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How might Northern Technology Benefit but Northern Money Hurt the South through Trade?*

Wenli Cheng[1] and Dingsheng Zhang[2]

Abstract:

This paper highlights a prominent yet neglected feature of North-South trade, namely that the Northern currency is used as the medium of exchange. It investigates how this feature may affect the way real and monetary shocks are transmitted from the North to the South through trade. It shows that technological progress in the North benefits its Southern trading partner. However, if Southern consumers need to hold Northern money to pay for imports, a monetary expansion in the North hurts the South. In particular, it increases the demand for Northern money in the South, which has to be met by a transfer of real resources from the South to the North. This has an adverse effect on the term of trade for the South and on the trade balance for the North.

Keywords: North-South trade, demand for foreign exchange, international transmission of monetary shocks
JEL Classification Numbers: F11, F42, E41

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[1] Department of Economics, Monash University
[2] Wuhan University, China. Central University of Finance and Economics, China.

1. Introduction

In the aftermath of the 2008 financial crisis four major central banks of the North have lowered official interest rates to their effective "zero lower bound" and turned to unconventional monetary policies including large-scale asset purchases (popularly referred to as quantitative easing or QE). Most notably, the US Federal Reserve (the Fed) engaged in three rounds of large-scale purchases of US Treasury securities, agency debt and agency mortgage-backed securities between 2009 and 2014. When the third round (QE3) was completed in October 2014, the Fed's balance sheet reached $4.5 trillion which was five times its pre-crisis level (Labonte, 2015). Much has been written about whether QE has or will achieve its intended objective of stimulating aggregate demand by putting downward pressure on long-term interest rates (see, for instance, Goodfriend, 2011; Bowdler, 2012; and Fawley and Neely, 2013), but little attention has been given to finding out what "unintended" effects QE might have, especially, on developing countries (the South) whose economies have already been hurt by the global financial crisis. Would the monetary stimulus in the North designed to speed up economic recovery inadvertently hurt the South a second time? This is an important question that warrants careful investigation.

Despite the slow economic recovery in the North, technological progress has not slowed down. The digital revolution has substantially reduced transaction costs and extended the size and the scope of the market. The massive growth in cheap computing power has lowered the cost of innovation in many areas including traditionally protected sectors such as education and healthcare. It has been suggested that we are entering the "age of Schumpeter" (Wooldridge, 2015). How would the Schumpeterian forces of "creative destruction" in the North affect the South? This is another question of great relevance today.

Motivated by the broad question as to how real and monetary shocks originated in the North might affect the South, we develop two simple models to study some plausible mechanisms through which the impact of economic changes in the North can be transmitted to the South through international trade. Each model characterises a specific pattern of trade between the South and the North based on their autarkic relative prices of tradable goods. In model 1, the South exports an intermediate good in exchange of a final good; and in model 2, the South imports an intermediate good to make a final good for exporting.

We find that in both models, a technological advance in the North (a positive "real shock") will benefit the South by lowering its import price. However, a monetary expansion in the North (a positive "monetary shock") has different effects on the South depending on whether there is an asymmetry in the demand for money. In model 1 there is an asymmetry in since Southern consumers have a demand for Northern money to buy final goods from the North whereas Northern consumers do not have a demand for Southern money. As a result, a monetary expansion in the North will hurt the South – it increases the demand for Northern money in the South, which has to be met by a transfer of real resources from the South to the North. Also the South's terms of trade deteriorates. In model 2, there is no asymmetry in the demand for money because Southern consumers do not buy final goods from the North. Hence a monetary expansion in the North will raise Northern prices and depreciate the Northern currency, but will have no effects on production or trade.

How do our findings compare to the existing literature? On the transmission of real shocks through trade, most mainstream economists agree that under normal circumstances trade benefits both trading partners, and a productive gain achieved by one party tends to be shared by another. However, it is theoretically possible that a technological improvement can alter the terms of trade or even the pattern of trade in such a way that one party's gain is accompanied by another's loss (Samuelson, 2004). In the long run, however, continued productivity advance

will benefit both parties to the exchange (Cheng and Zhang, 2007). This paper supports the view that a productivity improvement achieved by one party (the North) will benefit its trading partner (the South).

On the international transmission of monetary shocks, there is a large literature offering different perspectives. According to the classical Mundell-Flemming-Dornbusch model, a monetary expansion leads to exchange rate depreciation in the home country, which improves its trade balance (the expenditure-switching effect). However, a monetary expansion also stimulates domestic demand, which may increase imports and worsen of the trade balance (the income-absorption effect). Whether the net effect on the home country's trade balance is positive or negative depends on the relative magnitudes of the expenditure-switching and the income-absorption effect.

More recent theoretical studies have examined international monetary transmission in open economy macroeconomic settings. For example, Obstfeld and Rogoff (1995) develop a two-country model that integrates exchange rate dynamics and a supply framework based on monopolistic competition and sticky nominal prices. Their model predicts that an increase in money supply has a positive effect on the home country's trade balance and improves its terms of trade over the long term. It also suggests that a monetary expansion improves the welfare of both the home country and the foreign country by encouraging greater work effort. Goldberg and Till (2009) use a center-periphery model to show that the role of the US dollar as the international invoicing currency magnifies the exposure of periphery countries to the US monetary policy even when they have limited trade with the US. Haider (2012) develops a three-country two-period dynamic general equilibrium model to analyze cross-border macroeconomic linkages. He shows that a currency crisis can transmit from one country to another through trade.

Our paper draws on the existing literature, especially it benefits from the monetarist view that a monetary policy impulse will set off a transmission process which involves changes in many relative prices (Meltzer, 1995)[1]. For example a change in money supply alters the marginal utility of money therefore the demand for money, which has spill-over effects on output markets. Different from Meltzer (1995) and other studies noted above, our paper highlights a prominent yet neglected feature in North-South trade, namely that the trade is mediated by the currency of the North. The use of the Northern currency as the medium of exchange is one step further than its use as a unit of account (the invoicing currency as in Goldberg, and Tille, 2008, 2009) because the former gives rise to asymmetry in demand for foreign money. To illustrate, when an Indian exporter sells to the US market, he will most likely price his goods in US dollars and happily accept US dollars in payment. An US exporter, on the other hand, is unlikely to accept Rubee from an Indian buyer. The use of the US dollar as the medium of exchange in US-India trade means that Indians have a demand for holding US dollars (to buy things from the US), whereas Americans do not have a demand for holding Indian Rubees (as they can buy things from India using the US dollar). Our paper shows that this asymmetry in the demand for foreign money has implications for the way monetary shocks originated from the North is transmitted to the South. Specifically, when there is an asymmetry in demand for Northern money, a monetary expansion in the North raises the prices of Northern goods and increases the demand for holding Northern money in the South. Since this increased demand has to be met by net exports, the Northern monetary expansion results in a transfer of real resources from the South to the North.

The asymmetry in the demand for foreign money is examined in Cheng and Zhang (2012a) in the context of US-China trade under a fixed exchange regime. Cheng and Zhang (2012b)

[1] Although Meltzer's (1995) discusses monetary transmission processes in a closed economy, the key insight of monetarism applies readily in an open-economy context.

compare some theoretical differences in monetary transmission under different exchange regimes. Both papers consider trade in final goods. This paper differs from the two earlier papers in that it focuses on the implications of the asymmetric demand for foreign money for North-South trade under a flexible exchange regime. For this purpose, it introduces trade in intermediate goods, and considers two different trade patterns that characterise two typical types of North-South trade: one with the South exporting intermediate goods (for example raw materials such as crude oil); another with the South importing intermediate goods to make final goods for exporting (for example assembly of manufactured goods). Different trade patterns give rise to different demands for holding Northern money and have different implications for the transmission of Northern monetary shocks.

While we do not empirically test the hypotheses that our models generate in this paper, some evidence can be found in the literature that lends support to our conclusions. First of all, the fact that monetary shocks (including currency crises) can be transmitted through trade links is well documented. For instance, based on panel data of 20 industrial countries for the period 1959-93, Eichengreen et al. (1996) find that a currency crisis in one country significantly increases the likelihood of a crisis in another country. Glick and Rose (1999) study five different currency crises and show that they each affected countries with close trade links. Secondly, our paper concludes that in the presence of asymmetric demand for Northern money, a monetary expansion in the North will worsen the trade balance of the North because the South has to export more to meet its higher demand for Northern money. This is different from the Mundell-Flemming-Dornbusch model that suggests an ambiguous effect, and from Obstgeld and Rogoff (1995) who predict a positive effect. Our conclusion seems to be supported by two apparently contradictory findings: Kim (2001a) shows that over the period 1974-1996, a typical US monetary expansion led to a short-run worsening of US trade balance; in comparison, Kim (2001b) reports that a monetary expansion in some open European

countries over a similar period had the initial effect of improving the trade balance of these countries. Our explanation for these different findings would be that since the US dollar is the most widely used medium of exchange in international trade, a US monetary expansion increases the transaction demand for US dollars outside the US (in the short run), therefore US trade balance worsens, whereas an monetary expansion in a small European country has the main (short-run) effect of weakening that country's currency, thereby improving their trade balance.

We present our models in the following section. Based on the results of the models, we study the effects of real and monetary shocks originated from the North in section 3, and offer some concluding remarks in section 4.

2. Models

2.1. Autarky

Consider a Ricardian world with two countries: the South with a working population of N_1, and the North with a working population of N_2. There are two final goods X and Z, and an intermediate good Y which is used to produce X. In autarky, consumers in each country buy both final goods X and Z domestically using domestic currency. Using the traditional money-in-utility-function approach (Sidrauski, 1967) to model money demand, we can write the decision problem of the representative Southern consumer and that of the representative Northern consumer, respectively, as follows:

(1) The Southern consumer:

$$\max_{x_1, z_1, m_1} U_1 = U_1(x_1, z_1, \frac{m_1}{P_{1xz}}) = x_1^{\alpha_1} z_1^{\alpha_2} (\frac{m_1}{P_{1xz}})^{\alpha_3} \tag{1}$$

subject to: $p_{1x} x_1 + p_{1z} z_1 + m_1 = w_1 + \frac{\bar{M}_1}{N_1}$

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

(2) The Northern consumer:

$$\max_{x_2, z_2, m_2} U_2 = U_2(x_2, z_2, \frac{m_2}{P_{2xz}}) = x_2^{\beta_1} z_2^{\beta_2} (\frac{m_2}{P_{2xz}})^{\beta_3} \tag{2}$$

subject to: $p_{2x} x_2 + p_{2z} z_2 + m_2 = w_2 + \frac{\bar{M}_2}{N_2}$

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

In the above decision problems, subscript i (i=1,2) indicates country i; x_i, z_i are quantities of final goods X and Z demanded; p_{ix} and p_{iz} are money prices of goods X and Z; P_{ixz} is the price level; m_i / P_{ixz} is the demand for real balances; w_i is the wage rate; $\bar{M}_i$ is the initial money stock.

Solving the consumers' decision problems we obtain the demand functions for final goods and for money in each country.

On the supply side, we assume that final good Z and intermediate good Y are produced with labor only, and final good X is produced with labor and intermediate good Y. The production functions are:

$$Z_i = a_{iz} L_{iz}; \quad Y_i = a_{iy} L_{iy}; \quad X_i = a_{ix} y_i^{\gamma_i} (L_{ix})^{1-\gamma_i} \tag{3}$$

where Z_i, Y_i, X_i are quantities of goods Z, Y and X produced in country i (i=1,2); y_i is the quantity of intermediate good Y demanded by the X industry. a_{ix}, a_{iy}, a_{iz} and γ_i are technology parameters. We also assume that the firms operate in perfectly competitive markets.

In equilibrium, all markets clear in each country so that the following conditions are met:

Labour market: $L_{ix} + L_{iy} + L_{iz} = N_i$ (4)

Market for good Y: $y_i = Y_i$ (5)

Market for good X: $N_i x_i = X_i$ (6)

Market for good Z : $N_i z_i = Z_i$ (7)

Money: $m_i = \frac{\bar{M}_i}{N_i}$ (8)

Solving the system of equations consisting of the first-order conditions of consumers' and producers' decisions problems, and the market clearance conditions, we obtain the autarkic equilibrium prices and quantities in each country. These are presented in Table 1.

Table 1. Autarkic equilibrium

Wages and Prices	$w_1^* = \frac{(1-\alpha_3)\bar{M}_1}{\alpha_3 N_1}$, $p_{1z}^* = \frac{w_1^*}{a_{1z}}$, $p_{1y}^* = \frac{w_1^*}{a_{1y}}$, $p_{1x}^* = a_{1x}^{-1} a_{1y}^{-\gamma_1} (1-\gamma_1)^{\gamma_1 - 1} \gamma_1^{-\gamma_1} w_1^*$ $\frac{p_{1x}^*}{p_{1y}^*} = a_{1x}^{-1} a_{1y}^{1-\gamma_1} (1-\gamma_1)^{\gamma_1 - 1} \gamma_1^{-\gamma_1}$ $w_2^* = \frac{(1-\beta_3)\bar{M}_2}{\beta_3 N_2}$, $p_{2z}^* = \frac{w_2^*}{a_{2z}}$, $p_{2y}^* = \frac{w_2^*}{a_{2y}}$, $p_{2x}^* = a_{2x}^{-1} a_{2y}^{-\gamma_2} (1-\gamma_2)^{\gamma_2 - 1} \gamma_2^{-\gamma_2} w_2^*$ $\frac{p_{2x}^*}{p_{2y}^*} = a_{2x}^{-1} a_{2y}^{1-\gamma_2} (1-\gamma_2)^{\gamma_2 - 1} \gamma_2^{-\gamma_2}$
Consumption	$x_1^* = \frac{a_{1x} a_{1y}^{\gamma_1} \alpha_1 \gamma_1^{\gamma_1} (1-\gamma_1)^{1-\gamma_1}}{1-\alpha_3}$, $y_1^* = \frac{a_{1y} \gamma_1 \alpha_1}{1-\alpha_3} N_1$, $z_1^* = \frac{a_{1z} \alpha_2}{1-\alpha_3}$, $x_2^* = \frac{a_{2x} a_{2y}^{\gamma_2} \beta_1 \gamma_2^{\gamma_2} (1-\gamma_2)^{1-\gamma_2}}{1-\beta_3}$, $y_2^* = \frac{a_{2y} \gamma_2 \beta_1}{1-\beta_3} N_2$, $z_2^* = \frac{a_{2z} \beta_2}{1-\beta_3}$,
Labor allocation	$L_{1x}^* = \frac{(1-\gamma_1)\alpha_1}{1-\alpha_3} N_1$, $L_{1y}^* = \frac{\gamma_1 \alpha_1}{1-\alpha_3} N_1$, $L_{1z}^* = \frac{\alpha_2}{1-\alpha_3} N_1$ $L_{2x}^* = \frac{(1-\gamma_2)\beta_1}{1-\beta_3} N_2$, $L_{2y}^* = \frac{\gamma_1 \beta_1}{1-\beta_3} N_2$, $L_{2z}^* = \frac{\beta_2}{1-\beta_3} N_2$

We assume that final good Z is non-tradable. What interests us is the autarkic relative price of good X and good Y, as they determine the trade pattern when the two countries engage in trade with each other. From Table 1, it is clear that

$$\frac{p_{1x}^*}{p_{1y}^*} < \frac{p_{2x}^*}{p_{2y}^*} \quad \text{iff} \quad a_{1x} a_{1y}^{\gamma_1 - 1} (1-\gamma_1)^{1-\gamma_1} \gamma_1^{\gamma_1} > a_{2x} a_{2y}^{\gamma_2 - 1} (1-\gamma_2)^{1-\gamma_2} \gamma_2^{\gamma_2} \tag{9}$$

Condition (9) implies that a country is more likely to export good X if its productivity in making good X is relatively high, and if its X production technology is less reliant on the use of intermediate good Y. This condition captures the traditional Ricardian determinant of comparatives advantage, and to a degree connects to an "H-O" determinant of factor intensity. When both countries use the intermediate good at the same intensity in X production (i.e., $\gamma_1 = \gamma_2 = \gamma$), condition (9) reduces to:

$$\frac{p_{1x}^*}{p_{1y}^*} < \frac{p_{2x}^*}{p_{2y}^*} \quad \text{iff} \quad \frac{a_{1x}}{a_{2x}} > \left(\frac{a_{1y}}{a_{2y}}\right)^{1-\gamma} \tag{10}$$

which has a more distinct "Richardian" flavour, but still accounts for role of the intermediated good in the final good production.

In the following, we consider the two possible trade patterns with complete specialisation[2] when the two countries open up for international trade.

2.2. Model 1: The South Imports Final Good X

Suppose $a_{1x}a_{1y}^{\gamma_1-1}(1-\gamma_1)^{1-\gamma_1}\gamma_1^{\gamma_1} < a_{2x}a_{2y}^{\gamma_2-1}(1-\gamma_2)^{1-\gamma_2}\gamma_2^{\gamma_2}$ so that in Autarky, the South (country 1) has a lower price of good Y relative to good X, then when trade opens up the South will export good Y in exchange of good X. Good Z is a non-tradable good produced in both countries.

Internal trade is mediated by each country's domestic currency, whereas international trade is mediated by the currency of the North. As a result, a consumer in the South has a demand for Southern money (used in internal trade) and a demand for Northern money (used in international trade). In contrast, a consumer in the North has only a demand for Northern

[2] Other trade patterns involving incomplete specialization may occur (see Cheng, Sachs and Yang, 2000 for a discussion of the conditions under which different trade patterns emerge in general equilibrium). For our purpose we only consider the trade patterns with complete specialization. Our results remain valid in structures with incomplete specialization.

money, and no demand for Southern money. The decision problem of the representative Southern consumer is:

$$\max_{x_1, z_1, m_1, FX_1} U_1 = U_1(x_1, z_1, \frac{m_1}{P_{1xz}}, \frac{FX_1}{p_x}) = x_1^{\alpha_1} z_1^{\alpha_2} (\frac{m_1}{P_{1xz}})^{\alpha_3} (\frac{FX}{p_x})^{\alpha_4} \quad (11)$$

Subject to: $p_{2x} e x_1 + p_{1z} z_1 + m_1 + FX_1 e = w_1 + \frac{\bar{M}_1 + \overline{FX} e}{N_1}$

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

where e is the exchange rate (defined as the price of the Northern currency in terms of the Southern currency). Other variables are as defined in the model for Autarky.

The Northern consumer's decision problem is the same as that in Autarky (expression (2)).

Solving the consumers' decision problem, we have the demand for final goods and money in each country:

$$x_1 = \frac{\alpha_1 (w_1 + \frac{\bar{M}_1 + \overline{FX} e}{N_1})}{p_{2x} e} \; ; z_1 = \frac{\alpha_2 (w_1 + \frac{\bar{M}_1 + \overline{FX} e}{N_1})}{p_{1z}} \quad (12)$$

$$m_1 = \alpha_3 (w_1 + \frac{\bar{M}_1 + \overline{FX} e}{N_1}) ; \; FX_1 = \frac{\alpha_4 (w_1 + \frac{\bar{M}_1 + \overline{FX} e}{N_1})}{e} \quad (13)$$

$$x_2 = \frac{\beta_1 (w_2 + \frac{\bar{M}_2}{N_2})}{p_{2x}} \; ; \; z_2 = \frac{\beta_2 (w_2 + \frac{\bar{M}_2}{N_2})}{p_{2z}} ; \quad m_2 = \beta_3 (w_2 + \frac{\bar{M}_2}{N_2}) \quad (14)$$

As in Autarky, firms operate in perfectly competitive markets and maximize their profits given the production functions (3). The first-order conditions of the firms' decision problems give us:

$$p_{1z} = \frac{w_1}{a_{1z}} ; \quad p_{1y} = \frac{w_1}{a_{1y}} ; \quad p_{2z} = \frac{w_2}{a_{2z}} ; \quad y_1 = \frac{\gamma_2 p_{2x} X_2 e}{p_{1y}} ; \quad L_{2x} = \frac{(1-\gamma_2) p_{2x} X_2}{w_2} \quad (15)$$

In equilibrium, all markets clear so that the following conditions are met:

Labour: $L_{1y} + L_{1z} = N_1 ; \quad L_{2x} + L_{2z} = N_2$ (16)

Good Y: $y_1 = Y_1$ (17)

Good X: $X_2 = N_1 x_1 + N_2 x_2$ (18)

Good Z : $N_i z_i = Z_i \quad (i = 1, 2)$ (19)

Foreign exchange: $p_{2x} N_1 x_1 + N_1 FX_1 = \frac{p_{1y}}{e} y_1 + \overline{FX}$ (20)

Solving for the system of equations (12)-(20), we obtain the equilibrium values of all endogenous variables. These are presented in Table 2.

Table 2. Equilibrium of Model 1: The South Imports Final Good X

Wages and Prices	$w_1^* = \frac{(1-\alpha_3)\gamma_2\beta_1\bar{M}_2\bar{M}_1 + [(\alpha_1\gamma_2+\alpha_2)\beta_3 + (\alpha_1+\alpha_2)\gamma_2\beta_1]\overline{FX}\bar{M}_1}{\alpha_3(\beta_3+\gamma_2\beta_1)N_1\overline{FX} + \alpha_3\gamma_2\beta_1 N_1\bar{M}_2}$ $w_2^* = \frac{(1-\gamma_2)\alpha_1\overline{FX} + (\alpha_1+\alpha_4-\alpha_1\gamma_2)\bar{M}_2}{[(\alpha_1+\alpha_4-\alpha_1\gamma_2)\beta_3 + \alpha_4\gamma_2\beta_1]N_2}$ $p_{1z}^* = \frac{w_1^*}{a_{1z}}, \quad p_{1y}^* = \frac{w_1^*}{a_{1y}}, \quad p_{2z}^* = \frac{w_2^*}{a_{2z}}$ $p_{2x}^* = a_{2x}^{-1} a_{1y}^{-\gamma_2} (1-\gamma_2)^{\gamma_2-1} \gamma_2^{-\gamma_2} (e^*)^{-\gamma_2} (w_1^*)^{\gamma_2} (w_2^*)^{1-\gamma_2}$ $e^* = \frac{[(\alpha_1+\alpha_4-\alpha_1\gamma_2)\beta_3 + \alpha_4\gamma_2\beta_1]\bar{M}_1}{\alpha_3(\beta_3+\gamma_2\beta_1)\overline{FX} + \alpha_3\gamma_2\beta_1\bar{M}_2}$
Consumption	$x_1^* = \frac{\alpha_1\bar{M}_1}{\alpha_3 N_1 p_{2x}^* e^*}, \quad z_1^* = \frac{\alpha_2\bar{M}_1}{\alpha_3 N_1 p_{1z}^*}$ $x_2^* = \frac{\beta_1(w_2^* + \bar{M}_2/N_2)}{p_{2x}^*}, \quad z_2^* = \frac{\beta_2(w_2^* + \bar{M}_2/N_2)}{p_{2z}^*}$
Labor Allocation	$L_{1z}^* = \frac{\alpha_1(\beta_3+\gamma_2\beta_1)N_1\overline{FX} + \alpha_1\gamma_2\beta_1 N_1\bar{M}_2}{(1-\alpha_3)\gamma_2\beta_1\bar{M}_2 + [(\alpha_1\gamma_2+\alpha_2)\beta_3 + (\alpha_1+\alpha_2)\gamma_2\beta_1]\overline{FX}}$ $L_{1y}^* = \frac{(\alpha_2+\alpha_4)\gamma_2\beta_1 N_1\bar{M}_2 + [(\alpha_1\gamma_2+\alpha_2-\alpha_1)\beta_3 + \alpha_2\gamma_2\beta_1]N_1\overline{FX}}{(1-\alpha_3)\gamma_2\beta_1\bar{M}_2 + [(\alpha_1\gamma_2+\alpha_2)\beta_3 + (\alpha_1+\alpha_2)\gamma_2\beta_1]\overline{FX}}$ $L_{2z}^* = \frac{(1-\gamma_2)\beta_2\alpha_1 N_2\overline{FX} + [(\alpha_1+\alpha_4-\alpha_1\gamma_2)(1+\beta_3) + \alpha_4\gamma_2\beta_1]\beta_2 N_2\bar{M}_2}{(1-\gamma_2)\alpha_1\overline{FX} + (\alpha_1+\alpha_4-\alpha_1\gamma_2)\bar{M}_2}$ $L_{2x}^* = \frac{(1-\gamma_2)(1-\beta_2)\alpha_1 N_2\overline{FX} + (\alpha_1+\alpha_4-\alpha_1\gamma_2)N_2\bar{M}_2 - [(\alpha_1+\alpha_4-\alpha_1\gamma_2)(1+\beta_3) + \alpha_4\gamma_2\beta_1]\beta_2 N_2\bar{M}_2}{(1-\gamma_2)\alpha_1\overline{FX} + (\alpha_1+\alpha_4-\alpha_1\gamma_2)\bar{M}_2}$
Southern Holdings of Northern Money	$FX_1^* = \frac{\alpha_4(\beta_3+\gamma_2\beta_1)\overline{FX} + \alpha_4\gamma_2\beta_1\bar{M}_2}{[(\alpha_1+\alpha_4-\alpha_1\gamma_2)\beta_3 + \alpha_4\gamma_2\beta_1]N_1}$

2.3. Model 2: The South Imports Intermediate Good Y

We now consider the case where $a_{1x}a_{1y}^{\gamma_1-1}(1-\gamma_1)^{1-\gamma_1}\gamma_1^{\gamma_1} > a_{2x}a_{2y}^{\gamma_2-1}(1-\gamma_2)^{1-\gamma_2}\gamma_2^{\gamma_2}$ so that the South has a comparative advantage in producing good X, and the trade pattern is that the South imports intermediate good Y to produce final good X and exports good X. Since Southern consumers do not import final goods, there is no need to hold Northern money. The Southern consumer's decision problem is:

$$\max_{x_1,z_1,m_1} U_1 = U_1(x_1, z_1, \frac{m_1}{P_{1xz}}) = x_1^{\alpha_1} z_1^{\alpha_2} (\frac{m_1}{P_{1xz}})^{\alpha_3} \tag{21}$$

Subject to: $p_{1x}x_1 + p_{1z}z_1 + m_1 = w_1 + \frac{\bar{M}_1}{N_1}$

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

The Northern consumer's decision problem is:

$$\max_{x_2,z_2,m_2} U_2 = U_2(x_2, z_2, \frac{m_2}{P_{2xz}}) = x_2^{\beta_1} z_2^{\beta_2} (\frac{m_2}{P_{2xz}})^{\beta_3} \tag{22}$$

Subject to: $\frac{p_{1x}}{e}x_2 + p_{2z}z_2 + m_2 = w_2 + \frac{\bar{M}_2}{N_2}$

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

We assume the production technologies remain unchanged although now the North produces the intermediate good and the South produces the final good. Market clearing conditions are the same as those in Model 1 except that the foreign exchange market clearance condition changes to:

$$p_{2y}y_2 = \frac{p_{1x}}{e}N_2x_2 \tag{22}$$

The equilibrium values of Model 2 can be solved in a similar way as Model 1. The results are presented in Table 3.

Table 3. Equilibrium values: Model 2 The South Imports Intermediate Good Y

Wages and Prices	$w_1^* = \frac{(1-\alpha_3)}{\alpha_3}\frac{\bar{M}_1}{N_1}$ $w_2^* = \frac{(1-\beta_3)}{\beta_3}\frac{\bar{M}_2}{N_2}$ $p_{1z}^* = \frac{w_1^*}{a_{1z}}, \quad p_{2y}^* = \frac{w_2^*}{a_{2y}}, \quad p_{2z}^* = \frac{w_2^*}{a_{2z}}$ $p_{1x}^* = a_{1x}^{-1} a_{2y}^{-\gamma_1} (1-\gamma_1)^{\gamma_1 - 1} \gamma_1^{-\gamma_1} (e^*)^{\gamma_1} (w_1^*)^{1-\gamma_1} (w_2^*)^{\gamma_1}$ $e^* = \frac{\alpha_1 \beta_3 \gamma_1 \bar{M}_1}{\alpha_3 \beta_1 (1-\gamma_1) \bar{M}_2}$
Consumption	$x_1^* = \frac{\alpha_1 \bar{M}_1}{\alpha_3 N_1 p_{1x}^*}, \quad z_1^* = \frac{\alpha_2 \bar{M}_1}{\alpha_3 N_1 p_{1z}^*}$ $x_2^* = \frac{\beta_1 (w_2^* + \bar{M}_2 / N_2) e^*}{p_{1x}^*}, \quad z_2^* = \frac{\beta_2 (w_2^* + \bar{M}_2 / N_2)}{p_{2z}^*}$
Labor Allocation	$L_{1x}^* = \frac{\alpha_1}{1-\alpha_3} N_1, \quad L_{1z}^* = \frac{\alpha_2}{1-\alpha_3} N_1$ $L_{2y}^* = \frac{\beta_1}{1-\beta_3} N_2, \quad L_{2z}^* = \frac{\beta_2}{1-\beta_3} N_2$

3. Analysis

Based on the equilibrium solutions of the models in the last section, we now study how real and monetary shocks originated in the North may affect the economies of both the North and the South.

3.1. Real shocks

We consider the impact of a change in tradable sector productivity in the North (a_{2x} in model 1 and a_{2y} in model 2). From the equilibrium solutions in Tables 2 and 3, we derive the following comparative statics results, with subscripts I, II indicating model 1 and model 2 respectively:

$$(\frac{\partial p_{2x}^*}{\partial a_{2x}})_I < 0, \qquad [\frac{\partial (p_{1y}^* / p_{2x}^* e^*)}{\partial a_{2x}}]_I > 0, \qquad (\frac{\partial x_1^*}{\partial a_{2x}})_I > 0, \qquad (\frac{\partial x_2^*}{\partial a_{2x}})_I > 0 \qquad (23)$$

$$[\frac{\partial(L_{1y}^{*}/L_{1z}^{*})}{\partial a_{2x}}]_{I}=[\frac{\partial(L_{2x}^{*}/L_{2z}^{*})}{\partial a_{2x}}]_{I}=0 \tag{24}$$

$$(\frac{\partial p_{2y}^{*}}{\partial a_{2y}})_{II}<0,\quad [\frac{\partial(p_{1x}^{*}/p_{2y}^{*}e^{*})}{\partial a_{2y}}]_{II}>0,\quad (\frac{\partial x_{1}^{*}}{\partial a_{2y}})_{II}>0,\quad (\frac{\partial x_{2}^{*}}{\partial a_{2y}})_{II}>0 \tag{25}$$

$$[\frac{\partial(L_{1x}^{*}/L_{1z}^{*})}{\partial a_{2y}}]_{II}=[\frac{\partial(L_{2y}^{*}/L_{1z}^{*})}{\partial a_{2y}}]_{II}=0 \tag{26}$$

These suggest that regardless which tradable good the North specializes in, a productivity improvement in the Northern tradable sector will lower the price of Northern exports, improve the terms of trade for the South, increase the consumption of the tradable good without changing resource allocation in either country. This result is consistent with the widely accepted view that productivity improvement in one country benefits the country's trading partner (Cheng and Zhang, 2007).

3.2. Monetary shocks

First we look at the impact of an increase in Northern money supply on the exchange rate. From the results in Tables 2 and 3, it is easy to show:

$$(\frac{\partial e^{*}}{\partial \bar{M}_{2}})_{I}<0;\qquad (\frac{\partial e^{*}}{\partial \bar{M}_{2}})_{II}<0 \tag{27}$$

As expected, results (27) show that regardless of the trade pattern, a monetary expansion in the North leads to a depreciation of the Northern currency. This is consistent with the Mundell-Flemming-Dornbusch model and the purchasing power parity theory of exchange rate determination.

Now consider wages, prices and the terms of trade. The comparative statics of the equilibrium in model 1 show:

$$(\frac{\partial w_{2}^{*}}{\partial \bar{M}_{2}})_{I}>0;\qquad (\frac{\partial p_{2x}^{*}}{\partial \bar{M}_{2}})_{I}>0;\qquad (\frac{\partial p_{2z}^{*}}{\partial \bar{M}_{2}})_{I}>0 \tag{28}$$

$$(\frac{\partial w_1^*}{\partial \bar{M}_2})_I > 0; \qquad (\frac{\partial p_{1y}^*}{\partial \bar{M}_2})_I > 0; \qquad (\frac{\partial p_{1z}^*}{\partial \bar{M}_2})_I > 0 \tag{29}$$

$$[\frac{\partial (p_{1y}^* / p_{2x}^* e^*)}{\partial \bar{M}_2}]_I < 0 \tag{30}$$

Similarly we have the following comparative statics for model 2:

$$(\frac{\partial w_2^*}{\partial \bar{M}_2})_{II} > 0; \qquad (\frac{\partial p_{2y}^*}{\partial \bar{M}_2})_{II} > 0; \qquad (\frac{\partial p_{2z}^*}{\partial \bar{M}_2})_{II} > 0 \tag{31}$$

$$(\frac{\partial w_1^*}{\partial \bar{M}_2})_{II} = 0; \qquad (\frac{\partial p_{1x}^*}{\partial \bar{M}_2})_{II} = 0; \qquad (\frac{\partial p_{1z}^*}{\partial \bar{M}_2})_{II} = 0 \tag{32}$$

$$[\frac{\partial (p_{2x}^* / p_{1y}^* e^*)}{\partial \bar{M}_2}]_{II} = 0 \tag{33}$$

The above results indicate in mode1 1 where the South imports the final good X the price and wage increases in the North are “exported” to the South, and the South’s term of trade al so deteriorates. However, in model 2 where the South imports the intermediate good Y, the wage rate and prices in the South are insulated from the price increase in the North.

Next we examine the effect of an increase in Northern supply on the demand for foreign exchange (i.e., Northern money) in the South. From the results in Table 2 it is easy to see

$$(\frac{\partial FX_1^*}{\partial \bar{M}_2})_I > 0 \tag{34}$$

Result (34) suggests that in model 1, an increase in Northern money supply raises the demand in the South for holding Northern money. This is because the increase in Northern money increases the nominal demand in the North, which in turn increases the prices of goods and the nominal income of the Southern consumer, both having a positive effect on the demand for holding money.

Since the increased Southern demand for Northern money has to be met through an increase in net exports, it has to go into trade surplus, or put differently, the North will have a

trade deficit. Accordingly, the consumption patterns in the South and in the North change as shown by the following comparative statics results:

$$(\frac{\partial x_1^*}{\partial \bar{M}_2})_I < 0\,,\ (\frac{\partial z_1^*}{\partial \bar{M}_2})_I < 0\,,\quad (\frac{\partial x_2^*}{\partial \bar{M}_2})_I \text{ indeterminate sign, } (\frac{\partial z_2^*}{\partial \bar{M}_2})_I > 0 \tag{35}$$

Results (35) indicate that the consumption of all goods in the South fall (so that the South can increase its holdings of Northern money); the consumption of the non-tradable increases in the North, but the direction of change in the consumption of good X is ambiguous. The ambiguity arises because while more intermediate good Y is produced as labor moves towards the tradable sector in the South, total production of X may still fall as labor moves towards the non-tradable sector in the North as shown below:

$$[\frac{\partial(L_{1y}^*/L_{1z}^*)}{\partial \bar{M}_2}]_I > 0\,,\quad [\frac{\partial(L_{2x}^*/L_{2z}^*)}{\partial \bar{M}_2}]_I < 0 \tag{36}$$

While it is ambiguous whether the consumption of the tradable good would rise following a Northern monetary expansion, it is clear that the money expansion is not neutral as it changes consumption and production patterns in the South and the North. Corresponding to the increase in the South the holdings of Northern money, there is a transfer of real resources from the South to the North manifested as a fall in consumption levels in the South.

In contrast, if the South does not have a demand for Northern money as in model 2 where Southern consumers do not buy final goods from the North, money is neutral.[3] As shown below, a Northern monetary expansion has no effect on either consumption or production in

[3] Although Southern consumers do not have a demand for Northern money because they do not import final goods, Southern producers may have a demand for Northern money to import intermediate goods, in which case the implications of a monetary shock would be similar to those in model 1. We thank an anonymous referee for this observation. We have assumed away Southern producers' demand for Northern money in model 2 for two reasons: first, to adequately model producers demand for Northern money, an explicit allowance for production time would be required which greatly complicates the model; and secondly, the current model serves to highlight the role asymmetric demand for Northern money in as the driver of non-neutrality of international money.

either the South or the North:

$$(\frac{\partial x_1^*}{\partial \bar{M}_2})_{II} = 0; \quad (\frac{\partial z_1^*}{\partial \bar{M}_2})_{II} = 0; \quad (\frac{\partial x_2^*}{\partial \bar{M}_2})_{II} = 0; \quad (\frac{\partial z_2^*}{\partial \bar{M}_2})_{II} = 0 \tag{37}$$

$$[\frac{\partial (L_{1x}^* / L_{1z}^*)}{\partial \bar{M}_2}]_{II} = 0; \quad [\frac{\partial (L_{2y}^* / L_{2z}^*)}{\partial \bar{M}_2}]_{II} = 0 \tag{38}$$

We can summarize the analysis in this section as follows. In a world where international trade between the North and the South is mediated by the currency of the North, real and monetary shocks originated from the North can be transmitted to the South through trade. The transmission of real shocks follows a similar pattern regardless of the pattern of trade. In particular, a productivity improvement in the Northern tradable sector will lower the price of the Northern exports, and benefit both Northern and Southern consumers. However, the way monetary shocks are transmitted does depend on the tradable pattern. If the trade pattern is such that Southern consumers do not import final goods such that they do not have a demand for holding Northern money, then a monetary expansion in the North drives up prices in the North, and depreciates the Northern currency, but have no effects on production or consumption in either the North or the South. In contrast, if Southern consumers import final goods and have a demand for holding Northern money to facilitate their imports, then a Northern monetary expansion have real effects. Specifically (1) it increases the demand for holding Northern money in the South, with a corresponding transfer of real resources from the South to the North; (2) it leads to a deterioration of the terms of trade for the South and fall in trade balance for the North; and (3) it induces structural changes in both economies by encouraging the expansion of the tradable sector in the South and the expansion of the non-tradable sector in the North.

4. Concluding remarks

In this paper we have presented two simple trade models with money to study how real and nominal shocks are transmitted through international trade between the South and the North. By explicitly incorporating both the demand for domestic currency and that for foreign exchange, our models highlight the feature of an asymmetric demand in the South for Northern money and study its implications. Our model also makes a contribution to the large literature on the transmission mechanism of monetary shocks (see for instance, Meltzer, 1995) by looking at the issue from the perspective of international trade.

The results of our paper follow from the logic of general equilibrium. When there is an increase in the supply of Northern money, the nominal income of the North goes up, which pushes up the prices in the North and raises the demand for Southern goods. This increases the demand for Northern money by Southern individuals if there is an asymmetric demand for Northern money in the South. Since the increase in the holdings of Northern money is made possible only by an increase of Southern net exports to the North, the North's trade balance will fall, which is an indication of a corresponding transfer of real resources from the South to the North.

The increase in demand for Northern money partly offsets the downward pressure on the exchange rate, such that the exchange rate falls by less than proportionally relative to the increase in the supply of Northern money. At the same time, the terms of trade worsens for the South, which means more goods have to be exported for the same amount of imports. In the new equilibrium therefore, the export sector in the South needs to be larger, and that in the North needs to be smaller. In other words, the increase in the money supply in the North leads to structural changes of production in both countries.

The results of our paper suggest that the recent "quantitative easing" in major developed countries, especially the US, may have the unintended consequence of hurting the developing

world by taking real resources from them in exchange of newly created money with uncertain future value. Such North-South trade is also likely to worsen international imbalances.

Our paper may also offer a different perspective on the international linkages leading up to the 2008 financial crisis. An expansionary monetary policy in the North leading up to the crisis may have generated a boom in the export sector in the South, and a boom in the non-tradable sector in the North. When the boom turns into bust, the tradable sector in the South is forced to contract as is the non-tradable sector in the North. Of course, our models as they stand do not tell a compelling story about business cycles. However, it may be possible to extend them, for instance, by incorporating international capital flow, to analyse how cycle-generating monetary shocks are transmitted internationally.

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