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A Model of an Optimum Currency Area

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Abstract:

This paper develops a model of the circumstances under which it is beneficial to participate in a currency area. The proposed two-country monetary model of trade with nominal rigidities encompasses the real and monetary arguments suggested by the optimum currency area literature: correlation of real and monetary shocks, international factor mobility, fiscal adjustment, openness, difference in national inflationary biases, and transactions costs. The effect of openness on the net benefits is ambiguous, contrary to the usual argument that more open economies are better candidates for a currency area. Also, prospective member countries do not necessarily agree on whether a given currency union should be created.

JEL: E42, E52, E61, F02, F31, F33, F36, F4, H77, J61
Keywords: Optimum currency areas; cost- benefit analysis; exchange rate regimes; currency union; monetary integration

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Introduction

The creation of the European Monetary Union (EMU) has stimulated renewed interest in the theoretical and empirical investigation of optimum currency areas (OCA). Despite the dominance of political factors in the decision of whether to create the EMU, economists have attempted to assess whether the EMU is optimal or at least beneficial from an economic point of view. Such efforts have drawn extensively on the OCA literature, which was originally stimulated four decades ago by the first projects of European monetary integration, discussing the factors (such as shocks asymmetry, factor mobility, openness, fiscal stabilizers, and so on) that should determine whether a group of countries would optimally belong to a currency area. The vast majority of the arguments originally proposed have not been derived from formal models, but rather from general open-macroeconomic conceptual frameworks, often complemented with specific assumptions tailored to the analysis of one factor at the time.

This paper aims to formulate a comprehensive and integrated analysis of the costs and benefits involved in the assessment of whether a set of countries should optimally relinquish the exchange rate as an instrument of adjustment. A formal model is derived, weighing most of the real and monetary arguments suggested by the OCA literature. Such an approach does not confirm the conventional assertion that more open economies are better candidates for a currency area.

The subsequent sections are organized as follows. Section 1 summarizes the literature on optimum currency areas. Section 2 presents the model. Section 3 derives measures for the expected short-run adjustment costs (in terms of inflation and unemployment) arising in two alternative monetary regimes: flexible exchange rates and currency union. The contribution to the adjustment provided in a currency union by international labor mobility and by a fiscal tool is investigated in Sections 3.3 and 3.4. Section 4 measures and discusses the expected net benefits from the participation in a currency union. Section 5 summarizes the results and draws conclusions.

1 The Literature on Optimum Currency Areas

Under a traditional definition, a currency area adopts an irrevocably fixed exchange rate regime or a single currency within its area, and maintains a flexible exchange rate regime with the rest of the world.[1] An OCA has been implicitly defined by Mundell (1961) as a currency area for which the costs of relinquishing the exchange rate as an internal instrument of adjustment (i.e. within the area) are outweighed by the benefits of

[1] This model presented in this paper focuses on the more restrictive definition entailed by a currency union: as such, the model would consider the elimination of transaction costs, but neglect expectations of realignments.

adopting a single currency or a fixed exchange rate regime. Most of the subsequent literature on OCA has focused on the costs of renouncing the exchange rate, and devoted more limited attention to the benefits. For extensive reviews and discussions of the optimum currency area literature see, for example: Bofinger (1994), De Grauwe (2003), Ishiyama (1975), Krugman (1992), Masson and Taylor (1992), Mongelli (2002), Tavlas (1993a, 1993b, 1994), and Tower and Willet (1976), Wyplosz (1997). For a skeptic view, see Buiter (1995).

1.1 Costs of Adopting a Single Currency

When two areas face real and monetary shocks, the extent to which a currency union implies larger adjustment costs than a flexible exchange rate regime depends on the effectiveness and efficiency of the exchange rate as an instrument of short run adjustment.

The exchange rate between two areas is an effective instrument of short-run adjustment if the following three conditions hold: (1) the two areas face asymmetric shocks, so that an adjustment of the relative price of the goods produced in the two areas is required; (2) domestic prices are not fully flexible; hence prices do not adjust immediately to the shocks; and (3) pass-through is not large, so that a relative price change due to an exchange rate change is not immediately neutralized by domestic price movements.

The exchange rate between two areas is an efficient instrument of short run adjustment if—in addition to the conditions listed above—adjustment through the exchange rate is less costly than through other instruments, possibly because other mechanisms of adjustment—such as factor movements or automatic fiscal stabilizers—are limited. The importance of these alternative mechanisms has often been questioned. The effectiveness and the desirability of labor mobility as a form of adjustment has been criticized—although most economists agree on its importance for the long run adjustment to persistent shocks[2]—and the fiscal tool does not represent a true adjustment, but rather a way of financing temporary shocks. Capital mobility can also help smooth the effects of asymmetric shocks. This factor did not receive much attention originally, in part because of the limited contribution of capital flows to consumption smoothing (see for example the Feldstein-Horioka (1980) puzzle). However, it has been gaining increased emphasis, given the recent deepening in financial integration across countries.

Mundell (1961) and McKinnon (1963) suggested that the effectiveness of the exchange rate might decrease with openness, because prices and wages are more likely to rapidly neutralize the change in the exchange rate. However, more open areas are also more exposed to foreign shocks and might therefore face larger adjustment problems. It is therefore unclear whether a more open area should present larger adjustment costs to real shocks within a currency union than under a flexible exchange rate regime. The effect of openness becomes even more uncertain when monetary shocks are taken into account; this point will be discussed in detail in Section 4. As described in Section 1.2, also the benefits of a currency union should vary with openness.

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[2] On this controversy see for example Kenen (1969), Ishyiama (1975), Tower and Willet (1976).

Bofinger (1994) argues that monetary aspects, such as the degree of asymmetry of monetary shocks and the difference in domestic inflation levels (see Section 1.2), play a central role in the optimum currency area analysis, overcoming the importance of the traditional elements (labor mobility, openness, correlation of shocks, and so on). To capture also the rationale behind this view, the model presented in this paper encompasses both real and monetary shocks.

1.2 Benefits from the Adoption of a Single Currency[3]

Mundell (1961) stresses in particular the benefits deriving from: (1) the elimination of transaction costs, and (2) a better performance of money as a medium of exchange and as a unit of account.[4] First, the institution of a single currency eliminates the deadweight losses due to currency transactions and to the need to collect and process information related to exchange rates: the factors of production previously involved in these activities now become available for alternative uses.[5] The second kind of benefits correspond to the efficiency gains from: (2a) the elimination of the relative price distortions generated by the transaction costs, and (2b) the elimination of exchange rate uncertainty.[6] It is important to stress that these benefits could not be reaped (or could be reaped only to a lesser extent) if the currency area would be based on a fixed exchange rate regime rather than a single currency. It is very difficult to identify these benefits deriving from a single currency, both theoretically and empirically. It seems reasonable, however, to assume that these benefits increase with the level of trade between the two candidate areas, and therefore with their degree of openness (see Tower and Willet, 1976; Krugman, 1992; De Grauwe, 2003). Transaction costs are therefore included in the model as a proxy for the benefits in general.

The similarity of pre-union inflation rates across countries has been suggested as an important criterion in the determination of an optimum currency area (see for example Fleming, 1971). The basic idea is that countries may have different Phillips curves or different inflation-employment trade-offs, in which case a currency union, by imposing a unique level of inflation, would generate some costs. A similar conclusion is reached by Canzoneri and Rogers (1990), but for a completely different reason: if inflation is mainly a tax instrument, different countries may need different levels of inflation in order to satisfy the public finance principle that marginal disutility of revenues should be equalized across tax devices (in their example, Italy has a large underground economy—which can be taxed only via inflation—and therefore a higher optimal

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[3] The paper neglects political benefits, like the complementarity to an economic union, or avoiding beggar-thy-neighbor devaluations.

[4] Mundell (1961) also briefly discusses the ability of speculators to affect exchange rate markets if these markets are thin, suggesting that the currency area should not be small. For his deeper analysis of aspects related to transaction costs and to the international use of a currency for transaction purposes and for reserve holding, see Mundell (1973, Sections 4 and 5). For a microfoundation of an OCA based on the role of money, see Swofford (2000).

[5] The EU Commission estimated that for the EMU these benefits should be about 0.5 percent of GDP (EC, 1991).

[6] See Baldwin (1991) for an analysis. The extent of the relevant exchange rate volatility is, however, very hard to assess. In fact, part of exchange rate variability is an endogenous response to underlying sources of uncertainty, which would not be eliminated by a currency area (see also De Grauwe, 2003).

inflation than Germany which has a smaller underground economy). The extension of the time-consistency approach to monetary policy (see for example Barro and Gordon, 1983a, 1983b) to open economies suggest another possible benefit from the participation in a currency union: "the advantage of tying one's hands" (see Giavazzi Pagano, 1988). If the low inflation promises of the central bank of a traditionally high inflation country are not time consistent, this country could gain discipline and credibility by pegging its exchange rate to a low inflation currency.[7]

However, the level of inflation of a currency union might end up being higher than the lowest among the pre-union inflation levels of the member countries, in which case some countries would lose from their participation in the union. As Von Hagen (1995) shows, if council members of the central bank of a currency union dislike inflation but like easy money at the time of domestic elections, vote-trading can result in a positive inflationary bias (as well as in nominal and real fluctuations) which is welfare reducing. The model developed in this paper encompasses an exogenous increase in money supply (inflationary bias), in order to capture the contribution of inflation convergence in the cost-benefit analysis.

1.3 Empirical Evidence

Turning to the empirical evidence, the EMU has stimulated a rich empirical investigation aimed at understanding whether the adoption of a single currency would really imply higher costs of adjustment to shocks.

EC (1991) provides a broad positive assessment of the costs and benefits of the European Monetary Union. Many other academic contributions have provided a gloomier picture. The contributions have compared the degree of shock asymmetry, the role of labor mobility, the extent of regional capital mobility, and the use of fiscal tools in the U.S. regions with those in the European Union (EU) countries, under the premise that some lessons for EMU could be learnt by inspecting the adjustment within a currency area of size comparable to the EU. Across EU regions, the correlation of shocks is low, labor and capital mobility are relatively scarce, and the adjustment due to the EU fiscal system is insignificant; before the EMU, most of the adjustment to shocks seemed to arise through relative price movements and domestic fiscal policies. Regarding the correlation of shocks, Bayoumi and Eichengreen (1993a) find that it is higher across U.S. regions than EU countries, a result confirmed also by Erkel-Rousse and Melitz (1995), Bayoumi and Eichengreen (1993b), and Cheung and Hutchison (1997). Regarding the role of labor mobility, Blanchard and Katz (1992) show that in the United States labor mobility has played a major adjustment role, substituting for price flexibility, while evidence of lower European labor mobility is given by Bayoumi and Prasad (1997) and by Eichengreen (1993). Regarding capital mobility, Atkeson and Bayoumi (1994) find that capital mobility is higher among the U.S. regions than among European countries, where it provides a particularly low degree of insurance against

[7] In order to analyze these gains during the 'transition' to a currency union, Ricci (1992) extends the Barro-Gordon framework to a small open economy with perfect capital mobility, where inflation depends on a game between wage setters and fiscal authorities, and where fixed exchange rates are not perfectly credible. The results show that a high inflation economy gains more (in terms of fluctuations in inflation and unemployment) by creating a currency union early on than by pegging until inflation has gradually converged.

regional fluctuations. With respect to the role of automatic fiscal stabilizers, Sachs and Sala-i-Martin (1991) show that the U.S. federal fiscal system absorbs about 40 percent of the shocks suffered by individual States, while Eichengreen (1990) finds that the shock absorption due to EU taxes is insignificant. Erkel-Rousse and Melitz (1995) and Bayoumi and Masson (1995) find that fiscal policy is an effective tool of adjustment for most EU countries, suggesting that a possible constraint on fiscal policy imposed by the currency union might prove costly. Finally, Bayoumi and Thomas (1995) find that relative price variability is crucial for the adjustment to shocks within the European countries, while it is not so important in the United States. Overall, these studies suggest that a single European currency, by eliminating the exchange rate flexibility, could increase the adjustment costs in EMU countries. However, the Single Market has been enhancing labor and capital mobility within the EU, while the creation of the EMU might be altering the degree of symmetry of shocks and of price flexibility.

The empirical analysis of the adjustment costs associated with a currency area have also been applied to other regions. Alesina, Barro, and Tenreyro (2002) offer an empirical analysis of the optimality, for most countries in all regions of the world, of pegging to the three main currencies on the basis of three criteria: the extent of trade, symmetry of shocks, and similarity of inflation rates. Bénassy-Quéré (1999) shows that optimum currency area arguments are not likely to be the reason for the U.S. dollar peg of Asian currencies, as—among other things—the correlation of shocks with the U.S is low. Karras (2007) discusses the optimality of an African monetary union on the basis of business cycle synchronization and similarity of inflation. Furceri and Karras (2006) adopt a similar approach to assess the implications of adopting the Euro for the new EU accession countries. Bénassy-Quéré and Lahréche-Révil (2000) and Schadler and others (2005) provide an assessment of the adoption of the Euro in central Europe. Fasano and others (2003) and van Beek and others (2000) offer broad discussions of the desirability of monetary unions in, respectively, the GCC countries (Cooperation Council for the Arab States of the Gulf) and the Eastern Caribbean region, while Hernandez-Cata and others (1998) Masson and Pattillo (2001) focus on West Africa. For a stochastic simulations aimed at the assessment of the net benefits on the basis the main factors discussed in the literature, see Beine and Docquier (1998).

1.4 Existing Models of an OCA and the Aim of this Paper

Bayoumi (1994) builds a simple general equilibrium model to derive the welfare implications for most of the real aspects of the optimum currency area literature (correlation of real shocks, labor mobility, openness). In particular, the presence of multiple countries allows for very interesting results to arise. The creation of a currency union unambiguously lowers the welfare of the regions outside the union, as the benefits accrue only to the members of the union, while the output costs affect the consumption levels of all regions. Consequently, the creation of a currency union increases the incentive for third countries to join the union, as they anyhow suffer part of the losses generated by the union. However, the benefits that can be reaped if a third country joins a union are usually higher for the third country (which gains the elimination of transaction costs with all existing members) than for the participants in the union (which gain only the elimination of transaction costs with the third country). Ghosh and Wolf (1994) adopt a model similar to Bayoumi (1994) and investigate empirically how each

of certain areas of the world (the United States, Europe, the G-7, Former Soviet Union, CFA zone, and world itself) could be divided up into optimum currency areas.[8] A group of countries is considered an optimum currency area if the correlation of output shocks inside the area implies that the costs of adjustment are below an exogenous level of benefits. Both Bayoumi (1994) and Ghosh and Wolf (1994) do not consider monetary aspects nor their interaction with the real ones.

Alesina and Barro (2002) build a trade model with differentiated intermediate inputs and Dixit-Stiglitz monopolistic competition. In order to investigate optimal monetary policy, the model solution for output volatility is then entered in a standard authorities' loss function encompassing inflation and output volatility, which is exogenously assumed. This method eliminates some crucial interaction terms, like the one between openness and the correlation of shocks. The model developed by Aizenman and Flood (1993) focuses on the circumstances under which adjustment through labor mobility in a currency union is welfare superior to adjustment through flexible exchange rates. In a two-country one-good one-factor world with nominal wage rigidities, when productivity shocks hit asymmetrically the two member countries of a currency union, migration would bring the efficient adjustment since it would equalize (under specific assumptions) the marginal productivities of labor across countries. Under flexible rates, however, adjustment would occur through prices and exchange rates, and under certain conditions the gap in productivities across countries would persist (hence the inefficiency), matched by different real wages. These conditions seem, however, somewhat strong.

Other authors develop extensive modeling efforts to focus on specific issues. Canzoneri and Rogers (1990) build a general equilibrium cash-in-advance framework tailored to the case in which optimal inflation, as a tax instrument, might require different national levels of inflation. Minford (1995) also employs a cash-in-advance framework in the attempt to build the microfoundations for the OCA approach, by capturing the advantages of independent monetary policies as stabilization tools. Melitz (1996) offers a detailed analysis of the trade aspects associated with the creation of a currency area. Devarajan and Rodrik (1991) investigate the desirability of the CFA Zone, by weighing the credibility gains in terms of lower inflation with the losses implied by the inability to employ the exchange rate for stabilization purposes. Corsetti and Pesenti (2002) study the welfare implication of optimally chosen pass-through and monetary policy.

2 The Model

The model developed in this paper attempts to capture most of the cost-benefit analysis previously described, in a monetary model of trade with nominal rigidities. The innovative content of the paper stems from the simultaneous analysis of both the real and monetary aspects of the optimum currency area literature. The focus is on the short run adjustment to shocks under different exchange rate regimes, which requires a short

[8] The CFA zone includes the West African Economic and Monetary Union (WAEMU) and the Central African Economic and Monetary Community (CEMAC).

run trade-off between monetary and real adjustments.[9] In order to maintain the framework simple, an extreme Phillips curve is generated by assuming that in the short run wage are rigid and employment cannot rise above a given level: the implications of the cost-benefit analysis would hold under more general assumptions, provided that some market rigidities are maintained. The nonlinearity imbedded in such a Phillips curve is sufficient to generate a role for the variance of the shocks simply via the expectation of output and inflation outcomes, without needing a standard quadratic loss function in output and inflation. A loss function based on expected inflation and employment (not their volatility) is introduced simply to account for the welfare cost of inflation (whose importance is discussed in Section 1.2). In the absence of this function, inflation would not matter, and the welfare analysis would be similar to the one of Bayoumi—related only to expected output losses—but would still account for the role of monetary shocks. The model is tailored to the type of currency area implied by the adoption of a single currency and not a fixed exchange rate regime; the latter would not eliminate transaction costs nor expectations of realignments.

2.1 Structure of the Model and Agents' Behavior

Adapting from Dornbusch, Fischer and Samuelson (1977) and from Blanchard and Kiyotaki (1987), a two-country two-good Ricardian trade model is complemented with nontraded goods, nominal rigidities, exchange rates, trade costs, an authority's loss function, and random Cobb-Douglas preferences in goods and money. The analysis is static and neglects the existence of capital.

The world is constituted by two countries (home and foreign, the latter being denoted by a star "*****"). The only factor of production, labor (L and L^*) is fully mobile between sectors within the same country. Labor is initially assumed to be immobile across countries; this assumption will be relaxed from Section 3.3 onwards. Every individual can supply at most one unit of work (full employment).

2.1.1 Uncertainty, Rigidities, and Timing of Actions

Uncertainty arises from demand and monetary shocks. The world is initially in full employment equilibrium and the initial wages are denoted by (w_o, w_o^*). Inflation is defined as the change in prices with respect to those prevailing in the initial equilibrium.

Before the resolution of uncertainty, nominal wages are set at levels w_s and w_s^* which are above w_o, w_o^* by the expected percentage increase in the respective domestic money supply.[10] Such an assumption introduces at the same time both nominal rigidities and a reduced form of an inflationary bias à la Barro-Gordon (1983a, and 1983b), as specified later.

After the resolution of uncertainty, labor supply is infinitely elastic at the given wage until full employment is reached, but cannot rise above full employment. Taking the wage as given, firms choose competitively optimal employment and prices, under

[9] For a broad discussion on such a trade-off, see the Symposium on "The Natural Rate of Unemployment" (1997).

[10] For a discussion of microfoundations for nominal rigidities, see for example Mankiw and Romer (1992).

the constraint that aggregate employment must be less than or equal to full employment. Consumers choose optimal consumption and money balances, taking into account their new preferences and cash endowments.

These assumptions generate an extreme version of a Phillips curve in prices and employment; such curve is flat at the marginal cost pricing below full employment and vertical once full employment is reached. A smaller degree of convexity would not alter qualitatively the analysis.

2.1.2 Technology and Specialization

Each country produces one traded good (A at home and B abroad) and a nontraded one (N or N^*). Such pattern of specialization can be derived from a Ricardian comparative advantage, by assuming that the conditions for complete specialization hold.[11] Without loss of generality, the home country is assumed to specialize in the production of good A.

Production functions exhibit constant returns to scale to labor as the sole input. Supplies of goods are given by:

$$A^s = \gamma L_A \quad ; \quad B^{s*} = \delta L_B^* \quad ; \quad N^s = \psi L_N \quad ; \quad N^{*s^*} = \phi L_{N^*}^* \tag{1}$$

where: γ, δ, ψ, φ, are the labor productivities in sectors A, B^*, N, N^*, and L_A, L^*_B, L_N, L^*_{N*} are the employment of labor in the same sectors.

2.1.3 Preferences

Individuals have Cobb-Douglas preferences over money, two traded goods (A and B), and a nontraded good (N or N^*). Preferences are assumed to differ in the two countries in order to investigate the effects of the degree of openness and of the symmetry of shocks on the desirability of a currency union. After the resolution of uncertainty, i.e. taking into account of new preferences and cash balances, a representative home consumer i chooses nominal money balances (m_i') and consumption of three goods (A_i, B_i and N_i) so as to maximizes the following random preferences:

$$U_i = \left(A_i^{\alpha} B_i^{\beta} N_i^{(1-\alpha-\beta)} \right)^{\lambda} \left(m_i^{/} \right)^{1-\lambda} \tag{2}$$

subject to:

$$p_A A_i + e\, p^*_B \tau B_i + p_N N_i + m_i^{/} = y_i + m_i$$

while a representative foreign consumer j chooses nominal money balances ($m^*_j{}'$) and consumption of three goods (A_j, B_j and N^*_j) so as to maximize the following random preferences:

[11] The Appendix describes such conditions. Full specialization might seem a strong assumption in this context, as it might seem to limit the ability to analyze the degree of shock-asymmetry. However, even in the presence of full specialization, the effects of different degrees of shock-asymmetry can be investigated through the correlation coefficient of demand shocks. Alternative ways of generating a continuous degree of asymmetry across countries (such as for example an Heckscher-Ohlin model of trade with identical preferences in the two countries) would give similar results.

$$U_j^* = \left(A_j^{\alpha^*} B_j^{\beta^*} N_j^{*(1-\alpha^*-\beta^*)} \right)^{\lambda^*} \left(m_j^{*/} \right)^{1-\lambda^*} \tag{3}$$

subject to:

$$\frac{p_A}{e} \tau A_j + p_B^* B_j + p_{N^*}^* N_j^* + m_j^{*/} = y_j^* + m_j^*$$

where p_A, p^*_B, p_N, and $p^*_{N^*}$ are the local currency prices prevailing in sectors A, B^*, N, N^*. The exchange rate (e) is defined as units of domestic currency per unit of foreign currency.[12] The parameter τ>1 indicates the presence of Samuelson's iceberg-type transaction costs (see Sections 1.2 and 1.3) that the agents must incur when converting one currency into the other under flexible rates: the consumer needs to buy τ units of foreign goods to consume 1 unit. In a currency union τ=1 and e=1. The money endowments of the home and foreign representative consumers are given by m_i and m^*_j respectively, while y_i and y^*_j denote their levels of nominal income. Given that each individual supplies labor to domestic firms at the given wage and receives profits from these firms, her income is a share (*1/L* or *1/L**) of the domestic firm's revenues.

2.1.4 Shocks and Monetary Rule

Random preferences' parameters generate shocks to demand for goods and for money. The percentage changes in these parameters are distributed as truncated normals, whose means, variances, and bounds are described in Table 1. As the initial values of λ and λ^* are irrelevant for the analysis, they are set equal to 0.5 in order to simplify notation; this implies that initially in every country nominal income and money stock have equal value. As unexpected money supply shocks would enter the final formula similarly to money demand shocks (with opposite sign), it is unnecessary to introduce them. Money demand shocks can therefore be interpreted as monetary shocks in general.

Table 1

Variable	equal to	mean	std. dev.	bounded in
χ_α	$d\alpha/\alpha$	0	σ_α	$(-z_\alpha , z_\alpha)$
χ_β	$d\beta/\beta$	0	σ_β	$(-z_\beta , z_\beta)$
χ_λ	$d\lambda/\lambda$	0	σ_λ	$(-z_\lambda , z_\lambda)$
χ_{α^*}	$d\alpha^*/\alpha^*$	0	σ_{α^*}	$(-z_{\alpha^*} , z_{\alpha^*})$
χ_{β^*}	$d\beta^*/\beta^*$	0	σ_{β^*}	$(-z_{\beta^*} , z_{\beta^*})$
χ_{λ^*}	$d\lambda^*/\lambda^*$	0	σ_{λ^*}	$(-z_{\lambda^*} , z_{\lambda^*})$

Possible inflationary biases of the monetary authorities (see Section 1.2) are introduced through exogenous and anticipated increases in national money stocks (in percentage terms: μ and μ^*, for the home and foreign country respectively, with

[12] Free trade and Samuelson's type transaction costs ensure that each traded good has the same price (in a given currency) in both areas, independently of where it is produced.

$\mu=\mu^*=\mu^{cu}$ in a currency union).[13] Such increases take the form of lump-sum transfers to individuals, occur after the wages are set, and, being fully anticipated, are incorporated in the previously described wage-setting ($w_s=w_o(1+\mu)$ and $w_s^*=w_o^*(1+\mu^*)$).

Monetary authorities are not allowed to pursue discretionary policies.[14] Under flexible exchange rates, money supply would therefore change in each country k because of the authorities' inflationary bias (μ^k). In a currency union, money supply would change not only because of the inflationary bias (μ^{cu}) common across countries, but also because of the redistribution of money across countries that (ξ_{cu}^k, in percentage terms) that equilibrates the money market[15]:

$$M_{FLEX}^k = M_o^k(1+\mu^k) \quad , \quad M_{CU}^k = M_o^k(1+\mu^{cu}+\xi_{cu}^k) \tag{4}$$

where a subscript *o* denotes initial values.

2.2 Equilibrium

2.2.1 Consumers' Behavior

Maximizing the consumers' problems, and aggregating by virtue of homothetic preferences, one can derive the following demands for expenditure on goods:

$$\begin{gathered} p_A A^d = \alpha\lambda(Y+M) \;\; ; \;\; ep_B^*\tau B^d = \beta\lambda(Y+M) \;\; ; \;\; p_N N^d = (1-\alpha-\beta)\lambda(Y+M) \\ p_A\tau A^{d*} = \alpha^*\lambda^* e(Y^*+M^*) \;\; ; \;\; p_B^* B^{d*} = \beta^*\lambda^*(Y^*+M^*) \;\; ; \;\; p_{N^*}^* N^{*d} = (1-\alpha^*-\beta^*)\lambda^*(Y^*+M^*) \end{gathered} \tag{5}$$

and for money:

$$M^{/} = (1-\lambda)(Y+M) \quad ; \quad M^{*/} = (1-\lambda^*)(Y^*+M^*) \tag{6}$$

where the superscript "*d*" indicates aggregate demand, while Y^k and M^k are respectively the aggregate income and the aggregate money endowment of country *k*.

2.2.2 Firms' Behavior

After the resolution of uncertainty, domestic and foreign firms maximize profits subject to, respectively:

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[13] For an endogenous derivation of the inflationary bias within this context, see Alesina and Barro (2002).

[14] Alternatively, one could consider the shocks in this model as the residual component of the shock that authorities have not been able to offset via discretionary policies.

[15] The redistribution of money can be thought of as the within period cumulative trade imbalances associated with the temporary disequilibria until convergence to the new equilibrium, or as the automatic intervention implemented by the monetary authorities to equilibrate the money market, similarly to what the authorities would commit to do under a fixed exchange rate regime in order to maintain the peg.

$$w = w_s \quad ; \quad L_A + L_N \leq L$$
$$w^* = w_s^* \quad ; \quad L_B^* + L_{N^*}^* \leq L^* \tag{7}$$

When the initial equilibrium is disturbed by an increase in aggregate demand for goods of one country, firms in that country will find it optimal to increase the price above the marginal cost associated with the given wage, as they cannot hire more workers to produce more. When aggregate demand for goods of one country declines, given the fix wage, firms of that country will reduce employment until their aggregate output equals aggregate demand at the marginal cost pricing. For example, for the domestic country, either this set of conditions would hold:

$$p_A \geq {w_s}/{\gamma} \; ; \; p_N \geq {w_s}/{\psi} \quad ; \quad L_A + L_N = L \tag{8}$$

or the following

$$p_A = {w_s}/{\gamma} \; ; \; p_N = {w_s}/{\psi} \quad ; \quad L_A + L_N \leq L \tag{9}$$

Similar conditions apply to the foreign country.[16]

2.2.3 Markets' Equilibrium

This Section derives the equilibrium conditions that allow to investigate the adjustment to shocks under different exchange rate regimes (Section 3). Taking into account the first order conditions, the equilibrium in the four goods markets (for A, B, N and N^*) imply that:

$$p_A A^s + p_N N^s \equiv Y = (1-\beta)\lambda(Y+M) + \alpha^* \lambda^* e(Y^* + M^*)$$
$$p_B^* B^{s*} + p_{N^*}^* N^{*s} \equiv Y^* = \beta\lambda(Y+M)/e + (1-\alpha^*)\lambda^*(Y^* M^*) \tag{10}$$

while the equilibrium in the two money markets gives:

$$Y = \frac{\lambda}{1-\lambda} M \quad ; \quad Y^* = \frac{\lambda^*}{1-\lambda^*} M^* \tag{11}$$

The goods market equilibrium is reached through adjustment in the nominal income of both countries. The money market is equilibrated by exchange rate movements, under flexible exchange rates, and by monetary redistribution in a currency union.

When the goods and the money markets are in equilibrium, the trade balance (*tb*, measured in home currency) is zero, as it can be easily checked by aggregating individuals' budget constraints:

16 These two sets of conditions would hold with equality (thus being identical) if the expected changes in national money supplies happened to be equal to the ex-post changes in demand for national goods.

$$tb \equiv p_A \tau A^{d*} - e p^*_B \tau B^{d} = \alpha^* \frac{\lambda^*}{1-\lambda^*} e M^* - \beta \frac{\lambda}{1-\lambda} M = 0 \tag{12}$$

In a flexible exchange rate regime, the trade balance equilibrium determines the equilibrium level of the exchange rate:

$$e = \frac{M}{M^*} \frac{\beta}{\alpha^*} \frac{\lambda}{1-\lambda} \frac{1-\lambda^*}{\lambda^*} \tag{13}$$

while in a currency union (e=1) it determines the distribution of the world money stock, across the two countries, consistent with the overall equilibrium:

$$\frac{M}{M^*} = \frac{\alpha^*}{\beta} \frac{\lambda^*}{1-\lambda^*} \frac{1-\lambda}{\lambda} \tag{14}$$

Such equilibrium conditions hold for any value of the (opportunely bounded) shocks, and (being in nominal terms) are independent of the existence of nominal rigidities. If wages were flexible, each country would always be in full employment and profits would be zero. In the presence of wage rigidities, however, each country experiences either inflation in excess of μ^k (associated with positive profits) or unemployment, as described in Section 3.

2.2.4 Initial Equilibrium

In the initial equilibrium, i.e. at initial values of money stocks (M_o , M^*_o) and of preferences' parameters (α_o, α_o^*, β_o, β_o^*, and λ_o=λ_o^*=.5), wages (w_o, w^*_o) are consistent with full employment and zero profits in both countries; such equilibrium is therefore equivalent to the one reached in a case of flexible wages. The goods and money markets equilibria are very similar to those described above. In particular, given that λ_o=λ^*_o=0.5:

$$Y^k_o = w^k_o L^k = M^k_o \tag{15}$$

where k is a country index. Without loss of generality, currency units are chosen so as to ensure that e_o=1. The equilibrium relative wage (w_o/w_o^*) can be derived from the aggregate goods markets equilibrium, while the zero-profit conditions deliver the relative prices (p_A/p^*_B):

$$\frac{w_o}{w_o^*} = \frac{L^*}{L} \frac{\alpha_o^*}{\beta_o} \quad ; \quad \frac{p_{Ao}}{p^*_{Bo}} = \frac{\delta}{\gamma} \frac{w_o}{w_o^*} \quad ; \quad \frac{p_{Ao}}{p_{No}} = \frac{\psi}{\gamma} \quad ; \quad \frac{p^*_{Bo}}{p^*_{No^*}} = \frac{\phi}{\delta} \tag{16}$$

It is with respect to these initial prices that inflation will be defined in Section 3. The employment level of each sector is a share of the national labor force; such a share depends only on preferences:

$$L_{Ao} = (\alpha_o + \beta_o) L \quad ; \quad L_{No} = L - L_{Ao} \quad ; \quad L^*_{Bo} = (\alpha_o^* + \beta_o^*) L^* \quad ; \quad L^*_{N_o^*} = L^* - L^*_{Bo} \tag{17}$$

Finally, equilibrium output levels are given by Equation (1).

The same setup could be extended to a multiperiod model, by assuming that at the end of the period workers would receive their share of profits and the preset nominal wage, which would constitute the cash-balances they would bring along to the next period. At the beginning of the next period, agents would expect the economy to be in full employment equilibrium again, either because the shocks were temporary and disappeared, or because price, wages, money stocks (maneuvered by the authority), and the exchange rate, adjusted to the new levels that ensure full employment in the absence of "new" shocks. The continuum of short-run disequilibria would be costly even if shocks were to fade away or be adjusted the next period. It is left for future work to explore the interesting extension of an intertemporal optimization framework.

2.3 Transaction Costs

As specified in Section 1.2, transaction costs are meant to represent all the additional deadweight and efficiency losses that multiple currencies imply. These costs are measured in terms of the labor force. Due to the Samuelson's iceberg-type assumption, paying transaction costs is like wasting hours of work. From Equations (12) and (15), one can infer that the home country spends initially $\beta_o w_o L$ on foreign goods, but the amount its citizens effectively consume is $\beta_o w_o L/\tau$, the difference being due to the transaction costs. Therefore, at the given wages w_o and w^*_o, the transaction costs faced by country k (TC^k), as a percentage of its labor forces, are:

$$TC = \beta\, v \quad ; \quad TC^* = \alpha^*\, v \qquad with \quad v = 1 - \tau^{-1} < 1 \tag{18}$$

where v represents the transaction costs per unit of expenditure on goods produced in the other country.

3 Shocks and Adjustment

This section describes the consequences of the short run adjustment process for unemployment and inflation, both under flexible exchange rates and in a currency union. Unless otherwise specified, changes of variables are meant from the initial equilibrium (see Section 2.2) and are expressed in percentage terms.

3.1 Flexible Exchange Rates

Under this monetary regime, money stocks would change only because of the monetary increase due to the inflationary bias (μ^k). The percentage changes in the exchange rate (e, $\hat{}$) and in country k's nominal income ($\hat{Y^k}$, measured in domestic currency k) that equilibrate the goods and money markets can be derived from Equations (10) and (11):

$$\hat{M}^k = \mu^k > 0 \quad ; \quad \hat{Y}^k = \mu^k + 2\chi_{\lambda^k}$$
$$\hat{e} = \mu - \mu^* + \chi_\beta - \chi_{\alpha^*} + 2\chi_\lambda - 2\chi_{\lambda^*} \tag{19}$$

where χ_s represent the percentage changes of the preferences' parameters s (see Table 1). Note that χ_α and χ_{β^*} do not appear in the above expressions, because shifts of preferences between domestically produced tradables and nontradables are fully adjusted by sectoral labor mobility within countries. Exchange rate flexibility neutralizes perfectly any effect on nominal income of foreign monetary shocks as well as of demand shocks to tradables. Such flexibility, however, fully bottles in domestic monetary shocks, which generate either inflation in excess of μ^k or unemployment (see Section 3.5).

3.2 Currency Union

When the two countries form a currency union, they adopt the same currency ($e=1$) and the transaction costs disappear ($\tau=1$). Wages and prices are denominated in the same units in the two countries, and M and M^* denote domestic and foreign currency "holdings". The changes in nominal income that equilibrates the goods market (and can result in inflation and unemployment) can be derived from Equation (10):

$$\hat{Y} = \mu^{cu} + \frac{2\alpha_o^* \chi_\lambda + \beta_o(\chi_{\alpha^*} - \chi_\beta + 2\chi_{\lambda^*})}{\alpha_o^* + \beta_o}; \hat{Y}^* = \mu^{cu} + \frac{2\beta_o \chi_{\lambda^*} + \alpha_o^*(\chi_\beta - \chi_{\alpha^*} + 2\chi_\lambda)}{\alpha_o^* + \beta_o} \tag{20}$$

Money supply may now change not only because of the inflationary bias of the union μ^{cu}, but also because of the redistribution of money across countries ξ_{cu}^k (see Section 2.1.4). From Equations (10) and (11):

$$\hat{M} = \mu^{cu} + \frac{\beta_o(\chi_{\alpha^*} - \chi_\beta + 2\chi_{\lambda^*} - 2\chi_\lambda)}{\alpha_o^* + \beta_o}; \hat{M}^* = \mu^{cu} + \frac{\alpha_o^*(\chi_\beta - \chi_{\alpha^*} + 2\chi_\lambda - 2\chi_{\lambda^*})}{\alpha_o^* + \beta_o} \tag{21}$$

Therefore, in a currency union, unlike under flexible rates, demand shocks to tradables (χ_β and χ_{α^*}) and foreign monetary shocks (χ_{λ^*} or χ_λ, for the home and foreign country, respectively) affect domestic nominal income and can generate unemployment or inflation (in excess of μ^{cu}). Domestic monetary shocks, however, matter less than under flexible exchange rates, as part of them is transmitted abroad. Demand shocks between domestically produced goods and nontraded goods do not matter in either monetary regime, as sectoral labor mobility takes care of their adjustment.

I now turn to the investigation of two alternative forms of adjustment in a currency union, labor mobility and a federal fiscal system, and focus only on real shocks.

3.3 Labor Mobility as a Form of Adjustment

This Section allows for international labor mobility, which can bring the necessary adjustment to demand shocks in a currency union (see Section 1.1). Assuming that

wages are initially equalized across countries[17] ($w_o=w_o^*$), and recalling that initially $Y_o^k=w_o^k L_o^k$, one can derive from Equations (10) and (11) the migration flow that would fully adjust the demand shocks:[18]

$$dL=\frac{\beta_o L_o}{\alpha_o^*+\beta_o}(\chi_{\alpha^*}-\chi_\beta)=-\frac{\alpha_o^* L_o^*}{\alpha_o^*+\beta_o}(\chi_\beta-\chi_{\alpha^*})=-dL^* \tag{22}$$

where d is the differential operator. More generally, it is assumed that there is partial labor mobility, so that only a share q of the trade shocks is adjusted, where q represents the degree of labor mobility ($0\leq q\leq 1$). In this case, Equations (20) become:

$$\hat{Y}=\mu^{cu}+\frac{2\alpha_o^*\chi_\lambda+2\beta_o\chi_{\lambda^*}+\beta_o(1-q)(\chi_{\alpha^*}-\chi_\beta)}{\alpha_o^*+\beta_o}$$

$$\hat{Y}^*=\mu^{cu}+\frac{2\alpha_o^*\chi_\lambda+2\beta_o\chi_{\lambda^*}+\alpha_o^*(1-q)(\chi_\beta-\chi_{\alpha^*})}{\alpha_o^*+\beta_o} \tag{23}$$

3.4 Fiscal Federalism

This Section introduces a fiscal rule that generates a smoothing of real shocks (see Section 1.1). Obviously, there can be several other specifications for the employment of a fiscal tool. A comparison of alternative fiscal tools is very interesting but beyond the scope of this paper.

Assume that in a currency union a tax (transfer) is imposed proportionally to the increase (decrease) in nominal income due to real shocks. For such shocks, the changes in income of the two countries are of equal size and opposite sign. Hence, the tax raised from the country experiencing a boom is exactly equal to the transfer which the country facing a recession is entitled to. The federal budget is therefore balanced.[19] By applying a particular tax-transfer rate (t)

[17] See Appendix for the conditions under which wage equalization is compatible with a Ricardian trade model. If wages were not equalized, labor mobility could still provide a partial adjustment, but it could not totally prevent inflation or unemployment induced by demand shocks.

[18] Labor mobility is investigated only as a form of adjustment for real shocks; monetary shocks are usually less persistent and less likely to trigger migration decisions. In order to investigate the effectiveness of labor mobility more carefully, one should introduce individual and social costs of migration, take into account the intertemporal aspect of the migration choice, and distinguish between permanent and temporary shocks. Such lines of research are, however, beyond the scope of this paper.

[19] The same tax-transfer scheme could be employed for monetary shocks, provided that the federal budget is allowed to be in surplus or deficit (because monetary shocks affect similarly both countries in a currency union). Such feature is however more appropriate in a multiperiod framework; in a one period model it would equivalent to monetary policy. For the analysis of the interaction between fiscal and monetary policy under different exchange rate regimes, see, for example, Canzoneri and Henderson (1991) and Ginebri (1992). Previous versions of this paper have explored other more complicated fiscal rules, based on tax and public expenditure.

$$t\,dY = -t\,dY^* \qquad with \quad t = \frac{\varepsilon}{1-\varepsilon}\,\frac{\alpha_o^* + \beta_o}{1-\alpha_o^* - \beta_o} \tag{24}$$

one can obtain that a share ε ($0<\varepsilon<1$) of the change in income due to real shocks that is absorbed by the tax-transfer scheme. By taking into account the fiscal rule when solving Equations (10) and (11), and recalling Equation (23), one can derive the percentage changes in national income implied by the goods and money market equilibrium once the adjustment brought both by labor mobility and fiscal federalism (as measured by the parameters q and ε) has been accounted for:

$$\begin{aligned} \hat{Y} &= \mu^{cu} + \frac{2\alpha_o^*\chi_\lambda + 2\beta_o\chi_{\lambda^*} + \beta_o n(\chi_{\alpha^*} - \chi_\beta)}{\alpha_o^* + \beta_o} \equiv \mu^{cu} + x \\ \hat{Y}^* &= \mu^{cu} + \frac{2\alpha_o^*\chi_\lambda + 2\beta_o\chi_{\lambda^*} + \alpha_o^* n(\chi_\beta - \chi_{\alpha^*})}{\alpha_o^* + \beta_o} \equiv \mu^{cu} + x^* \end{aligned} \tag{25}$$

where $n=1-\varepsilon-q$ (with $0<n<1$) is the part of real shocks that is not adjusted by labor mobility (q) or fiscal federalism (ε); $n=0$ if migration and the fiscal rule fully adjust the demand shocks; $n=1$ if they do not contribute at all to the adjustment. The previous equations also implicitly define x and x^* as linear combinations of zero-mean shocks.

3.5 Expected Inflation and Unemployment in the Two Exchange Rate Regimes

As already described in Section 2, because of the rigid wages, changes in nominal income can give rise to inflation (beyond μ^k) or unemployment. Recalling that $w_s = w_o(1+\mu)$ and $w_s^* = w_o^*(1+\mu^*)$, the following can be obtained:

$$\hat{Y}^k = \pi^k > \mu^k \qquad if \qquad \hat{Y}^k > \mu^k \tag{26}$$

$$\hat{Y}^k - \mu^k = -u^k < 0 \quad \& \quad \pi^k = \mu^k \qquad if \qquad \hat{Y}^k < \mu^k \tag{27}$$

where $\pi = \pi_A = \pi_N$ and $\pi^* = \pi_{B^*} = \pi_{N^*}$ are the domestic and the foreign inflation levels, measured as percentage increase in prices with respect to initial ones. The variable $u^k>0$ denotes unemployment of country k as percentage of its labor force.

One can now derive the expressions for the expected inflation and unemployment levels that the authorities can anticipate before the resolution of uncertainty. From Equations (20) and (26), we find that, under flexible exchange rates:

$$E(\pi^k) = \mu^k + \left(\int_{\mu^k}^{\hat{Y}_s^k} (\hat{Y}^k - \mu^k)\; f(\hat{Y}^k / \hat{Y}^k > \mu^k)\; d\hat{Y}^k \right) P(\hat{Y}^k > \mu^k) \approx \mu^k + 2C\,\sigma_{\lambda^k} \tag{28}$$

$$E(u^k) = -\left(\int_{\hat{Y}_i^k}^{\mu^k} (\hat{Y}^k - \mu^k)\; f(\hat{Y}^k / \hat{Y}^k < \mu^k)\; \hat{d}Y^k \right) P(\hat{Y}^k < \mu^k) \approx 2C\,\sigma_{\lambda^k} \tag{29}$$

where the approximation originates from neglecting the truncation of the normal. The constants $\hat{Y}_i^k$ and $\hat{Y}_s^k$ are respectively the inferior and superior boundaries of $\hat{Y}^k$ under flexible rates, which can be derived from the second of Equation (19) as ($\mu^k - 2z_{\lambda\hat{k}}$, $\mu^k + 2z_{\lambda k}$). The notation *f(.)* stands for the conditional probability density function of Y^k , and *P(.)* stands for the probability of the event described within the parenthesis. The constant *C* is the value of the normal density function at the mean, equal to $1/(2\Pi)^{1/2}$, capital Π being the geometric ratio of a circumference to its diameter.

As in Equations (28) and (29), from Equations (25), (26), and (27) one can derive the levels of expected inflation and unemployment when countries participate in a currency union:

$$E(\pi^k) \approx \mu^{cu} + C\,\sigma_{x^k} \qquad ; \qquad E(u^k) \approx C\,\sigma_{x^k} \tag{30}$$

where σ_x and σ_{x*} are respectively the standard deviation of x and x^*, which have been defined in Section 3.4.

As anticipated, expected unemployment and inflation differ in the two regimes. I now turn to the cost-benefit analysis of a currency union.

4 Cost-Benefit Analysis of a Currency Union

This Section provides a simple way to measure the net benefits that a country may expect to gain from the participation in a currency union.[20] For the purpose of assessing the net benefits, it is convenient to define a loss function in inflation and unemployment similar to the one commonly used in macroeconomics from Barro-Gordon (1983a and 1983b) onwards:[21]

$$H^k = E(\, u^k + \theta^k \pi^k + TC^k \,) \tag{31}$$

where k indicates the country, E is the expectation operator, $u^k > 0$ is the unemployment rate, π^k is the inflation rate (measured as GDP-deflator inflation, which is the indicator Mundell (1961) uses in his seminal discussion on optimum currency areas), and θ^k is the relative weight the authority assigns to inflation versus unemployment. The loss function is measured as a percentage of the labor force (or equivalently as a percentage of full employment GDP, given the constant returns to scale assumption); as a consequence, transaction costs and unemployment have the same weight.

Thus a formal derivation of the cost-benefit analysis can be obtained by weighing, via the authorities loss function: (a) the difference between the expected adjustment costs (in terms of inflation and unemployment) that follow shocks under the two

[20] This is a one period analysis, but the components of the cost-benefits analysis are likely to occur every period, implying that the net benefits should be adjusted for net present value calculations.

[21] Note the absence of square terms in the specification, as discussed in Section 1.4. A welfare analysis based on the utility function, rather than on this loss function, would not account for the costs of inflation (its importance being discussed in Section 1.2), but would still account for the transaction cost and the expected output cost, which encompasses both monetary and real aspects. As such, it would still account for the role of volatility and hence of the symmetry of shocks (as in Bayoumi, 1994).

monetary regimes; (b) the difference between the inflationary-bias costs under the same regimes; and (c) the transaction costs, as a proxy for the deadweight and efficiency losses eliminated through the adoption of a single currency.

Equations (18), (28), (29), and (31) imply that the expected losses for the home country under a flexible exchange rate regime (H_{FLEX}) are:

$$H_{FLEX} = (1+\theta)2C\,\sigma_\lambda + \theta\mu + \beta_o y \tag{32}$$

and, from Equations (18), (30), and (31), the expected losses for the home country in a currency union (H_{CU}) are:

$$H_{CU} = (1+\theta)C\,\sigma_x + \theta\mu^{cu} \tag{33}$$

The net benefits from the participation in a currency union therefore are:

$$NB = (1+\theta)C\,(2\sigma_\lambda - \sigma_x) + \theta(\mu - \mu^{cu}) + \beta_o y \tag{34}$$

The expression of the net benefits may differ for the two countries, indicating that the two countries may disagree, on purely economic grounds, about the adoption of a common currency. The two countries constitute an optimum currency area if both countries expect positive net gains from the creation of a currency union.

To investigate the effect of the parameters it is helpful to spell out the variance of x:

$$\begin{aligned}\sigma_x^2 \quad = \quad & (\alpha_o^* + \beta_o)^{-2}\,[\,4\alpha_o^{*2}\sigma_\lambda^2 + 4\beta_o^2\sigma_{\lambda^*}^2 + \beta_o^2 n^2(\sigma_{\alpha^*}^2 + \sigma_\beta^2) + \\ & + 4\alpha_o^*\beta_0(2\sigma_{\lambda\lambda^*} + n\sigma_{\lambda\alpha^*} - n\sigma_{\lambda\beta}) + 2\beta_o^2 n(2\sigma_{\lambda^*\alpha^*} - 2\sigma_{\lambda^*\beta} - n\sigma_{\alpha^*\beta})\,]\end{aligned} \tag{35}$$

where $n=1-q-\varepsilon$ (defined in Section 3.4, with $0<n<1$) is inversely related to the degree of adjustment provided by migration (ε) and by the fiscal rule (q).

4.1 The Adjustment Costs Component

Most of the analysis will discuss the net benefits resulting from the adjustment costs (NB_{AC}) in terms of inflation and unemployment:

$$NB_{AC} = D\,(2\sigma_\lambda - \sigma_x) \tag{36}$$

where $D=(1+\theta)C$ varies only with θ. The NB_{AC} component is positive if $2\sigma_\lambda > \sigma_x$. The variability of nominal domestic income under flexible exchange rates is only due to domestic monetary shocks (σ_λ), whose entire effect is actually borne by the home country. In a currency union, the variability of nominal domestic income is due to all monetary and real shocks (σ_x), whose effect is shared by the two countries. The NB_{AC} component increases with the relative weight (θ) assigned to inflation by the authority.

4.1.1 Monetary Shocks

If real shocks are absent or fully adjusted ($n=0$), the adjustment cost component due to monetary shocks ($NB_{AC.M}$) is given by:

$$NB_{AC.M} = 2D\left(\sigma_\lambda - (\alpha_o^* + \beta_o)^{-1}\sqrt{\alpha_o^{*2}\sigma_\lambda^2 + \beta_o^2\sigma_{\lambda^*}^2 + 2\alpha_o^*\beta_o\sigma_{\lambda\lambda^*}}\right) \quad (37)$$

Under flexible exchange rates, each country's nominal income is fully affected by domestic monetary shocks. In a currency union, both domestic and foreign monetary shocks affect domestic income only partially, depending on the degree of openness (β). Therefore, the variability of domestic monetary shocks (σ_λ) influences positively the net benefits, as the creation of a currency union lowers the domestic impact of σ_λ. The variability of foreign monetary shocks ($\sigma_{\lambda*}$) reduces the net benefits because these shocks affect the home country only in a currency union. However, a negative correlation between monetary shocks ($\rho_{\lambda,\lambda*}$) would dampen the last effect, as foreign and domestic monetary shocks would tend to offset each other. In general, a decrease in the correlation coefficient of monetary shocks increases the net benefits. To make this point clearer, it might be useful to discuss two cases more in depth.

(i) If domestic and foreign monetary shocks are perfectly and positively correlated ($\rho_{M,M*}=1$), $NB_{AC.M}$ becomes:

$$NB_{AC.M} = 2D\,\beta_o(\alpha_o^* + \beta_o)^{-1}(\sigma_\lambda - \sigma_{\lambda^*}) \quad (38)$$

This equation captures the argument that, when monetary shocks are positively correlated across countries, the country with higher monetary instability (home, if $\sigma_\lambda > \sigma_{\lambda*}$) would gain stability from the creation of a currency union. As McKinnon (1963) already noted, the more open the country, the higher these gains. In fact, in a currency union (or fixed exchange rate regime) monetary shocks are transmitted across countries, which is an advantage for the more unstable country. The more open the country (β), the higher the transmission. However, the other country would obviously lose in terms of adjustment costs to monetary shocks, and the more open it is, the more it would lose. Openness of a country simply amplifies its adjustment cost component due to monetary shocks. Therefore, this result does not univocally support McKinnon's (1963) argument that more open economies would gain monetary stability by joining a currency area. Equation (38) shows that McKinnon's argument holds only if the economy under consideration normally experience less monetary stability than the other members of the currency area.

(ii) If domestic and foreign monetary shocks are perfectly and negatively correlated ($\rho_{M,M*}=-1$) and if $\alpha_o^*\,\sigma_\lambda > \beta_o\,\sigma_{\lambda*}$,[22] then:

$$NB_{AC.M} = 2D\,\beta_o(\alpha_o^* + \beta_o)^{-1}(\sigma_\lambda + \sigma_{\lambda^*}) \quad (39)$$

When monetary shocks are negatively correlated, both countries gain monetary stability from the currency union, and the more open they are, the more they will gain. In fact, in this case, not only do domestic monetary shocks leak abroad, but foreign monetary shocks also dampen the domestic ones (given the negative correlation).[23]

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[22] This condition holds if the home country is relatively close and monetary unstable.

[23] Several studies (see for example Martinengo and Padoan (1983), Masera (1987)) have shown that the fluctuations of the dollar/deutsche mark exchange rate had asymmetric effects within the EMS. To the

4.1.2 Real Shocks

In this model, demand shocks to tradables have an effect only in a currency union and therefore they reduce the net benefits. If one neglects monetary shocks the adjustment cost component due to real shocks ($NB_{AC.R}$) is given by:

$$NB_{AC.R} = -D\, n\, \beta_o (\alpha_o^* + \beta_o)^{-1} \sqrt{\sigma_{\alpha^*}^2 + \sigma_\beta^2 - 2\sigma_{\beta\alpha^*}} \leq 0 \tag{40}$$

This negative component increases with the variance of trade shocks (σ_β, σ_{α^*}) and diminishes with the correlation coefficient between the two demand shocks (ρ_{β,α^*}). The effect of the correlation coefficient supports the usual argument that countries facing asymmetric real shocks (ρ_{β,α^*} close to –1) would have high costs if they renounced the exchange rate as an instrument of adjustment, while countries facing symmetric shocks (ρ_{β,α^*} close to 1) would have lower costs. If the real shocks were perfectly and positively correlated, and had equal standard deviation, their adjustment would not imply any cost in a currency union.

The relevance of trade shocks (and the cost of renouncing the exchange rate) increases with the country's openness (β) and decreases with the degree of adjustment provided by migration and by the fiscal tool ($q+\varepsilon=1-n$). If the degree of adjustment is full ($\varepsilon+q=1$, or equivalently $n=0$) the component due to trade shocks disappears; the same result obviously applies to the uninteresting case of a closed economy ($\beta=0$).

4.1.3 Correlation between Monetary and Real Shocks

A positive correlation between monetary shocks and demand shocks to domestic tradables (both $\rho_{\lambda\beta}$ and $\rho_{\lambda^*\beta}$) reduces the variability of x, reduces the adjustment cost of a currency union, and therefore increases the net benefits for the home country. In fact, when domestic demand for the import good increases (β goes up), the home country experiences unemployment, which can be dampened by the inflationary effect of a contraction in domestic or foreign money demand. Also a negative correlation between monetary shocks and foreign demand shocks ($\rho_{\lambda\alpha^*}$ and $\rho_{\lambda^*\alpha^*}$) increases the net benefits for the home country, as an increase in export demand (α^* up) is inflationary for the home country. However, opposite signs for the four mentioned correlations would increase the net benefits of the other country. Hence, different levels of correlations between monetary and real shocks are associated with advantages for either one country or the other.

4.2 The Inflationary Bias Component

The component of the net benefits due to the existence of authority's inflationary bias (NB_{IB}) is given by:

$$NB_{IB} = \theta(\mu - \mu^{cu}) \tag{41}$$

extent that these asymmetric effects reflect asymmetric monetary shocks, there could be an advantage, both for the deutsche mark area and for the other European countries, in adopting a single currency.

This component indicates a net benefit if the union chooses an average rate of growth of money supply (inflationary bias), which is lower than the rate that the home country is willing or able to adopt under flexible exchange rates. A high relative weight assigned to inflation by the authority (θ) reinforces this component. This case corresponds to the nominal anchor argument, or what the game-theoretical approach of the time-consistency literature has called "the advantage of tying one's hands" (see Giavazzi and Pagano, 1988): a high inflation country can reduce its inflation by pegging its exchange rate to a low-inflation currency. However, this argument holds from the perspective of the high inflation country. The inflationary bias component can be negative or null for the low inflation country, as it seems improbable that the union will choose an average monetary growth rate lower than the lowest among all rates of the candidates to the currency union.

4.3 Transaction Costs

The transaction costs are a proxy for the deadweight and efficiency losses associated with the existence of multiple currencies (see Section 1.2). They constitute a net benefit which increases with the openness of the country and with the size of the transaction costs per unit of expenditure:

$$NB_{TC} = \beta_o v \tag{42}$$

4.4 Openness

The effect of an increase in the degree of openness on the net benefits is not uniquely determined, but depends on the relative importance of the different components of the net benefits.[24] First, an increase in openness increases the net benefits component due to the elimination of the deadweight and efficiency losses associated with multiple currencies (see Sections 1.2 and 4.3). Second, it increases the relevance of trade shocks, which reduce the net benefits. This effect is smaller the higher the correlation between real shocks across countries, and the larger the adjustment provided by labor mobility and by a fiscal tool (see Sections 4.1.2). Third, it increases the relevance of monetary shocks, with uncertain outcome. As discussed in Section 4.1.1, the existence of monetary shocks increases the net benefits if monetary shocks are negatively correlated, or if monetary shocks are positively correlated and domestic monetary variability is higher than the foreign one. Monetary shocks decrease the net benefit if they are positively correlated, and domestic monetary variability is lower than the foreign one. Overall, the effect of openness is unclear.

[24] The model does not incorporate one important effect of openness, stressed by Mundell (1961) and McKinnon (1963): in more open economies, wages and prices are more likely to follow exchange rate movements, partially neutralizing its effectiveness as an instrument of adjustment.

5 Conclusions

The paper develops a monetary model of trade with nominal rigidities which allows for a comprehensive consideration of the monetary and real arguments suggested by the literature on optimum currency areas and monetary integration. Such arguments have usually been developed individually and in partial equilibrium analyses which were not formalized. The results are in line with most but not all of the arguments proposed by the literature.

The nature of the issue makes it impossible to find a rule of thumb for the identification of an optimum currency area (defined as a currency area in which all members expect positive net benefits from their participation). The net benefits that one country expects from its participation in a currency union increase with: (1) the correlation of real shocks between countries, since the exchange rate becomes less useful as an instrument of adjustment; (2) the degree of adjustment provided by fiscal tools and by international labor mobility, as these substitute for the exchange rate; (3) the difference between the inflationary bias of the domestic authority and the inflationary bias of the currency union, since in this case the participation in the currency union presents advantages equivalent to "tying one's hands" (see Giavazzi and Pagano, 1988); (4) the variability of domestic monetary shocks, as parts of these shocks are transmitted to other countries within a currency union (unlike under flexible exchange rates); (5) the size of the deadweight and efficiency losses eliminated through the adoption of a single currency.

The same net benefits decrease with: (6) the variability of real shocks, as these shocks generate adjustment costs in a currency union; (7) the variability of foreign monetary shocks, since parts of these shocks are transmitted to the home country within a currency union (unlike under flexible exchange rates); (8) the correlation of monetary shocks between countries, as an increase in such correlation diminishes the probability that the monetary shocks neutralize each other in a currency union.

The two countries do not necessarily agree on the creation of a currency union. The conditions under which the two countries have the same net benefits formula ($\sigma_\lambda=\sigma_{\lambda *}$; $\theta=\theta^*$; $\beta=\alpha^*$; $\mu=\mu^*$; $\nu=\nu^*$; $\sigma_{\lambda\alpha *}=\sigma_{\lambda *\beta}$; $\sigma_{\lambda\beta}=\sigma_{\lambda *\alpha *}$) are too restrictive to be of interest.

Most of these results have been discussed extensively in the literature on optimum currency areas. One important result is however at odds with the literature: the effect of the degree of openness on the net benefits is ambiguous when both real and monetary shocks are taken into account. Mc Kinnon (1963) argument that small countries would be gain monetarily stability by joining a currency area (and the more open the more they would gain) was largely applicable to the sixties, when most countries were already part of a fixed exchange rate regime. However, it does not need to hold in general, especially in present times, as some countries may have a smaller variance of monetary shocks than the currency area they may consider belonging to. Similarly, the claim by other authors (Tower and Willet, 1976; De Grauwe, 2003) that openness summarizes all criteria for the determination of an optimum currency area is not confirmed by the present formal analysis of the net benefits: more open economies not necessarily gain monetary stability by pegging (as just mentioned), and they also import more real shocks, so that their overall need for adjustment is not necessarily lower in a currency area than under flexible rates (see section 4.4).

Several extensions would be of great interest: the addition of a third country; the investigation of optimal monetary policy and of its interaction with fiscal policy; the adoption of an intertemporal optimization approach (which would also allow for the analysis of financial capital movements); the endogenous derivation of the authority's loss function and of the cost of inflation; the introduction of microfoundations for the nominal rigidities, and of variable political boundaries across regions. The paper, however, captures most of the essential elements of the study of an optimum currency area, within a manageable framework.

It should be noted, however, that the theoretical analysis of an optimum currency area is far from complete. For example, more research should be devoted to assessing the benefits deriving from the adoption of a single currency (see Baldwin 1991), the effects of the creation of a currency union on the relations between member countries and third countries (see: Bayoumi, 1994; Bénassy-Quéré, Mojon, and Pisani-Ferri, 1997; Ghironi and Giavazzi, 1997; Masson and Turtelboom, 1997; Ginebri, 1992; Ricci and Isard, 2002) and the timing for joining a currency area (see for example Martin, 1995, and Ricci 1992). Even more generally, there is limited consensus on the empirical assessment of the welfare cost of inflation.

It is particularly important to bear in mind that the delimitation of an optimum currency area may change over time, as most of the "parameters" of the cost-benefit analysis are not fixed but may evolve over time. For example, it has been asserted that the completion of the single market in Europe would affect the degree of openness, labor mobility, and correlation of shocks, while the creation of a currency union could induce a convergence of the behavior of national trade unions and might force member countries to adopt some form of fiscal federalism (see for e.g., Krugman 1991, 1992, 1993, and De Grauwe, 2003). Moreover, modeling firms' location choices under different exchange rate regimes and in the presence of market rigidities, Ricci (2006a) argues that countries tend to be more specialized under flexible rates than under fixed rates, a result consistent with the evidence of Fontagné and Freudenberg (1998).[25] This result implies that the net benefits that can be expected from the creation of a currency area are endogenous to—and rising in—the institution of such currency area, as the latter induces sectoral dispersion and consequently reduces the degree of asymmetry of shocks. A similar effect has been empirically found via the trade channel. Starting with Rose (2000), many authors find that that trade is much higher among participants in a currency union (for a recent analysis, see Barro and Tenreyro, 2007), while Frankel and Rose (1998) find that an increase in trade increases the syncronisation of the business cycle. All these considerations suggests that dynamic effects (exogenous or endogenous to the creation of the currency area) should not be underestimated when evaluating the desirability of a currency area.

When considering the process of European monetary integration and the implications for the optimality of exchange rate regimes of neighboring countries, optimum currency area arguments would indicate quite different results across group of countries. Central Eastern European countries are quite likely to face an increase in the symmetry of shocks with the EMU group due to their ongoing economic integration, so that the costs of relinquishing to the exchange rate would decline. For further away regions, such as the CIS countries or middle-eastern countries, the correlation of shocks

[25] For the effect of a currency union on the agglomeration of economic activity, see Ricci (2006b)

with the EMU is likely to remain small, while the correlation with each other (and with a large local economy such as Russia for the CIS countries) would be larger. This would suggest, on the one hand, large costs in terms of economic adjustment by joining to the EMU or pegging to it; on the other hand, the benefits from lower inflation may also be large when joining the EMU.

6 Appendix

This appendix shows under which conditions a Ricardian model could justify the assumptions of full specialization (Section 2.1) and of wage equalization (Section 3.3).

Let me neglect the nontraded sector and introduce a Ricardian comparative advantage in the traded sectors, by adding two sectors to the model described in the text: a constant returns to scale (CRS) production of B in the home country and a CRS production of A in the foreign country:

$$A^s = \gamma L_A \quad ; \quad B^s = \gamma' L_B \quad ; \quad A^{s*} = \delta' L_A^* \quad ; \quad B^{s*} = \delta L_B^*$$

As the choice of the line of production is not of a short-run nature, I evaluate the conditions for full specialization at equilibrium flexible prices and wages:[26]

$$w = \gamma p_A = \gamma' p_B \quad ; \quad w^* = \delta p_B^* = \delta' p_A^* \qquad ; \qquad \frac{w}{w^*} = \frac{L^*}{L}\frac{\alpha^*}{\beta}\frac{\lambda^*}{1-\lambda^*}\frac{1-\lambda}{\lambda}$$

The home country specializes in good A, while the foreign country specializes in good B, if:

$$p_B > \tau e p_B^* \qquad ; \qquad e p_A^* > \tau p_A$$

By combining the two conditions and by substituting for prices and wages, one can derive:

$$\frac{\tau \gamma'}{\delta} < \frac{L^*}{L}\frac{\alpha^*}{\beta}\frac{\lambda^*}{1-\lambda^*}\frac{1-\lambda}{\lambda} < \frac{\gamma}{\tau \delta'}$$

which has two implications. First, the extent of the comparative advantage must be large enough to make it convenient for both countries to remain fully specialized even in the presence of transaction costs (by comparing left and right terms). Second, for the international relative prices to fall between domestic ones adjusted for transport costs, the previous condition must be satisfied for any value of the shocks to the preferences' parameters.

From the previous condition one can derive that wage equalization in the initial equilibrium requires that (1) every country has an absolute (and not only comparative) advantage in the good it specializes in, even when adjusting for the transaction costs;

[26] It is in fact conceivable that firms would base such choice on the equilibrium relative prices that would occur in the absence of short-run market rigidities, and not on temporary profit opportunities due to these rigidities.

and that (2) labor distribution across countries is inversely related to their initial share of expenditure on foreign goods. Respectively:

$$\frac{\tau\,\gamma'}{\delta} < 1 < \frac{\gamma}{\tau\,\delta'} \qquad ; \qquad \frac{L}{L^*} = \frac{\alpha_o^*}{\beta_o}$$

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