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A Model of an Optimum Currency Area[1]

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Abstract

This paper investigates the circumstances under which it is beneficial to participate in a currency area. A 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 shocks, international factor mobility, fiscal adjustment, openness, difference in national inflationary biases, correlation of monetary shocks, and benefits of a single currency. 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. Countries do not necessarily agree on whether a given currency union should be created.

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SUMMARY

This paper develops a two-country model to investigate the circumstances under which it is beneficial to participate in a currency area. It captures both the real and monetary arguments suggested by the optimum currency area literature in a simple monetary model of trade with nominal rigidities. The net benefits that one country expects from participation in a currency union increase with the correlation of real shocks between countries; the degree of international labor mobility; the degree of adjustment provided by a fiscal tool; the difference between the inflationary bias of the domestic authority and the inflationary bias of the authority of the currency union; the variability of domestic monetary shocks; and the extent of the deadweight and efficiency gains deriving from the adoption of a single currency. The same net benefits decrease with the variability of real shocks; the variability of foreign monetary shocks; and the correlation of monetary shocks between countries.

The main result of the study is that the effect of the degree of openness on the net benefits is ambiguous, in contrast with the usual argument that the more open economies are, the better candidates they make for a currency area. It is also interesting to note that countries do not necessarily agree on the desirability of creating a given currency union.

I. INTRODUCTION

The project of establishing a European Monetary Union has stimulated new interest in the theoretical and empirical investigation of optimum currency areas (OCA). Several arguments (such as shocks asymmetry, factor mobility, and fiscal adjustments), indicated as crucial in the assessment of whether a set of countries should relinquish the exchange rate as an instrument of adjustment, have been the object of extensive empirical research. In spite of the large number of theoretical and empirical contributions on the subject, there are very few attempts to model a comprehensive and integrated analysis of the various economic aspects involved. This paper provides a framework which formally derives and weighs most of the real and monetary arguments suggested by the literature on OCA in the last thirty-five years. Our model does not confirm the conventional assertion that the more open economies are, the better candidates they are for a currency area.

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. 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 adopting a single currency or a fixed exchange rate regime. We focus on the type of currency area generated by the adoption of a single currency.[2]

In Sections I.A and I.B we briefly describe the elements of the cost-benefit analysis and the related empirical investigation. The fundamental intuition has been provided by Mundell (1961) in his seminal paper. Most of the subsequent literature on OCA has focused on the costs of renouncing the exchange rate, while almost neglecting the benefits. For extensive reviews and discussions of the optimum currency area literature see, for example: Bofinger (1994), De Grauwe (1992), Ishiyama (1975), Krugman (1992), Masson and Taylor (1992), Tavlas (1993a, 1993b, 1994), and Tower and Willet (1976).

A. 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.[3]

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[2]There are several differences between a single currency and a fixed exchange rate regime. In particular, the latter would still allow authorities to realign and would not eliminate transaction costs nor expectations of realignments.

[3]We are concerned with the short run adjustment, under the standard assumption that the long run equilibrium would be the same in the two monetary regimes.

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;

3.   domestic prices are *not immediately indexed* to the exchange rate (exchange rate illusion), implying 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:

4.   other mechanisms of adjustment, such as *factor movements* or a *fiscal federalism*, are absent or small; *or*

5.   adjustment through the exchange rate is less costly than through other instruments.

As Mundell (1961) and McKinnon (1963) noticed, the effectiveness of the exchange rate might decrease with *openness*, as prices and wages will neutralize the change in the exchange rate more quickly. However, more open areas are more exposed to foreign shocks. 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; we will discuss this point in detail in Section IV. As described in Section I.B, also the benefits of a currency union are likely to vary with the openness.

Not many authors stress the importance of the degree of asymmetry of monetary shocks in the evaluation of the costs of a currency area. Bofinger (1994) argues that *monetary aspects*, such as the degree of asymmetry of monetary shocks and the difference in domestic inflation levels (see Section I.B), play a central role in the optimum currency area analysis, overcoming the importance of the traditional elements (labor mobility, openness, correlation of shocks . . .). In our model, we introduce both real and monetary shocks.

A recent survey dismissing the whole discussion about the costs of EMU is proposed by Buiter (1995).

Empirical evidence

The interest for the EMU project has also stimulated a rich empirical investigation aimed at understanding whether the adoption of a single currency would really imply higher costs of adjustment to shocks. The main emphasis has been laid on comparing 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 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. The picture that we obtain is not too promising for the EU: across its 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. Most of the adjustment to shocks seems to arise through relative price movements and domestic fiscal policies. A single currency would eliminate an important component (the exchange rate) of the relative price adjustment, while the political management of EMU is likely to require restrictions on the independence of domestic fiscal policies.

Let us briefly review the literature. Bayoumi and Eichengreen (1993), identifying demand and supply shocks through the Blanchard and Quah (1989) estimation procedure, find that the correlations of shocks across U.S. regions is higher that across European Union countries. Both in the United States and in the EU, the correlation is higher for a core of countries (Germany, France, Belgium, the Netherlands, and Denmark in the EU; Eastern Seaboard, Midwest, and Farwest in the United States), than for the others. Bayoumi and Eichengreen (1993b) extend this analysis to the EFTA countries, showing that Austria, Sweden, and Switzerland seem to belong to the EU core (on this point see also Cheung and Hutchison, 1994).

Erkel-Rousse and Melitz (1995) identify five sources of shocks for the six major European countries, through the Blanchard and Quah technique, and extend the analysis from the usual correlation of shocks (their findings confirm the low correlation among European countries) to the effectiveness of domestic monetary and fiscal policy as a stabilization device. Through the contribution that absorption shocks and relative money-velocity shocks add to the explanation of output and net exports, they infer that fiscal policy is an effective tool for all countries except Germany (suggesting that they will need to retain some fiscal independence in the EMU), and that only in Germany and United Kingdom monetary policy has real effect (indicating that these two countries would lose from forgoing the independence of such instrument).

Mundell (1961) argued that international factor mobility can bring the necessary adjustment to demand shocks. The discussion on labor mobility that followed his contribution criticized the effectiveness and the desirability of labor mobility as an form of adjustment; however, most economists agree on its importance for the long run adjustment to persistent

shocks.[4] Blanchard and Katz (1992) show that, in the United States, labor mobility has played a major adjustment role, substituting for price flexibility. It has been repeatedly argued that labor mobility is lower among European countries than in the United States, inducing worries that the EU would face significant adjustment costs if the exchange rate were relinquished. Bayoumi and Eichengreen's (1993) findings that adjustment to shocks is faster in the United States than in Europe are consistent with this assertion and with the results of Blanchard and Katz. Evidence confirming the lower European labor mobility is given, for example, by Bayoumi and Prasad (1995) and by Eichengreen (1993). This last contribution, however, challenges the worrisome implication for the EMU, showing that labor markets adjustment is not slower in Europe than in the United States: the limited labor mobility in Europe would be partly of endogenous nature, as its role in the adjustment of regional labor markets would be substituted for by other mechanisms. Bayoumi and Thomas (1995) find in fact that relative price variability is crucial for the adjustment to shocks within the European Union, while it is not so important in the United States. The conclusion could as well be that a single European currency, by eliminating the exchange rate flexibility, is likely to increase the adjustment cost.

A basic macroeconomic textbook would suggest that a country facing a bad time because of temporary shocks could borrow and pay back in future good times. However, a basic international macroeconomic textbook would contrast the Feldstein-Horioka (1980) puzzle: domestic savings and investment tend to be highly correlated, suggesting relatively little international capital mobility. It is therefore natural to ask whether the EU can count on capital mobility to smooth the effects of asymmetric shocks. The empirical investigation of Atkeson and Bayoumi (1994) suggests that capital mobility is higher among the U.S. regions than among European countries, where it provides a particularly low degree of insurance against regional fluctuations. Will the Single Market enhance capital mobility within the EU?

It has been suggested that a fiscal tool could substitute for flexible exchange rates or migration. Such substitution is imperfect, as a fiscal tool does not represent a true "adjustment," but rather a way of *"financing" temporary shocks*. The rationale is in fact a lessening of the short term costs (in terms of unemployment and inflation) of the business cycle. One possible institution is a federal fiscal system endowed with stabilization devices as in the United States and Canada. 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. The European Union does not have a fiscal system engineered to cope with shocks,[5] and it is questionable whether such a system will ever come about. As Eichengreen (1990) estimates,

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

[5]The EU "structural funds," aimed at reducing the long run divergence of regional per capita GDP, are instead similar to the long run redistributive fiscal flows of the Canadian and American federal fiscal system. They are however much smaller (Bayoumi and Masson, 1995).

the shock absorption due to EU taxes is insignificant. Bayoumi and Masson (1995) show, however, that national fiscal policies of EU countries have so far performed an adjustment role whose extent is comparable to the one of the North-American federal systems. Consistent evidence is brought by Erkel-Rousse and Melitz (1995), as mentioned above.

B. Benefits from the Adoption of a Single Currency

Mundell (1961) stresses in particular[6] 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. First, the institution of a single currency eliminates the *deadweight loss* due to currency transactions[7] and to the need to collect and process information: the factors of production previously involved in these activities now become available for alternative uses. 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.[8] It is important to stress that these benefits could not be reaped (or could be reaped only to a lesser extent) if a fixed exchange rate regime rather than a single currency were adopted.

It is very difficult to identify the 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, 1992). *In our model,* we therefore include *transaction costs as a proxy for the benefits* in general.

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[6]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 an original 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 IV and V).

[7]The EU Commission estimated that for the EMU these benefits should be of the order of 0.5 percent of EU GDP (EC, 1990).

[8]Point (2b) is controversial. It has been argued that exchange rate uncertainty generates higher price uncertainty and consequently increases the distortion in microeconomic choices; in particular, it reduces capital accumulation and growth (EC, 1990). It should be borne in mind, however, that in a general equilibrium framework, exchange rate variability is an endogenous variable; therefore, the elimination of the exchange rate would not eliminate the fundamental variability of the system, which would simply affect other variables. See De Grauwe (1992) for a review of these arguments and of the related empirical evidence.

Inflation convergence: cost or benefit?

The similarity of preunion 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 was that countries may have different Phillips curves or different inflation-employment targets, 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 black market and a higher optimal inflation than Germany which does not have a black market).

The time consistency approach to monetary policy (see for example Barro and Gordon, 1983a, 1983b) argues that the Phillips curve is vertical and that inflation is mostly due to a game between wage setters and the central bank. Its extensions 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.[9] However, in a currency union, the level of inflation might not be the lowest among the preunion 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.

We introduce in our model an exogenous increase in money supply (inflationary bias) in order to capture the contribution of inflation convergence in the cost-benefit analysis.

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[9]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 each period on a game between wage setters and fiscal authorities (monetary policy is ineffective), 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 quickly a currency union than by pegging until inflation has gradually converged.

C. Existing Models of an OCA and the Aim of this Paper

Bayoumi (1994)[10] has the merit of providing a simple general equilibrium framework to analyze most of the "real" aspects of the optimum currency area literature (correlation of real shocks, labor mobility, openness, diversification); his model, however, does not consider the "monetary" aspects and their interaction with the real ones. The presence of 'n' 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 already suffer part of the losses generated by the union; "it is possible that a region which would ideally prefer that all regions have separate currencies may still have an incentive to join a currency union which other regions intend to form." 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). This result bears a worrisome implication for a "two-speed" monetary union in Europe.

Ghosh and Wolf (1994) adopt a model similar to Bayoumi (1994) and investigate empirically how each of certain zones of the world (the United States, Europe, the G-7, Former Soviet Union, CFA zone, and world itself) could be divided into optimum currency areas. They write a program that recognizes an optimum currency area when the correlation of output shocks inside the area implies that the costs of adjustment are below an exogenous level of benefits.

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 affected by 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 the exchange rate; the gap in productivities across countries would persist (hence the inefficiency), matched by different real wages. The conditions for the endurance of a real wage gap seem, however, too strong.

Melitz (1993) offers a detailed analysis of the trade aspects associated with the creation of a currency area. Although complex, his analysis does not address monetary issues.

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[10]His and our model present some similarities, but are the fruit of independent research. We have in fact become aware of Bayoumi's contribution while writing previous versions of this paper.

Devarajan and Rodrik (1991) investigate the desirability of the CFA Zone; their model weighs the credibility gains in terms of lower inflation with the losses implied by the inability to employ the exchange rate for stabilization purposes.

Other authors adopt a general equilibrium cash-in-advance framework to investigate some of the monetary aspects of the optimum currency area approach. Canzoneri and Rogers (1990) focus on the possibility that the optimal employment of inflation, as a tax instrument, might require different national levels of inflation. They develop a model which weighs the efficiency cost of renouncing a local choice of the inflation-tax with the benefits deriving from the elimination of conversion costs. Minford (1993) attempts to build the microfoundations for the OCA approach by capturing the advantages of independent monetary policies as stabilization tools. Unfortunately, the adoption of a cash-in-advance framework forces these authors to omit the other traditional issues addressed by the optimum currency area literature.

Our model attempts to capture the cost-benefit analysis previously described in a monetary model of trade with nominal rigidities. The innovative content of our paper, with respect to the reviewed models, stems from our simultaneous analysis of **both the real and monetary aspects** of the optimum currency area literature. Our focus is on the short run adjustment to shocks under different exchange rate regimes in the presence of nominal rigidities. We adopt restrictive assumptions in order to keep the framework simple.

The subsequent sections are organized as follows. Section II presents the model. Section III measures 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 III.C and III.D. Section IV measures and discusses the expected net benefits for the home country from the participation in a currency union; these benefits are measured as a percentage of the labor force (which is equivalent to measuring them as a percentage of full employment GDP, given the constant returns to scale assumption). Section V summarizes the results and draws conclusions.

II. THE MODEL

A. Structure of the Model and Agents' Behavior

Adapting from Dornbusch, Fischer and Samuelson (1977) and from Blanchard and Kiyotaki (1987), we add nontraded goods, random Cobb-Douglas preferences in goods and money, exchange rates, trade costs, an authority's loss function, and nominal rigidities to a two-country two-good Ricardian trade model. The analysis is static and neglects the existence of capital. The results of our cost-benefit analysis would hold under more general

assumptions, provided that some market rigidities are maintained (if markets cleared instantly, a currency union would not imply any cost).

Imagine a world 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. We first solve our model assuming that labor is immobile across countries; from Section III.C onwards, we investigate the role of international labor mobility. Every individual can supply at most one unit of work (full employment).

Uncertainty and timing of actions

Uncertainty arises from demand and monetary shocks.

The *initial equilibrium*. We assume that the world is initially in full employment equilibrium. The corresponding wages are denoted by (w_0, w_0^*). We define 'inflation' as the change in prices with respect to those prevailing in the initial equilibrium.

Before the resolution of uncertainty, nominal wages are set[11] at levels w_s and w_s^* which are above w_0, w_0^* by the expected percentage increase in the respective national money supply (or, equivalently, in the nominal domestic GDP). Such assumption introduces nominal rigidities and allows to 'account for' an inflationary bias à la Barro-Gordon (1983a, and 1983b), as specified later in this section.

After the resolution of uncertainty. Taking for given the wage, firms choose competitively optimal employment and prices, under 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.

Technology and specialization

Each country produces one traded good (A or B) and a nontraded one (N or N^*). Such pattern of specialization can be derived from a Ricardian comparative advantage, by

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[11]The following alternative assumptions would give equivalent results: 'minimum wages' institutionally set at w_s and w_s^*; or wages bargained at w_s and w_s^* and upwardly indexed to GDP inflation. Short run nominal rigidities are essential for the exchange rate to have a short run adjustment role; a wide variety of microfoundations for such rigidities can be found in Mankiw and Romer (1992).

assuming that the conditions for complete specialization hold.[12] Without loss of generality, we can assume that the home country specializes 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: $\gamma, \delta, \psi, \phi$, are the (average and marginal) 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.

Preferences

Individuals have Cobb-Douglas preferences over money,[13] 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 his/her 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:

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

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:

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[12]In Appendix we describe such conditions. This would not seem an innocuous hypothesis for the issue we want to analyze: when one country starts producing both goods, the degree of shock-asymmetry between the two countries changes. However, even in the presence of full specialization, we can investigate the effects of different degrees of shock-asymmetry through the correlation coefficient of demand shocks.

[13]Other authors have adopted money in the utility function in a static problem; see for example Blanchard and Kiyotaki (1987).

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

subject to

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

where p_A, p_B^*, p_N, and $p_{N^*}^*$ are the local currency prices[14] prevailing in sectors A, B^*, N, N^*. **e** is the exchange rate defined as units of domestic currency per unit of foreign currency. The parameter $\tau > 1$ indicates the presence of Samuelson 's iceberg-type transaction costs (see Sections I.B and II.C) 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 $\tau = e = 1$. m_i and m_j^* are the money endowments of the home and foreign representative consumers 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, his income is a share ($1/L$ or $1/L^*$) of the domestic firm's revenues.

Shocks and monetary rule

Preferences' parameters are subject to shocks. Their percentage changes 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 our analysis, we set them equal to 0.5 in order to simplify notation; this implies that initially in every country nominal income and money stock have equal value. *Actual* values of λ and λ^* differ from 0.5 and from each other in the occurrence of money demand shocks.

As unexpected money supply shocks would enter the final formula similarly to money demand shocks ($\chi_{\lambda k}$), it is unnecessary to introduce them. Money demand shocks can however be interpreted as *monetary shocks in general*.

We assume that monetary authorities are not allowed to pursue discretionary policies that would enable them to counteract the shocks. One could think of these shocks as the ones authorities have been unable to fully offset.

In order to represent possible **inflationary biases** of the authority (see Section I.B), along the lines indicated by the time consistency literature (see Barro and Gordon, 1983a,

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[14]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.

1983b and Giavazzi and Pagano, 1988), it is convenient[15] to assume that national money stocks are increased by given amounts (in percentage terms: μ and μ^*, for the home and foreign country respectively). Such increases occur simultaneously to the happening of shocks and take the form of lump-sum transfers to individuals. The values of μ and μ^* may differ across the two countries only under flexible exchange rates; in a currency union, $\mu=\mu^*=\mu^{cu}$. Such changes in money supply are *anticipated* and incorporated in the previously described wage-setting ($w_s=w_0(1+\mu)$ and $w_s^*=w_0^*(1+\mu^*)$).

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^*}	$(-z_{\lambda^*}, z_{\lambda^*})$

B. Equilibrium

Consumers' behavior

Maximizing the consumers' problems, and aggregating by virtue of homothetic preferences, we obtain the following demands for money and expenditures on goods:[16]

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[15]Deriving the inflationary bias endogenously through a game between monetary authorities and wage setters (as in Barro-Gordon, 1983a,b) would unnecessarily complicate the framework, without adding significant insights.

[16]Note that although consumption levels of imported goods are affected by the transaction costs, the sales (indicated within brackets) are not; this result is due to the Cobb-Douglas preferences.

$$p_A A^d = \alpha\lambda(Y+M) \quad ; \quad ep_B^*[\tau B^d] = \beta\lambda(Y+M) \quad ; \quad p_N N^d = (1-\alpha-\beta)\lambda(Y+M)$$

$$p_A[\tau A^{d*}] = \alpha^*\lambda^* e(Y^*+M^*) \quad ; \quad p_B^* B^{d*} = \beta^*\lambda^*(Y^*+M^*) \quad ; \quad p_{N*}^* N^{*d} = (1-\alpha^*-\beta^*)\lambda^*(Y^*+M^*)$$

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

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**.

Firms' behavior

Firms behave competitively and face a labor supply curve which is infinitely elastic at the given wage until full employment is reached. National employment cannot raise above full employment. Hence, after the resolution of uncertainty, domestic and foreign firms maximize profits subject to, respectively:

$$w = w_s \quad ; \quad L_A + L_N \leq L$$

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

When the initial equilibrium is disturbed by an increase in demand for goods of one country, firms in that country find it optimal to raise price, as they cannot hire more workers to produce more.[17] When demand for goods of one country goes down, in order to avoid losses (due to the fix wage), firms of that country will reduce employment until their aggregate output equals aggregate demand at the marginal cost pricing. In formulas, either:[18]

$$p_A \geq w_s/\gamma \quad ; \quad p_N \geq w_s/\psi \quad ; \quad p_B^* \geq w_s^*/\delta \quad ; \quad p_{N*}^* \geq w_s^*/\phi \quad ; \quad L_A + L_B = L \quad ; \quad L_B^* + L_{N*}^* = L^*$$

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$$p_A = w_s/\gamma \quad ; \quad p_N = w_s/\psi \quad ; \quad p_B^* = w_s^*/\delta \quad ; \quad p_{N*}^* = w_s^*/\phi \quad ; \quad L_A + L_B \leq L \quad ; \quad L_B^* + L_{N*}^* \leq L^*$$

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[17]It is irrelevant for our analysis whether such price increase is associated with an increase in profits, as in our case, or in wage, as under the alternative assumption specified in footnote 11.

[18]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.

Hence, our 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. Any smaller degree of convexity would not alter qualitatively our analysis.

Markets' equilibrium

We now derive the equilibrium conditions that will allow us to investigate the adjustment to shocks under different exchange rate regimes (Section III). Taking into account the first order conditions, the equilibrium in the four goods markets (for A, B, N and N^*) implies that:

$$p_A A^s + p_N N^s \equiv Y = (1-\beta)\lambda(Y+M) + \alpha^*\lambda^* e(Y^*+M^*)$$

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

(10)

while the equilibrium in the two money markets gives:

$$Y = \frac{\lambda}{1-\lambda}M \qquad ; \qquad Y^* = \frac{\lambda^*}{1-\lambda^*}M^*$$

(11)

The goods market equilibrium is reached through adjustment in the nominal income of both countries, while the money market is equilibrated by exchange rate movements, under flexible exchange rates, and by redistribution of currency across countries, in a currency union. Such redistribution may be thought of as occurring through (within period) trade imbalances, intervention of monetary authorities aimed at equilibrating the money market, or (in reality) international capital flows.[19] In each country k, money supply would therefore change because of the authorities' inflationary bias (μ^k, in percentage terms) and, in a fixed exchange rate regime, because of the currency redistribution (v^k_{fix}, in percentage terms) that equilibrates the money market:

$$M^k = M_o^k (1 + \mu^k + v_{fix}^k)$$

where a subscript 'o' denotes initial values.

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:

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[19]We could alternatively solve the currency union case holding initial money stock distribution constant (hence without worrying about how the redistribution occurs), allowing for money market and trade balance disequilibria. We did so in previous versions: the formulas for the net-benefits were very similar and yielded identical conclusions.

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

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

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

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:

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

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, each country experiences either unemployment or inflation in excess of μ^k (associated with positive profits), as we will describe in Section III.

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 $\lambda_o=\lambda_o^*=.5$), 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 identical to those described above provided that we replace the initial values of parameters. In particular (recalling that $\lambda_o = \lambda^*_o = .5$):

$$Y_o^k = w_o^k L^k = M_o^k \tag{15}$$

where k is a country index. The equilibrium relative wage (w_o/w_o^*, choosing $e_o=1$) can be derived from the aggregate goods markets equilibrium, while the zero-profit conditions give the relative prices (p_A/p^*_B):

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

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

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

Finally, equilibrium output levels can be read from Equation (1).

If we want to interpret this model as a sequence of periods, we might want to think that at the end of the period workers receive their share of profits and the preset nominal wage, which constitutes the cash-balances they bring along to the next period. At the beginning of the next period, agents expect the economy to be in full employment equilibrium again, either because the shocks were temporary and disappeared, or because price, wages, money stocks (manoeuvred by the authority), and the exchange rate, adjust to the new levels that ensure full employment in the absence of "new" shocks. Under these assumptions, each period will look similar. For our purposes, whether shocks fade away or are adjusted is immaterial. We are in fact interested in the short-run costs of adjustment, in terms of inflation and unemployment; we therefore consider inflation and unemployment arising from shocks within the period. These costs have a permanent nature even if permanent shocks are adjusted after one period, because shocks occur repeatedly over time and therefore there will always be a continuum of short-run adjustment costs. It would nonetheless be interesting to extend this model to an intertemporal optimization framework.

C. Transaction Costs

As specified in Section I.B, transaction costs are meant to represent all the additional deadweight and efficiency losses that multiple currencies imply. We want to measure these costs 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), we 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 approximately:[20]

$$TC = \beta v \quad ; \quad TC^* = \alpha^* v \qquad with \qquad v=1-\tau \qquad (18)$$

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[20]For convenience, we do not measure the transaction costs at actual employment; the approximation is however extremely close, the error being of the order of thousandths (if unemployment caused by shock is 5 percent and v is 2 percent, the error would be in the order of 1 thousandth of the labor force).

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

D. The Authority's Loss Function

Throughout the literature on optimum currency areas, the net-benefits that are expected to arise from the participation to a currency union are mostly presented as adjustment costs in terms of inflation and unemployment versus gains from the adoption of a single currency. In order to 'measure' these net-benefits, we define an authority's loss function in inflation and unemployment similar to the one commonly used in macroeconomics[21] from Barro-Gordon (1983a and 1983b) onwards. The use of agent's utility functions would be more appropriate, but much more complex and probably still unsatisfactory. In fact, although money in the utility function is a very convenient specification to investigate real effect in the presence of market rigidities (see for example Blanchard and Kiyotaki, 1987) it provides unreliable welfare implications.

The authority's loss function of country k is assumed to be:

$$H^k = E(\ u^k\ +\ \theta^k\ \pi^k\ +\ TC^k\ ) \tag{19}$$

where **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[22]), 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; as a consequence, transaction costs and unemployment have the same weight.

III. SHOCKS AND ADJUSTMENT

In this section, we describe the consequences of the short run adjustment to shocks 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 II.B) and are expressed in percentage terms.

A. Flexible Exchange Rates

Under this monetary regime, money stocks would just change because of the monetary increase due to the inflationary bias (μ^k). The percentage changes in the exchange rate ($\hat{e}$) and

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[21]Note the absence of square terms in our specification.

[22]Adopting a CPI price index would introduce terms of trade effects.

in country k's nominal income (Y^k, measured in currency k) that equilibrate the goods and money markets can be derived from Equations (10) and (11):[23]

$$\hat{M}^k = \mu^k > 0 \qquad ; \qquad \hat{Y}^k = \mu^k + 2\,\chi_{\lambda^k}$$

$$\hat{e} = \mu - \mu^* + \chi_\beta - \chi_{\alpha^*} + 2\,\chi_\lambda - 2\,\chi_{\lambda^*} \tag{20}$$

where the χs represent the percentage changes of the preferences' parameters denoted by the subscripts (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, bottles in domestic monetary shocks, which generate either inflation in excess of μ^k or unemployment (see Section III.E).

B. Currency Union

When the two countries form a currency union, they adopt the same currency (e=1) and the transaction costs disappear.[24] Wages and prices are denominated in the same units in the two countries, but we still distinguish M and M^* to denote domestic and foreign currency "holdings". The change in nominal income that equilibrates the goods market can be derived from Equation (10):

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

Money supply may now change not only because of μ^{cu}, but also because of monetary flows (or authorities intervention) υ^k_{fix}, that equilibrate the money markets in the occurrence of money demand shocks and real shocks. From Equations (8) and (11):

$$\hat{M} = \mu^{cu} + \frac{\beta_o\,(\chi_{\alpha^*} - \chi_\beta + 2\chi_{\lambda^*} - 2\chi_\lambda)}{\alpha_o^* + \beta_o} \quad ; \quad \hat{M}^* = \mu^{cu} + \frac{\alpha_o^*\,(\chi_\beta - \chi_{\alpha^*} + 2\chi_\lambda - 2\chi_{\lambda^*})}{\alpha_o^* + \beta_o} \tag{22}$$

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[23]Or from Equation (11) and by setting the total differential of Equation (12) to 0.

[24]If the two countries adopted a *fixed exchange rate regime*, the transaction costs would still be present.

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 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.

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

C. Labor Mobility as a Form of Adjustment

In this section, we allow for international labor mobility, which can bring the necessary adjustment to demand shocks (see Section I.A). Assuming that wages are initially equalized across countries[25] ($w_o = w_o^*$), and recalling that initially $Y_o^k = w_o^k L_o^k$, we can derive from Equations (10) and (11) the migration flow that would fully adjust the demand shocks.[26]

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

where **d** is the differential operator. More generally we can assume 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, Equation (21) become:

$$\hat{Y} = \mu^{cu} + \frac{2\alpha_0^* \chi_\lambda + 2\beta_0 \chi_{\lambda^*} + \beta_0 (1-q) (\chi_{\alpha^*} - \chi_\beta)}{\alpha_0^* + \beta_0}$$

$$\hat{Y}^* = \mu^{cu} + \frac{2\alpha_0^* \chi_\lambda + 2\beta_0 \chi_{\lambda^*} + \alpha_0^* (1-q) (\chi_\beta - \chi_{\alpha^*})}{\alpha_0^* + \beta_0}$$

(24)

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[25]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.

[26]We investigate labor mobility as a form of adjustment only for real shocks; monetary shocks are usually less persistent and less likely to trigger migration decisions.

These equations represent the change in nominal income that can result in inflation and unemployment. The effect of demand shocks is now lower than in Equation (21), part of it being absorbed by migration. If labor is fully mobile (q=1), demand shocks will be totally adjusted and would not affect income.

This analysis of labor mobility is based on ad hoc assumptions to keep our framework simple. 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.

D. Fiscal Federalism

In this section we introduce a fiscal rule that generates a smoothing of real shocks (see Section I.A). 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.[27] By applying a particular tax-transfer rate (t)

$$t \, dY = - \, t \, dY^* \qquad \textit{with} \qquad t = \frac{\epsilon}{1-\epsilon} \, \frac{\alpha_o^* + \beta_o}{1 - \alpha_o^* - \beta_o}$$

we obtain that a share ϵ $(0 < \epsilon < 1)$ of the change in income due to real shocks is absorbed by the tax-transfer scheme. By taking into account the fiscal rule when solving Equations (10) and (11), and recalling Equation (24), we can derive the percentage changes in national

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[27]The same tax-transfer scheme could be employed for monetary shocks, provided that we allow the federal budget 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). Other more complicated fiscal rules, based on tax and public expenditure can be adopted, as we have done in previous versions of this paper.

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:

$$\hat{Y} = \mu^{cu} + \frac{2\alpha_o^* \chi_\lambda + 2\beta_o \chi_{\lambda^*} + \beta_o \, n \, (\chi_{\alpha^*} - \chi_\beta)}{\alpha_o^* + \beta_o} \equiv \mu^{cu} + x$$

$$\hat{Y}^* = \mu^{cu} + \frac{2\alpha_o^* \chi_\lambda + 2\beta_o \chi_{\lambda^*} + \alpha_o^* \, n \, (\chi_\beta - \chi_{\alpha^*})}{\alpha_o^* + \beta_o} \equiv \mu^{cu} + x^*$$

$$(26)$$

where **n=1-ϵ-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.*

We have therefore shown that both migration and fiscal federalism can smooth demand shocks and lower the costs of a currency union. At the moment the European Union lacks both labor mobility and an agreement on the employment of fiscal policy as a short term stabilizer. It would be very useful to investigate within a more specific framework whether authorities should ease and promote migration or make an effort to agree on the employment of some fiscal instrument. In this respect it is also important to bear in mind that migration might constitute an auspicious solution for permanent shocks, while the employment of a fiscal tool is useful for transitory ones. In fact, it is not probable that shocks which are perceived to be temporary can induce migration, nor that the governments of different countries can (even if sometimes are willing to) "finance" indefinitely persistent shocks. It is not the aim of this paper to deepen this discussion.

E. Expected Inflation and Unemployment in the Two Exchange Rate Regimes

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

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

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

$$(27)$$

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.

We 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 (27), we find that, *under flexible exchange rates*:

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

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

$$(28)$$

where the approximation originates from neglecting the truncation of the normal. The constants Y_i and Y_s are the inferior and superior boundaries of Y under flexible rates, which can be derived from the second of Equation (20) as $(\mu^k + 2z_{\lambda k}, \mu^k + 2z_{\lambda k})$. The notation $f(.)$ stands for the conditional probability density function of Y. The constant C is equal to $1/(2\Pi)^{1/2}$, capital Π being the geometric ratio of circumference to its diameter.

As in Equation (28), from Equations (26) and (27) we derive the levels of expected inflation and unemployment when countries participate *in a currency union*:

$$E(\pi^k) \approx \mu^{cu} + C\,\sigma_{x^k} \quad ; \quad E(u^k) \approx C\,\sigma_{x^k} \qquad (29)$$

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

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

IV. COST-BENEFIT ANALYSIS OF A CURRENCY UNION

In this section, we want to measure and discuss the net benefits that the home country[28] expects to gain from the participation in a currency union.[29] We define the net benefits as the difference between the expected losses under flexible exchange rates and the expected losses in a currency union. Such expected losses are evaluated through the authority's loss function defined in Section II.D, and are therefore measured as a percentage of the labor force (or equivalently as a percentage of full employment GDP, given the constant returns to scale assumption). We thus provide a formal derivation of the cost-benefit analysis presented in Sections I.A and I.B, by weighing: (a) the difference between the adjustment costs (in terms of inflation and unemployment) that follow shocks under the two 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.

From Equations (18), (19), and (28), we know that the expected losses for the home country under a flexible exchange rate regime (H_{FLEX}) are:

$$H_{FLEX} = (1+\theta)2C \ \sigma_\lambda + \theta\mu + \beta_o v \tag{30}$$

and, from Equations (18), (19), and (29), the expected losses for the home country in a currency union (H_{CU}) are:

$$H_{CU} = (1+\theta)C \ \sigma_x + \theta\mu^{cu} \tag{31}$$

The **net benefits** therefore are:

$$NB = (1+\theta)C \ (2\sigma_\lambda - \sigma_x) + \theta(\mu - \mu^{cu}) + \beta_o v \tag{32}$$

Equation (32) captures several criteria and arguments related to the choice of the exchange rate regime, in one cost-benefit analysis. Criteria such as labor mobility, openness, correlation of real shocks, and similarity of inflation levels, have often been individually stressed as key features for the identification of an optimum currency area. We will now

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[28]Similar formulas and identical intuition applies to the foreign country.

[29]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 we identify should be adjusted for net present value calculations, giving rise to a much larger number.

discuss the effects of all parameters on the net benefits. However, it is the whole set of effects that has to be taken into consideration: *the two countries constitute an optimum currency area if both countries expect net gains from the creation of a currency union.* It is evident that the expression of the net benefits may differ for the two countries. It is therefore possible that the two countries disagree, on purely economic grounds, about the adoption of a common currency.

To proceed with our investigation it is helpful to specify the variance of x, which is where most of the action is taking place:

$$\sigma_x^2 = (\alpha_o^*+\beta_o)^{-2} \cdot [\ 4\alpha_o^{*2}\sigma_\lambda^2 + 4\beta_o^2\sigma_{\lambda^*}^2 + \beta_o^2 n^2(\sigma_{\alpha^*}^2+\sigma_\beta^2) +$$

$$+ 4\alpha_o^*\beta_0\ (2\sigma_{\lambda\lambda^*} + n\sigma_{\lambda\alpha^*} - n\sigma_{\lambda\beta}) + 2\beta_o^2 n\ (2\sigma_{\lambda^*\alpha^*} - 2\sigma_{\lambda^*\beta} - n\sigma_{\alpha^*\beta})\ ]$$

(33)

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

A. The Adjustment Costs Component

Most of our analysis will discuss the net benefits resulting from the *adjustment costs* (**NB**$_{AC}$) in terms of inflation and unemployment:

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

where **D**=(1+θ)C varies only with θ. The NB$_{AC}$ component is positive if $\sigma_\lambda>\sigma_x$. 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 rises with the relative weight (θ) assigned to inflation by the authority.

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:

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

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 effects 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 *correlation between monetary shocks* ($\rho_{\lambda,\lambda*}$) close to -1 can reverse the last effect, as foreign and domestic monetary shocks 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, we find it 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:

$$NB_{AC.M} = 2D \ \beta_o \ (\alpha_o^* + \beta_o)^{-1} \ (\sigma_\lambda - \sigma_{\lambda*})$$ (36)

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 monetarily unstable country. The more open the country (β), the higher the transmission. 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. *This result does not univocally support McKinnon's (1963) argument* that more open economies would gain monetary stability by joining a currency area. Equation (36) shows that McKinnon's argument holds only if the economy under consideration is *less* monetarily stable 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 $\alpha_o^* \ \sigma_\lambda > \beta_o \ \sigma_{\lambda*}$ [30], then:

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

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). It is important to note that this case can

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

indicate a *benefit for Germany* from its participation in the European Monetary Union (and in the EMS). Several studies[31] have shown that the fluctuations of the dollar/deutsche mark exchange rate have asymmetric effects within the EMS. To the extent that these asymmetric effects can be represented by asymmetric monetary shocks, there is an advantage, both for the deutsche mark area and for the other European countries, in adopting a fixed exchange rate regime or a single currency.

2. Real shocks

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

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

This negative component rises 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+ϵ=1-n). If the degree of adjustment is full (ϵ+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 (β=0).

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 raises the net benefits for the home country; in fact, when domestic demand for the import good rises (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 a rise in export demand (α goes up) is inflationary for the home country. Unfortunately, opposite signs

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[31]See for example Martinengo and Padoan (1983), Masera (1987).

for the four mentioned correlations would raise 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.

B. The Inflationary Bias Component

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

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

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 (average) 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. In the case of the European Union (and of the EMS), economists have always implicitly assumed that this component would represent a loss for Germany, and have been wondering which advantages were pushing Germany to promote and participate in the process of European monetary integration. Other elements of the cost-benefit analysis might constitute an expected gain for Germany, such as the one mentioned in Section IV.A.1 and the one we will mention in the next section.[32] From Equation (32), we can identify the highest inflationary bias of the union that would still make the home country willing to join the currency union:

$$\mu^{cu} \le \mu + \theta^{-1}[(1+\theta)C \ (2\sigma_\lambda - \sigma_x) + \beta v]$$

C. Transaction Costs

The transaction costs are a proxy for the deadweight and efficiency losses associated with the existence of multiple currencies (see Section I.B). 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*:

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[32]Other important reasons, like for example political ones or avoiding beggar-thy-neighbor devaluations, are not present in our cost-benefit analysis.

$$NB_{TC} = \beta_o \, v$$

As in the previous section, we can find the minimum level of transaction costs per unit of expenditure (to be born under flexible rates) at which the home country is willing to participate in the currency union:

$$v \geq \beta^{-1} [(1 + \theta)C \; (\sigma_\kappa - 2\sigma_\lambda) + \theta(\mu^{cu} - \mu)]$$

D. Openness

In our analysis, 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.[33] In fact, an increase in openness:

1. increases the net benefits component due to the elimination of the deadweight and efficiency losses associated with multiple currencies (see Sections I.B and IV.C);

2. 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 IV.A.2);

3. increases the relevance of monetary shocks, the effect of which is *uncertain*; as we have seen (Section IV.A.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.

V. CONCLUSIONS

The last ten years have witnessed an increased interest in the debate on whether the European Union constitutes an optimum currency area, both on theoretical and on empirical grounds (see Sections I.A and I.B). In spite of the political and economic importance of the

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[33]Our 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.

issue, and of the huge literature on the topic, theoretical contributions have been mostly limited to a critical survey of the numerous arguments suggested by the literature on OCA, while very little effort has been devoted to formalizing an integrated view of the subject (see, however, Section I.C).

We develop a monetary model of trade with nominal rigidities which allows for a comprehensive and simultaneous 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. Our 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 authority 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 results described have been discussed extensively in the literature on optimum currency areas. We would like to underline other points which stem from our model.

1. The effect of the degree of openness on the net benefits is ambiguous when both real and when monetary shocks are taken into account (see Section IV.D). This result contrasts with the usual argument that more open economies are better candidates for a currency area (such McKinnon, 1963; Tower and Willet, 1976; De Grauwe, 1992).

2. The investigation of monetary shocks deserves more attention. 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, and the more open it is the more it would gain (Section IV.A.1). This result does not univocally support McKinnon's (1963) argument that more open economies would gain monetary stability by joining a currency area; in our model, his statement is true only if the economy under consideration is less monetarily stable than the other members of the currency area.

3. When monetary shocks are negatively correlated, both countries gain monetary stability from the currency union, and the more open the greater the gains. This might indicate a benefit for Germany as a result of its participation in the EMS or EMU, to the extent that the asymmetric effects on European countries of the dollar/deutsche mark fluctuation correspond to asymmetric monetary shocks (Section IV.A.1).

4. 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 ($\sigma_\lambda = \sigma_{\lambda*}$; $\theta = \theta^*$; $\beta = \alpha^*$; $\mu = \mu^*$; $v = v^*$; $\sigma_{\lambda\alpha*} = \sigma_{\lambda*\beta}$; $\sigma_{\lambda\beta} = \sigma_{\lambda*\alpha*}$) are too restrictive to be of interest.

5. We find it interesting to note that our model gives a regional dimension[34] to the traditional macroeconomic trade-off between inflation and unemployment. In a currency area experiencing downwards nominal rigidities and labor immobility, trade shocks result in inflation in one region and unemployment in the other. Allowing further inflation in the first region (say through monetary expansion) could eliminate unemployment in the second region. In a standard micro-based model there are no costs associated with inflation. It would be of interest to derive such costs endogenously and to investigate the optimal trade-off.

6. The introduction of nontraded goods plays no role in the evaluation of the cost-benefit analysis of a currency union. The crucial measure of the openness of a country is the share of domestic expenditure that falls on foreign goods as opposed to domestically produced goods. The ratio of tradables to nontradables (suggested by McKinnon, 1963) is irrelevant if there is sectoral labor mobility within each country.

Let us briefly apply this framework to some economies in transition. Some FSU countries have been thinking about whether they should link their currency to the Russian rouble or to the deutsche mark. The first choice would present a very high monetary component of costs, as the Russian monetary policy is both very inflationary (high μ) and very unstable (high $\sigma_{\lambda*}$; recall from Section II.A that χ_λ can be interpreted as both money demand

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[34]Such a regional aspect was already noted by Mundell (1961).

and supply shocks). The deutsche mark link would definitely imply smaller costs from inflation and monetary shocks, but probably higher costs from real shocks, as presumably the correlation of real shocks is smaller between Germany and some FSU economies than between such economies and Russia.

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; the introduction of microfoundations for the nominal rigidities, and of variable political boundaries across regions. We hope, however, that our paper can capture most of the essential elements of the study of an optimum currency area, within a manageable framework.

Let us note, though, that the theoretical analysis of an optimum currency area is far from complete. For example, economists still do not have a clear understanding of the benefits deriving from the adoption of a single currency, and very little research has been devoted to the effects of the creation of a currency union on the relations between member countries and third countries (on this last point see Bayoumi, 1994, and Ginebri, 1992). Another crucial issue is the timing of the creation of a currency area. This issue is especially relevant when countries have historically different inflation levels, as witnessed by the EMS experience (Ricci 1992 shows that a fast creation of a currency union implies less fluctuation in inflation and output than pegging until inflation has converged; see Section I.B)

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 will affect the degree of openness, of labor mobility, and of correlation of shocks, while the creation of a currency union might 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, 1992). Modeling firms' location choices under different exchange rate regimes and in the presence of market rigidities, Ricci (1995) finds that countries tend to be more specialized under flexible rates than under fixed rates. 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. 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.

In this appendix we show under which conditions a Ricardian model could justify our assumptions of full specialization (Section II.A) and of wage equalization (Section III.C).

Let us neglect the nontraded sector and introduce a Ricardian comparative advantage in the traded sectors, by *adding* 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, we evaluate the conditions for full specialization at equilibrium flexible prices and wages.[35]

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

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

$$p_B > \tau \, e \, p_B^* \quad ; \quad e \, p_A^* > \tau \, p_A \tag{45}$$

By combining the two conditions and by substituting for prices and wages, we 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: (1) 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); (2) 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 we 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; and that (2) labor distribution across countries is inversely related to their initial share of expenditure on foreign goods. Respectively:

$$\tau \gamma' / \delta < 1 < \gamma / (\tau \delta') \quad ; \quad L / L^* = \alpha_o^* / \beta_o$$

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[35]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.

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