpha} + \frac{\alpha}{\chi}\tilde{\tau}_i^{\kappa}\right)\left(\kappa_i - \bar{\kappa}_i\right)$$
$$+ \phi\frac{\alpha}{\chi}\tilde{\tau}_i^{\kappa}\, \eta_i + \phi\varepsilon_i - \phi\gamma\vartheta d_i + \phi\gamma\omega f_i \tag{15}$$

$$y_i = (1-\phi)\alpha\left[\left(1 - \tilde{\tau}_i^{\theta}\right)\left(\theta_i - \bar{\theta}_i\right) - \tilde{\tau}_i^{\theta}\, \varsigma_i\right] + \phi\left[\left(1 - \tilde{\tau}_i^{\kappa}\right)\left(\kappa_i - \bar{\kappa}_i\right) - \tilde{\tau}_i^{\kappa}\, \eta_i\right]$$
$$- (1-\phi)\alpha\varepsilon_i + (1-\phi)\alpha\gamma\vartheta d_i - (1-\phi)\alpha\gamma\omega f_i \tag{16}$$

Optimal inflation and output depend on the central bank's targets θ_i and κ_i, the private sector's priors $\bar{\theta}_i$ and $\bar{\kappa}_i$, the signal noise terms ς_i and η_i, and the supply shock ε_i. Although the degrees of transparency $\tilde{\tau}_i^{\theta}$ and $\tilde{\tau}_i^{\kappa}$ influence inflation and output, they have no effect on the values of these variables that the central bank and the public expect. Under perfect (actual and perceived) transparency ($\tilde{\tau}_i^{\theta} = \tilde{\tau}_i^{\kappa} = 1$, and $\varsigma_i = \eta_i = 0$), the equations become simply $\pi_i = \bar{\theta}_i + (\alpha/\chi)\kappa_i - (\phi/\alpha)\varepsilon_i$ and $\gamma_i = (1 = \phi)\varepsilon_i$, which gives the standard result that the targets θ_i and κ_i influence inflation but fail to affect output.

To derive the optimal degrees of actual and perceived transparency, substitute (10) and (11) into (5) using (14), and rearrange to get

$$L_i = \frac{1-\phi}{2}\Big[\alpha(\tilde{\tau}_i^{\theta}-1)(\theta_i-\bar{\theta}_i)+\alpha\tilde{\tau}_i^{\theta}\varsigma_i+\frac{\bar{\kappa}_i}{1-\phi}+\left(1+\frac{\alpha^2}{\chi}\tilde{\tau}_i^{\kappa}\right)(\kappa_i-\bar{\kappa}_i)$$
$$+\frac{\alpha^2}{\chi}\tilde{\tau}_i^{\kappa}\eta_i+\alpha\varepsilon_i-\frac{\alpha}{1-\phi}\gamma\vartheta d_i+\frac{\alpha}{1-\phi}\gamma\omega f_i\Big]^2 \tag{17}$$

Taking unconditional expectations and substituting for $\tilde{\sigma}^2_{\varsigma_i}$ and $\tilde{\sigma}^2_{\eta_i}$ using (9) yields

$$E(L_i) = \frac{1-\phi}{2}\Bigg[\alpha^2\left(1-2\tilde{\tau}_i^{\theta}+\frac{\left(\tilde{\tau}_i^{\theta}\right)^2}{\tau_i^{\theta}}\right)\sigma^2_{\theta_i}+\left(\frac{\bar{\kappa}_i}{1-\phi}\right)^2+\phi\left(1+2\frac{\alpha^2}{\chi}\tilde{\tau}_i^{\kappa}\right.$$
$$\left.+\left(\frac{\alpha^2}{\chi}\right)^2\frac{\left(\tilde{\tau}_i^{\kappa}\right)^2}{\tau_i^{\kappa}}\right)\sigma^2_{\kappa_i}+\alpha^2\sigma^2_{\varepsilon_i}+\left(\frac{\alpha}{1-\phi}\right)^2\left(\gamma^2\sigma^2_{d_i}+\omega^2\sigma^2_{f_i}\right)\Bigg] \tag{18}$$

Optimization takes into account the constraint that actual and perceived degrees of transparency must lie between 0 and 1. In (18), $E(L_i)$ is decreasing in the actual degrees of transparency τ_i^{θ} and τ_i^{κ}, so that it is best to achieve perfect actual transparency ($\tau_i^{\theta}=\tau_i^{\kappa}=1$). It is also optimal to set $\tilde{\tau}_i^{\theta}=\tau_i^{\theta}$ and $\tilde{\tau}_i^{\kappa}=0$. Taking together, these conditions imply maximum actual and perceived transparency about the inflation target ($\tau_i^{\theta}=\tilde{\tau}_i^{\theta}=1$)[8], while for the output target it is best to have complete actual transparency ($\tau_i^{\kappa}=1$) and minimal perceived transparency ($\tilde{\tau}_i^{\kappa}=1$). These results are reasonable. Perfect transparency (both actual and perceived) about the inflation target, together with perfect actual transparency about the output target, make it simpler for the central bank to achieve its inflation and output targets, thanks to their stabilizing impact on private-sector expectations. At the same time, it is optimal to minimize perceived transparency about the output target, which makes it easier to reach the target without upsetting inflation expectations.

In equilibrium, using (1)-(4) as well as (10), (11) and (14), the interest rate equals

[8] This implies that $\varsigma=0$ as both determined by the central bank and perceived by the public.

$$R_i = \theta_i + \frac{\alpha}{\chi}\bar{\kappa}_i - \phi\vartheta\left(\kappa_i - \bar{\kappa}_i\right) + (1-\phi)\alpha\vartheta\varepsilon_i + \vartheta[1-(1-\phi)\alpha\gamma\vartheta]d_i$$
$$+ \vartheta[\delta - (1-\phi)\alpha\gamma\omega]f_i \qquad (19)$$

In the absence of shocks, the interest rate simply amounts to $\bar{\theta}_i + (\alpha/\chi)\bar{\kappa}_i$, which is the deterministic value for expected inflation previously derived. In addition, the central bank tightens policy as a result of an unanticipated rise in the inflation target and an exogenous decline in the output target, as well as in response to a favorable demand shock and adverse realizations of supply and risk premium shocks.

Moreover, using (19), the levels of inflation and output in (15) and (16) simply become

$$\pi_i = \theta_i + \frac{\alpha}{\chi}\bar{\kappa}_i - \frac{1}{\alpha\vartheta}\left(R_i - \theta_i - \frac{\alpha}{\chi}\bar{\kappa}_i\right) + \varepsilon_i + \left(\frac{1}{\alpha} - \gamma\vartheta\right)d_i + \left(\frac{\delta}{\alpha} + \gamma\omega\right)f_i \qquad (20)$$

$$y_i = \theta_i - \frac{1}{\vartheta}\left(R_i - \theta_i - \frac{\alpha}{\chi}\bar{\kappa}_i\right) + d_i + \delta f_i \qquad (21)$$

5. The currency union

Here we examine the case when n small open economies (indexed by i) form a currency union. The union's monetary authority chooses R to minimize the loss function[9]:

$$L_u = \frac{1}{2}[(y_u - \kappa_u)^2 + \chi(\pi_u - \theta_u)^2] \qquad (22)$$

where u denotes monetary union. In (22), the objective function of the central bank penalizes departures of union-wide output and prices from desired values κ_u and θ_u , respectively. The country-level assumptions regarding information, timing of events and error distributions are analogous to those used in the last section. It is worth stressing that the individual countries' targets θ_i and κ_i are not constrained to be the same, so θ_u and κ_u should be seen as aggregates derived from potentially different and randomly variable country-specific targets.

[9] Union-wide variables are weighted averages using weights $\varphi_i \in (0,1)$ so that $\sum_{i=1}^{n}\varphi_i = 1$.

5.1 Union-wide Output and Prices

Aggregating over national Phillips curves (1) yields

$$y_u = \alpha(\pi_u - \pi_u^e) + \Lambda \tag{23}$$

where $\Lambda \equiv \alpha\gamma(\omega q^e_{u,+1} + \vartheta d_u - \omega f_u)$.

In analogy to the previous section, the single monetary authority selects the interest rate so as to stabilize inflation and output. It is simpler to start solving this problem by minimizing the expected value of (22) with respect to τ_u subject to (23), given union-wide inflation expectations π^e_u. Again, we invoke the result that the monetary policy reaction function is linear in the shocks, which enables us to impose from the beginning the equalities $\pi^e_i = \pi^e_{i,+1}$ and, since $\omega \in (0,1)$, $q^e_{i,+1} = 0$ for all i. By doing so, we once more simplify the derivation of key model results. Optimization leads to inflation and output levels as given by

$$\pi_u = \phi\left(\pi_u^{\,e} + \frac{\chi}{\alpha^2}\theta_u + \frac{\kappa_u}{\alpha} + \varepsilon_u - \gamma\vartheta d_u + \gamma\omega f_u\right) \tag{24}$$

$$y_u = (1-\phi)\alpha\left(-\pi_u^{\,e} + \theta_u + \frac{\alpha}{\chi}\kappa_u - \varepsilon_u + \gamma\vartheta d_u - \gamma\omega f_u\right) \tag{25}$$

Equation (24) and (25) show that π_u and y_u are determined by union-wide private-sector inflation expectations π^e_u and unanticipated developments in all member states, as captured by inflation target θ_u, output target κ_u and economic shocks ε_u, d_u and f_u. As only union-wide aggregate variables feature in (24) and (25), the reaction of overall macroeconomic fluctuations to events in a given country is seen to be proportional to latter's size.

In resemblance to the monetary autonomy case, transparency perceptions $\tilde{\tau}_u^{\theta}$ and $\tilde{\tau}_u^{\kappa}$ influence the private sector's union-wide inflation expectations. The latter can be written as

$$\pi_u^{\,e} = \bar{\theta}_u + \tilde{\tau}_u^{\theta}\left(\theta_u - \bar{\theta}_u\right) + \tilde{\tau}_u^{\theta}\varsigma_u + \frac{\alpha}{\chi}\left[\bar{\kappa}_u + \tilde{\tau}_u^{\kappa}\left(\kappa_u - \bar{\kappa}_u\right) + \tilde{\tau}_u^{\kappa}\eta_u\right] \tag{26}$$

The optimal degrees of actual and perceived transparency can be obtained as follows. First, substitute (24) and (25) into (22) using (26), and rearrange to obtain L_u as the union-wide counterpart to (17). Second, take unconditional expectations to obtain $E(L_u)$ following analogous steps as in the previous section, which using the definition of Λ yields

$$E(L_u) = \frac{1 \quad \varphi}{2} \alpha^2 1 \quad 2\tilde{\tau}_u^{\theta} + \frac{\tilde{\tau}_u^{\theta\,2}}{\tau_u^{\theta}} \sigma_{\theta_u}^2 + \frac{\bar{\kappa}_u}{1 \quad \varphi}^2 + 1 + 2\frac{\alpha^2}{\chi}\tilde{\tau}_u^{\kappa} + \frac{\alpha^2}{\chi}^2 \frac{\tilde{\tau}_u^{\kappa\,2}}{\tau_u^{\kappa}} \sigma_{\kappa_u}^2$$

$$\sigma^2 \quad + \alpha^2 \sigma_{\varepsilon_u}^2 + \frac{\alpha}{1 \quad \varphi}^2 \gamma^2 \quad {}^2\sigma_{d_u}^2 + \omega^2 \sigma_{f_u}^2 \tag{27}$$

As with the case of autonomous monetary policy, $E(L_u)$ depends on the volatility of disturbances at the union level as well as a number of structural parameter values. In equilibrium, the single monetary authority delivers perfect actual and perceived transparency about the inflation target ($\tau_u^{\theta} = \tilde{\tau}_u^{\theta} = 1$). For the output target, it is best to have complete actual transparency ($\tau_u^{\kappa} = 1$) and minimal perceived transparency ($\tilde{\tau}_u^{\kappa} = 0$). The overall mix of actual and perceived transparency is the one that best limits the volatility of private-sector expectations and thus facilitating the task of the single monetary authority. In light of the optimal result that $\tilde{\tau}_u^{\kappa} = 0$, output target noise disturbances η_i turn out not to play any role. Moreover, given that it is optimal for the single monetary authority to deliver complete actual and perceived transparency about the inflation target, this target's signal is provided without noise at the union-wide level ($\varsigma_u = 0$). While this could still be consistent with asymmetric non-zero inflation target noise disturbances, we rule this special case out by assuming that $\varsigma_i = 0$ for all i. Therefore, we will disregard shocks η_i and ς_i in the welfare analysis of Section 6.

The optimal interest rate set by the single monetary authority can be found to be

$$R = \theta_u + \frac{\alpha}{\chi}\bar{\kappa}_u - \phi\vartheta\left(\kappa_u - \bar{\kappa}_u\right) + (1-\phi)\alpha\vartheta\varepsilon_u + \vartheta[1-(1-\phi)\alpha\gamma\vartheta]d_u$$
$$+ \vartheta[\delta - (1-\phi)\alpha\gamma\omega]f_u \tag{28}$$

It is worth saying that R is the same (linear) function of shocks as the autonomous interest rate reaction function (19), but depending on union-wide as opposed to national shocks and constants. In the absence of shocks, the interest rate simply amounts to $\bar{\theta}_u + (\alpha/\chi)\,\bar{\kappa}_u$, which is the deterministic value for expected inflation previously derived. In (28), the central bank tightens policy in reaction to a rise in the inflation target and a decline in the output target, as well as – in the case of economic disturbances – in response to a favorable demand shock and adverse realizations of supply and risk premium shocks.

5.2 Country-level Welfare

Our welfare analysis, which labels the reference country as I, compares the latter's loss function under autonomous monetary policy [L_I for $i=I$ in (5)] with that derived from currency union membership, L_I^u. The latter is captured by the loss function

$$L_I^u = \frac{1}{2}[(y_I^u - \kappa_I)^2 + \chi(\pi_I^u - \theta_I)^2] \tag{29}$$

where Y_I^u and π_I^u denote I's output and prices under currency union participation.

The equilibrium values of Y_I^u and π_I^u can be determined as follows. Using the results that $\underline{\tilde{\tau}}_u^{\theta} = 1$, $\tilde{\tau}_u^{\kappa} = 0$ and $\varsigma_u = 0$, equation (26) implies that $\pi_u^e = \theta_u + (\alpha/\chi)\bar{\kappa}_u$. That is, union-wide inflation expectations depend on aggregates of individual country shocks θ_i and ς_i, as well as the aggregate of mean output targets κ_i in a way that is proportional to the output-inflation tradeoff faced by the single monetary authority, α. Therefore, it is reasonable to assume that individual country shocks inflation expectations follow $\pi_i^e = \theta_i + (\alpha/\chi)\bar{\kappa}_i$ for all i. Using optimal levels of π_u and y_u obtained by plugging π_u^e into (24) and (25), and taking into account domestic Phillips curves (1), we thus obtain the following values of y_I^u and π_I^u:

$$\pi_I^u = \theta_I + \frac{\alpha}{\chi}\bar{\kappa}_I - \frac{1}{\alpha\vartheta}\left(R - \theta_I - \frac{\alpha}{\chi}\bar{\kappa}_I\right) + \varepsilon_I + \alpha d_I + \delta\alpha f_I \tag{30}$$

$$y_I^u = -\frac{1}{\vartheta}\left(R - \theta_I - \frac{\alpha}{\chi}\bar{\kappa}_I\right) + d_I + \delta f_I \tag{31}$$

which can be replaced into (29) to find reference member state's welfare, L_I^u. The expressions (30) and (31) are formally the same as the corresponding ones under monetary autonomy, except that monetary policy is now represented by R instead of being conducted at the country level. In (30) and (31), country I's macroeconomic variables are influenced by the single monetary policy, with R entering in deviation from deterministic expected inflation $\bar{\theta}_I + (\alpha/\chi)\ \bar{\kappa}_I$. Taking (28) into account, this role of R implies that output and inflation in reference country I are influenced by developments in each other member state indirectly. Further to this, country I's macroeconomic variables are driven by its own shocks – the latter failing to be offset by R to the extent done by a national central bank. This highlights the stabilization costs implied by renouncing monetary sovereignty.

6. Relative welfare and sensitivity analysis

The welfare considerations raised by the different shocks hitting member states are complex in nature. Output and inflation in reference country I are first and foremost driven by its own shocks, which however elicit different monetary policy responses depending on whether the country participates in a currency union or not. Unanticipated developments in all other participating countries, through their impact on monetary policy responses at the union level, also affect macroeconomic variables in reference country I. The welfare study of all the possible relevant cases is quite involved, with neither autonomous monetary policy nor the currency union outperforming its alternative on an *a priori* basis.

Against this backdrop, here we proceed to a quantitative welfare study. We consider five sources of uncertainty at the country level, namely, supply shocks ε_i, demand shocks d_i, risk premium shocks f_i, and disturbances hitting inflation and output targets (θ_i and κ_i, respectively). The way the cross-country distribution of shocks impinges on currency union's relative stabilization properties is influenced by specific parameter values. A key feature of our welfare analysis thus consists of investigating the sensitivity of stabilization performance to the main parameter values. Prior to the sensitivity analysis of Subsection 6.2, we tackle in Subsection 6.1 some preliminary aspects that characterize our study of welfare.

6.1 Calibration and a Taxonomy of Shocks

The main parameters of the model used here are the supply slope, a, the reaction of domestic prices to the exchange rate, the reference country's size, φ_I, the price stability coefficient, χ, and the responsiveness of aggregate demand to interest rates and exchange rates, β and δ, respectively. We examine the sensitivity of stabilization performance to changes in key parameters of the model from benchmark values. Some of these parameters enter the main equations of the model as such, while others are part of composite coefficients α, ω, ϑ and ϕ. The parameter values used here follow calibrations from previous work on small open economies. We set $a = 0.4$, $\beta = 0.6$, $\delta = 0.2$ and $\gamma = 0.2$, in line with Ball (1999). Our benchmark value for φ_I is 0.1. Policy target's central values are assumed to equal zero, that is, $\theta_i = \kappa_i = 0$, for all i. Finally, lacking previous estimates for χ for small open economies, we use a benchmark value of 2.58, which matches Broadbent and Barro's (1997) calibration using US data. In our sensitivity analysis we will change one of these parameters at a time. In addition, we will later discuss in the cases of φ_I and γ also in connection with each other, in light of the inverse relation often documented between country size and trade openness.

In our welfare analysis, we classify each of the five shocks of interest into three different types, depending on their distribution across the union's economies. Such three types are: (i) asymmetric; (ii) idiosyncratic; and (iii) common. Shocks are normalized to one for country I, which is – without loss of generality – the focus of our comparisons across regimes. Asymmetric shocks are defined to be shocks that vanish at the currency union level; in particular, country I of size φ_I is assumed to face a shock equal to 1, while each of the remaining countries faces a shock equal to $-\varphi_I/(1-\varphi_I)$. Idiosyncratic shocks are those in which shocks to country I equal 1, and shocks to any other country equal 0. Finally, common shocks are shocks such that all countries face a shock equal to 1. In making these distinctions between shocks, we treat the size and asymmetry of disturbances as given. As mentioned earlier, this simplification neglects the situation where the cross-country distribution of shocks vary with the depth of regional integration and thus across the monetary arrangements considered here.

6.2 Sensitivity Analysis

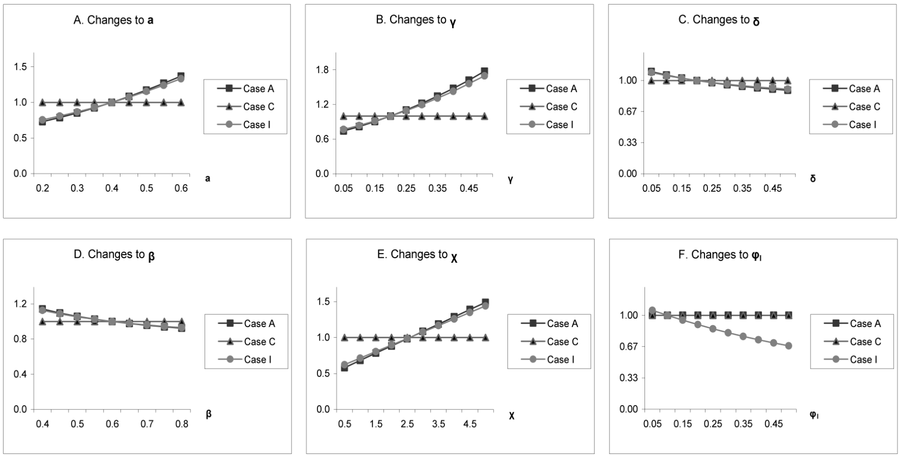
The present subsection assesses the sensitivity of a currency union's stabilization performance to changes in parameter values. To this aim we construct the relative welfare loss ratio $C_{uI}=L^u_I/L_I$. This ratio expresses the value of the loss function (5) for the reference country (that is, for $i=I$) when the latter participates in a currency union in proportion to the same country-level loss function evaluated under monetary autonomy. A decrease in C_{uI} means that country I enjoys higher welfare from participating in a currency union. We set this ratio to one at benchmark parameter values; that is, all values of the ratio are to be interpreted in relation to the benchmark case. As we shall see, the computation of C_{uI} breaks down in one special case, namely, in the event of inflation target shocks θ_i. In this case, the central bank is able to offset the shock in its entirety for all parameter values. Therefore, L_I turns out to be always zero and welfare ratio C_{uI} is indeterminate. We thus decide to report the values of L_I^u for relevant ranges of parameter values. This has no substantial consequences for our overall welfare analysis, given that the value of the loss function under monetary autonomy is parameter-free. For each range of parameter values considered, Figures 1 through 4 show the relative welfare loss as measured by the ratio C_{uI} (relative to baseline) for the remaining four relevant disturbances (to supply, demand, risk premia, and output targets). With regard to inflation targets, Figure 5 presents the value of the loss function under monetary union participation, L_I^u. Moreover, all Figures report welfare results for the three possibilities considered for the cross-country distribution of shocks. These possibilities are labelled as Cases A, C and I, which stand for asymmetric, common and idiosyncratic shocks, respectively. We now turn to the description of our sensitivity results by proceeding one parameter at a time.

A few general aspects concerning our sensitivity results are worth mentioning upfront. First, the welfare effects of parameter changes in general depend substantially on the specific shock considered. Partly due to this reason, we prefer to describe the results by shock rather than by parameter. Second, it turns out that shocks of the common type do not appear to affect the reference country's loss function under currency union membership relative to that under monetary autonomy. Third, in most cases the welfare results of changing a given parameter are similar – qualitatively, but also quantitatively – under the asymmetric and idiosyncratic cases. This suggests that it is the country-specific nature of both shock types (relating to the standard stabilization costs of renouncing monetary sovereignty), and not specifically the monetary policy spillovers induced by asymmetric foreign shocks, that dominate the welfare results in question. The analysis of asymmetric shocks is simpler, so we start by analyzing this case and then assess whether the results carry over to that of idiosyncratic disturbances. The exception to the afore-mentioned similarity in results between asymmetric and idiosyncratic shocks concerns parameter φ_I. Changes in the latter parameter exclusively affect welfare under monetary union, and this only for idiosyncratic shocks. The irrelevance of asymmetric disturbances for the sensitivity of welfare to country size is related to the definition of this shock type, for which the cross-country distribution of shocks is assumed to be such that they offset each other at the union level. Finally, further to the discussion of welfare results for each of the five relevant disturbances – carried out in items a) through e) below – we provide a general discussion in item f), including a summary of results across the model's main parameters.

a) Sensitivity under Supply Shocks

Figure 2 reports sensitivity analysis for the case where only supply shocks ε_i are allowed to hit reference country I and, depending on the shock type, the other $n-1$ currency union members considered. As with all other disturbances studied below, the ranges over which parameters are considered to vary are: a over the range [0.2-0.6], γ over the range [0.05-0.5], δ over the range [0.05-0.5], β over the range [0.4-0.8], χ over the range [0.5-5] and φ_I over the range [0.05-0.5].

FIGURE 2 - *Relative Welfare: Sensitivity under Supply Shocks*



From (20) and (21) using (19), in the present case the values of inflation and output under monetary autonomy are $\pi_I = \phi$ and $y_I = -(1-\phi)\alpha$, respectively. Intuitively, the proportionality factors affecting inflation and output in the event of supply shocks involve composite coefficients ϕ and α, with the former being in turn affected by the latter. The former coefficient captures the way in which the autonomous monetary authority splits the impact of supply shocks between π_I and y_I, while the latter reflects the inflation-output tradeoff facing the policymaker taking all supply- and demand-side considerations into account. In the face of common shocks, from (30) and (31) using (28), the corresponding expressions under monetary union are exactly the same. Therefore, for all parameter values, common supply shocks fail to influence welfare under currency union participation relative to the monetary autonomy case.

In the event of asymmetric supply shocks, (30) and (31) using (28) imply that inflation and output under currency union membership equal $\pi^u_I = 1$ and $y^u_I = 1$, respectively. Given that these values are parameter-free, the welfare ratio C_{uI} depends on parameter values only due to changes in the loss function under monetary autonomy. We now turn to this analysis for each parameter of interest, focusing on the results under asymmetric shocks and comparing them with those obtained under idiosyncratic shocks.

As we have just seen, for shocks of the asymmetric type the effects of changing parameters on relative welfare lie entirely with the loss function under monetary autonomy, L_I. The latter in turn depends on π_I and y_I, which are affected by supply shocks in proportion to ϕ and $(1-\phi)\alpha$, respectively. It is easier to start by realizing that these factors are functions of χ and composite parameter α. Most parameters influence welfare indirectly, via their effect on α. A rise in α induces an increase in ϕ and a fall in $(1-\phi)\alpha$, thereby being responsible – under supply shocks – for higher inflation variability and lower output variability. In light of their inverse relation with α, increases in the supply slope, a, and the reaction of domestic prices to the exchange rate, γ, thus reduce inflation variability while raising output variability. On balance, the former effect turns out to dominate welfare results, with higher values for a and γ improving the performance of monetary autonomy and thus hampering relative welfare under the currency union (see Figure 2, panels A and B). In contrast, rises in the responsiveness of aggregate demand to interest rates and exchange rates, which are respectively denoted by β and δ and both vary positively with, deteriorate welfare under monetary autonomy which improves the currency union's stabilization performance (see Figure 2, panels C and D). The analysis of changes in the price stability coefficient, χ, can be made directly, without looking at those in α. A higher χ leads to a reduction in ϕ and thus an increase in $(1-\phi)$, which induces a fall in inflation variability and a rise in output variability, respectively, when monetary policy is carried out at the country level. Although the increase in χ implies a stronger penalization of inflation deviations from target, the reduction in these deviations drives the result that the parameter change in question on balance favors autonomous monetary policies over those conducted under the currency union regime (see Figure 2, panel E). All sensitivity results discussed thus far for the case of asymmetric supply shocks carry over to the case of idiosyncratic shocks.

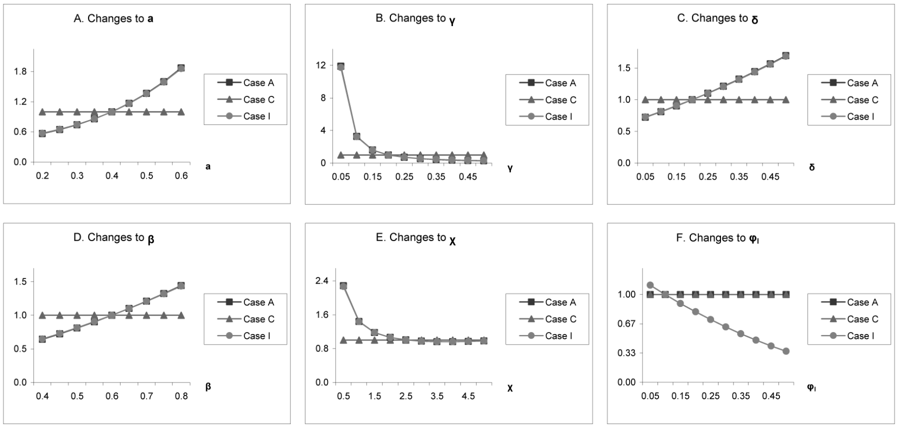
Finally, as mentioned earlier, a change in country size coefficient, φ_I, have welfare implications only under monetary union membership. In this case, the reference country's welfare is unchanged in the face of shocks of the common and asymmetric types. When country I is hit by idiosyncratic shocks, from (30) and (31) using (28), inflation and output in the reference member state are given by $\pi^u_I = 1-(1-\phi)\ \varphi_I$ and $y^u_I = -(1-\phi)\alpha\varphi_I$, respectively. From these two equalities, we can see that a higher φ_I leads to lower variability in both inflation and output under monetary union. This, together with the lack of changes under the monetary autonomy case, is responsible for the higher relative welfare under the currency union.

b) Sensitivity under Demand Shocks

Figure 3 shows sensitivity results for demand disturbances d_i. The analysis is more involved than that of supply shocks. Following the same steps as for the latter, inflation and output can be found to equal $\pi_I = -\phi\gamma\vartheta$ and $y_I = (1-\phi)\alpha\gamma\vartheta$, respectively. On top of factors ϕ and α also weighing on the effect of supply shocks, the product γ ϑ – which combines supply- and demand-side parameters – affects the variability of both π_I and y_I when the reference country is hit by demand shocks. As with ε_i, under demand disturbances of the common type the corresponding levels of inflation and output for a currency union member are exactly the same. For all parameter values, common shocks thus have no impact on relative welfare.

In the case of asymmetric demand disturbances, the same steps followed for supply shocks allow us to express inflation and output in a monetary union participant as $\pi^u_I = a$ and $y^u_I = 1$, respectively. Changes in welfare ratio C_{uI} are mostly attributable to changes in the loss function under monetary autonomy. The only exception, in which L^u_I fails to be parameter-free, is given by inflation developments under the currency union regime in the case of changes to supply slope parameter, a. As before, we address the role of each parameter in driving relative welfare changes, first by looking at the case of asymmetric shocks and then turning to a comparison with respect to idiosyncratic disturbances.

FIGURE 3 - *Relative Welfare: Sensitivity under Demand Shocks*



In our welfare analysis, we still use the intermediate result that an increase in composite coefficient α leads to a rise in ϕ and a fall in $(1-\phi)\alpha$, which in the present case also contributes to raise inflation variability and reduce output variability. For changes in the supply slope, as mentioned in the previous paragraph, we need to consider the sensitivity of welfare results under monetary autonomy and the currency union. With regard to the former, the inverse relation of a with α implies that a steeper supply schedule reduces inflation variability while raising output variability. On balance, the former effect turns out to dominate welfare results, with a higher a improving the stabilization properties of autonomous monetary policies. Additionally, the rise in a causes inflation to be more volatile under a currency union, overall hampering welfare in the latter regime relative to monetary autonomy (see Figure 3, panel A).

Changes in the reaction of domestic prices to the exchange rate, γ, operate both indirectly via α and directly. The two channels amplify the impact of the demand shock in the case of y_I. Concerning π_I, in resemblance to what was analyzed for supply shocks, the link between γ and α points to lower inflation variability. However, the direct pass-through effect of γ tends to raise inflation variability overall. All in all, these sensitivity results indicate that an increase in the responsiveness of prices to the exchange rate is detrimental to monetary autonomy, thereby improving a currency union's relative stabilization properties (see Figure 3, panel B).

Turning to the reaction of aggregate demand to interest rates and exchange rates, higher values of β and δ are associated with an overall reduction in inflation and output variability under monetary autonomy. The fall in output variability of the type already described for supply shocks is now compounded by the induced reduction in composite coefficient ϑ. As regards inflation variability, the rise described under supply shocks (in turn associated with a larger ϕ) is now more than offset by the fall in ϑ, as just mentioned for the case of y_I. Owing to the declines in both inflation and output variability, an increase in either β or δ worsens monetary union stabilization relative to monetary autonomy (see Figure 3, panels C and D).

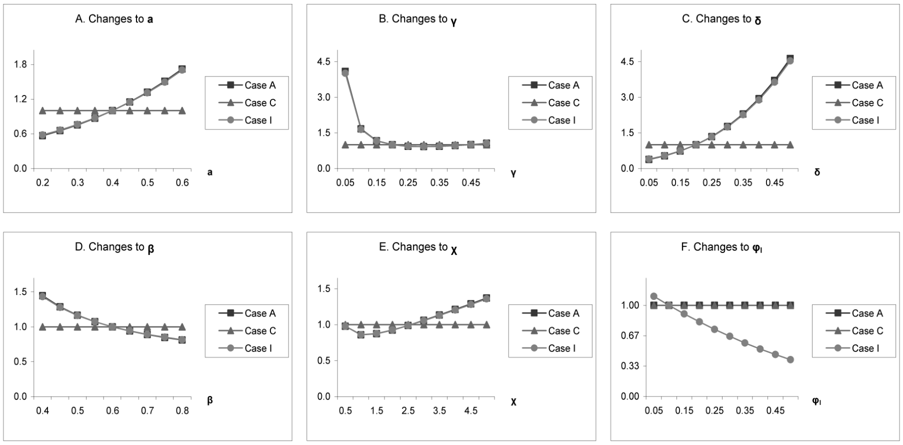
As seen earlier, a higher χ leads to a reduction in ϕ and thus an increase in $(1-\phi)$. Under monetary autonomy, this induces a fall in inflation variability and a rise in output variability. The latter, together with the stronger penalization of inflation deviations from target involved by a rise in χ, drives the result that the parameter change in question on balance hampers autonomous monetary policies compared to that conducted under the currency union regime (see Figure 3, panel E). All sensitivity results discussed thus far for the case of asymmetric demand shocks carry over to the case of idiosyncratic shocks.

Finally, as with supply shocks, a rise in country size parameter φ_I influences welfare only under monetary union participation, and this only in the event of idiosyncratic demand disturbances. Under the influence of the latter, inflation and output levels can be expressed as $\pi^u_I = a(1-\varphi_I) - \phi\gamma\vartheta\varphi_I$ and $y^u_I = 1-\varphi_I + (1-\phi)\alpha\gamma\vartheta\varphi_I$, respectively. From these two equalities, it is clear that an increase in φ_I reduces both inflation and output variability under the currency union. This, together with the absence of changes under the monetary autonomy case, leads to a higher relative welfare when the reference country joins a monetary union.

c) Sensitivity under Risk Premium Shocks

Figure 4 shows changes in welfare ratio C_{uI} in the face of risk premium shocks f_i. From (20) and (21), in the present case the values of inflation and output under monetary autonomy are $\pi_I = \phi\gamma\omega$ and $y_I = -(1-\phi)\alpha\gamma\omega$, respectively. The only difference between these expressions and the corresponding ones derived under demand shocks is the use of composite coefficient ω instead of ϑ. As with supply shocks, inflation and output are affected by factors ϕ – capturing the way monetary policy splits the effect of the disturbance between inflation and output – and overall inflation-output tradeoff coefficient α, but also by the product $\gamma\omega$. Once more, the currency union case implies that country I attains the same levels of inflation and output, and thus of welfare, reached under monetary autonomy.

FIGURE 4 - *Relative Welfare: Sensitivity under Risk Premium Shocks*



Under asymmetric risk premium disturbances, the steps followed in items a) and b) above permit us to express inflation and output under currency union membership as $\pi_I^u = \delta\alpha$ and $y_I^u = \delta$, respectively. The presence of δ in the latter expressions makes the sensitivity analysis of welfare ratio C_{uI} slightly more involved than that under demand shocks. In general, parameters may affect both the loss function under monetary autonomy and that in the case of currency union participation. Under the latter arrangement, the loss function changes only in response to half of the parameters considered, namely, a, δ and χ.

In the cases of parameters a and γ, welfare results are qualitatively similar to those reported for demand shocks. The study of welfare sensitivity with respect to a requires consideration of both regimes. Under monetary autonomy, a steeper supply schedule induces lower inflation variability and higher output variability. The beneficial effect on inflation is stronger, with a rise in a thus on balance improving stabilization under monetary autonomy. Moreover, a steeper supply curve raises inflation variability when interest rates are set by the single monetary authority, thus worsening welfare relative to the monetary autonomy regime (see Figure 4, panel A). Changes in the reaction of domestic prices to the exchange rate, γ, operate both via its indirect effect on α and directly. Both channels tend to amplify the impact of the demand shock in the case of y_I. In the case of π_I, in resemblance to what was analyzed for supply shocks, the link between γ and α points to lower inflation variability. However, the direct effect of γ tends to raise inflation variability overall, in line with the parameter change's contribution to raising exchange rate pass-through. All in all, these sensitivity results indicate that an increase in the responsiveness of prices to the exchange rate is detrimental to monetary autonomy, thereby improving a currency union's relative stabilization properties (see Figure 4, panel B).

Regarding the reaction of aggregate demand to exchange rates, δ, it impacts welfare in both monetary regimes. The effect of a rise in δ under monetary autonomy is qualitatively similar to that described for the case of demand disturbances, leading to a fall in both inflation and output variability. In addition, under risk premium shocks a higher δ induces a higher volatility in both the levels of inflation and output of a country joining a currency union. Overall, thus, relative stabilization properties of the latter monetary arrangement are worse the more responsive aggregate demand to changes in the exchange rate (see Figure 4, panel C). Turning to β, an increase in this parameter leads to higher variability in inflation and output when monetary policy is conducted at the country level. Given that loss function L_I^u is not affected by β, a stronger reaction of aggregate demand to interest rates unambiguously favors participation in a monetary union (see Figure 4, panel D).

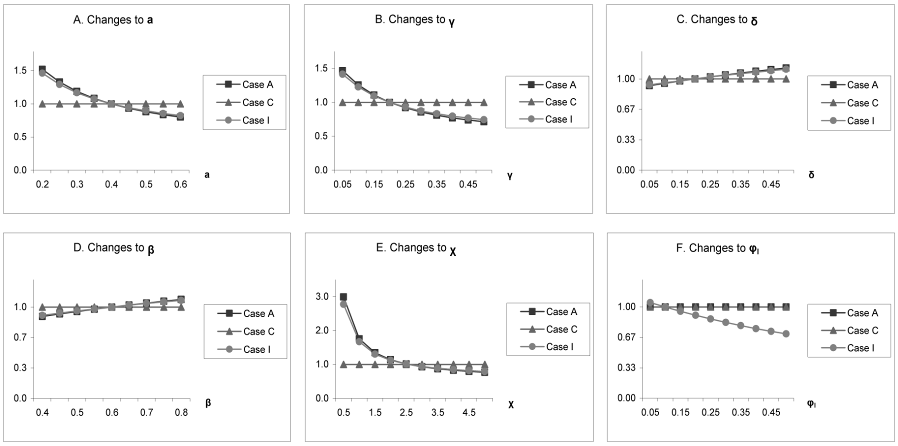
In analogy to the analysis of demand shocks, when monetary policy operates at the country level a higher χ yields a fall in inflation variability and a rise in output variability. In addition, the parameter change under discussion brings about a harsher penalization of inflation deviations from target. Once all these effects are taken into consideration, a rise in χ for values below 1 (at which output stability is deemed more important than inflation stability) is seen to lead to a relative improvement in monetary union stabilization performance. In contrast, the more likely scenario of increases in the price stability parameter above this threshold – and in particular closer to its baseline value of 2.58 – instead favors autonomous monetary policies over those conducted under the currency union regime (see Figure 4, panel E). As can be seen in Figure 4, all sensitivity results discussed for asymmetric risk premium shocks (that is, for parameters a, γ, β, δ and χ) carry over to the case of idiosyncratic shocks.

Turning to country size, the welfare comparison is neutral under risk premium disturbances of the common and asymmetric types. For idiosyncratic shocks, the steps followed in the cases of supply and demand shocks to derive expressions for inflation and output now yield $\pi^u_I = \delta\alpha - [\delta + (1-\phi)\alpha\gamma\omega]\varphi_I/\alpha$ and $y^u_I = \delta - [\delta + (1-\phi)\alpha\gamma\omega]\varphi_I$, respectively. As implied by these equations, a reference country of larger size displays lower variability in inflation and output in a monetary union. These outcomes drive the improvement of a currency union's stabilization performance associated with a higher φ_I.

d) Sensitivity under Output Target Shocks

In Figure 5 we present our sensitivity analysis for output target disturbances κ_i. Unlike the situation under the shocks investigated in items a) through c), those hitting output targets enter the loss functions under monetary autonomy and currency union membership directly, on top of their indirect welfare implications through macroeconomic developments.

FIGURE 5 - *Relative Welfare: Sensitivity under Output Target Shocks*



Inflation and output under monetary autonomy are now given by $\pi_I = \phi/a$ and $y_I = \phi$, respectively. The scenario of common disturbances implies that the macroeconomic variables of a country joining a currency union adopt identical values to these found when monetary policy is conducted at the country level. Consequently, for all parameter values supply shocks of the common type fail to influence the reference country's welfare under currency union participation relative to the monetary autonomy case.

Under asymmetric output target shocks, the values of inflation and output under currency union membership can be found to be $\pi_I^u=0$ and $y_I^u=0$, respectively. Given that level of inflation and the deviation of y_I^u from the corresponding target ($\kappa_I=1$) are both parameter-free, the way welfare ratio C_{uI} depends on parameter values is entirely attributable to changes in the loss function under monetary autonomy. We now turn to this analysis for each parameter of interest, focusing on the results under asymmetric shocks and comparing them with those obtained under idiosyncratic shocks.

As we have just seen, for asymmetric κ_i's sensitivity analysis lies entirely with the loss function under monetary autonomy, L_I. The latter in turn depends on π_I and y_I, which are affected by output target shocks in proportion to and ϕ/α and ϕ, respectively. It is easier to start by realizing that these factors are functions of χ and composite parameter α. Most parameters influence welfare indirectly, via their effect on α. A rise in α induces a fall in ϕ/α and an increase in ϕ, thereby being responsible in the present case for lower variability in both inflation and deviations of output from target. Given their inverse relation with α, increases in the supply slope, a, and the reaction of domestic prices to the exchange rate, γ, produce the opposite effects, thereby hampering the performance of monetary autonomy and improving relative welfare under the currency union (see Figure 5, panels A and B).

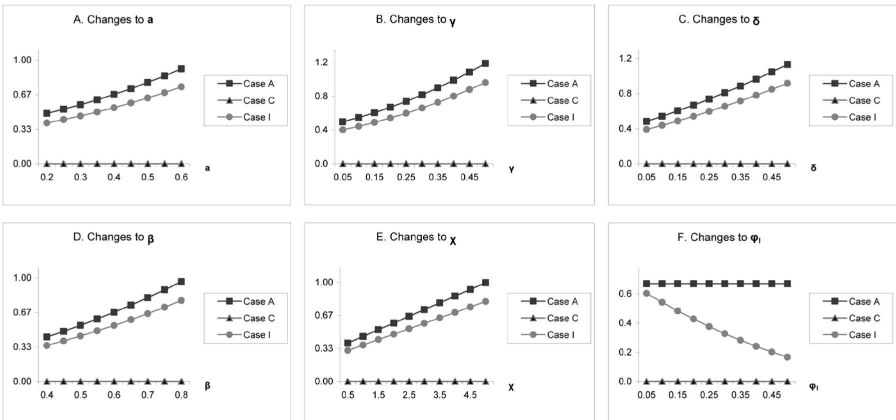
Aggregate demand parameters β and δ both vary positively with composite coefficient α (via their effect on ϑ). Therefore, a rise in the responsiveness of aggregate demand to interest rates and/or exchange rates hampers relative welfare when monetary policy is conducted at the country level (see Figure 5, panels C and D). Turning to χ, an increase in this parameter induces a fall in ϕ and thus a lower variability in both inflation and output. This reduction in output volatility in turn implies larger deviations of output from target, which – together with the stronger penalization of excessive inflation directly implied by the higher χ – determines that a rise in the preference for price stability favors a currency union over monetary autonomy (see Figure 5, panel E). Again, as can be seen in Figure 4 the sensitivity of welfare to the parameter changes examined until now for asymmetric disturbances are qualitatively and quantitatively similar to those found for idiosyncratic shocks.

In resemblance to all other shocks previously examined, a change in country size has welfare implications only if country I joins a currency union and, in addition, output target disturbances are of the common or asymmetric types. In the face of idiosyncratic disturbances, a reference country that joins monetary union has inflation and output levels equal to $\pi^u_I = \phi\varphi_I / a$ and $y^u_I = \phi\varphi_I$, respectively. These expressions imply that a higher φ_I raises both inflation and output variability under monetary union. The latter effect is crucial in that it is in turn associated with a reduction in the gap between output and the corresponding target, which has been shocked. On balance, also in light of the lack of response under monetary autonomy, a larger country size favors the currency union over the alternative regime.

e) Sensitivity under Inflation Target Shocks

Figure 6 shows welfare results concerning the case when only inflation target disturbances θ_i hit the economies involved. Under these shocks, inflation and output under monetary autonomy are $\pi_I = \theta_I$ and $y_I = 0$, respectively. This means that a single-country central bank has no problem completely offsetting this type of shocks. Given that this implies that the loss function L_I vanishes, welfare ratio C_{uI} is always indeterminate. For this reason, in Figure 6 we do not report the same ratio as shown in Figures 2 through 5 but simply the value attained by the loss function under currency union

FIGURE 6 - *Monetary Union Member's Loss Function: Sensitivity under Inflation Target Shocks*



membership, L^u_I. The value of L^u_I under common shocks equals zero also when country I engages in a monetary union (see Figure 6). As was concluded in items a) through d), inflation target shocks of the common type thus exert no effect whatsoever on the sensitivity of welfare to parameter values.

In the event of asymmetric inflation target shocks, inflation and output under currency union membership are $\pi^u_I = 1 + a/\vartheta$ and $y^u_I = 1/\vartheta$, respectively. In general, the way loss function L^u_I is affected by parameter values involves consideration of developments under both monetary autonomy and the currency union. Once more, we start with the assessment under asymmetric shocks. In the case of parameters a and γ, they affect L^u_I only through their influence on inflation. Both a steeper supply curve and a stronger responsiveness of prices to the exchange rate raise the gap between inflation and the associated target level, thereby deteriorating monetary union stabilization performance (see Figure 6, panels A and B). Aggregate demand parameters β and δ affect welfare only indirectly via the effect of composite coefficient ϑ on inflation and output. A rise in the responsiveness of aggregate demand to interest rates and/or exchange rates, which lowers ϑ, increases the variability in both inflation (in deviation from target) and output. This accounts for the deterioration of welfare when the single monetary policy is in place (see Figure 6, panels C and D). In addition, price stability coefficient χ fails to impact macroeconomic developments in a currency union. It does however contribute to hampering the latter's stabilization properties because it implies a heavier penalization of the prevailing deviation of inflation from target. Once more, the sensitivity results assessed so far under the present item also apply to idiosyncratic disturbances.

Among all cases considered, country size only impacts relative welfare when member states are hit by idiosyncratic shocks. In this scenario, reference country I exhibits inflation and output levels $\pi^u_I = 1 + (1 - \varphi_I)/(a\vartheta)$ and $y^u_I = (1 - \varphi_I)/\vartheta$, respectively. The analysis of these expressions indicates that a higher φ_I unambiguously lowers macroeconomic volatility and thus improves a currency union's stabilization properties relative to monetary autonomy.

f) Discussion

A general result reported here is that, in the event of common shocks, sensitivity results fail to influence welfare under a currency union relative to the monetary autonomy case. Moreover, with the exception of country size, the welfare results of changing a given parameter are similar between asymmetric and idiosyncratic disturbances, which capture stabilization costs of renouncing monetary sovereignty. Changes in country size exclusively influence welfare in a currency union, and this only under idiosyncratic shocks. A larger country size then favors currency union participation as it receives more attention from the single monetary authority. A more intense reaction of domestic prices to the exchange rate improves monetary union stabilization performance in the event of three shocks (to demand, the risk premium and output targets), while in the other cases (supply and inflation target disturbances) it favors national monetary policy. A small open economy can be assessed by combining these results for country size and the reaction of prices to the exchange rate – the latter rising with the degree of openness. A small country catches little attention from the single monetary authority, thereby increasing the monetary stabilization costs generated by idiosyncratic shocks. In turn, a high degree of openness elicits welfare results that depend on the specific shock considered. Overall, a small open economy may have reasons to keep its monetary autonomy, especially if the currency union were to be largely hit by supply and inflation target disturbances of a country-specific nature.

Finally, sensitivity results for the reaction of aggregate demand to interest rates and the preference for price stability are not so clear cut. An increase in these parameter values raises relative welfare under monetary union for two shocks in each case, namely, supply and risk premium shocks for the aggregate demand coefficient, and demand and output target disturbances for the price stability parameter.

7. Concluding remarks

This paper extends the literature of currency unions by jointly allowing for small-open-economy characteristics and monetary policy transparency considerations. The theoretical analysis, involving welfare comparisons between monetary autonomy and currency union regimes, is motivated by an examination of data on transparency, country size and Phillips curves. Overall, our sample includes many countries from existing monetary unions and potential candidates to engage in one. No clear empirical connections are detected between country sizes and transparency scores, owing to diverse experiences across the countries considered and over time, as well as – to some extent – due to differences in transparency scores across available data sources. Our understanding of supply slopes is also marred by imprecise estimates which depend on the data and the empirical model used. In light of all these uncertain results, we proceed to gain a deeper comprehension of the role played by transparency misperceptions in monetary union by developing a general setup with the following features: i) unobservable policy goals and economic size are allowed to be country-specific; and ii) changes in other structural characteristics (including supply slopes and exchange-rate pass-through) are studied assuming for simplicity that they are uniform across member states.

Turning to our general model predictions, they appear to align with widespread evidence of numeric inflation targets, coupled with the absence of explicit targets concerning output. In particular, we find that it is optimal for monetary policy to achieve complete actual and perceived transparency about the inflation target, while for the output target it is beneficial to deliver perfect actual transparency and minimal perceived transparency. This mix effectively limits expected inflation volatility, thus making it easier for policymakers to reach their goals.

The welfare comparisons between monetary autonomy and currency union depend on structural parameters and the cross-country distribution of shocks, which propagate across the union via the induced interest rate response. Only common shocks fail to influence welfare under a currency union relative to monetary autonomy. For a small open country, small size is a liability under monetary union, where interest rates are set with union-wide goals in mind. The welfare effect of trade openness, which influences the reaction of domestic prices to exchange rates, depends on the specific disturbance considered. Under supply and inflation target shocks – those making openness more likely to hamper a currency union's stabilization – are sufficiently prevalent, a small open economy would overall have stronger incentives to maintain monetary autonomy. If member states are instead driven by country-specific disturbances impinging on demand, risk premia and output targets, then a tradeoff emerges between the detrimental effects of small size and the beneficial influence of openness.

Concerning other parameters, a steeper supply curve and a more intense responsiveness of aggregate demand to the interest rate both mostly hamper monetary union stabilization. The only exceptions to these results concern the occurrence of supply shocks for the aggregate demand parameter and that of output target disturbances in the case of the supply slope. The latter result implies that, absent transparency imperfections, a steeper supply curve unambiguously favors monetary autonomy. We thus enrich the analysis by showing that output target shocks qualify sensitivity results involving the supply slope. Finally, the preference for price stability has not very clear-cut welfare implications, with our study however abstracting from favorable credibility effects stemming from a stronger such preference.

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ABSTRACT

The cross-country examination of monetary policy transparency scores, economic size and supply slopes produces no clear patterns for the empirical relations in question. This evidence prompts us to formulate a general setup for the study of currency union stabilization when there is monetary policy uncertainty and structural parameters may vary. For small open economies, small size is detrimental to the relative effectiveness of the single monetary policy, while a higher degree of openness yields results that depend on the specific shock considered. A steeper supply schedule hampers monetary union stabilization performance, except under output target shocks. A stronger reaction of aggregate demand to the interest rate is likewise detrimental, except in the event of supply disturbances. The welfare implications of the central bank preference for price stability are ambiguous.

Keywords: Monetary Union, Small Open Economies, Asymmetric Information, Transparency

JEL Classification: D82, E52, E58, F33, F41

RIASSUNTO

Unità monetaria delle piccole economie aperte: il ruolo di un'errata percezione della trasparenza

L'esame *cross-country* degli standard di trasparenza della politica monetaria in funzione di altre variabili non consente di individuare empiricamente relazioni univoche. Questo fatto ci ha indotto a procedere ad uno studio generale degli effetti di stabilizzazione dell'unione monetaria quando vi è incertezza nella politica monetaria ed i parametri strutturali possono variare. Nel caso delle piccole economie aperte la dimensione ha un'influenza negativa sull'efficacia della politica monetaria del singolo paese, mentre un maggior livello di apertura produce risultati che dipendono dallo shock specifico considerato. Una curva di offerta più inelastica ostacola in generale l'effetto stabilizzatore dell'unione monetaria. Una reazione più forte della domanda aggregata al tasso di interesse risulta altrettanto negativa, tranne il caso di disturbi dal lato dell'offerta. Infine le conseguenze in termini di *welfare* indotte dalla preferenza della banca centrale per la stabilità dei prezzi risultano ambigue.