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WP/92/39

INTERNATIONAL MONETARY FUND

Research Department

A Theory of Optimum Currency Areas: Revisited 1/

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May 1992

Abstract

Starting with Friedman and Mundell the academic literature has conducted a high level debate concerning the design of cross-country monetary arrangements. That debate has become very complex and the data requirements necessary for appropriate application of the principles developed are far beyond the means of the very nations for which the principles might be valuable. In this paper we return to the simplicity of the early arguments and formalize them in a way that may be helpful for currency area decisions where little is known about economic structure.

JEL Classification Numbers:
F30; F31; F41; F47

1/ This paper was prepared for a special issue of the Greek Economic Review. The authors thank George Tavlas for comments. Any views expressed are the views of the authors and are not necessarily those of the International Monetary Fund or Dartmouth College.

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Contents

Summary

The academic debate concerning cross-country currency arrangements started in earnest with Milton Friedman (1953), who argued for a worldwide flexible exchange rate system. He was joined by Robert Mundell (1963), who made an elegant case for a worldwide mixture of fixed and flexible rates. Since Friedman and Mundell, the debate has continued to rage, with those advocating cross-country currency arrangements arguing that their success depends on considerations ranging from countries' production structures to the credibility of their monetary authorities. The complexity of the arguments has far outstripped the ability of policymakers to apply the principles developed in the arguments. Indeed, the countries for which these arguments may be relevant are often among the less sophisticated in terms of market development and data collection.

This paper provides an explicit model of Mundell's optimum currency area argument, which indicates that Mundell somewhat understated the case for fixed exchange rates between two areas of labor mobility Whereas Mundell assumed that the relevant macroeconomic shocks were demand-side shocks, the model in the paper includes supply-side shocks. The paper concludes that such shocks can give rise to strong efficiency gains for a fixed-rate system when labor is mobile and prices are sticky.

I. Introduction

The breakups of the former Soviet Union and Yugoslavia and the reuniting of the two Germanies are among the most dramatic events in modern history. These are huge political events with correspondingly huge economic implications. Developing the cross-country currency and clearing arrangements for these emerging sovereigns is a high priority since pre-existing trading arrangements setup these new nations as each others' primary trading partners. For many years the academic literature has studied the design of cross-country monetary arrangements, but in recent years the literature has become very complex and the data requirements necessary for appropriate application of the principles developed in the literature are far beyond the means of the emerging nations. Still, these nations need to make decisions about their currency arrangements. The purpose of this paper is to review briefly and formalize some of the existing literature on the optimal choice of currency area and then extend that literature in a direction that may be helpful for currency area decisions in a situation where little is known about the current economic situation and structure in these new nations.

Roughly, currency area choice is the choice between fixed and flexible exchange rates. A newly sovereign nation needs some initial property rights enforcement mechanism and needs an initial allocation of property rights to individuals and to the state. We will assume that the rights to make choices about money reside with the state. We will also assume that for public finance reasons the state issues its own money. Once it has decided to issue its own money, the country needs to choose between fixed and flexible exchange rates. 1/

In Section II we review some of the original exchange rate regime literature and discuss some subsequent developments. In section III we develop a simple formal model that is capable of capturing some aspects of the early discussions. In section IV we provide extensions of the model and indicate the model's implications for currency area choice.

1/ It may well be that public revenue requirements are so strong in these countries that little attention can be paid to cross-country currency prices, and we would expect that to be the case, at least in the short term, in many instances. There will be other instances, however, where a large nation may offer an inducement to a smaller nation to adopt the currency of the larger nation. In such cases, weighing the inducement against the costs of joining the larger currency area will require some way of evaluating those costs.

II. Fixed Versus Flexible Exchange Rates and the Optimal Currency Area

Following WWII the International Monetary Fund was designed and implemented to facilitate aggregate cross-country commercial transactions. The Fund was conceived as an institution responsible for short-term lending primarily for balance of payments purposes and in defense of a system of fixed but adjustable exchange rates. Worldwide capital markets were poorly developed at the time, and the Fund acted as an official version of the yet to be developed international financial structure. Measured on the basis of the size and frequency of exchange rate changes, the Fund's early years were a success. However, not everyone agreed on such a standard of measurement.

In 1953 Milton Friedman published "The Case for Flexible Exchange Rates," which was conceived as a reply to the widespread adoption of the Bretton Woods fixed rate system. 1/ Friedman's case rested on market-determined exchange rate changes being, in his view, the best way for countries to accommodate cross-country demand shifts. His alternatives to flexible exchange rates involved either: (1) changes in official exchange rates, (2) changes in countries internal prices and incomes, (3) direct controls, or (4) the use of monetary reserves. In Friedman's view the Bretton Woods system, which the Fund administered, relied excessively on option (1) and, he felt, that the crises that would surround currency realignments would be a much greater disturbance to economic activity than would be market-determined exchange rate movements. The other three alternatives were dismissed as: impractical for option (2) because of sticky prices and wages, too unpredictable for option (3) because of difficulties in predicting and monitoring imports, exports and capital flows and too restrictive for option (4) since reliance on monetary reserve flows to correct cross-country disturbances allows external considerations to dictate domestic monetary policy.

Friedman's case was rejoined by Robert Mundell in his article "A Theory of Optimum Currency Areas," in which he pointed out that a world in which all countries maintain fixed exchange rates, and a world with all countries maintaining flexible exchange rates are polar extremes, and an ideal cross-country monetary system probably lies in an arrangement wherein some countries join in a currency area maintaining fixed rates or possibly adopting a single currency, and other countries, not joining the currency area, float relative to the currency area. According to Mundell's ideas, the currency area and the region of labor mobility are roughly the same. Since, by definition, labor cannot move across regions of labor mobility and with prices and wages sticky the only way to meet shocks in the demand for one region's product relative to another region's product, without causing unemployment or inflation, is to change the exchange rate between the regions. If labor were mobile between the regions then laborers could just migrate to booming areas and no exchange rate change would be necessary.

1/ See also James Meade (1955) and Tibor Scitovsky (1958).

Mundell's ideas were clear but they were hard to model formally and models evaluating exchange rate regime choice moved away from those ideas and toward looking at the composition of production, the stochastic structure of shocks, and more recently to signal extraction and credibility arguments. 1/ It is our intention to revisit the optimum currency area problem and confront it on the same terms as the original contributors, but to try to sharpen the original arguments by putting them in terms of a formal model with an explicit stochastic structure. We will develop a model in which labor can move across regions--at a cost. And in which labor is induced to move by regional productivity and demand shocks. In the text we treat explicitly the case of negatively correlated productivity shocks. In our model, the choice of exchange rate regime will matter for real variables for the same reasons Mundell conjectured: nominal wages are sticky and as other prices change relative to wages, labor allocations are affected. The model in the text is the simplest case that illustrates our point, which is that Mundell may have understated his case for fixed exchange rates across regions of labor mobility. Our model makes Mundell's point even more strongly than he made it originally, because we allow supply-side shocks to drive a wedge between the productivity of labor in a pair of countries thus giving rise to strong efficiency reasons for labor to move across national borders. Fixed exchange rates provide a monetary equilibrium in which labor will move for such efficiency reasons. Flexible exchange rates discourage labor mobility and thus provide an environment in which productivity difference are not be exploited.

III. A Model of Labor Mobility

We consider, at the outset, a minimal model capable of addressing the implications of labor mobility: a two countries, one good economy. 2/ The effective supply of labor (denoted by EF) is given by:

1/ McKinnon (1963) began the production structure view, Flood and Marion (1982), and Aizenman and Frenkel (1985) were early contributors to the stochastic view. Fischer (1988) begins to develop signaling and credibility arguments. A brief survey of recent contributions in this area is given by Flood and Marion (1991).

2/ This example is a formalization of Scitovsky's (1958) case study of the European Coal and Steel Community. According to Scitovsky, p. 136, the goal of the community was "[to] establish conditions which will in themselves assure the most rational distribution of production at the highest possible level of productivity."

$$EF = \begin{cases} L, & \text{if } L < \bar{L} \\ L - \frac{\tau}{2\bar{L}}(L-\bar{L})^2 + (1-c)L_n^*, & \text{if } L > \bar{L} \end{cases}$$

$$EF^* = \begin{cases} L^*, & \text{if } L^* < \bar{L}^* \\ L^* - \frac{\tau}{2\bar{L}^*}(L-\bar{L}^*)^2 + (1-c)L_f & \text{if } L^* > \bar{L}^*, \end{cases} \tag{1}$$

where $0 \leq c \leq 1$, $0 \leq \tau$ and where $\bar{L}$, $\bar{L}^*$ denotes full employment at home and abroad respectively. L_h^* denotes the foreign labor employed by the home economy, and L_f is the employment of home workers by the foreign economy. Employment of the domestic labor force beyond the full employment is subject to diminishing effectiveness, as is reflected by τ. Employing foreign labor at home is associated with a cost, measured by c. This term reflects transportation and time costs associated with the reallocation of workers across countries, implying that the effective supply of a reallocated worker is 1-c. Henceforth, we will normalize the supply of labor in each country to 1.

In our setup behavior is asymmetric at full employment. Labor's effective supply falls one-for-one as domestic labor input is reduced below full employment. However, as domestic labor is increased beyond full employment its marginal effectiveness decreases. For simplicity we have adopted a quadratic form for the decreased effectiveness of domestic-based labor input beyond full employment.

The production function exhibits diminishing marginal product to effective labor input:

$$Y = \frac{1}{a}(EF)^{\gamma}; \; Y^* = \frac{1}{a^*}(EF^*)^{\gamma}$$

$$0 < \gamma < 1, \tag{2}$$

where Y and Y* are domestic and the foreign output, which are assumed to be identical, and 1/a and 1/a* correspond to domestic and the foreign productivity. The domestic money price of output is P and P* is the foreign money price of output. Since Y and Y* are identical the law of one price gives $P = P^*S$, where S is the exchange rate, quoted as the domestic currency price of the foreign currency.

a. <u>The money market</u>

We adopt here the simplest specification of monetary equilibrium: constant velocity. The demand for money equals a fraction q of nominal domestic GNP, and for simplicity we assume q = 1. Under a <u>fixed exchange</u>

rate regime, the national money markets are integrated into a unified international money market. The equilibrium is characterized by the equality of the global demand and supply of money, where the balance of payments mechanism generates the desirable distribution of money across countries:

$$\begin{aligned} &\text{a.} \quad M^d = PY; \ (M^*)^d = PY^* \\ &\text{b.} \quad M_o^s + (M_o^*)^s = P(Y+Y^*) \qquad (3) \\ &\text{c.} \quad M_o^s = (M_o^*)^s = \bar{M}, \end{aligned}$$

where M_o^s and $(M_o^*)^s$ denote the initial supply of money in each country and where we set $S = 1$. Equation (3) states the equality of the global supply of money with the demand.

With a flexible exchange rate the money market clears in each country separately, determining the price levels in the two economies and thus the exchange rate. The money market equilibrium conditions under a flexible exchange rate system are:

$$\begin{aligned} &\text{a.} \quad M^s = PY \\ &\text{b.} \quad (M^*)^s = P^*Y^* \\ &\text{c.} \quad M^s = (M^*)^s = \bar{M} \qquad (4) \\ &\text{d.} \quad P = SP^*. \end{aligned}$$

We adopt the Fischer-Gray formulation of labor contracts, where labor is employed subject to nominal contracts. The wage for the current period is preset at level W_o so that the expected employment equals the full employment target, 1:

$$E(L+L_f) = 1; \ E(L^*+L_n^*) = 1, \qquad (5)$$

where E is the expectation operator. Note that the expected employment takes into account the possibility of the mobility of labor.

Within the period, employment is demand determined: producers demand labor so as to maximize their profits at the contract wage. We assume that the contract wage in a given economy applies to both domestic and foreign-based labor. The cost associated with employing foreign labor (c in (1)) implies that domestic producers will employ foreign workers only in states of overemployment of domestic labor.

To gain further insight, we turn to the case where the two countries are subject to productivity shocks. The simplest interesting example is the case of two states of nature, such that productivity is given by:

$$(a,\ a^*) = \begin{cases} \left(\frac{1}{1+h};\ \frac{1}{1-h}\right) & \text{prob. } \frac{1}{2} \quad \text{State A} \\ \left(\frac{1}{1-h};\ \frac{1}{1+h}\right) & \text{prob. } \frac{1}{2} \quad \text{State B.} \end{cases} \tag{6}$$

Note that a positive correlation among the productivity shocks is trivial to analyze, because there are no gains from reallocating labor. The perfectly negatively correlated shocks that we study are clearly a polar extreme--they maximize the gains from reallocating labor because they make the models' aggregate uncertainty disappear. As the correlation of the shocks moves toward a perfect positive correlation, which will maximize the aggregate or uninsurable uncertainty, these gains will disappear. However, that situation is also a polar extreme. Appendix A provides the formal solution of our system. We summarize it here with the help of several Figures.

b. A fixed exchange rate

From the global point of view, the two states of nature result in with the same price level, and hence the same real wage. This is an outcome of the symmetry of the shocks and the fact that under a fixed exchange rate the money market (which determines the price level P) is global. Hence, the global GNP, given by Y + Y*, is the same in the two states of nature. Assuming a given global supply of money, it implies that the price level is the same. While the results of our analysis do not hinge on the constancy of the real wage across state of nature, exposition of the key points is greatly simplified by this feature. Figure 1 depicts the equilibrium in home economy labor market. Similar analysis is applicable to the foreign country. Figure 1 plots the marginal product of labor employed by the home economy is states A and B (denoted by $MP_{L,A}$ and $MP_{L,B}$, respectively). The real wage is given by $\frac{W_o}{P_o}$. In state A domestic employment exceeds the full employment level. Equation (1) implies that as long as the marginal contribution of domestic labor to the effective labor exceeds 1-c, the producer will employ only domestic workers. Once that equality is reached, the domestic producer will employ $1 + \frac{c}{\tau}$ domestic labor, and will employ foreign workers as to equate their marginal product (net of reallocation cost) to the real wage. Figure 1 summarizes these possibilities, where curve $MP^{N.M.}_{L,A}$ corresponds to the marginal product of labor in the absence of labor mobility, and curve $MP^{L.M.}_{L,A}$ corresponds to the case where mobility of labor is allowed. The two curves diverge at point M, once that the domestic employment exceeds the full employment by a fraction $\frac{c}{\tau}$. The extent of the mobility of labor is determined by the magnitude of the shocks. For large shocks, the cost of reallocation is small relative to the demand in the country experiencing the favorable productivity shock, as is depicted in Figure 1a. In state A domestic

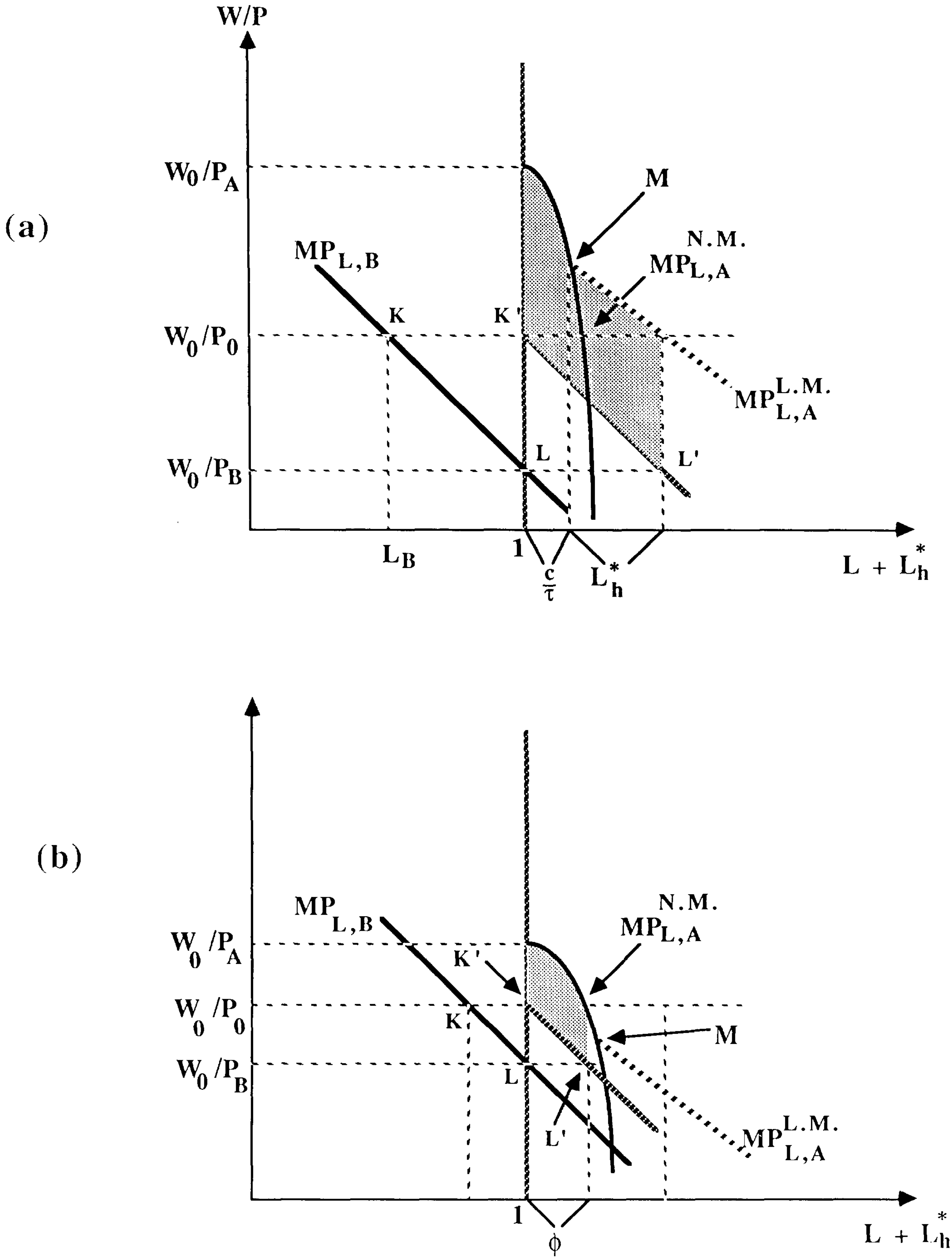

FIGURE 1
THE LABOR MARKET

employment will be $1 + \frac{c}{\tau}$ and in addition L_n^* foreign workers will be employed by domestic producers. The symmetry of the two countries implies that in state B only L_B workers will be employed by the home economy producers, and $L_f = L_h^*$ domestic workers will reallocate and will be employed by foreign producers. Figure 1b corresponds to the case of small shocks, such that at resultant equilibrium the real wage exceeds the marginal product of foreign labor. For large shocks, the country experiencing the positive shock will employ foreign workers. Labor will move if the marginal product of labor at point M exceeds the real wage, as is the case in Figure 1a. Note that in such a case the condition of full employment implies that the wage contract is set such that:

$$\frac{1}{2}\left(L_B + L_f\right) + \frac{1}{2}\left(1 + \frac{c}{\tau}\right) = 1. \tag{7}$$

From which we infer that the variance of the home labor force employment is:

$$\text{Var}\ (L + L_f) = \left(\frac{c}{\tau}\right)^2, \tag{8}$$

where Var(z) denotes the variance of z. In terms of Figure 1a, the standard deviation of employment is given by the horizontal distance between points M and 1. In the Appendix we show that labor will be reallocated if h is large enough, such that $h > c\,\frac{2(1-\gamma) + \tau}{2\tau}$.

c. A flexible exchange rate

Under a flexible exchange rate, employment is stable, at the full employment level, and hence expected output will be 1 (see the Appendix for further details). The country experiencing the positive productivity shock will experience a corresponding appreciation, whose effect is to eliminate the incipient excess demand for labor. This will stabilize employment across the two states of nature, making the mobility of labor redundant. In terms of Figure 1, the real wage will fluctuate between $\frac{W_o}{P_A}$ and $\frac{W_o}{P_B}$, stabilizing employment at 1. Figure 1 reveals that expected output under a fixed exchange rate exceeds expected output under a flexible exchange rate by half the shaded area (where curve K'L' is obtained by shifting curve KL horizontally by $1 - L_B$).

IV. The Effect of Changing Labor-Mobility Costs

We can apply our methodology to study the impact of a drop in the labor reallocation cost, c. This exercise is summarized in Figure 2. Suppose that we start in an equilibrium where the magnitude of the productivity shock (h) is large enough to induce labor to move. A lower mobility cost c will encourage the reallocation of labor, shifting point M up to M'. At the initial real wage, total employment in state A, $(1 + \frac{c}{\tau} + L_h^*)$, will go up. Recalling that the wage contract is preset as to yield expected employment of 1, we deduce that a drop in c will induce a rise in the contract wage, from $\left(\frac{W}{P}\right)_o$ to $\left(\frac{W}{P}\right)$. This will increase the fluctuations of employment in a given country by ϵ, while it reduce the volatility of the employment of the labor force of each country by the horizontal distance between points M and M'. The expected GNP will go up by the shaded area in Figure 2.

We summarize these observations with the help of Figure 3, tracing the expected GNP and the volatility of employment (as measured by the variance of employment). If the labor reallocation cost is zero, a fixed exchange rate regime is associated with an equilibrium at point FIX(c=0), whereas a flexible exchange rate is associated with an equilibrium at point FLX. With costlessly mobility of labor, the two countries are fully integrated under a fixed exchange rate regime. The negative correlation among the productivity shocks implies that the sum of the two production functions is nonstochastic. Labor will be reallocated among the two counties in a way that will eliminate the volatility of employment from the viewpoint of labor, while it maximizes the volatility of employment from the producers point of view. In such an environment, the marginal product of labor is equated across all producers, and hence the expected GNP is maximized. In these circumstances, flexible exchange rate will operate as an obstacle for the efficient reallocation of labor: it will generate wedges between the real wages in the two countries due to the adjustment of the exchange rate. In our case, it will eliminate the incentive to reallocate labor, hence employment will be stable for both workers and producers. The lower expected GNP under a flexible exchange rate regime reflects the inefficiency introduced due to the inequalities between the marginal product of labor.

The effect of higher transportation cost c is to shift the point representing fixed exchange rate to FIX(c > 0). The reallocation cost reduces the ability to smooth employment, increasing thereby the volatility of employment from the point of view of labor. A by-product of the lower mobility of labor is a corresponding drop of the magnitude of labor reallocated from a low marginal product activity towards a high marginal product activity. This has the efficiency cost in the form of reducing the expected GNP. Applying the logic of Figure 1, it follows that expected GNP under a fixed exchange rate regime exceeds expected GNP under a flexible exchange rate regime by a margin that depends negatively on the reallocation cost.

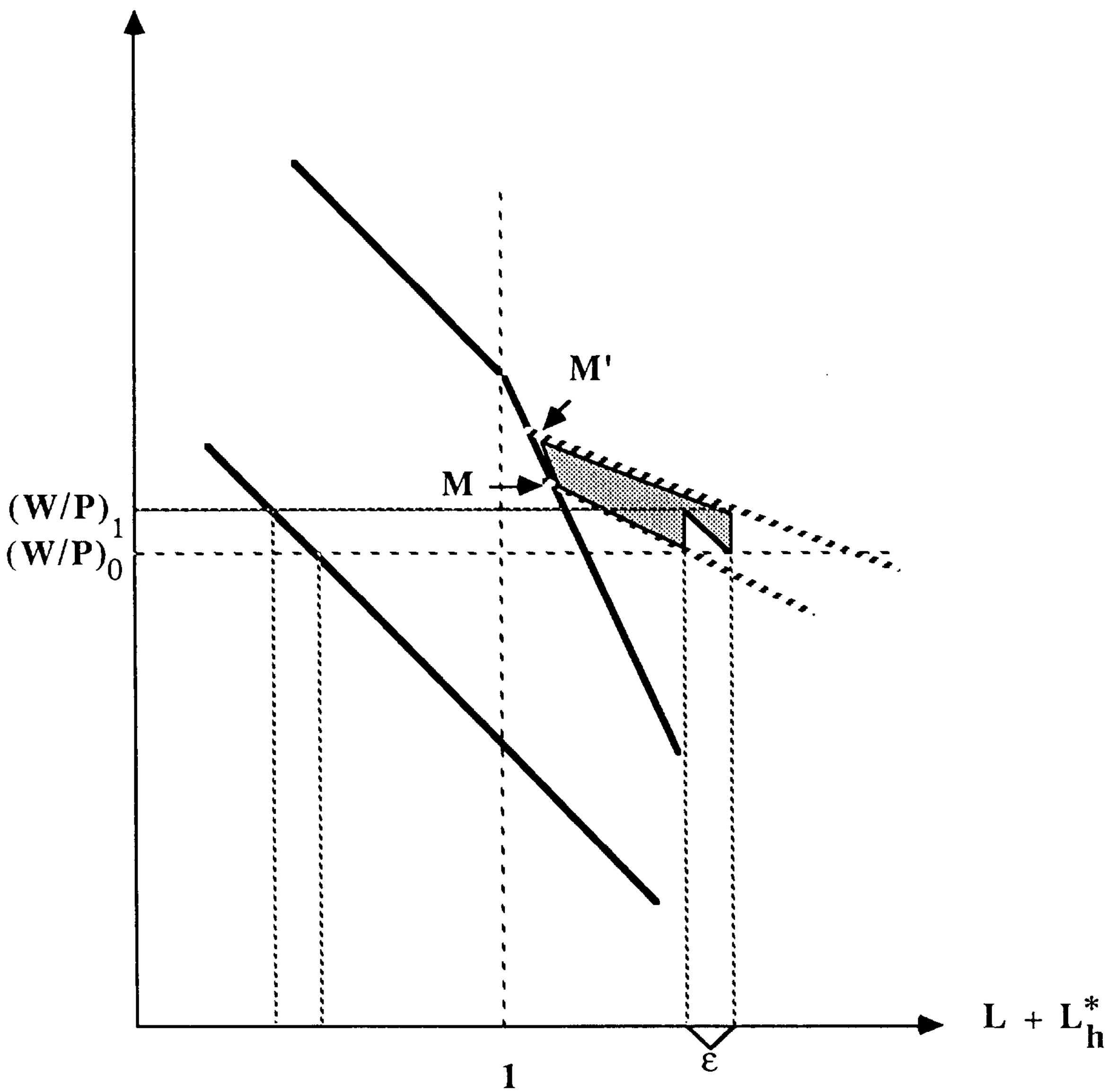

FIGURE 2
REALLOCATION COST, OUTPUT AND EMPLOYMENT

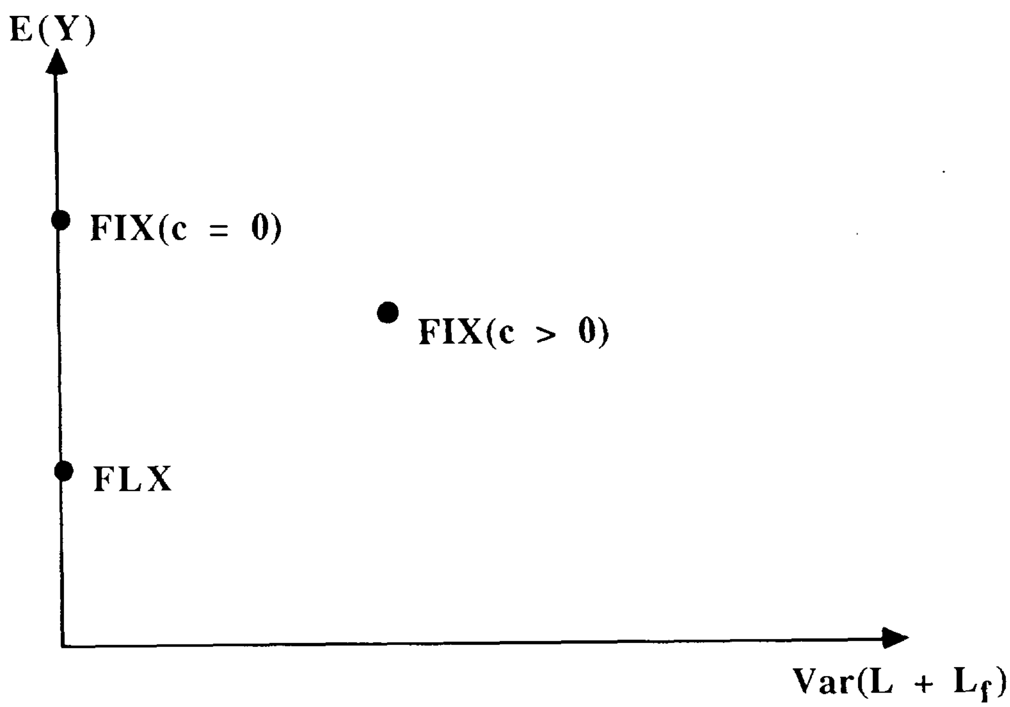

FIGURE 3
EXPECTED OUTPUT AND THE VARIANCE OF EMPLOYMENT

V. Review

We may summarize the insights of this analysis in the following way:

a. Regions whose labor market is segmented face a trade-off in making the choice regarding the proper exchange rate regime: a fixed exchange rate regime is associated with a higher expected GNP, as well as a higher volatility of employment relative to a flexible exchange rate regime. In these circumstances, a flexible exchange rate regime operates as a costly employment stabilizer. The magnitude of this cost goes up the higher is the integration of the labor markets of the various regions.

b. Regions that are fully integrated into a common labor market will unambiguously benefit from sharing the same currency, or alternatively adopting a fixed exchange rate regime.

c. Steps that increase the integration of labor market across regions will increase the benefits from adopting fixed exchange rates, by increasing expected GNP under a fixed exchange rate and reducing the volatility of employment.

d. If increasing the integration of regional labor markets is not feasible, mechanisms that will stabilize regional employment will enhance the benefits of a fixed exchange rate. While our model ignores the fiscal side and the presence of non-traded goods, we can add them into our model. In such an environment, a federal tax system that reallocates resources from regions that undergo an expansionary period towards regions that undergo a recessionary episode will be beneficial in reducing the volatility of employment under a fixed exchange rate system (as may be the case in the United States, see Martin and Sachs and (1991)).

e. Our analysis was confined to productivity shocks. One can extend it to account for monetary shocks. It is easy to show that monetary shocks will increase the benefits from a fixed exchange rate: monetary shocks will depress the expected output under a flexible exchange rate, and will increase the volatility of employment. These effects are absent (or weaker) under a fixed exchange rate regime, due to its ability to isolate the labor market from monetary shocks.

We simplified the analysis by assuming a fixed velocity of the demand for money. Allowing for a flexible velocity specification will not affect the qualitative nature of our results, while it will change the solution. For example, our result that a flexible exchange rate stabilizes completely the employment in the presence of productivity shocks will not hold, but employment will fluctuate less under a flexible exchange rate regime.

f. Our model ignored the role of investment and capital mobility. Allowance for capital mobility in the form of foreign direct investment will have similar qualitative effects as allowing for the mobility of labor: it zero), let us invoke the logarithmic approximation, $\log(1 + x) \simeq x$. Applying it to (A5) we obtain that

$$\phi = \frac{2}{2(1-\gamma) + \tau} h. \tag{A6}$$

Applying (A6) to (A3) we infer that labor will not move if

$$C > \frac{2\tau}{2(1-\gamma) + \tau} h. \tag{A7}$$

Alternatively, using the same methodology it can be verified that foreign labor will be employed by the home economy in state A if the reverse inequality holds in (A7). Due to the presence of mobility cost c, labor will move only if the relative productivity shock h is large enough to overcome the cost. If labor moves, then the domestic employment is determined by the condition that its marginal contribution to the effective supply of labor is 1-c (= the marginal contribution of foreign labor). Applying this condition to (1), we infer that the employment of domestic labor in state A is given by $1 + c/\tau$.

We turn now to the derivation of the expected GNP for the case where the shocks are significant enough to induce labor to move. From the production function (2), we infer that

$$E(Y) = \frac{1}{2}\left[(1+h)(EF_A)^\gamma + (1-h)(EF_B)^\gamma\right], \tag{A8}$$

where EF_x is the effective labor employed in state x (x = A, B). Applying the profit maximization condition (i.e., equating the marginal product of labor to real wages), we infer that

$$EF_A = \left(\frac{\gamma P(1+h)(1-c)}{W_o}\right)^{\frac{1}{1-\gamma}} ; \; EF_B = \left(\frac{\gamma P(1-h)}{W_o}\right)^{\frac{1}{1-\gamma}} . \tag{A9}$$

In deriving EF we take into account the fact that the marginal employment in state A is obtained by hiring foreign labor. We turn now to characterize the real wage. Recall that the contract wage is set such that on average full employment prevails, and hence:

$$\frac{1}{2}(L_B+L_f) + \frac{1}{2}\left(1 + \frac{c}{\tau}\right) = 1. \tag{A10}$$

The symmetry of the two countries implies that $L_f = L_h^*$. The demand for labor in the two states is obtained by equating the marginal product of labor to the real wage, from which we infer that

$$\gamma(EF_A)^{\gamma-1}(1-C)(1+h) = \gamma(EF_B)^{\gamma-1}(1-h) = \frac{W_o}{P} \tag{A11}$$

$$EF_A = 1 - \frac{\tau}{2}\left(\frac{c}{\tau}\right)^2 + L_f(1-c);\ EF_B = L_B. \tag{A12}$$

Equations (A10) - (A12) form a system of 3 simultaneous equations in L_f, L_B and $\frac{W_o}{P}$. We can solve it for the real wage and the level of employment. It can be shown that the following consistency requirement is meet:

$$L_f = L_h^* < 1 - L_B = 1 - L_A^*. \tag{A13}$$

Equation (A13) implies that the home producer's demand for foreign workers at state A is satisfied by the existing slack of employment in the foreign country. A similar consistency condition is satisfied in state B. We can apply the real wage solved from (A10) - (A12) to (A8), obtaining a value for the expected output:

$$E(Y) = 0.5\left[1 + \frac{1}{1-c} + \frac{c^2}{2\tau(1-c)}\right]^{\gamma} \left[(1-h)^{\frac{1}{1-\gamma}} + (1+h)^{\frac{1}{1-\gamma}} (1-c)^{\frac{\gamma}{1-\gamma}}\right]^{1-\gamma} \tag{A14}$$

Applying the same methodology we can derive the expected output in the absence of labor mobility (i.e., the case where h is small relative to c).

A.2. Flexible exchange rate

The shortest way to solve the case of flexible exchange rate system is to illustrate that even in state B, where productivity at home is low, full employment of the demotic labor will prevail. From the production function it follows that the demand for labor in state B is given by:

$$L_B^d = \left[\frac{\gamma(1-h)P_B}{W_o}\right]^{\frac{1}{1-\gamma}} \tag{A15}$$

where P_B is the price level in state B. Recalling that output is demand determined, we infer from (A15) the output level. Substituting it into the money equilibrium condition (4) we can solve the price level, obtaining:

$$P_B = \frac{1}{1-h}\left(\frac{W_o}{\gamma}\right)^{\gamma} (M^s)^{1-\gamma}. \tag{A16}$$

Note that the elasticity of the price level with respect to the productivity shock is minus one. Applying the price level to the demand for labor we infer that the price level increase enough to offset the adverse productivity shock, reducing the real wage and stabilizing employment. It is easy to verify that in state B we will observe a corresponding depreciation, such that the spot rate will be

$$S = \frac{1+h}{1-h}. \tag{A17}$$

Similarly, it follows that in state B foreign prices will go down, increasing thereby the real wage and stabilizing employment abroad. The complete stabilization of employment in the presence of productivity shocks is due to the assumption of a unitary velocity. Modifying this will not affect the qualitative feature: the endogenous adjustment of real wages under a flexible exchange rate system tends to reduce the volatility of employment in the presence of productivity shocks.

B. Demand disturbances

Mundell's contribution (1961) focused on the case where the shocks are due to demand disturbances. For completeness, we sketch here the analysis for that case. We do not elaborate on the details of this case due to two reasons. First, the qualitative results are similar to the one obtained in the paper for the case of supply disturbances. Second, the welfare interpretation of these results is problematic if the disturbances are due to a change in preferences.

In order to model the role of demand shocks, assume that domestic and the foreign goods are imperfect substitutes. Specifically, suppose that the utility function of the representative consumer is $U = Y^{0.5a} (Y*)^{1-0.5a}$.

The demand uncertainty stems from stochastic preferences, where 'a' is following a distribution given by:

$$\left(\frac{a}{2}, 1 - \frac{a}{2}\right) = \begin{cases} \left(\frac{1+h}{2}, \frac{1-h}{2}\right) \\ \left(\frac{1-h}{2}, \frac{1+h}{2}\right) \end{cases} \tag{A18}$$

we preserve all the previous assumptions regarding the labor and the money markets. It is easy to verify that the Cobb-Douglas specification implies that

$$YP \frac{2-a}{2} = Y*P*S \frac{a}{2}. \tag{A19}$$

Under a fixed exchange rate regime, it follows that the money market equilibrium condition is

$$YP + Y*P* = 2\bar{M}. \tag{A20}$$

Applying (A19) and (A20) we infer that

$$YP = a\bar{M};\ Y*P* = (2-a)\ \bar{M}. \tag{A21}$$

Applying the methodology described in part A of our Appendix, it follows that if shocks are large enough to reallocate labor, then the expected GNP of the home economy and the variance of employment are given by

$$E(Y) = 0.5\left[\frac{1 + \frac{1}{1-c} + \frac{c^2}{2\tau(1-c)}}{2}\right]^{\gamma}\left\{\left[(1+h)(1-c)+ (1-h)^{\gamma}\right]\right\} \tag{A22}$$

$$\text{Var }(Y) = \left(\frac{c}{t}\right)^2.$$

The behavior of the economy under a flexible exchange rate regime is similar to the one traced in the paper. Applying the money market equilibrium condition (4) and (A19) we infer that the exchange rate is given by

(A23) $S = (2 - a)/a.$

It is easy to verify that both output and employment are stable: higher demand for domestic goods triggers a depreciation high enough to eliminate the incipient excess demand for domestic goods, isolating the goods and the labor markets from the demand shocks. Applying these results it follows that the logic of our discussion, summarized in Figure 3, continues to hold.

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