International Transmission of Monetary Shocks and the Non-Neutrality of International Money

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Abstract: This paper investigates how monetary shocks are transmitted internationally. It shows that where a national currency is used as an international medium of exchange, the international money is non-neutral. In particular, an increase in the supply of international money leads to a transfer of real resources to the international money-issuing country from its trading partner. It also induces an expansion of the non-tradable sector in the international money-issuing country, and an expansion the tradable sector in its trading partner. The real impact of a monetary shock is greater under a fixed exchange rate system than under a flexible exchange rate system.

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International Transmission of Monetary Shocks in a Ricardian World

1. Introduction

What is the mechanism through which monetary policy decisions affect output and prices? This is a perennial question that has generated a large literature offering different perspectives. According to standard textbooks, monetary policy affects short-term interest rates, which in turn affect investment and consumption decisions. Extending this standard position, the lending view observes that given information asymmetry and other frictions in credit markets, a monetary policy that raises (lowers) market interest rates tends to raise (lower) the external finance premium (which is the difference between the costs of external and internal finance), thereby amplifying the impact on borrowing (Bernanke & Gertler, 1995). In contrast, the monetarist's view contends that a monetary impulse, by changing the stock of money, changes the marginal utility of money relative to other goods and assets. To restore equilibrium, money holders adjust their spending and asset portfolios. Therefore, apart from the impact on interest rates, monetary shocks can directly influence consumer decisions (Meltzer, 1995).

In an increasingly globalised economy and in light of the recent global financial turmoil and subsequent stabilising policies implemented by various governments, it is timely to extend the traditional question and ask whether monetary policies in one country can affect output and prices of its trading partners and if so, through what mechanism. There is an extensive empirical literature that studies the international monetary transmission mechanism by examining movements of financial market prices including the exchange rates (Taylor, 1995). However, to our knowledge, few theoretical studies have explicitly modelled the international transmission of monetary policy impulses through their impact on international trade. This is probably due to the fact that most trade models deal with "barter" rather than "monetary" transactions. The choice of barter models is reasonable because if one accepts the "separability hypothesis" which states that in cases where the marginal rate of substitution between goods is independent of the demand for money, the analyses of the traditional barter models remain valid for monetary models (Anderson & Takayama, 1977; Takayama & Anderson, 1978). Of those trade models that do incorporate money, most adopt the "small country" assumption, and focus on how the small country's policies such as currency devaluation and monetary expansion can affect its own welfare (Kemp, 1982; Takayama & Anderson, 1978).

The purpose of this paper is to develop a set of monetary trade models to investigate how monetary policy shocks are transmitted internationally. In particular, we ask (1) how a monetary policy change in one country may affect itself and its trading partner; and (2) how the transmission mechanisms of monetary shocks may differ under different exchange rate regimes.

We conduct our investigation in a simple two-country, three-good Ricardian framework and study the international transmission of monetary shocks under three different regimes. We start with a benchmark model of Regime One where two national currencies are used in international trade, but there is no demand in one country for holding another country's currency. In this benchmark model, money is shown to be neutral, which is consistent with the findings of the mainstream literature.

In light of the observation that most international trade is mediated by a few currencies, of which the US dollar is dominant (Goldberg & Tille, 2008), we develop two other models of Regime Two and Regime Three, where only country 2's national currency is used in international trade. A flexible exchange rate system operates in Regime Two, and a fixed exchange rate system operates in Regime Three.

Suppose international trade is mediated by the national currency of country 2. Since country 2's national currency becomes an international currency, there will be a demand for holding it in country 1 as well. Consequently a change in the supply of the international currency will not only affect economic decisions in country 2, but also affect those in country 1. Specifically, an increase in the supply of money in country 2 tends to increase the nominal demand for imports from country 1, which in turn increases country 1's nominal income and its demand for country 2's currency. As this increased demand for country 2's currency can only be satisfied by increased exports to country 2, there must be a transfer of real resources from country 1 to country 2. The increased exports also mean that the tradeable sector in country 1 has to expand at the expense of the non-tradable sector; correspondingly the tradable sector contracts in country 2 as some of import needs are financed by the newly created money instead of export revenue. Therefore in contrast to the benchmark model in which money is neutral, when a national currency also serves as an international currency, the international money is no longer neutral even in the absence of any price rigidities. In particular, an increase in the supply of international money leads to a real resource transfer to the international money-issuing country and structural changes in both countries.

The extent to which an international monetary shock has real effects may be affected by exchange rate systems. Under a flexible exchange rate system, an increase in country 2's money supply tends to lower the exchange rate (defined as the price of country 2's currency in terms of country 1's currency). This downward pressure on exchange rate is however partly offset by the increased demand for country 2's currency in country 1; hence the exchange rate does not fall to the same extent as the increase in the money supply. Under a fixed exchange rate system, an increase in country 2's money supply puts downward pressure on the exchange rate, which compels country 1's monetary authority to intervene by buying country 2's currency using its own created money. The upshot is that both foreign exchange reserve and money supply in country 1 go up. Since the increase in foreign exchange reserve also has to be backed by an increase in exports to country 2, the real transfer to country 2 is larger, and consequently a greater structural change needs to take place under a fixed exchange rate system.

In the following, we develop three simple models which formalise the above narrative. Section 2 presents the benchmark model in which two freely convertible national currencies are used in international trade. Section 3 adapts the benchmark model by assuming that international trade is mediated by one of the national currencies. It investigates the international transmission mechanism of monetary shocks under a flexible exchange rate system and a fixed exchange rate system, respectively. The concluding section, section 4, discusses some distinctive features of our models and their implications.

2. Regime One: The Benchmark Model

Consider a Ricardian world with two countries, country 1 with a population of N_1, and country 2 with a population of N_2. There are three goods, X, Y and Z. Country 1 specialises in the production of good X, and country 2 in good Y. Good Z is produced in both countries, and is not traded internationally. Labor is assumed to be immobile between the two countries.

International trade between the two countries is meditated by the currencies of both countries. The currencies are freely convertible. Individual consumers in both countries are assumed to derive utility from the consumption of the three goods and from the holding of real balances of their own currencies[1]. The decision problem of a representative consumer in country 1 is:

[1] If both national currencies are used in international trade, then arguably there should be a demand for holding both currencies in both countries. However, we have chosen the simpler benchmark where there is no separate

$$\max_{x_1, y_1, z_1, m_1/P_{1xyz}} U_1 = U_1(x_1, y_1, z_1, \frac{m_1}{P_{1xyz}}) = x_1^{\alpha_1} y_1^{\alpha_2} z_1^{\alpha_3} (\frac{m_1}{P_{1xyz}})^{\alpha_4}$$

s.t. $p_{1x} x_1 + (p_{2y} e) y_1 + p_{1z} z_1 + m_1 = w_1 + \bar{m}_1$

$\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 = 1$

The decision problem for a representative consumer in country 2 is similar:

$$\max_{x_2, y_2, z_2, m_2/P_{2xyz}} U_2 = U_2(x_2, y_2, z_2, \frac{m_2}{P_{2xyz}}) = x_2^{\beta_1} y_2^{\beta_2} z_2^{\beta_3} (\frac{m_2}{P_{2xyz}})^{\beta_4}$$

s.t. $(p_{1x} / e) x_2 + p_{2y} y_2 + p_{2z} z_2 + m_2 = w_2 + \bar{m}_2$

$\beta_1 + \beta_2 + \beta_3 + \beta_4 = 1$

The variables in the above decision problems are defined as follows.

x_i, y_i, z_i (i=1, 2) are quantities of goods X, Y, and Z consumed by an individual in country i; p_{ij} (i=*1, 2; j=x,y,z*) is the price of good j in country i, and is denominated in the currency of the country producing the good;

$P_{1xyz}(\equiv \frac{\alpha_1}{\alpha_1 + \alpha_2 + \alpha_3} p_x + \frac{\alpha_2}{\alpha_1 + \alpha_2 + \alpha_3} p_y e + \frac{\alpha_3}{\alpha_1 + \alpha_2 + \alpha_3} p_{1z})$ is the average price in country 1;

$P_{2xyz}(\equiv \frac{\beta_1}{\beta_1 + \beta_2 + \beta_3} \frac{p_x}{e} + \frac{\beta_2}{\beta_1 + \beta_2 + \beta_3} p_y + \frac{\beta_3}{\beta_1 + \beta_2 + \beta_3} p_{2z})$ is the average price in country 2;

w_i (i=1, 2) is the wage rate in country i;

$\bar{m}_i$ (i=1, 2) is the initial nominal money balance held by an individual in country i;

m_i / P_{ixyz} is the demand for real balances by an individual in country i; and

e is the exchange rate (defined as the price of country 2's currency in terms of country 1's currency).

Solving the decision problems give us the demand functions for goods and real balances in both countries:

$$x_1 = \frac{\alpha_1(w_1 + \bar{m}_1)}{p_{1x}}; \qquad y_1 = \frac{\alpha_2(w_1 + \bar{m}_1)}{p_{2y} e}; \qquad z_1 = \frac{\alpha_3(w_1 + \bar{m}_1)}{p_{1z}}; \qquad m_1 = \alpha_4(w_1 + \bar{m}_1)$$

(2.1)

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demand in one country for another country's currency because this seems to be the assumption implicit in much of the existing literature, see, for instance, Kemp (1982), Dusansky (1989) and Palivos and Yip (1997).

$$x_2 = \frac{\beta_1(w_2 + \bar{m}_2)e}{p_{1x}}; \qquad y_2 = \frac{\beta_2(w_2 + \bar{m}_2)}{p_{2y}}; \qquad z_2 = \frac{\beta_3(w_2 + \bar{m}_2)}{p_{2z}}; \qquad m_2 = \beta_4(w_2 + \bar{m}_2) \qquad \textbf{(2.2)}$$

On the production side, we assume that all goods are produced with labor only. The production functions are:

Country 1: $X_1 = a_{1x}L_{1x}$; $Z_1 = a_{1z}L_{1z}$

Country 2: $Y_2 = a_{2y}L_{2y}$; $Z_2 = a_{2z}L_{2z}$

Assuming perfect competition, we obtain the money prices of goods which, in equilibrium, are equal to the labor cost of production:

$$p_{1x} = \frac{w_1}{a_{1x}}, \qquad p_{1z} = \frac{w_1}{a_{1z}}, \qquad p_{2y} = \frac{w_2}{a_{2y}}, \qquad p_{2z} = \frac{w_2}{a_{2z}} \tag{2.3}$$

In equilibrium, all markets clear, which means the following conditions are met:

Labor markets: $L_{1x} + L_{1z} = N_1$; $L_{2y} + L_{2z} = N_2$ (2.4)

Markets for good Z: $N_1 z_1 = Z_1$; $N_2 z_2 = Z_2$ (2.5)

Market for good X: $N_1 x_1 + N_2 x_2 = X_1$ (2.6)

Market for good Y: $N_1 y_1 + N_2 y_2 = Y_2$ (2.7)

Foreign exchange market: $N_1 p_{2y} y_1 = N_2 (\frac{p_{1x}}{e}) x_2$ (2.8)

Solving equations (2.1)-(2.8), we obtain the equilibrium exchange rate, wages, prices, and quantities of goods consumed in each country:

$$e^* = \frac{\alpha_2\beta_4 N_1 \bar{m}_1}{\alpha_4\beta_1 N_2 \bar{m}_2}, \qquad w_1^* = \frac{1-\alpha_4}{\alpha_4}\bar{m}_1, \qquad w_2^* = \frac{1-\beta_4}{\beta_4}\bar{m}_2,$$

$$p_{1x}^* = \frac{w_1^*}{a_{1x}}, \qquad p_{1z}^* = \frac{w_1^*}{a_{1z}}, \qquad p_{2y}^* = \frac{w_2^*}{a_{2y}}, \qquad p_{2z}^* = \frac{w_2^*}{a_{2z}}$$

$$x_1^* = \frac{\alpha_1 a_{1x}}{(1-\alpha_4)}, \qquad y_1^* = \frac{a_{2y}\beta_1 N_2}{(1-\beta_4)N_1}, \qquad z_1^* = \frac{\alpha_3 a_{1z}}{(1-\alpha_4)}$$

$$x_2^* = \frac{\alpha_2 a_{1x} N_1}{(1-\alpha_4)N_2}, \qquad y_2^* = \frac{\beta_2 a_{2y}}{1-\beta_4}, \qquad z_2^* = \frac{\beta_3 a_{2z}}{1-\beta_4}$$

Clearly,

$$\frac{\partial e^*}{\partial \bar{m}_2} < 0, \qquad \frac{\partial w_2^*}{\partial \bar{m}_2} = a_{2y}\frac{\partial p_{2x}^*}{\partial \bar{m}_2} = a_{2z}\frac{\partial p_{2z}^*}{\partial \bar{m}_2} > 0, \qquad \frac{\partial w_1^*}{\partial \bar{m}_2} = a_{1x}\frac{\partial p_{1x}^*}{\partial \bar{m}_2} = a_{1z}\frac{\partial p_{1z}^*}{\partial \bar{m}_2} = 0$$

That is, an increase in the supply of country 2's currency weakens the currency, raises the wage rate in country 2 and the prices of goods produced in country 2, but has no impact on the wage rate in country 1 or the prices of goods produced in country 1.

Moreover, it is easy to see that the quantities of goods consumed in each country are independent of the money supply of either country ($\bar{m}_1, \bar{m}_2$), which means money is neutral.

To summarize, we have

Proposition 1. *If both national currencies are used in international trade, and if there is no demand in one country for holding another country's currency, then money is neutral. That is, an increase in the supply of one country's currency leads to a depreciation of that currency and raises the nominal wage rate and prices in that country; but has no effects on real variables in either country.*

3. International trade mediated by a single national currency

In the last section, we assume that both currencies are used in international trade, and that there is no demand in either country for holding another country's currency. This is not, in our judgement, a realistic assumption. As mentioned earlier, only a few currencies are routinely used in international trade, of which the US dollar enjoys a dominant position. Consequently in most countries, there is a demand for holding these international currencies. In light of this observation, we assume in this section that international trade is mediated by one national currency, namely the currency of country 2. We also assume that since country 2's currency becomes an international currency, there is a demand for holding it in country 1 as well as in country 2.

3.1. Regime Two: Flexible exchange rates

First consider the case under a flexible exchange rate system. Since, by assumption, there is a demand in country 1 for holding country 2's currency, the decision problem of the representative consumer in country 1 changes to:

$$\max_{x_1, y_1, z_1, m_1 / P_{1xz}, FX_1 / p_{2y}} U_1 = U_1(x_1, y_1, z_1, \frac{m_1}{P_{1xz}}, \frac{FX_1}{p_{2y}}) = x_1^{\alpha_1} y_1^{\alpha_2} z_1^{\alpha_3} (\frac{m_1}{P_{1xz}})^{\alpha_4} (\frac{FX_1}{p_{2y}})^{\alpha_5}$$

$$\text{s.t.} \quad p_{1x}x_1 + (p_{2y}e)y_1 + p_{1z}z_1 + m_1 + FX_1 e = w_1 + \bar{m}_1 + \overline{FX}_1 e$$

$$\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 + \alpha_5 = 1$$

where $P_{1xz}(\equiv \frac{\alpha_1}{\alpha_1 + \alpha_3} p_{1x} + \frac{\alpha_3}{\alpha_1 + \alpha_3} p_{1z})$ is the average price of good X and good Z; m_1 / P_{1xz} is the demand for real balances in domestic currency; FX_1 / p_{2y} is the demand for real balances in foreign exchange (i.e., the currency of country 2); $\bar{m}_1$ and $\overline{FX}_1 e$ are initial money holdings in domestic and foreign currency, respectively.

The decision problem for individuals in country 2 remains the same as in the benchmark model. Solving the consumer decision problems in both countries, we obtain the demand functions for goods, domestic moneys and foreign exchange:

$$x_1 = \frac{\alpha_1(w_1 + \bar{m}_1 + \overline{FX}_1 e)}{p_{1x}}, \qquad y_1 = \frac{\alpha_2(w_1 + \bar{m}_1 + \overline{FX}_1 e)}{p_{2y}e}, \qquad z_1 = \frac{\alpha_3(w_1 + \bar{m}_1 + \overline{FX}_1 e)}{p_{1z}} \tag{3.1}$$

$$m_1 = \alpha_4(w_1 + \bar{m}_1 + \overline{FX}_1 e), \qquad FX_1 = \frac{\alpha_5(w_1 + \bar{m}_1 + \overline{FX}_1 e)}{e} \tag{3.2}$$

$$x_2 = \frac{\beta_1(w_2 + \bar{m}_2)e}{p_{1x}}, \qquad y_2 = \frac{\beta_2(w_2 + \bar{m}_2)}{p_{2y}}, \qquad z_2 = \frac{\beta_3(w_2 + \bar{m}_2)}{p_{2z}}, \qquad m_2 = \beta_4(w_2 + \bar{m}_2) \tag{3.3}$$

The production side remains unchanged, so we have the same price-wage relationship as in the benchmark model (equations (2.3)). The market clearing conditions for labor and goods also remain unchanged (equations (2.4)-(2.7)). However due to the demand for holding foreign exchange in country 1, the clearing condition for the foreign exchange market changes to:

$$N_1(FX_1 + p_{2y}y_1) = N_2(\frac{p_{1x}}{e})x_2 + N_1\overline{FX}_1 \tag{3.4}$$

The left-hand side of equation (3.4) is the quantity of foreign exchange demanded which is the sum of the demand for foreign exchange holdings and the foreign exchange demanded to finance imports. The right-hand side is the supply of foreign exchange consisting of foreign exchange earnings from exports and initial foreign exchange holdings.

Jointly solving equations (3.1)-(3.4) and (2.3)-(2.7), we obtain the equilibrium values of all the endogenous variables, which we discuss below.

(1) Quantities demanded for foreign exchange holdings and for goods

$$FX_1^* = \frac{\alpha_5[\beta_1 N_2 \bar{m}_2 + (\beta_1 + \beta_4) N_1 \overline{FX}_1]}{(\alpha_2\beta_4 + \alpha_5\beta_1 + \alpha_5\beta_4) N_1}$$

$$x_1^* = \frac{\alpha_1 a_{1x}[\beta_1 N_2 \bar{m}_2 + (\beta_1 + \beta_4) N_1 \overline{FX}_1]}{(1-\alpha_4)\beta_1 N_2 \bar{m}_2 + [(\alpha_1 + \alpha_3)(\beta_1 + \beta_4) + \alpha_2\beta_1] N_1 \overline{FX}_1}$$

$$y_1^* = \frac{\alpha_2 a_{2y}(\beta_1 + \beta_4) N_2[\beta_1 N_2 \bar{m}_2 + (\beta_1 + \beta_4) N_1 \overline{FX}_1]}{[\alpha_2\beta_1 + (\alpha_2\beta_4 + \alpha_5\beta_1 + \alpha_5\beta_4)(\beta_2 + \beta_3)] N_1 N_2 \bar{m}_2 + \alpha_2(\beta_1 + \beta_4) N_1 N_1 \overline{FX}_1}$$

$$z_1^* = \frac{\alpha_3 a_{1z}[\beta_1 N_2 \bar{m}_2 + (\beta_1 + \beta_4) N_1 \overline{FX}_1]}{(1-\alpha_4)\beta_1 N_2 \bar{m}_2 + [(\alpha_1 + \alpha_3)(\beta_1 + \beta_4) + \alpha_2\beta_1] N_1 \overline{FX}_1}$$

$$x_2^* = \frac{\beta_1 a_{1x} N_1[\alpha_2 N_1 \overline{FX}_1 + (\alpha_2 + \alpha_5) N_2 \bar{m}_2]}{(1-\alpha_4)\beta_1 N_2 N_2 \bar{m}_2 + [(\alpha_1 + \alpha_3)(\beta_1 + \beta_4) + \alpha_2\beta_1] N_1 N_2 \overline{FX}_1}$$

$$y_2^* = \frac{\beta_2 a_{2y}(\beta_1 + \beta_4)[\alpha_2 N_1 \overline{FX}_1 + (\alpha_2 + \alpha_5) N_2 \bar{m}_2]}{\alpha_2(\beta_1 + \beta_4) N_1 \overline{FX}_1 + [(\alpha_2\beta_4 + \alpha_5\beta_1 + \alpha_5\beta_4)(\beta_2 + \beta_3) + \alpha_2\beta_1] N_2 \bar{m}_2}$$

$$z_2^* = \frac{\beta_3 a_{2z}(\beta_1 + \beta_4)[\alpha_2 N_1 \overline{FX}_1 + (\alpha_2 + \alpha_5) N_2 \bar{m}_2]}{\alpha_2(\beta_1 + \beta_4) N_1 \overline{FX}_1 + [(\alpha_2\beta_4 + \alpha_5\beta_1 + \alpha_5\beta_4)(\beta_2 + \beta_3) + \alpha_2\beta_1] N_2 \bar{m}_2}$$

From the above, we can see that the equilibrium quantities of goods are dependent on the supply of money in country 2 ($\bar{m}_2$), but not by the supply of money in country 1 ($\bar{m}_1$). In other words, the money not used in international trade is neutral, but the international money is not. Also, we derive from above that:

$$\frac{\partial FX_1^*}{\partial \bar{m}_2} > 0, \qquad \frac{\partial x_1^*}{\partial \bar{m}_2} < 0, \qquad \frac{\partial y_1^*}{\partial \bar{m}_2} < 0, \qquad \frac{\partial z_1^*}{\partial \bar{m}_2} < 0,$$

$$\frac{\partial x_2^*}{\partial \bar{m}_2} > 0, \qquad \frac{\partial y_2^*}{\partial \bar{m}_2} > 0, \qquad \frac{\partial z_2^*}{\partial \bar{m}_2} > 0$$

These suggest that with an increase in supply of money in country 2, there is an increased demand in country 1 for holding foreign exchange (country 2's currency). Meanwhile, the quantities of all goods consumed in country 2 fall, whereas the quantities of all goods consumed in country 1 increase. Thus an increase in the supply of money in country 2 leads to a transfer of wealth from the country 1 to the country 2 because the newly created money, while costs no real resources, commands real purchasing power in the international market. The negative impact on country 1 is also apparent from other variables which we turn to next.

(2) Allocation of productive resources

Since the international monetary shock has a real impact on consumption decisions as shown above, it is to be expected that this will have ramifications for production as well. From our model, we can derive relative shares of labor resources devoted to the tradable and non-tradable sectors in both countries.

$$\frac{L_{1x}^*}{L_{1z}^*} = \frac{\dfrac{N_1 x_1^* + N_2 x_2^*}{a_{1x}}}{\dfrac{N_1 z_1^*}{a_{1z}}} = \frac{\beta_1(\alpha_1+\alpha_2+\alpha_5)N_2\bar{m}_2 + (\alpha_1\beta_1+\alpha_1\beta_4+\alpha_1\alpha_2\beta_1+\alpha_2\beta_1)N_1\overline{FX}_1}{\alpha_3[\beta_1 N_2\bar{m}_2 + (\beta_1+\beta_4+\alpha_2\beta_1)N_1\overline{FX}_1]}$$

$$\frac{L_{2y}^*}{L_{2z}^*} = \frac{\dfrac{N_1 y_1^* + N_2 y_2^*}{a_{2y}}}{\dfrac{N_2 z_2^*}{a_{2z}}} = \frac{(\alpha_2\beta_1+\alpha_2\beta_4+\alpha_2\alpha_2\beta_1+\alpha_2\beta_2)N_1\overline{FX}_1 + (\alpha_2\beta_1+\alpha_2\beta_2+\alpha_5\beta_2)N_2\bar{m}_2}{\beta_3[\alpha_2 N_1\overline{FX}_1 + (\alpha_2+\alpha_5)N_2\bar{m}_2]}$$

It can be shown that

$$\frac{\partial(\dfrac{L_{1x}^*}{L_{1z}^*})}{\partial \bar{m}_2} > 0, \qquad \frac{\partial(\dfrac{L_{2y}^*}{L_{2z}^*})}{\partial \bar{m}_2} < 0.$$

These imply that an increase in the supply of money in country 2 leads to a relative expansion of the tradable sector in country 1, and a relative contraction of the tradable sector in country 2. The tradable sector in country 1 expands because the increase in demand for good X in country 2, and the increased demand in country 1 for holding country 2's currency which has to be met through increased foreign exchange earnings.

(3) Consumer prices, relative wage rate and the terms of trade

The equilibrium exchange rate, wages and prices are:

$$e^* = \frac{(\alpha_2\beta_4 + \alpha_5\beta_1 + \alpha_5\beta_4)N_1\bar{m}_1}{\alpha_4(\beta_1 + \beta_4)N_1\overline{FX}_1 + \alpha_4\beta_1 N_2\bar{m}_2}$$

$$w_1^* = \frac{(1-\alpha_4)\beta_1 N_2\bar{m}_2\bar{m}_1 + [(\alpha_1 + \alpha_3)(\beta_1 + \beta_4) + \alpha_2\beta_1]N_1\overline{FX}_1\bar{m}_1}{\alpha_4(\beta_1 + \beta_4)N_1\overline{FX}_1 + \alpha_4\beta_1 N_2\bar{m}_2}$$

$$w_2^* = \frac{\alpha_2(\beta_1 + \beta_4)N_1\overline{FX}_1 + [(\alpha_2\beta_4 + \alpha_5\beta_1 + \alpha_5\beta_4)(\beta_2 + \beta_3) + \alpha_2\beta_1]N_2\bar{m}_2}{(\alpha_2\beta_4 + \alpha_5\beta_1 + \alpha_5\beta_4)(\beta_1 + \beta_4)N_2}$$

$$p_{1x}^* = \frac{w_1^*}{a_{1x}}, \qquad p_{1z}^* = \frac{w_1^*}{a_{1z}}, \qquad p_{2y}^* = \frac{w_2^*}{a_{2y}}, \qquad p_{2z}^* = \frac{w_2^*}{a_{2z}}$$

$$p_{2y}^* e^* = \frac{N_1\bar{m}_1}{a_{2y}(\beta_1 + \beta_4)N_2} \frac{\alpha_2(\beta_1 + \beta_4)N_1\overline{FX}_1 + [(\alpha_2\beta_4 + \alpha_5\beta_1 + \alpha_5\beta_4)(\beta_2 + \beta_3) + \alpha_2\beta_1]N_2\bar{m}_2}{\alpha_4(\beta_1 + \beta_4)N_1\overline{FX}_1 + \alpha_4\beta_1 N_2\bar{m}_2}$$

We derive from above that

$$\frac{\partial e^*}{\partial \bar{m}_2} < 0, \qquad \frac{\partial p_{1x}^*}{\partial \bar{m}_2} > 0, \qquad \frac{d(p_{2y}^* e^*)}{d(\bar{m}_2)} > 0, \qquad \frac{\partial p_{1z}^*}{\partial \bar{m}_2} > 0.$$

Not surprisingly, an increase in the supply of money country 2 lowers the exchange rate. Moreover, the monetary shock originated in country 2 increases the prices of all goods in country 1, or in other words, following the monetary shock in country 2, inflation is "exported" to country 1.

The monetary shock also affects relative wages and the terms of trade. It can be shown that

$$\frac{\partial(w_1^*/w_2^*e^*)}{\partial \bar{m}_2} < 0, \qquad \frac{\partial(p_{1x}^*/p_{2y}^*e^*)}{\partial \bar{m}_2} < 0, \text{ if } \alpha_2\beta_1 < (\alpha_1+\alpha_3)(\beta_2+\beta_3).$$

A sufficient condition for $\alpha_2\beta_1 < (\alpha_1+\alpha_3)(\beta_2+\beta_3)$ to hold is that in both countries the expenditure share for imports is smaller than the expenditure share for domestically made goods (which is the case for most, if not all, countries in the real world).

Given $\alpha_2\beta_1 < (\alpha_1+\alpha_3)(\beta_2+\beta_3)$, an increase in the supply of money in country 2 results in country 1's wage rate falling relative to that of country 2, and the terms of trade deteriorating for country 1 as well. Intuitively, as money supply in country 2 increases, nominal demand in country 2 for all goods increases. That is, country 2 wants to consume more of its domestically made goods (leaving less to export) and to import more. This is made possible by country 1 importing less, exporting more and holding more of country 2's currency. Therefore the terms of trade tends to fall for country 1. The relative wage in country 1 also falls due to the linear relationship between prices and the wage rate in the Ricardian framework. It is theoretically possible (although practically unlikely) that country 1's terms of trade may improve if both countries are heavily reliant on imports (i.e., both α_2 and β_1 are very large so that $\alpha_2\beta_1 > (\alpha_1+\alpha_3)(\beta_2+\beta_3)$). In that case, a large β_1 would translate an increase in country 2's money supply into a large increase in demand for country 1's export, which could push up the terms of trade for country 1. Since meeting the increased export demand requires the contraction of the non-tradable sector in country 1, it is more likely to succeed if a large portion country 1's domestic demand is met by imports (i.e., a large α_2).

3. 2. Regime Three: Fixed exchange rates

Next consider the case under a fixed exchange rate system. We assume that country 1's currency is fixed at a certain level to the currency of country 2 and that it is the responsibility of country 1's monetary authority to maintain that fixed rate. Under the fixed exchange rate system, the decision problems for individuals in both countries are the same as those under a flexible exchange rate system, except that the exchange rate in the budget constraints is fixed at $\bar{e}$. Correspondingly, the demand functions for goods, domestic moneys and foreign exchange become:

$$x_1 = \frac{\alpha_1(w_1 + \bar{m}_1 + \overline{FX}_1\bar{e})}{p_{1x}}, \qquad y_1 = \frac{\alpha_2(w_1 + \bar{m}_1 + \overline{FX}_1\bar{e})}{p_{2y}\bar{e}}, \qquad z_1 = \frac{\alpha_3(w_1 + \bar{m}_1 + \overline{FX}_1\bar{e})}{p_{1z}} \qquad \textbf{(3.1')}$$

$$m_1 = \alpha_4(w_1 + \bar{m}_1 + \overline{FX}_1\bar{e}), \qquad FX_1 = \frac{\alpha_5(w_1 + \bar{m}_1 + \overline{FX}_1\bar{e})}{\bar{e}} \qquad \textbf{(3.2')}$$

$$x_2 = \frac{\beta_1(w_2 + \bar{m}_2)\bar{e}}{p_{1x}}, \quad y_2 = \frac{\beta_2(w_2 + \bar{m}_2)}{p_{2y}}, \quad z_2 = \frac{\beta_3(w_2 + \bar{m}_2)}{p_{2z}}, \quad m_2 = \beta_4(w_2 + \bar{m}_2) \qquad (3.3')$$

The price-wage relationship and the market clearing conditions for labor and goods remain the same as in the benchmark model (equations (2.3)-(2.7)). The fixed exchange rate is maintained by country 1's monetary authority through buying or selling country 2's currency in the foreign exchange market. The authority is assumed to have a initial foreign exchange reserve of $\bar{R}_1$. The clearing condition for the foreign exchange market is:

$$N_1 p_{2y} y_1 + N_1 FX_1 + R_1 = N_2(\frac{p_{1x}}{\bar{e}})x_2 + N_1\overline{FX}_1 + \bar{R}_1 \qquad (3.4')$$

On the left-hand side of equation (3.4') is the demand for foreign exchange consisting of the transaction demand for foreign exchange, the private demand for foreign exchange holdings, and foreign exchange reserve held by country 1's monetary authority. On the right-hand side is the supply for foreign exchange consisting of the foreign exchange receipts from trade, initial private foreign exchange holdings and initial official foreign exchange reserve.

The general equilibrium solutions for the model with fixed exchange rates are as follows:

$$R_1^* = \bar{R}_1 + \frac{\alpha_2(\beta_1 + \beta_4)N_1\overline{FX}_1\bar{e} + \beta_1\alpha_4 N_2\bar{m}_2\bar{e} - (\alpha_2\beta_4 + \alpha_5\beta_1 + \alpha_5\beta_4)N_1\bar{m}_1}{[\alpha_2\beta_4 + (\alpha_4 + \alpha_5)(\beta_1 + \beta_4)]\bar{e}}$$

$$w_1^* = \frac{[\alpha_2\beta_1 + (\alpha_1 + \alpha_3)(1 - \beta_2 - \beta_3)]N_1(\bar{m}_1 + \overline{FX}_1\bar{e}) + \beta_1 N_2\bar{m}_2\bar{e}}{[\alpha_2\beta_4 + (\alpha_4 + \alpha_5)(\beta_1 + \beta_4)]N_1},$$

$$w_2^* = \frac{\alpha_2 N_1(\bar{m}_1 + \overline{FX}_1\bar{e}) + [\alpha_2\beta_1 + (1 - \alpha_1 - \alpha_3)(\beta_2 + \beta_3)]N_2\bar{m}_2\bar{e}}{[\alpha_2\beta_4 + (\alpha_4 + \alpha_5)(\beta_1 + \beta_4)]N_2\bar{e}},$$

$$p_{1x}^* = \frac{w_1^*}{a_{1x}}, \; p_{1z}^* = \frac{w_1^*}{a_{1z}}, \; p_{2y}^* = \frac{w_2^*}{a_{2y}}, \; p_{2z}^* = \frac{w_2^*}{a_{2z}},$$

$$x_1^* = \frac{\alpha_1 a_{1x}[(\beta_1 + \beta_4)N_1(\bar{m}_1 + \overline{FX}_1\bar{e}) + \beta_1 N_2\bar{m}_2\bar{e}]}{[\alpha_2\beta_1 + (\alpha_1 + \alpha_3)(1 - \beta_2 - \beta_3)]N_1(\bar{m}_1 + \overline{FX}_1\bar{e}) + \beta_1 N_2\bar{m}_2\bar{e}},$$

$$y_1^* = \frac{\alpha_2 a_{2y} N_2[(\beta_1+\beta_4)N_1(\bar{m}_1+\overline{FX}_1\bar{e})+\beta_1 N_2\bar{m}_2\bar{e}]}{\alpha_2 N_1 N_1(\bar{m}_1+\overline{FX}_1\bar{e})+[\alpha_2\beta_1+(1-\alpha_1-\alpha_3)(\beta_2+\beta_3)]N_1N_2\bar{m}_2\bar{e}},$$

$$z_1^* = \frac{\alpha_3 a_{1z}[(\beta_1+\beta_4)N_1(\bar{m}_1+\overline{FX}_1\bar{e})+\beta_1 N_2\bar{m}_2\bar{e}]}{[\alpha_2\beta_1+(\alpha_1+\alpha_3)(1-\beta_2-\beta_3)]N_1(\bar{m}_1+\overline{FX}_1\bar{e})+\beta_1 N_2\bar{m}_2\bar{e}},$$

$$FX_1^* = \frac{\alpha_5[(\beta_1+\beta_4)N_1(\bar{m}_1+\overline{FX}_1\bar{e})+\beta_1 N_2\bar{m}_2\bar{e}]}{[\alpha_2\beta_4+(\alpha_4+\alpha_5)(\beta_1+\beta_4)]N_1\bar{e}},$$

$$x_2^* = \frac{\beta_1 a_{1x} N_1[\alpha_2 N_1(\bar{m}_1+\overline{FX}_1\bar{e})+(1-\alpha_1-\alpha_3)N_2\bar{m}_2\bar{e}]}{[\alpha_2\beta_1+(\alpha_1+\alpha_3)(1-\beta_2-\beta_3)]N_1N_2(\bar{m}_1+\overline{FX}_1\bar{e})+\beta_1 N_2N_2\bar{m}_2\bar{e}},$$

$$y_2^* = \frac{\beta_2 a_{2y}[\alpha_2 N_1(\bar{m}_1+\overline{FX}_1\bar{e})+(1-\alpha_1-\alpha_3)N_2\bar{m}_2\bar{e}]}{\alpha_2 N_1(\bar{m}_1+\overline{FX}_1\bar{e})+[\alpha_2\beta_1+(1-\alpha_1-\alpha_3)(\beta_2+\beta_3)]N_2\bar{m}_2\bar{e}},$$

$$z_2^* = \frac{\beta_3 a_{2z}[\alpha_2 N_1(\bar{m}_1+\overline{FX}_1\bar{e})+(1-\alpha_1-\alpha_3)N_2\bar{m}_2\bar{e}]}{\alpha_2 N_1(\bar{m}_1+\overline{FX}_1\bar{e})+[\alpha_2\beta_1+(1-\alpha_1-\alpha_3)(\beta_2+\beta_3)]N_2\bar{m}_2\bar{e}},$$

$$\frac{w_1^*}{w_2^*\bar{e}} = \frac{[\alpha_2\beta_1+(\alpha_1+\alpha_3)(1-\beta_2-\beta_3)]N_1N_2(\bar{m}_1+\overline{FX}_1\bar{e})+\beta_1 N_2N_2\bar{m}_2\bar{e}}{\alpha_2 N_1N_1(\bar{m}_1+\overline{FX}_1\bar{e})+[\alpha_2\beta_1+(1-\alpha_1-\alpha_3)(\beta_2+\beta_3)]N_1N_2\bar{m}_2\bar{e}},$$

$$\frac{L_{1x}^*}{L_{1z}^*} = \frac{(\alpha_1\beta_1+\alpha_1\beta_4+\alpha_2\beta_1)N_1(\bar{m}_1+\overline{FX}_1\bar{e})+\beta_1(1-\alpha_3)N_2\bar{m}_2\bar{e}}{\alpha_3[(\beta_1+\beta_4)N_1(\bar{m}_1+\overline{FX}_1\bar{e})+\beta_1 N_2\bar{m}_2\bar{e}]},$$

$$\frac{L_{2y}^*}{L_{2z}^*} = \frac{\dfrac{N_1y_1^*+N_2y_2^*}{a_{2y}}}{\dfrac{N_2z_2^*}{a_{2z}}} = \frac{(\alpha_2\beta_1+\alpha_2\beta_4+\alpha_2\beta_2)N_1(\bar{m}_1+\overline{FX}_1\bar{e})+[\alpha_2\beta_1+\beta_2(1-\alpha_1-\alpha_3)]N_2\bar{m}_2\bar{e}}{\beta_3[\alpha_2 N_1(\bar{m}_1+\overline{FX}_1\bar{e})+(1-\alpha_1-\alpha_3)N_2\bar{m}_2\bar{e}]},$$

From the above, we can derive comparative statics results with respect to similar categories of variables as in the case under a flexible exchange rate system:

1) Quantities demanded for foreign exchange holdings and for goods

$$\frac{\partial R_1^*}{\partial\bar{m}_2}>0, \qquad \frac{\partial FX_1^*}{\partial\bar{m}_2}>0, \qquad \frac{\partial x_1^*}{\partial\bar{m}_2}<0, \qquad \frac{\partial y_1^*}{\partial\bar{m}_2}<0, \qquad \frac{\partial z_1^*}{\partial\bar{m}_2}<0,$$

$$\frac{\partial x_2^*}{\partial \bar{m}_2} > 0, \qquad \frac{\partial y_2^*}{\partial \bar{m}_2} > 0, \qquad \frac{\partial z_2^*}{\partial \bar{m}_2} > 0$$

(2) Allocation of productive resources

$$\frac{\partial(\frac{L_{1x}^*}{L_{1z}^*})}{\partial \bar{m}_2} > 0, \qquad \frac{\partial(\frac{L_{2y}^*}{L_{2z}^*})}{\partial \bar{m}_2} < 0$$

(3) Consumer prices, relative wage rate and the terms of trade

$$\frac{\partial p_{1x}^*}{\partial \bar{m}_2} > 0, \qquad \frac{d(p_{2y}^* \bar{e}^*)}{d(\bar{m}_2)} > 0, \qquad \frac{\partial p_{1z}^*}{\partial \bar{m}_2} > 0.$$

$$\frac{\partial(w_1^* / w_2^* \bar{e})}{\partial \bar{m}_2} < 0, \quad \frac{\partial(p_{1x}^* / p_{2y}^* e^*)}{\partial \bar{m}_2} < 0 \quad \text{if} \quad \alpha_2\beta_1 < (\alpha_1 + \alpha_3)(\beta_2 + \beta_3)$$

The above results show that if we are concerned with consumption, production, prices, relative wage, and the terms of trade, the directions of the impact of a monetary shock on these variables are the same under both exchange rate systems. The only difference is that under a flexible exchange rate, an increase in money supply in country 2 leads to a fall in exchange rate, but under a fixed exchange rate, it results in an increase in official foreign exchange reserve in country 1 and correspondingly an increase in country 1's money supply.

To summarise the results so far in this section, we have

Proposition 2. *If only one of the national currencies is used in international trade, and if there is a demand for holding the international currency in both countries, then the international money is not neutral. In particular, an increase in the supply of the international money induces an expansion of the non-tradable sector in the international money-issuing country, and an expansion of the tradable sector in its trading partner. The monetary expansion leads to a transfer of real resources to the international money-issuing country from its trading partner. Meanwhile, inflation is exported to the trading partner, and the trading partner is likely to experience a fall in relative wage rate and a deterioration of its term of trade.*

3.3. Transmission of monetary shocks: flexible exchange rates vs. fixed exchange rates

We have shown above that a change in the supply of international money have real effects under both a flexible exchange rate system and a fixed exchange rate system. However, the magnitudes and the paths of transmission differ under different exchange rate systems. Under a fixed exchange rate system, an increase in the money supply in country 2 puts downward pressure on the exchange rate, but since exchange rate is not allowed to adjust, country 1's foreign exchange reserve must increase, so must the money supply in country 1. Consequently, the inflationary impact on country 2 is likely to be greater. In addition, since both the private demand for foreign exchange holdings and official foreign exchange reserve change in response to the monetary shock, the proportion of the newly created money that is held in country 1 would be greater. As a result there would be a larger transfer of real resources to country 1, and correspondingly a greater impact on consumption and production decisions in both countries.

We have conducted 4 numerical simulations to compare the relative response to a monetary shock under two different exchange rate systems. All simulations give us the same results. We present one simulation in detail below as an illustration.[2]

Consider the flexible exchange rate system first. Assuming the following parameter values:

$\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = 0.2$, $\beta_1 = \beta_2 = \beta_3 = \beta_4 = 0.25$, $N_1 = 10$, $N_2 = 1$, $\overline{FX}_1 = 1$,

$a_{1x} = a_{1z} = 1$, $a_{2y} = a_{2z} = 2$,

we can calculate the equilibrium values of the endogenous variables of our concern as follows.

$$e^* = \frac{30\bar{m}_1}{20 + \bar{m}_2}, \quad FX_1^* = \frac{\bar{m}_2 + 22}{30},$$

$$P_{1xyz} = \bar{m}_1 \frac{33\bar{m}_2 + 200}{3\bar{m}_2 + 60}, \quad P_{2xyz} = \frac{27\bar{m}_2 + 75}{15}$$

[2] Details of other simulation results can be obtained from the corresponding author. Other simulations have different values of preference variables (α_i, β_i, i=1, 2, …5) and different values of population size in each country (N_1 and N_2).

$$x_1^* = \frac{\bar{m}_2 + 22}{4\bar{m}_2 + 50}, \quad y_1^* = \frac{\bar{m}_2 + 22}{25\bar{m}_2 + 200}, \quad z_1^* = \frac{\bar{m}_2 + 22}{4\bar{m}_2 + 50}$$

$$x_2^* = \frac{10\bar{m}_2 + 50}{2\bar{m}_2 + 25}, \quad y_2^* = \frac{4\bar{m}_2 + 20}{5\bar{m}_2 + 40}, \quad z_2^* = \frac{4\bar{m}_2 + 20}{5\bar{m}_2 + 40}$$

$$\frac{L_{1x}^*}{L_{1z}^*} = \frac{3\bar{m}_2 + 32}{\bar{m}_2 + 22}, \quad \frac{L_{2y}^*}{L_{2z}^*} = \frac{3\bar{m}_2 + 32}{2\bar{m}_2 + 10}$$

If $\bar{m}_1 = 10, \bar{m}_2 = 30$ the exchange rate is $e^* = 6$. Suppose the exchange rate is fixed at $\bar{e} = 6$, we can calculate the corresponding equilibrium values for the case under a fixed exchange rate system:

$$R_1^* - \bar{R}_1 = \frac{\bar{m}_2 - 5\bar{m}_1 + 20}{5}, FX_1^* = \frac{10\bar{m}_1 + 3\bar{m}_2 + 60}{150}$$

$$P_{1xyz} = \frac{6\bar{m}_1 + 4\bar{m}_2 + 30}{3}, \quad P_{2xyz} = \frac{45\bar{m}_1 + 31\bar{m}_2 + 270}{30},$$

$$x_1^* = \frac{10\bar{m}_1 + 3\bar{m}_2 + 80}{25\bar{m}_1 + 15\bar{m}_2 + 150}, \quad y_1^* = \frac{10\bar{m}_1 + 3\bar{m}_2 + 60}{100\bar{m}_1 + 105\bar{m}_2 + 600}, \quad z_1^* = \frac{10\bar{m}_1 + 3\bar{m}_2 + 80}{25\bar{m}_1 + 15\bar{m}_2 + 150},$$

$$x_2^* = \frac{10\bar{m}_1 + 18\bar{m}_2 + 60}{5\bar{m}_1 + 3\bar{m}_2 + 30}, \quad y_2^* = \frac{10\bar{m}_1 + 18\bar{m}_2 + 60}{20\bar{m}_1 + 21\bar{m}_2 + 120}, \quad z_2^* = \frac{10\bar{m}_1 + 18\bar{m}_2 + 60}{20\bar{m}_1 + 21\bar{m}_2 + 120},$$

$$\frac{L_{1x}^*}{L_{1z}^*} = \frac{15\bar{m}_1 + 12\bar{m}_2 + 90}{10\bar{m}_1 + 3\bar{m}_2 + 60}, \quad \frac{L_{2y}^*}{L_{2z}^*} = \frac{15\bar{m}_1 + 12\bar{m}_2 + 105}{5\bar{m}_1 + 9\bar{m}_2 + 30}$$

Starting from an equilibrium with the chosen parameter values, including that $\bar{m}_1 = 10, \bar{m}_2 = 30$, we can see how economies respond to an international monetary shock differently under different exchange rate systems. From the above calculations, we derive:

$$\left(\frac{\partial P_{1xyz}}{\partial \bar{m}_2}\right)_X < \left(\frac{\partial P_{1xyz}}{\partial \bar{m}_2}\right)_F, \quad \left(\frac{\partial P_{2xyz}}{\partial \bar{m}_2}\right)_X > \left(\frac{\partial P_{2xyz}}{\partial \bar{m}_2}\right)_F,$$

where the subscript X denotes flexible exchange rate system, and the subscript F denotes fixed exchange rate system.

The above inequalities imply that under a flexible exchange rate system, an increase in the supply of money in country 2 will have a smaller inflationary impact in country 1, but a larger inflationary impact in country 2.

Moreover, we have

$$(\frac{\partial FX_1^*}{\partial \bar{m}_2})_X < (\frac{\partial FX_1^*}{\partial \bar{m}_2})_F + \frac{\partial (R_1^* - \bar{R}_1)}{\partial \bar{m}_2}$$

$$\left|(\frac{\partial x_1^*}{\partial \bar{m}_2})_X\right| < \left|(\frac{\partial x_1^*}{\partial \bar{m}_2})_F\right|, \quad \left|(\frac{\partial y_1^*}{\partial \bar{m}_2})_X\right| < \left|(\frac{\partial y_1^*}{\partial \bar{m}_2})_F\right|, \quad \left|(\frac{\partial z_1^*}{\partial \bar{m}_2})_X\right| < \left|(\frac{\partial z_1^*}{\partial \bar{m}_2})_F\right|,$$

$$(\frac{\partial x_2^*}{\partial \bar{m}_2})_X < (\frac{\partial x_2^*}{\partial \bar{m}_2})_F, \quad (\frac{\partial y_2^*}{\partial \bar{m}_2})_X < (\frac{\partial y_2^*}{\partial \bar{m}_2})_F, \quad (\frac{\partial z_2^*}{\partial \bar{m}_2})_X < (\frac{\partial z_2^*}{\partial \bar{m}_2})_F.$$

These inequalities imply that under a flexible exchange rate system, a smaller amount of the newly created international money is held in country 1, and there is correspondingly a smaller reduction in consumption in country 1 and a smaller increase in consumption in country 2. In other words, a flexible exchange rate system allows a smaller amount of real resource transfer to country 2.

Finally, we have

$$\frac{\partial(\frac{L_{1x}^*}{L_{1z}^*})}{(\frac{\partial}{\partial \bar{m}_2})_X} < \frac{\partial(\frac{L_{1x}^*}{L_{1z}^*})}{(\frac{\partial}{\partial \bar{m}_2})_F}, \quad \left|\frac{\partial(\frac{L_{2y}^*}{L_{2z}^*})}{(\frac{\partial}{\partial \bar{m}_2})_X}\right| < \left|\frac{\partial(\frac{L_{2y}^*}{L_{2z}^*})}{(\frac{\partial}{\partial \bar{m}_2})_F}\right|.$$

These suggest that under a flexible exchange rate system, less resource re-allocation takes place following a monetary shock. In other words, the monetary shock has a smaller impact on stimulating the tradeable sector in country 1 and the non-tradable sector in country 2. (here please check the last sentence because I corrected the sign in the second inequality above)

Summarising the above analysis, we have:

Proposition 3. *Compared to the case with a fixed exchange rate system, under a flexible exchange rate system, an increase in the supply of international money has a larger*

inflationary impact on the international money-issuing country, and a smaller impact on its trading partner. Moreover the monetary shock leads to a smaller amount of real resource transfer to the international money-issuing country, and has a smaller impact on resource re-allocation in both the money-issuing country and its trading partner.

Propositions 2 and 3 suggest that a flexible exchange rate system does not insulate a country from international monetary shocks as generally believed even in the absence of any price rigidities. However, from the perspective of the country that uses another country's currency in international trade, a flexible exchange rate system has the advantage of reducing the impact of the international monetary shock.

4. Conclusion

In this paper, we have developed a set of three models to study the mechanism through which monetary shocks are transmitted internationally. Our conclusions are threefold. First, if there is no demand in one country for holding another country's currency, then money is neutral. Secondly, if there is an international currency that is held in both countries, then the international money is not neutral. An expansion of the international money leads to a transfer of real resources to the international money-issuing country and induces an expansion of both the non-tradable sector in the international money-issuing country and the tradable sector of its trading partner. Thirdly, the real impact of an international monetary shock is greater under a fixed exchange rate system than under a flexible exchange rate system.

The paper has some distinct features. First, the paper explicitly models the demand for holding international money in a Ricardian setting. This allows us to highlight the possibility that a foreign monetary shock can affect the domestic economy by changing the domestic demand for holding foreign exchange, which correspondingly affects production and consumption outcomes. This transmission mechanism is different from those emphasized in the literature. For example, under a flexible exchange rate regime, incomplete exchange rate pass-through is considered to be an important reason why international monetary shocks may have real effects (Goldberg & Knetter, 1997). In our model, a change in exchange rate is completely passed through to prices, but there is an incomplete pass-

through from a change in foreign money supply to exchange rate since the demand for holding foreign money changes.

Second, the model includes both the tradeable sector and non-tradable sector and emphases the structure changes in both countries in response to the monetary shock. This seems to be relevant to the debate on the causes and the global ramifications of financial crises. For example, it is possible to infer from our models that a monetary expansion in an international money-issuing country (e.g. the US) can lead to an artificial expansion in its non-tradable sector, and an artificial expansion in the tradeable sector in its trading partners, such as China. To the extent that such artificial expansion is not sustainable in the long term, one might expect that the impact of the system breakdown would be more intensely felt by the non-tradable sector in the international money-issuing country and the tradeable sector in the international money-using country. Of course, to tell a compelling story about the international implications of a financial crisis, it would be necessary to explicitly model capital and its movements across national borders, which we hope to do in future research. Another possible extension to this paper is to introduce a third country and a second international currency to the models. Such an extension could be used to study the implications of the rise of a new international currency (e.g., the Euro) in a US dollar dominated world market.

A weakness of our model is that it has a highly specific structure partly due to the Ricardian framework. This gives rise to the question as to whether the results of our model are robust. In our view, while the concrete results in our paper are obtained based on a very specific model, the logic of the results seem to hold in more general settings provided that country 1's demand for holding country 2's money increases when the supply of country 2's money increases. Since country 2 has to meet the increased demand for country 2's money by exporting more, production structure will need to change to accommodate that and relative prices will change correspondingly. The question is then whether country 1's demand for country 2's money will in fact increase under more general model specifications. We believe the answer is most likely yes because a higher money supply in country 2 increases its total demand including the demand for country 1's exports. Consequently, country 1's nominal income tends to increase which in turn increases its demand for country 2's money.

Therefore it is likely that the basic results of our paper would carry over to a more general model.

It is of course possible that an increase in money supply in country 2 may lead to a fall (instead of a rise) in the demand for holding country 2's money. For example, if the increase in money supply is so substantial that country 1 loses its confidence in country 2's money, it will reduce its holdings. But in that case, country 2's money would be in danger of losing its standing as accepted international money.

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