Risk Sharing and the Theory of Optimal Currency Areas: A Re-examination of Mundell 1973

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Abstract

Mundell (1973) argues that a common currency area provides benefits for its members by offering insurance against region-specific shocks. We develop a simple model to analyse the nature of risk-sharing benefits of a single currency area for emerging market economies, based on Mundell's hypothesis. An important pre-requisite for the risk-sharing benefits of a single currency is that there be limited trade among countries in national-currency denominated bonds. The evidence for emerging markets supports this assumption. In this case, we show that a single currency area may support risk sharing that could not be achieved under floating exchange rates. Based on a simple quantitative evaluation of our model, we show that the implied risk sharing can be substantial.

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1. Introduction

The theory of optimum currency areas (OCA), developed by Mundell (1961), McKinnon (1963) and Kenen (1969), has been used extensively in the debate on a single currency in Europe, and more generally to evaluate proposals for exchange rate stability, currency boards, and dollarization. OCA theory has been applied to Asia by Eichengreen and Bayoumi (1999). They note that the East Asian economies are, on strictly OCA criteria (such as similarity in trade patterns, subject to common macro shocks, and labour mobility), at least as prepared for a single currency as were the countries of Europe. Thus, the *costs* of a single currency might be less in Asia than in Europe. But the benefits of a single currency, in Eichengreen and Bayoumi's view, remain largely political. In Europe, the political cohesion of the EU led national governments to accept the costs of a single currency, even if in strictly economic terms they could not be shown to be less than the benefits. In Asia, there is no such political cohesion, and therefore a single currency is not feasible.

One aspect of this argument, and with much of the OCA literature, is that the *economic* benefits of a single currency area are seldom made explicit. Writers normally discuss the benefits of eliminating transactions costs of currency exchange, the elimination of the foreign currency hedging costs for firms, and the enhanced transparency of prices across the member states. The purpose of this short paper is to explore a different dimension of the economic benefits of a single currency, arising from the potential risk-sharing that such an arrangement can achieve. Our interest in this is stimulated by a less well-known contribution of Mundell (1973), to which McKinnon (1999) has recently drawn attention. In Mundell's (1973) words,

"If two countries form a currency area the domain of risk sharing is extended .... A harvest failure, strikes or war in one of the countries causes a loss of real income, but the use of a common currency allows the country to run down its currency holdings and cushion the impact of the loss, drawing on the resources of the other country until the cost of adjustment has been efficiently spread over the future."

This argument emphasizes the automatic adjustment process that takes place in a single currency area through a common price level and money flows from one region to another. But it also presupposes the absence of other forms of international insurance arrangements through capital markets. If there were complete international capital markets, the exchange rate regime would not provide any help or hindrance to international risk sharing.

In the analysis below, we evaluate Mundell's case for the risk sharing benefits of a single currency area[1]. Our argument is based upon the well-accepted proposition that capital markets are at best incomplete[2]. This places a limit on the risk-sharing that can be directly achieved by international capital markets. Of

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1 A recent paper by Voss (1997) also focuses on the risk-sharing implications of a single currency area. But he highlights quite a different mechanism. Assuming that seigniorage revenue accruing to a single currency area central bank can be distributed by state-contingent rules, he shows that full risk sharing can be supported within a single currency area. By contrast, our analysis rules out the possibility of the state-contingent distribution of seigniorage.

2 See Tesar (1995), Tesar and Werner (1992) or Lewis (1999), for evidence and theoretical discussion of the limitations on international capital markets.

course even with incomplete capital markets it is possible to argue that exchange rate flexibility allows some indirect risk-sharing in the presence of trading in nominal bonds (e.g. Svensson and Persson 1989)[3]. But this ignores a central point about the financial systems of emerging market economies, recently emphasised by Eichengreen and Hausmann (1999). Almost all debt issued by emerging market economies is in foreign currency-denominated issue (typically US dollar or Yen). Even for capital flows between emerging markets themselves, very little is denominated in their own national currencies[4]. Without trade in national currency denominated bonds, the risk-sharing generated by floating exchange rates is severely circumscribed. On the other hand, the potential for risk-sharing within a single currency area remains.

We construct a simple two country, two period model. We first show that if there is no restriction on the currency composition of international bond trading, floating exchange rates can achieve full risk sharing. But this requires very large gross flows of bonds between countries, and provides significant incentives for national authorities to gain by currency devaluation. On the other hand, if credibility problems or other forms of market failures prevent the international acceptance of any nominal assets, and all trade is restricted to a real, indexed bond, then no risk sharing at all is feasible under floating exchange rates. But under a single currency area, the movement of the regional price level and acceptance of single money effectively supports risk-sharing between countries. This provides theoretical support for Mundell's (1973) argument. But how important is it from a practical point of view? We do a very rough calibration of the extent of risk sharing generated by a single currency area in our model. While the model is not properly equipped to give a precise quantitative answer to this question, our rough calibration suggests that risk sharing may in fact be reasonably large. The extent of risk sharing for our estimates is at least half way between no risk sharing at all, and the full risk sharing implied by complete markets.

Most emerging markets do have capital flows with the industrial countries however. To encompass this, we extend the model to three countries — two emerging markets and 'the US'. US dollar bonds might be acceptable because the US monetary authority has credibility, but emerging market-currency denominated bonds lack this credibility. We show that in this model, there is risk-sharing between the US and each of the emerging market economies, but not between emerging market economies. There is still a welfare case for a single currency area between the two emerging market economies. In fact, we show that the risk-sharing benefits of a single currency area between emerging markets are independent of whether as a group they peg to the US dollar or allow a floating exchange rate.

2. A Model of Floating Exchange Rates and Capital Market Restrictions

In this section we set out the basic model of the paper. Most of the derivations are given in an appendix. We focus here on the economic intuition. Say there are two countries (emerging markets). Call them countries 1 and 2. There are two periods of time, and each country has an endowment of the single

3 The return on a foreign bond is fixed in foreign currency only, and to the extent that exchange rate fluctuations generate a real return that does not perfectly mimic domestic returns, the bond allows for some international risk-sharing.

4 An APEC 1998 study (APEC, 1998) finds that bond markets in many East Asian countries are lacking in liquidity, have unreliable yield curves, and have limited secondary markets.

goods in each of the two periods. Second period endowments are uncertain however. In addition, consumers of each country hold money balances, from which they get utility. This is a short-hand way to describe the implicit transactions services that agents get from money balances.

Initially let there be unrestricted trade in nominal bonds issued in the currency of either country. We let consumers across countries have identical preferences. Country i consumer preferences are given by

$$\max \quad \log c_1^i + \gamma \log \frac{M_1^i}{P_1^i} + \beta E_s (\log c_2^i(s) + \gamma \log \frac{M_2^i(s)}{P_2^i(s)})$$

(1) $$\text{s.t.} \quad P_1^i c_1^i + M_1^i + B_i^i + e_{1j}^i B_j^i = P_1^i y_1^i + M_0^i$$

(2) $$P_2^i(s) c_2^i(s) + M_2^i(s) = P_2^i(s) y_2^i(s) + M_1^i + (1+r_i) B_i^i + (1+r_j) e_{2j}^i(s) B_j^i$$

where i = 1,2 , j = 1,2, $i \neq j$. Here c_1^i is consumption of country i in period 1, y_1^i is the period 1 endowment of country i, P_1^i represents country i's price level in period 1, M_1^i represents its money holdings, etc. B_i^i represents country i's holdings of its own currency denominated bonds, B_j^i are country i's holdings of country j denominated bonds, and e_{1j}^i is the currency i price of currency j. (Clearly $e_{1j}^i = (e_{1i}^j)^{-1}$ must hold.)

Imagine that the countries are *ex ante* exactly identical. That is, each country has an identical period 1 endowment given by y_1, and the distribution of period 2 endowments is identical (but not perfectly correlated) across countries. Moreover, assume that the money supply in each country is fully predictable for period 2, so the money growth rate is known with certainty, and money growth rates are identical across countries. Then it is easy to show that the equilibrium nominal interest rate for either country will be

$$r = \frac{(1+\mu)}{\beta} - 1$$

where μ is the common money growth rate.

We wish to show that if countries can hold nominal bonds denominated in both currencies, then in principle the two countries can sustain full risk sharing. A full risk sharing allocation is one where in each state of the world in period 2, the representative consumer in each country consumes half of world output.

This is an economy with a single goods, so purchasing power parity will hold at all times. In addition, with floating exchange rates and no foreign exchange market intervention, there will be no direct money flows across countries. In the appendix, we show that the following is an equilibrium allocation of resources in the world economy.

(3) $$c_1^i = y_1$$

(4) $$B_i^i + e_{1j}^i B_j^i = 0$$

(5)
$$c_2^i(s) = y_2^i(s) + (1+r)\frac{B_i^i}{P_2^i(s)} + (1+r)\frac{B_j^i}{P_2^j(s)}$$

Is it possible to design a pattern of bond holdings such that in period 1, countries have a net portfolio value of zero, as in equation (4), but yet sustain risk sharing? To see how it is, note that the price level in the second period in country i is given by[5]

$$P_2^i(s) = \frac{\bar{M}_2^i}{\gamma c_2^i(s)} \ ,$$

where $\bar{M}_2^i$ is country *i*'s total money stock in period 2. Substitute this into equation (5) to get

(6)
$$c_2^i(s) = y_2^i(s) + (1+r)\frac{\gamma B_i^i c_2^i(s)}{\bar{M}_2^i} + (1+r)\frac{\gamma B_j^i c_2^j(s)}{\bar{M}_2^j}$$

Moreover, because of complete symmetry, we can surmise that

$$(1+r)\frac{B_i^i}{\bar{M}_2^i} = -(1+r)\frac{B_j^i}{\bar{M}_2^j}$$

Then define

$$b = -(1+r)\frac{\gamma B_i^i}{\bar{M}_2^i}.$$

We may therefore write out consumption values in state s for each country as

(7)
$$c_2^i(s) = \frac{(1+b)y_2^i(s) + b y_2^j(s)}{(1+2b)}$$

This establishes that there is some risk-sharing sustained through exchange rate fluctuations. When country 1 holds country 2 bonds, an increase in country 2 output, bringing a fall in country 2 prices, will raise the return on country 2 bonds. This increases country 1 consumption, and at the same time leads country 2 consumption to rise by less than its income. But in general, this is imperfect. In order to achieve full risk sharing, the exchange rate must reflect country specific shocks. But the movements in the exchange rate are dominated by consumption rather than output. Because consumption does not fully reflect country specific shocks, simply holding a net negative position in domestic bonds and positive position in foreign bonds will not achieve full risk-sharing.

5 This is easy to establish, since equilibrium money demand is $M_2^i = P_2^i(s)\gamma c_2^i(s)$.

Is it possible to sustain full risk-sharing? The higher is b the more closely we approximate full risk sharing. In the limit, as $b \rightarrow \infty$, we obtain

$$c_2^i = \frac{y_2^1(s) + y_2^2(s)}{2}$$

Thus, in principle we can approach full risk sharing with trade in nominal bonds, under floating exchange rates.

But note that in order to achieve this, the gross flows of bonds must be very large, relative to nominal GDP. In the second period, each country is holding a very large positive position in foreign debt, and negative position in its own debt. This sets up a significant incentive problem. Each monetary authority has a large incentive to inflate away "ex-post" the value of the debt. This throws some doubt on the sustainability of such a set-up.

It is easy to show also that if the countries were allowed to trade in an indexed, real bond, this would not add anything at all to the picture. In fact, there would be no trade at all in the indexed bond, and so no risk sharing possibilities.

3. A Single Currency Area (SCA)

Now let us look at the case where the countries move together and form a currency union. They face the same set of endowments, but now agree to issue a common currency in a given supply.

Country i now has budget constraint:

(8) $$P_1 c_1^i + M_1^i + B_1^i = P_1 y_1^i + M_0^i$$

(9) $$P_2(s) c_2^i(s) + M_2^i(s) = P_2(s) y_2^i(s) + M_1^i + (1+r) B_1^i$$

Superscripts are suppressed for variables that are common to the two economies in the single currency area.

The full derivation for the single currency area is done in the appendix. Intuitively, we show that if the countries are *ex ante* identical, then there is zero net trade in a nominal bond. But the critical difference between a floating exchange rate (or even a fixed exchange rate sustained by a one-sided peg) and a single currency area is that the allocation of world money supply between national consumers is endogenous. This leads to the world money market clearing condition given by

(10) $$\bar{M} = M_2^i(s) + M_2^j(s) = \gamma P_2(s)(c_2^i(s) + c_2^j(s)) = \gamma P_2(s)(y_2^i(s) + y_2^j(s))$$

It is shown in the appendix that consumption for country in time 2 can be obtained as

$$c_2^i(s) = \frac{1}{(1+\gamma)}(y_2^i(s) + \frac{M_1^i}{P_2(s)})$$

But then using the money market clearing condition, we arrive at

(11) $$c_2^i(s) = \frac{1}{(1+\gamma)}(y_2^i(s) + \frac{M_1^i}{\bar{M}}\gamma(y_2^i(s) + y_2^j(s)))$$

Note that the *ex ante* identical assumption also implies that $\frac{M_1^i}{\bar{M}} = \frac{1}{2}$ [6]. After rearranging terms, this yields

(12) $$c_2^i(s) = \frac{(2+\gamma)y_2^i(s) + \gamma y_2^j(s)}{2(1+\gamma)}$$

Equation (12) shows that $c_2^i(s)$ is a weighted average of $y_2^i(s)$ and y_2^j, i.e. some risk sharing is achieved. The degree of risk sharing is determined by the weight put on real balances in preferences. When γ is very high, more risk sharing is achieved. The intuition behind the risk sharing in the single currency area is as follows. A high relative outcome for the home country output leads home consumers to hold more money as well as consume more goods. The increase in money holdings is obtained by exchanging this for goods with the foreign country. In the process, some of the higher home output is transferred to the foreign country.

This result establishes that the hypothesis of Mundell (1973) on the benefits of risk-sharing within a single currency area can be supported within our simple general equilibrium framework. But how important could the risk sharing benefits be, from an empirical standpoint? In our model, this resolves down to the issue of the size of the parameter γ. According to our model, this parameter should be identified as the ratio of money to nominal consumption. Table 1 gives this ratio for Hong Kong, Indonesia, Korea, Malaysia. Philippines, Taiwan, and Thailand[7]. The ratio depends on the money aggregate used. For M1, the average across the three countries is close to unity, while for M2, the average is seven.

6 We are implicitly assuming that the issue of the distribution of initial money holdings across countries within the single currency area has been solved prior to the single currency area being formed.

7 Money data are monthly average for October-December 1999, and consumption is private consumption expenditure for fourth quarter 1999.

The consumption sharing rules implied by equation (12) are given in Table 2. Even for the low estimate of γ, the sharing rules are half-way between complete autarky and full risk sharing. For the higher estimate of γ, the sharing rules are only about 10 percent away from complete risk-sharing![8,9]

4. A Model with Two Emerging Markets and One Developed Economy

Practically speaking, exchange rate policies in emerging markets are made with respect to the currencies of large industrial countries; i.e. the US, Japan, or Europe. Thus, the issue of whether there are welfare gains from a currency area between two emerging market economies is unlikely to be independent of the presence of large, stable, third country trading partners.

In this section, we investigate this issue by extending the model to allow for a third country, country 3. We assume that country 3 is distinct from countries 1 and 2 in two ways. First, country 3 has a an established reputation for following a stable monetary policy, such as inflation targeting, so that its domestic currency denominated bonds are accepted in international capital markets. Second we assume that country 3 is very large, i.e. that its trade with the two smaller countries is effectively a negligible proportion of its domestic GDP and consumption. Thus, we can treat country 3 as if it were in effect a third, closed economy, in which its prices and interest rates are determined independently of those of the two emerging markets. We examine the risk sharing possibilities under two alternative scenarios. First, let us look at the case of flexible exchange rates between the two emerging markets and between the emerging market countries and the large third country.

4.1 Floating Exchange Rates between Emerging Markets

Let i = 1,2,3. The preferences and budget constraints of consumers in economy i are

$$\max \quad \log c_1^i + \gamma \log \frac{M_1^i}{P_1^i} + \beta E_s (\log c_2^i(s) + \gamma \log \frac{M_2^i(s)}{P_2^i(s)})$$

$$\text{s.t.} \quad P_1^i c_1^i + M_1^i + e_{13}^i B^i = P_1^i y_1^i + M_0^i$$

$$P_2^i(s) c_2^i(s) + M_2^i(s) = P_2^i(s) y_2^i(s) + M_1^i + e_{23}^i(s)(1+r)B^i$$

8 These sharing rules are comparable to the ones under floating exchange rates when $r = 0.1$ and $\frac{B_i^i}{\bar{M}_2^i} = 0.5$. For comparable results, those under a SCA can be more reliable, since they are not subject to the credibility problem mentioned in the previous section.

9 One qualification to these estimates should be stressed however. In the two-period model employed here, there is no interest elasticity of money demand in the second period. When we employ a more general infinite horizon framework, the implied estimate of gamma may be much less, because the predicted ratio of money to nominal consumption, for reasonably low interest rates, will be lower in this setting.

When i = 3, clearly we have $e_{13}^3 = e_{23}^3 = 1$.

Under floating exchange rates, agents in the second period consume

$$c_2^i(s) = y_2^i(s) + \frac{(1+r)B^i}{P_2^3}, \ i = 1,2,3 .$$

But because country 3 is so large, we can say that to a first approximation[10],

$$c_2^3(s) = y_2^3(s)$$

The price level in the second period in economy 3 is given by

$$P_2^3(s) = \frac{\bar{M}^3}{\gamma y_2^3(s)}$$

Substituting this into the consumption equations for country i, i =1,2, gives

$$c_2^i(s) = y_2^i(s) + \frac{(1+i)B^i\gamma}{\bar{M}^k} y_2^k(s) \tag{13}$$

Risks are pooled across the three economies when $B^i \neq 0$. The two emerging markets have the opportunity to engage in effective diversification by engaging in intertemporal trade with the large industrial country. Whether they wish to borrow or lend depends on the nature of the risks and correlation of shocks. For log utility functions and i.i.d. shocks across countries, they would wish to have $B^k > 0$, so they should run first period current account surpluses. Note however that risk sharing is limited to sharing the risk of the large foreign economy. There is clearly no possibility for risk sharing between the two emerging markets, because of the absence of nominal bond holdings in the currencies of those countries.

4.2 A Single Currency Area for the Emerging Markets

Now say that the two emerging markets 1 and 2 form a single currency area. This single currency area can maintain a flexible or fixed exchange rate with the developed economy. The case of a flexible exchange rate is considered first. The budget constraints of consumers in i become

$$P_1 c_1^i + M_1^i + e_1 B^i = P_1 y_1^i + M_0^i$$

$$P_2(s) c_2^i(s) + M_2^i(s) = P_2(s) y_2^i(s) + M_1^i + e_2(s)(1+r)B^i$$

10 We can easily show this as the limiting case of a situation where country 3 has a larger population or endowment than countries 1 and 2, and the divergence in GDPs gets larger and larger.

Consumption in the second period in economy 3 is the same as before, i.e.

$$c_2^3(s) = y_2^3(s)$$

Consumption in the second period in the currency union differs from that of the previous sub-section, however. The difference is due to the endogenity of money allocation in the single currency area.

$$\bar{M} = M_2^1(s) + M_2^2(s) = \gamma P_2(c_2^1(s) + c_2^2(s))$$

This money market equilibrium follows from the condition $M_2^i(s) = \gamma P_2(s) c_2^i(s)$, i.e. money demand schedules for each of the emerging markets in the second period. Now, optimal consumption for each of the emerging markets is given by

$$c_2^i(s) = \frac{1}{1+\gamma}\left(y_2^i(s) + \frac{M_1^i(s)}{P_2(s)} + \frac{(1+r)B^i}{P_2^3(s)}\right) \qquad i = 1, 2. \tag{14}$$

Substituting this into the money market equilibrium yields

$$\bar{M} = \gamma P_2\left(y_2^1(s) + y_2^2(s) + \frac{(1+r)(B^1 + B^2)}{P_2^3(s)}\right)$$

Solving for the single currency price level $P_2(s)$, and substituting for the country 3 price level, and finally substituting into (14), gives the solution for second period consumption in *i* as[11]:

$$c_2^i(s) = \frac{2+\gamma}{2(1+\gamma)} y_2^i(s) + \frac{\gamma}{2(1+\gamma)} y_2^j(s) + \frac{(1+r)B^i\gamma}{\bar{M}_2^3} y_2^3(s) \tag{15}$$

As in Section 3, the currency union allows consumers in member economies to (partially) pool their risks *vis a vis* each other, while still being able to use international capital markets to pool risk against the large trading partner. What happens now if the emerging market single currency area decides to peg to the US dollar? Now while it is possible for the emerging market economies to fix their exchange rate to the US dollar, it is very unlikely that they would be invited into a common currency area with the US. Nor would the US Federal Reserve adjust its monetary policy to ensure the peg. Thus, the only practical way for a single currency to peg to the US is by way of a one-sided or unilateral peg. When the currency area maintains a fixed exchange rate $\bar{e}$ with the developed economy, consumers in the currency union face the following budget constraints:

$$P_1 c_1^i + M_1^i + \bar{e}B^i = P_1 y_1^i + M_0^i + X_1^i$$

$$P_2(s)c_2^i(s) + M_2^i(s) = P_2(s)y_2^i(s) + M_1^i + X_2^i(s) + \bar{e}(1+i)B^i$$

In these equations X_1^i and $X_2^i(s)$ represent the intervention of the monetary authority of the single currency area that is required in order to maintain the exchange rate peg $\bar{e}$. Intervention is done in the form of

11 To obtain the above equation, we employ the *ex ante* identical assumption for the two emerging markets again.

positive or negative payments of single currency area money issue to consumers of the emerging markets. Since the distribution of intervention across countries has no implications for the maintenance of the currency peg (all that matters is the aggregate amount of intervention), a natural assumption, that goes along with our *ex ante* identical framework, is that $X_1^1 = X_1^2$ and $X_2^1(s) = X_2^2(s)$. Thus, we assume that intervention is done by equal amounts across the two countries. Then, again using the fact that $M_1^1 = M_1^2$ and $B^1 = B^2$, the appendix shows that second period consumption is given by

$$c_2^i(s) = \frac{2+\gamma}{2(1+\gamma)} y_2^i(s) + \frac{\gamma}{2(1+\gamma)} y_2^j(s) + \frac{(1+r)B}{P_2^3(s)}$$

Substituting for the country 3 price level, we see that consumption is identical to that under the arrangement where the single currency area floats against the US currency, for a given value of B. But since all other factors remain the same, the optimal B chosen with a unilateral peg against the US will be the same as that chosen when the single currency area of the emerging market floats against the US. Thus, in all respects the two situations are identical, and the benefits of a single currency area within emerging markets are independent of whether they float against the currencies of large, stable trading partners.

The equivalence of the fixed and floating regimes in the case of a unilateral peg is similar to the result of Helpman (1981). He shows that a floating exchange rate and a one-sided peg are equivalent in terms of allocations and welfare. Our analysis is somewhat different due to the stochastic character of the model and the presence of incomplete markets. But the intuition is similar in that endogenous intervention rules keep the economy of the emerging markets 'on its budget constraint', preventing any net transfers between the emerging markets and the US economy.

5. Conclusions

This paper uses a simple utility-based model to examine the risk-sharing benefits of a single currency area for emerging markets where trade in national-currency denominated bonds is limited. It shows that the implied risk-sharing can be substantial. The result is extended to a more complete model in which the SCA can trade bonds with a developed economy, e.g. US dollar bonds. Somewhat surprisingly, the latter result does not depend on whether the SCA maintains a flexible or fixed exchange rate with the developed economy. These benefits of OCA have been over-looked by the literature. Our results indicate that they may have been under-estimated as well. A comprehensive assessment of the benefits is left for future research.

Table 1: Ratio of Money to Nominal Consumption

	M1	M2
Hong Kong	1.12	9.86
Indonesia	0.58	3.12
Korea	0.55	4.54
Malaysia	2.02	9.75
Philippines	0.59	2.14
Taiwan	1.28	12.39
Thailand	0.74	7.10
Average	0.98	6.99

Table 2: Equilibrium Sharing Rules

	Domestic	Foreign
M1	0.75	0.25
M2	0.56	0.44

APPENDIX

Here, we derive equations (3), (4) and (5) in Section 2 and the second-period consumption in Section 3 and show that when transfers (under fixed exchange rate) are the same across different states for the two emerging markets, fixed and floating exchange rates are equivalent.

Section 2: Equations (3), (4) and (5)

Since countries 1 and 2 are *ex ante* identical, the net bond holding of 1 is positive (negative) if and only if the net bond holding of 2 is positive (negative), i.e. $B_1^1 + e_{12}^1 B_2^1 > (<) 0 \Leftrightarrow B_2^2 + e_{11}^2 B_1^2 > (<) 0$. Note that $B_i^i = -B_i^j$, i, j = 1,2 and $i \neq j$. Therefore, $B_i^i + e_{1j}^i B_j^i = 0$, which establishes equation (4).

With equation (4), equation (3) follows from the fact that currency is held only by country i consumer. equation (5) is an immediate consequence of the same fact.

Section 3: Consumption in the Second Period

Similarly, the *ex ante* identical assumption and $B_1^i = -B_1^j$ together imply that $B_1^i = 0$. (Note that this argument does not depend on whether the bond is nominal or indexed.) Using equation (9) and $M_2^i(s) = \gamma P_2(s) c_2^i(s)$, it follows that

$$c_2^i(s) = \frac{1}{1+\gamma}\left(y_2^i(s) + \frac{M_1^i}{P_2(s)}\right).$$

Section 4: Equivalence of the Two Exchange Rate Regimes

Recall that under a fixed exchange rate, country i's budget constraint in time 2 is,

$$P_2(s)c_2^i(s) + M_2^i(s) = P_2(s)y_2^i(s) + M_1^i + X_2^i(s) + \bar{e}(1+r)B_3^i, \qquad i = 1,2 .$$

By using $M_2^i(s) = \gamma P_2(s) c_2^i(s)$, the second-period consumption can be expressed as:

$$P_2(s)c_2^i(s) = \frac{1}{1+\gamma}\left(P_2(s)y_2^i(s) + M_1^i + X_2^i(s) + \bar{e}(1+r)B_3^i\right).$$

Let $M_1^1 = M_1^2 = M_1$, $X_2^1(s) = X_2^2(s) = X_2(s)$ and $B_3^1 = B_3^2 = B_3$. The money demand is then, j = 1,2 and $j \neq i$,

$$M_2^i(s) + M_2^j(s) = \frac{\gamma}{1+\gamma}(P_2(s)(y_2^i(s) + y_2^j(s)) + 2(M_1 + X_2(s)) + 2\bar{e}(1+r)B_3).$$

Note that the money supply is $2(M_1 + X_2(s))$. The money market equilibrium thus implies

$$M_1 + X_2(s) = \frac{\gamma}{2}(P_2(s)(y_2^i(s) + y_2^j(s)) + 2\bar{e}(1+r)B_3).$$

Substitute the above expression into the budget constraint yields

$$c_2^i(s) = \frac{2+\gamma}{2(1+\gamma)} y_2^i(s) + \frac{\gamma}{2(1+\gamma)} y_2^j(s) + \frac{(1+r)B_3}{P_2^3(s)}.$$

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