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# EXCHANGE RATE REGIMES, SPECIALIZATION AND TRADE VOLUME

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# Exchange Rate Regimes, Specialization and Trade Volume*

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## Abstract

We develop a general equilibrium monetary model of endogenous specialization and international trade to examine the degree of specialization and trade volume under alternative exchange rate regimes. Where demand shocks are important, we demonstrate an increase in specialization, trade and welfare under coordinated fixed exchange rates, equivalent to a common currency, relative to flexible exchange rates. Where supply shocks are important, the effects on specialization and trade are smaller and ambiguous in direction, though the welfare effects are comparable to those for demand shocks.

*Keywords:* Exchange Rates, Common Currency, International Trade
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# 1. Introduction

A large empirical literature documents an increase in trade volume for countries that adopt a common currency. Rose (2004) provides a summary and meta-analysis of this literature, which was initiated with his earlier work, Rose (2000). Despite the large body of empirical work, however, there is relatively little theoretical analysis of the relationship between exchange rate systems and trade volume. This paper is an initial attempt to do so, providing a general equilibrium analysis of trade, specialization, and welfare under different exchange rate systems.

The framework we develop is a monetary version of trade under uncertainty models of Helpman and Razin (1978).[1] Within this framework, there are no nominal rigidities or other related issues that arise in exchange rate studies such as pricing to market; our focus is very much on how the classical price system works under different exchange rate systems, similar in spirit to Helpman (1981). Of course, there need be some market imperfection for exchange rate regimes to matter at all and the one we focus on directly relates to specialization of production. Following Helpman and Razin, we consider economies where resource allocation decisions are made in an uncertain environment and with no asset trade to minimize risk exposure. With resource allocations in place and no subsequent resource mobility, the economies engage in perfectly competitive international trade in a monetary economy with either a coordinated fixed exchange rate or a flexible exchange rate.[2]

The role for the exchange rate system in this environment arises from the manner in which a coordinated fixed exchange rate distributes the effects of country specific shocks through the nominal price system. As we demonstrate below, consumption allocations under fixed exchange rates depend upon both own and aggregate world output. To the extent that aggregate world output is less volatile than own country output, which will be true when there are country specific shocks, there is a potential for real consumption to be less volatile under the fixed exchange rates relative to flexible exchange rates. This can, for risk averse consumers, directly affect welfare. We are, however, more interested in the potential effect this has on resource allocation decisions. In an uncertain environment, the initial resource allocation decisions will reflect a simple trade off: comparative advantage, a tendency toward specialization, and diversification of risk, which *may* provide a tendency against specialization. If this fixed exchange rate system reduces risk exposure, then this may permit greater specialization and trade volume than occurs under the flexible exchange rate system.

From this discussion, it should be clear that the effects on welfare and trade depend upon the nature of the underlying shocks. Country specific shocks rather than global or common shocks are going to provide the increases in trade and welfare from a fixed exchange rate. This of course contradicts the standard arguments for common currencies due to Mundell (1961), where common shocks are a key

1 See also the earlier work of Kemp and Liviatan (1973).

2 The focus on resource allocation in face of uninsurable risk is similar to earlier studies that focus on trade and investment decisions in face of exchange rate instability, see for example Krugman (1988). Critically, our's is a general equilibrium approach whereas these studies take the volatility of exchange rates as exogenous.

criteria. It turns out as well that the effects on trade and welfare will also depend upon whether the shocks are demand shocks or supply shocks. The reason for this is the role the terms of trade performs in international trade. Cole and Obstfeld (1991) demonstrate that the effects of country specific supply shocks are distributed between countries through terms of trade effects. This leaves less role, if any, for the exchange rate mechanism we describe. The terms of trade does not, however, redistribute the effects of country specific demand shocks; consequently, there is a much greater potential role for the exchange rate mechanism to reduce the effects of these shocks. Our analysis below considers both demand shocks, through changes in preferences, and supply shocks, through changes in productivity.

One recent study also provides a theoretical framework to examine the empirical relationship between trade and exchange rate systems, Rose and van Wincoop (2001), and it is useful to distinguish between their approach and that here. These authors adapt the theoretical gravity model in Anderson and van Wincoop (2001) to consider the effects of a common currency. The trade effects arise in this model through reduced transactions costs and resistance to trade assumed to arise under a common currency. There are no trade volume effects arising from changes in production decisions as we emphasize here, countries are assumed to be entirely specialized in production. Similarly, the welfare gains they are able to measure also depend upon reduced trade costs. Apart from the different mechanism, our study also differs by explicitly modelling the exchange rate systems rather than introducing their effects in a reduced form manner (that is, modelled as reducing transactions costs).

In the next section, we lay out the theoretical model and characterize the solutions under both a flexible and coordinated fixed exchange rate system. While it is straightforward to calculate the competitive equilibrium allocations conditional on production, it is necessary to use numerical methods to examine the labour allocation decisions and the full solution to the model. In section three of the paper we consider two sets of numerical experiments, distinguished by the nature of the underlying shocks the economies face. The first experiments consider preference or demand shocks, which turn out to provide the most interesting results. Under these types of shocks, we consider both symmetric and asymmetric economies, where the asymmetry is a difference in country size. The second set of experiments briefly consider supply shocks, where the effects are relatively less. Section four concludes.

## 2. An Exchange Rate Model with Resource Allocation Decisions under Uncertainty

The model has two countries, domestic and foreign. Foreign variables are denoted by an asterisk. There are two goods, $x$ and $y$, both of which are produced in both countries, though with different production technologies. Production technologies are given as:

$$\begin{aligned} x &= a_x f(L_x) \qquad y = a_y f(L_y) \\ x^* &= a_x^* f(L_x^*) \qquad y^* = a_y^* f(L_y^*) \end{aligned}$$

where $\{a_x,\ a_y,\ a_x^*,\ a_x^*\}$ are sector and country specific random productivity variables and $L_i\ \ (L_i^*)$ is the labour allocated to production in sector $i$ by the domestic (foreign) economy. In each country there is a fixed amount of labour $L$ and $L^*$ such that

$$\begin{aligned} L_x + L_y &= L \\ L_x^* + L_y^* &= L^* \end{aligned}$$

Prior to the state of the world being revealed (productivity and or preference shocks), firms allocate labour to each sector to maximize consumers' (the owners of the firms) expected welfare. After the state of the world is revealed, production levels are determined and consumption decisions are made in perfectly competitive markets. The labour allocation decisions will reflect the benefits from comparative advantage as well as the possible benefits from diversification.

To solve the model, we first find a solution for the competitive trade equilibrium conditional on levels of production and exchange rate regime. We then solve for the optimal allocation of labour by firms given the conditional trade equilibrium under either flexible or fixed exchange rates.

### 2.1 Consumption Decisions

Consumption of the two goods is denoted $c_x$ and $c_y$. To facilitate consumption agents use money, which enters agent's preferences directly in terms of real balances. Real balances are denoted $M/P$ and only domestic real balances enter the domestic agent's preferences so that the services from real balances are treated as a non-traded good.[3]

Each country has a single representative agent with preferences:

$$\begin{aligned} U(c_x, c_y, M/P) &= \left[C(c_x, c_y)^{\theta}(M/P)^{1-\theta}\right]^{1-R}/(1-R) \\ C(c_x, c_y) &= \left[\gamma^{1-\rho}c_x^{\rho} + (1-\gamma)^{1-\rho}c_y^{\rho}\right]^{1/\rho}, \qquad \rho \leq 1 \end{aligned}$$

For these preferences, $R$ is the inverse of the coefficient of relative risk aversion over the composite commodity index $C$ and real balances $M/P$. The commodity index takes a constant elasticity of substitution (CES) form with $1/(1-\rho)$ the elasticity of substitution.[4]

The aggregate price level $P$ is an index of the prices of the two goods in the model, expressed in terms of the domestic currency. It is defined as the minimum expenditure function evaluated at one unit of the composite commodity index $C$. For these preferences it takes the form:

$$P(p_x, p_y) = \left[\gamma p_x^{-\rho/(1-\rho)} + (1-\gamma)p_y^{-\rho/(1-\rho)}\right]^{-(1-\rho)/\rho}$$

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3 See Obstfeld and Rogoff (1996) for further discussion of open economy models with preferences dependent upon real balances.

4 When $\rho = 0$ the composite commodity index reduces to a Cobb-Douglas specification with weights $\gamma$ and 1 - $\gamma$.

The domestic agent's budget constraint is

$$p_x c_x + p_y c_y + M \quad = \quad w_x L_x + w_y L_y + \pi + M_0$$

where $M_0$ is an exogenous monetary transfer, $w_x L_x + w_y L_y$ is wage income, and $\pi$ measures firm's profits which accrue, by assumption, to the domestic agent. Since in any state of the world, $w_x L_x + w_y L_y + \pi = p_x x + p_y y$, we rewrite the budget constraint as

$$p_x c_x + p_y c_y + M \quad = \quad p_x x + p_y y + M_0.$$

Foreign agent preferences, including preference parameters, and constraints are identical.

To find consumption and money demand functions conditional on production levels of $x$ and $y$, we choose $\{c_x,\ c_y,\ M/P\}$ to maximize $U(c_x, c_y, M/P)$ subject to the representative agent's budget constraint. A useful feature of this economy is that the terms of trade, defined as the relative price of good $y$, is determined in equilibrium solely by the level of production and preference parameters; it is independent of the monetary regime. To see this, note that the optimal consumption levels satisfy

$$\begin{aligned} c_y/c_x &= \left(\frac{1-\gamma}{\gamma}\right) p^{-1/(1-\rho)} \\ c_y^*/c_x^* &= \left(\frac{1-\gamma}{\gamma}\right) p^{-1/(1-\rho)} \end{aligned}$$

where $p \equiv p_y/p_x$ is defined as the terms of trade. These conditions combined with the market clearing conditions, $c_x + c_x^* = x + x^*$ and $c_y + c_y^* = y + y^*$, determine the terms of trade:

$$p \quad = \quad \left(\frac{1-\gamma}{\gamma} \cdot \frac{x + x^*}{y + y^*}\right)^{1-\rho}$$

As expected, an increase in demand for good $y$ (a fall in $\gamma$) or a decrease in supply of good $y$ serve to raise its relative price.

With the terms of trade determined, we can solve for consumption and money demand functions; these are as follows:

$$\begin{aligned} c_x &= \frac{I_x + M_0/p_x}{(1/\theta)\left[1 + \frac{1-\gamma}{\gamma} p^{-\rho/(1-\rho)}\right]} \\ c_y &= \frac{I_y + M_0/p_y}{(1/\theta)\left[1 + \frac{\gamma}{1-\gamma} p^{\rho/(1-\rho)}\right]} \\ M &= (1-\theta)[I + M_0] \end{aligned}$$

where $I_x \equiv x + py$ and $I_y \equiv x/p + y$ are real income from production, and $I = p_x x + p_y y$ measures nominal income from production. We can also express the solution for the composite commodity as simply $C = \theta[I + M_0]/P$. These demand functions, and similar ones for foreign, depend upon the type of exchange rate regime in place, which we now specify.

#### *2.1.1 Flexible Exchange Rate Regime*

The demand functions already make use of the market clearing conditions for the two commodities. The remaining market clearing conditions are for the money market and these determine the nominal price levels for each country. The market clearing conditions are:

$$\tilde{M} = M_0 \qquad \tilde{M}^* = M_0^*$$

where the tilde $(\tilde{\ })$ is used to denote the flexible exchange rate allocations. These conditions and the money demand functions determine price levels for good $x$ and $y$:

$$\tilde{p}_x = \frac{\theta}{1-\theta}\frac{M_0}{I_x} \qquad \tilde{p}_y = \frac{\theta}{1-\theta}\frac{M_0}{I_y}$$
$$\tilde{p}_x^* = \frac{\theta}{1-\theta}\frac{M_0^*}{I_x^*} \qquad \tilde{p}_y^* = \frac{\theta}{1-\theta}\frac{M_0^*}{I_y^*}$$

These equations are velocity equations for individual prices, where the velocity of money is measured as $\theta/(1-\theta)$. As there are no restrictions on trade and convertibility of currencies, and as domestic and foreign goods of each type $x$ and $y$ are perfect substitutes, the nominal exchange rate can be measured as the ratio of domestic to foreign prices of either good $x$ or $y$. That is,

$$\tilde{e} \quad = \quad \frac{M_0}{M_0^*}\frac{I_x^*}{I_x} = \frac{M_0}{M_0^*}\frac{I_y^*}{I_y}$$

where $e$ is defined as the relative price of foreign currency in terms of domestic currency.[5]

Given these price levels, equilibrium allocations for consumption are:

$$\tilde{c}_x = \frac{I_x}{1 + \frac{1-\gamma}{\gamma}p^{-\rho/(1-\rho)}} \qquad \tilde{c}_y = \frac{I_y}{1 + \frac{\gamma}{1-\gamma}p^{\rho/(1-\rho)}} \tag{1}$$

and similarly for the foreign economy. Finally, we can relate real balances in equilibrium to aggregate output:

$$\frac{\tilde{M}}{\tilde{P}} = \frac{M_0}{\tilde{P}} \quad = \quad \left(\frac{1-\theta}{\theta}\right)\frac{\tilde{p}_x x + \tilde{p}_y y}{\tilde{P}}$$

5 Equivalently, the nominal exchange rate is equal to the ratio of the money supplies multiplied by the ratio of foreign to domestic real gross domestic product, where the latter is defined for the domestic economy as $(p_x x + p_y y)/P$.

$$= \left(\frac{1-\theta}{\theta}\right)\left[\gamma {I_x}^{\rho/1-\rho} + (1-\gamma){I_y}^{\rho/1-\rho}\right]^{(1-\rho)/\rho}$$

where the second line follows with some manipulation and identifies an index for real output associated with these preferences. We define this measure as $I_C$, output measured in terms of the composite commodity. Again, $\theta/(1-\theta)$ is identifiable as the velocity of money.

### *2.1.2 Coordinated Fixed Exchange Rate Regime*

Under a coordinated fixed exchange rate system, the money market condition is

$$M + M^* = M_0 + M_0^*$$

where $e$, the nominal exchange rate, has been normalized to unity. We have in mind an arrangement where the domestic and foreign money stocks are set exogenously by a central monetary authority. Clearly, this is equivalent to the two countries adopting a common currency. Price levels for each good are then determined as:

$$\hat{p}_x = \left(\frac{\theta}{1-\theta}\right)\frac{M_0 + M_0^*}{I_x + I_x^*} \qquad \hat{p}_y = \left(\frac{\theta}{1-\theta}\right)\frac{M_0 + M_0^*}{I_y + I_y^*}$$

The circumflex $(\hat{\ })$ denotes the fixed exchange rate equilibrium. Consumption allocations solve as,

$$\hat{c}_x = \frac{\left(\theta I_x/I_x^W + (1-\theta)M_0/M_0^W\right) I_x^W}{1 + \frac{1-\gamma}{\gamma}p^{-\rho/(1-\rho)}} \qquad \hat{c}_y = \frac{\left(\theta I_y/I_y^W + (1-\theta)M_0/M_0^W\right) I_y^W}{1 + \frac{\gamma}{1-\gamma}p^{\rho/(1-\rho)}} \tag{2}$$

and similarly for the foreign economy. Here we have introduced the notation $I_x^W \equiv I_x + I_x^*$, $I_y^W \equiv I_y + I_y^*$, and $M_0^W \equiv M_0 + M_0^*$. We can also solve for real balances and represent them in a similar way to that of consumption allocations:

$$\frac{\hat{M}}{\hat{P}} = \left(\theta\frac{I_x}{I_x^W} + (1-\theta)\frac{M_0}{M_0^W}\right)\frac{M_0^W}{\hat{P}}$$

The first term, which identifies the share of world real income accruing to the domestic economy, may be equivalently written as $I_y/I_y^W$; it may also be equivalently written as the ratio of the domestic income to world income measured in composite commodity terms.

Some important features emerge from these solutions. First, money is not neutral. Real allocations depend upon the relative money supplies of the domestic and foreign agents. This is not too surprising; money is a desirable good and allocations are going to depend in part upon endowments of this good.[6] There is a second feature that is not so obviously anticipated, however, and this concerns the manner in which the single currency, through the price level, reduces exposure to country specific risk.

First notice that if $\theta = 1$, so that real balances have no weight in the utility function, then the fixed exchange rate consumption allocations reduce to those of the flexible exchange rate solution (for given levels of production). As $\theta$ falls below one, however, the domestic economy's consumption allocations depend in part upon its own real income through $I_x$ and in part upon world real income through $I_x^W$. A similar story emerges from the solution for real balances. If $\theta = 1$, the solution for real balances becomes equivalent to the velocity conditions under flexible exchange rates, so that domestic price levels depend only upon domestic money supplies and income measures. For $\theta < 1$, real balances depend in part upon world real income, in a similar manner to consumption allocations. By making consumption allocations and real balances a function of aggregate income there is a potential that country specific shocks will be spread across both countries.

### 2.2 Labour Allocation Decisions

The domestic representative firm's decision problem is to choose $\{L_x, L_y\}$ to maximize

$$W = E\left(\max_{\{c_x,c_y,M\}} U(c_x, c_y, M/P) + \lambda\left(w_x L_x + w_y L_y + \pi + M_0 - p_x c_x - p_y c_y - M\right)\right)$$

where $E$ is the mathematical expectation operator and $\lambda$ is the Lagrange multiplier for the consumer's constrained optimization problem. An envelope result can be exploited to provide a simple characterization of the first order conditions from the above maximization problem for the domestic economy and the similar problem for the foreign economy,

$$E\left(U_1(c_x, c_y, M/P)\frac{dx}{dL_x} + U_2(c_x, c_y, M/P)\frac{dy}{dL_x}\right) = 0 \tag{3}$$

$$E\left(U_1(c_x^*, c_y^*, M^*/P^*)\frac{dx^*}{dL_x^*} + U_2(c_x^*, c_y^*, M^*/P^*)\frac{dy^*}{dL_x^*}\right) = 0 \tag{4}$$

where it is understood that consumption and real balances are the optimal allocations from the consumers' decision problems, either $\tilde{c}$ or $\hat{c}$, and that these are dependent upon the nominal exchange rate regime in place. As well, we have implicitly used the labour endowment conditions $L = L_x + L_y$ etc. to reduce the agent's problem to that of choosing only $L_x$. Conditions (3) and (4), the consumption and

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6 Notice for the fixed exchange rate solution that if a central monetary authority chose to set $M_0$ and $M_0^*$ on a state contingent basis, $M_0/M_0^W = I_x/I_x^W$ etc, then it can achieve the flexible exchange rate allocations. Consequently, with state contingent money supplies, it is always possible to do at least as well as under the flexible exchange rate system. This is the argument developed in Voss (1998). Throughout this paper, however, we treat money supplies as constant across all states. There is also scope here to introduce money demand and supply shocks. We abstract from these issues in this paper instead focusing on exchange rate systems with passive money supplies. One can motivate this as consistent with monetary policy focused on price stability.

real balance allocations (which are functions of labour allocations), and the conditions $L_x + L_y = L$ and $L_x^* + L_y^* = L^*$ solve for optimal labour allocations.

The conditions above are very intuitive. They set the expected marginal benefits from an increase in the production of good $x$ equal to the expected marginal cost, which arises because of the necessary reduction in the production of good $y$. To solve these conditions, we specify simple discrete space distributions for the underlying random variables, specify parameter values, and use simple numerical methods to solve the non-linear system of equations.[7]

# 3. Model Economies

We consider two sources of shocks: preference (demand) shocks and productivity (supply) shocks. As our principal objective is to examine the workings of the model, we find it most useful to examine the effects of each of these shocks separately. We first consider preference shocks under two situations, symmetric economies and economies of different size. We then consider supply shocks. As foreshadowed, we focus most of our attention on preference shocks as this is where we observe substantive results.

### 3.1 Preference Shocks

To introduce demand-type shocks into the model, we treat $\gamma$, the preference weighting parameter across the two goods $x$ and $y$, as a random variable. We have to take some care in setting up the model, however, since the results, particularly the magnitudes of the effects of different exchange rate systems, depend very much on the other parameters of the model and the exact nature of the underlying uncertainty. Consequently, in order for the results to be meaningful, we need to ensure that we specify these aspects of the model sensibly. This suggests that we calibrate our model as best as possible to economies where a comparison between flexible and fixed exchange rates is reasonable and interesting. At the same time, we are also interested in exploring how the model works along various directions, such as changes in risk aversion, velocity of money, and substitutability between goods for example. These latter directions preclude a tight calibration exercise as is usually performed in the real business cycle literature (for example, Backus, Kehoe, and Kydland, 1992, 1993). Moreover, the static nature of our model somewhat restricts our ability to calibrate accurately various aspects of our model, as does our focus on preference shocks.[8] The balance we strike is to consider a range of different parameter values but set the underlying innovations in such a way as to come close to various relevant data-based measures of international economic behaviour.

7 We use the NLSYS routines for GAUSS. The GAUSS code is available upon request.

8 Backus, Kehoe, and Kydland (1993) note that relatively little work has been done in quantifying preference shocks, which makes them difficult to calibrate.

Specifically, we ensure that the correlation between economies, terms of trade volatility and productivity volatility are roughly comparable to empirical studies of international business cycles. One minor amendment is that we set the underlying innovations so that we generally achieve a quite high degree of correlation between real output of the two economies, say at least 0.65 across experiments.[9] The reason for doing so is that those countries that are considering fixed exchange rate systems are typically those that have highly correlated output. Generally speaking, focusing on highly correlated economies tends to mitigate our trade and welfare effects since there are less gains available the greater role there is for global shocks. So from this perspective, our results do not overstate the effects of a fixed exchange rate system.

To begin, we specify a discrete distribution for the productivity parameters $\{a_x,\ a_y,\ a_x^*,\ a_y^*\}$ and the weighting parameter $\gamma$. Variation in the productivity parameter is going to arise from global productivity shocks; this ensures that the two countries will have positively correlated aggregate output. Were we to consider just variation in the preference parameters then output would tend to be negatively correlated between countries. These distributions are used for both the symmetric and asymmetric cases.

Because we have more information about the nature of productivity, we first condition on a simple state space distribution for the productivity parameters broadly consistent with other studies. For example, BKK (1993) in their study of international business cycles determine that the standard deviation of productivity shocks relative to that for output is roughly between 0.70 and 1.00. The distribution we employ for the global productivity shock delivers ratios in this region across the experiments we consider, as well as correlations between economies of 0.65 or greater (though this latter statistic depends on demand shocks as well).

The underlying stochastic structure is a discrete state space model with four states. The probability of each state is equal across all states. The distribution for the productivity parameters is determined as follows, for $i = x,\ y$:

$$\begin{aligned} a_i(s) &= \mu_i + \epsilon(s) \\ a_i^*(s) &= \mu_i^* + \epsilon(s) \end{aligned}$$

where $\epsilon(s)$ is a mean zero global shock defined over $s$ as: $\epsilon(s) \in$ {-0.15, 0.15, 0.15, -0.15}. The standard deviation of this shock is 0.15. The mean productivities are set so that the domestic economy has a comparative advantage in good $x$, foreign in good $y$:

$$\mu_x = \mu_y^* = 1.5 \quad \mu_y = \mu_x^* = 1.0$$

The preference weighting parameter is specified as,

$$\gamma(s) \quad = \quad \mu_\gamma + \epsilon_\gamma(s), \quad \mu_\gamma = 0.5$$

9 Otto, Voss, and Willard (2004) document business cycle correlations for most OECD countries over the last forty years. European bilateral pairs and US-Canada are good examples of highly correlated economies with bilateral correlations around 0.65. These are also countries that pursued coordinated exchange rate systems or in the case of US-Canada have been considered as reasonable candidates by some authors (see Courchene and Harris, 1999).

where $\epsilon_\gamma$ is a mean zero shock defined over $s$ as: $\epsilon_\gamma(s) \in$ {-0.125, 0.00, 0.00, 0.125}. The standard deviation of the demand shock is 0.085, slightly less than the supply shock, and $\gamma(s)$ is naturally centred at 0.5.

This parameter, along with the substitution parameter $\rho$, greatly influences the volatility of the terms of trade. For our benchmark parameter values, this specification for $\gamma(s)$ gives a mean and standard deviation for the terms of trade $\rho$ of roughly 1.03 and 0.24; that is, a standard deviation of roughly 23%.[10] This figure is somewhat larger than generally reported for large industrialized countries (roughly 4-7%) but consistent with developing countries (Frenkel and Razin, 1996, pp. 228-30, based on Hodrick-Prescott detrended data). The simplicity of our model, however, requires us to consider demand shocks of a magnitude that we do here. Given the productivity specification, in order to generate output correlations of magnitudes between 0.65 and 0.75 (as we discussed previously), then we need to have a reasonable amount of volatility in the demand shocks. An alternative would be to introduce a richer specification of productivity shocks allowing for greater idiosyncratic behaviour; however, this prevents a clean assessment of how the model works in the presence of preference shocks.

#### *3.1.1 Symmetric Economies*

The production and preference parameters of the model are set as follows. Throughout, the marginal product of labour $\alpha$ is set to 0.65, consistent with labour share values for most industrialized countries. The remaining parameters, $\theta$, $\rho$, and $R$ are allowed to vary across a range of values so we may determine how each influences model outcomes. We first set as our benchmark the following values: $\{\theta = 0.5,\ \rho = 1/3,\ R = 2\}$. This value for $\theta$ delivers a velocity of money equal to one, which seems a natural starting place. The value for $\rho$ is consistent with other studies of multiple commodity general equilibrium models, see BKK (1993) and the references cited therein. Similarly, our choice for $R$ is also consistent with BKK (1993). With these values as a benchmark, we then consider variations in each parameter holding the other parameters at their benchmark values. The values we consider are,

$$\theta \in \{0.33,\ 0.50,\ 0.67,\ 0.83\},\ \rho \in \{0.33,\ 0.50,\ 0.67,\ 0.99\},\ R \in \{2.0,\ 4.0,\ 10.0,\ 30.0\}$$

The values for $\theta$ mean the velocity of money ranges from 1/2 to 5, which seem reasonable. More importantly, however, variation in this parameter allows us to gauge how the fixed exchange rate system operates since it determines the level of risk sharing that occurs, recall equation (2). The values for $\rho$ steadily increase toward one becoming near perfect substitutes while the increasing values for $R$ allow us to consider the effects of increasing risk aversion. Finally, aggregate labour and money supplies are normalized to one: $L = L^* = 1;\ M_0 = M_0^* = 1$.

Table 1 reports a selection of summary statistics for both fixed and flexible exchange rate equilibria under the different possible parameterizations, with the benchmark parameterization identified as column BM. Because the economies are symmetric, we need only report the domestic economy results. We first discuss the summary statistics for the prices and quantities, which give an indication of how close the model is in some directions to the data and how this depends in part on the parameters of the model we vary. For simplicity we focus on the flexible exchange rate solution.

[10] The exact numbers vary with the experiments we report; the relevant statistics are reported for the experiments in Table 1.

The mean and standard deviation of the terms of trade $\rho$ are reported as $E(p)$ and $\sigma(p)$. Recall that $\rho$ is the relative price of good $y$ in terms of good $x$ so strictly speaking this is the terms of trade for the foreign economy. We refer to this generically as the terms of trade unless its exact definition bears on the discussion. The mean varies between 1.0 and 1.02 while the standard deviation, as indicated previously, is generally around 0.24. Only when the degree of substitution between these two goods is increased (as $\rho$ increases) does this variation in the terms of trade fall.[11]

The next statistic reported is the correlation of the terms of trade with domestic output, denoted $\rho(p^{-1}, I_C)$, where $\rho(x, y)$ denotes correlation between $x$ and $y$ (not to be confused with the substitution parameter). Note that output is measured in terms of the composite commodity, $I_C$, and the correlation is for the relative price of good $x,\ p^{-1}$, which domestic exports. Because what matters here for the terms of trade are the preference shocks, it is not surprising that the terms of trade is pro-cyclical: a positive preference shock for $x$ raises the relative price of that good while raising the income of the domestic economy that exports it. Evidence in the data on the correlation of income and the terms of trade is mixed; BKK (1993) find it to vary from country to country and usually with quite small magnitudes as we have here. Again, as we would expect, the correlation falls as $\rho$ increases simply because as $\rho \rightarrow 1$, the variation in $p^{-1}$ falls to zero. The correlation also falls as the degree of risk aversion $R$ increases. This occurs because as risk aversion increases, the economy diversifies less reducing its exposure to demand shocks (the ratio $\tilde{L}_x/\tilde{L}_y$ reported in Table 1 is seen to fall as $R$ increases). This tends to reduce the relationship between the terms of trade, which transmits these preference shocks, and real output.

The next statistic reported is the correlation between output in the two economies, $\rho(I_C, I_C^*)$. For the benchmark economy, this is 0.68, based on the calibration of productivity and preference shocks. As we would anticipate, the degree of correlation increases as both $\rho$ increases and $R$ increases, the former because the goods are increasingly substitutable so the relative preference shocks are less meaningful, the latter because increasing risk aversion reduces specialization and hence exposure to idiosyncratic risk. The statistic does not vary with changes in $\theta$ since this variable has no bearing on the real economy with flexible exchange rates.

Finally, we report the ratio of the standard deviation of productivity shocks to that of output, $\sigma(a)/\sigma(I_C)$. Here we construct an aggregate productivity shock for the domestic economy, denoted a, by weighting each sector productivity shock by the share of labour in that sector. As discussed the productivity shocks are specified to give values somewhere between 0.7 and 1.0, consistent with BKK(1993). Again, this does not vary with $\theta$. It does however rise with both $\rho$ and $R$. The reasons again relate to the reduced exposure to or relevance of preference shocks, which reduce the variation in real output. Taken together, the price and quantity statistics provide some confidence that the parameter values and underlying stochastic structure are reasonable focus. From here, we can consider the predictions of the model with regard to trade volume and welfare.

11 The reason the terms of trade has a mean greater than one even though the economies are identical is because of the non-linear dependence of the terms of trade upon $\gamma$.

The degree of specialization is summarized as the ratio of labour used in $x$ production to that used in $y$ production. For the flexible exchange rate system, this is $\tilde{L}_x/\tilde{L}_y$ while for the fixed rate system it is $\hat{L}_x/\hat{L}_y$. Given domestic's comparative advantage in good $x$, these numbers are all greater than one.[12] Comparing the flexible and fixed outcomes, across all parameterizations we see increased specialization under the fixed exchange rate system. This arises because of the way in which the fixed exchange rate system reduces exposure to idiosyncratic shocks, as indicated in the previous section.

Along with increased specialization, we naturally see an increase in mean trade volume. Let trade volume be measured as

$$T \quad = \quad (1/P) \times \left(\left|p_x\left(x_h - c_x\right)\right| + \left|p_y\left(y_h - c_y\right)\right|\right)$$

Table 1 reports the ratio of mean trade volume under the fixed exchange rate system to that under flexible exchange rates, $E(\hat{T})/E(\tilde{T})$. In most instances, the increases in trade volume are non-trivial; for the benchmark economy, we see an increase of three percent. Recall, within the context of our model, this is a permanent increase in trade volume. In situations where the fixed exchange rate system distributes shocks well, the increase is more substantial. For example, as $\theta$ falls, the redistributive role of money under fixed exchange rates increases, so that country specific shocks are distributed well between the two economies. Consequently, we see a rise in specialization and trade volume.

Even greater effects on trade volume, as high as 15 percent, occur as the degree of risk aversion rises. Here this reflects the substantially reduced specialization that occurs as $R$ increases under the flexible exchange rate system and the gains that can be made with the co-insurance that arise with the fixed exchange rate system. However, if risk aversion increases sufficiently then the increase in trade volume stops rising to the same extent. Presumably, for very high degrees of risk aversion, there is a general tendency against specialization.

Finally, we turn to the welfare effects. Two measures of welfare changes are reported. The first is a measure of the change in welfare across regimes measured in terms of the composite commodity and relative to total output under the flexible exchange rate system. The welfare effect of a finite increase in $C$, across all states, is equivalent to a one unit increase in $M_0/P$. Consequently, we can write $dW \approx E(\lambda P)d(M_0/P) = E(\lambda P)dC$. Thus, if $d\bar{W} = \hat{W} - \tilde{W}$ represents the welfare gain from moving the fixed exchange rate system, we can scale it by $1/E(\tilde{\lambda}\tilde{P})$, evaluated at the flexible exchange rate solution, to determine the comparable value in terms of the composite commodity. We then scale this by average output so that the statistic reported in Table 1 is calculated as:

$$d\bar{W}_C = \left(d\bar{W}/E(\tilde{\lambda}\tilde{P})\right)/E(\tilde{I}_C)$$

[12] The actual labour allocations for the benchmark economy are $\tilde{L}_x$ = 0.7500, $\tilde{L}_y$ = 0.2500 and $\hat{L}_x$ = 0.7585, $\hat{L}_y$ = 0.2415. Interestingly, there is no guarantee that domestic specializes in good $x$. For large preference shocks relative to productivity shocks and sufficient risk aversion it is possible that the solution has $L_x < 0.5$ as the economy diversifies away from the risky sector. This further emphasizes the need to focus discussion on model parameterizations that give model economies that behave in important dimensions in a manner similar to observed behaviour.

Note that part of these welfare gains arises from effects the fixed exchange rate system has on real balances. As money in the utility function is a reduced form means of introducing money into the economy, we might wish to examine the welfare effects abstracting from real balances. A simple means of doing so is to measure the change in welfare associated with the composite commodity component only. That is,

$$d\bar{C} = E\left(\hat{C}^{1-R}/(1-R)\right) - E\left(\tilde{C}^{1-R}/(1-R)\right)$$

This is done in other studies that employ a similar framework, for example Obstfeld and Rogoff (1995) and Devereux (forthcoming).[13] These studies justify this in part by appealing to large values of $\theta$, so that money plays only a small role in preferences. Unfortunately, this is less compelling here; in the first instances, we are considering variations of $\theta$ as part of our analysis. Secondly, the fixed exchange rate transmission mechanism is dependent upon a non-trivial role for money in preferences and the economy. As an alternative, we can appeal to this as simply a risk adjusted measure of the composite commodity. A second difficulty is how to evaluate the magnitude of this variable. For this, we turn to the approach in Devereux, Engel and Tille (2003) and compare the gain from the fixed exchange rate system relative to the gain under flexible exchange rates were the key source of uncertainty removed, in this case setting the variance of $\gamma(s)$ to zero (but not the productivity shocks). This is denoted as “Rel. Gain” in Table 1.

The welfare gains are uniformly non-negative but quite small. For the benchmark economy, the gain in welfare broadly measured is 0.7 of one percent of output. As expected, this rises as the degree of risk aversion increases. For $R = 10$ or $R = 20$, the gains are roughly three percent of output, which is a fairly substantial gain. It also rises as $\theta$ falls, since this increases the role of money in the economy, and falls to zero as the two goods are increasingly substitutable.[14] Of perhaps greater interest are the gains measured as a fraction of those available from reduced uncertainty. Here, the gains from the benchmark economy are roughly 20%, a figure that compares to the sorts of gains measured in Devereux et al. (2003), which looks at gains from the introduction of the euro although with a much different focus than that here. As risk aversion increases, these gains get quite large, upwards of fifty percent of those from reduced uncertainty.

In summary, we have managed to show qualitatively, for model parameterizations that ensure the economies are roughly consistent with observed behaviour along certain dimensions, that there are increases in specialization, trade volume, and welfare for symmetric economies choosing to pursue a coordinated fixed exchange rate system. Moreover, although these effects are quantitatively small, they are non-trivial and comparable to other welfare-based assessments of exchange rate systems.

As a small detour, it is interesting to consider our results in the context of the optimum currency area literature, Mundell (1961). A generally accepted criterion for a currency area is a high degree of correlation between the two economies; indeed, this has motivated us to focus on stochastic structures and

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13 It is also the same metric used in Rose and van Wincoop (2001), though without uncertainty.

14 Although not reported, as $\rho \to 0$, the unit elasticity of substitution case, the gains in trade and welfare get larger, comparable to outcomes when R is large.

parameter values that deliver a high degree of correlation. We can consider the results in Table 1 from this perspective, although it is important to bear in mind that the underlying stochastic structure here is somewhat limited, consisting of asymmetric demand shocks and perfectly symmetric supply shocks.

First, consider variation in $\rho$. As $\rho$ increases toward one, two things happen: first, the degree of correlation between the two economies increases. Second, the welfare gains fall, in contrast to standard optimal currency area arguments. (This is apparent from the table for $d\bar{W}$ and is also true for $d\bar{C}$, which is not reported for space considerations.) We can make this point more strongly by considering the case $\rho$ = 0.01. In this case the correlation between country output is reduced to just under 0.5 under flexible exchange rates and welfare gains are roughly twice those of the benchmark economy (measured as $d\bar{C}$). A similar point can be made if the variation in demand shocks is increased relative to the productivity shocks. If the standard deviation of $\epsilon_\gamma(s)$ is increased to 0.25 for the benchmark economy, the correlation of output between countries falls again to just under 0.5, the terms of trade becomes very volatile, and the welfare gains, measured in terms of $d\bar{C}$, are about four times those of the benchmark economy reported in Table 1. For completeness, we also note that trade volumes increase by about 13% in this case.

There is at least one situation, however, in which more highly correlated economies do experience higher welfare gains and that is when the increasing correlation is driven by increased risk aversion. Higher risk aversion tends to raise the correlation between the two economies since it reduces specialization under flexible exchange rates. At the same time, it means there are greater welfare gains (however measured) from pooling risk through the fixed exchange rate system; this is evident in Table 1. The lesson from all of this is that the extent of correlation between two economies depends upon the underlying shocks and the preferences and behaviour of agents in anticipation of these shocks and there is no simple clear cut linkage between output correlations and gains from fixed exchange rates. While the model here is narrowly focused, it seems likely that similar conclusions arise in alternative more complex environments.

#### *3.1.2 Economies of Different Size*

We now consider how the results differ if the economies differ substantially in size. This is motivated by the possibility of Canada and the US pursing a coordinated fixed exchange rate, as has been debated in recent years (see for example, Courchene and Harris 1999), and we parameterize the model to reflect the relative size of these two economies. Since the US economy and population is approximately ten times that of Canada, we adjust the size of the labour force accordingly: $L$ = 0.1 and $L^*$ = 1.0. Otherwise, the analysis is similar to the previous section. The results are reported in Table 2, which differs slightly from Table 1 in the following ways. For space reasons, not all of the statistics concerning the behaviour of the two economies are reported as they differ little from the experiments of Table 1. In contrast to the previous experiments, however, it is now necessary to consider the trade and welfare effects for both economies. And since it is of interest to compare the welfare effects across economies, we concentrate exclusively on the relative gain in the risk adjusted composite commodity measure. (For reasons to be explained shortly, we also report $d\bar{C}$ for each parameterization.) Finally, the asymmetry in the model makes the solution methods less robust at more extreme parameter values, notably $\rho \rightarrow 1$ and $R$ large. Consequently, we restrict our attention to less extreme values of these parameters. In addition, we consider values of $\theta$ of 1/2 and larger. To our mind, these are the more interesting values, with the smaller values tending to overstate the role of money in preferences. Furthermore, this makes our focus on the composite commodity index as a measure of preferences more compelling.

In addition to labour market size, there is one other adjustment we make to the model - the relative size of the money stock endowments. Under fixed exchange rates, this is a non-trivial feature of the model, directly affecting the consumption allocations that depend upon the share of the world stock of money. The natural allocation to consider for our economy is the one associated with a flexible exchange rate of one (in expectation) as this is the exchange rate value we impose on the fixed exchange rate solution. Given the solution for the exchange rate presented in the previous section, we set $M_0$ = 1 and $M_0^*$ as

$$M_0^* = \frac{I_x^*}{I_x}$$

where $I_x$ and $I_x^*$ are evaluated at the flexible exchange rate labour allocations.

With these preliminaries out of the way, we can now consider the results of Table 2. First, the qualitative results as we vary parameter values are broadly consistent with Table 1. As we increase $\theta$, the extent of the increase in specialization and increase in trade volume between exchange rate system falls, as does welfare (in terms of Rel. Gain), though not monotonically (more on the welfare results shortly). Similarly, changes in $\rho$ and $R$ give rise to similar behaviour as we observed in Table 1.

That said, there are some interesting and puzzling results in Table 2. Consider first the benchmark economy. The extent of specialization by the small economy is now very high: the ratio of labour in the sector in which it has a comparative advantage to that of the other sector is six, compared to three in the symmetric equilibrium. In contrast, the large economy is much less specialized; the same ratio is approximately 1.6 (equal to one over 0.61, the number reported in the table) compared to three in the symmetric equilibrium. It is not difficult to see what is driving this result. Both economies require a balance of both goods to satisfy demand. For the large economy, this results in a large absolute demand for both goods. Since the small economy cannot produce sufficiently large quantities to meet this demand, the large economy must balance its resources between both sectors. Similar reasoning in reverse explains why the small economy can now specialize more than in the symmetric case. This also explains why the move to a fixed exchange rate results in relatively little changes in the degree of specialization for the large economy. For the small economy, we see a larger increase in specialization but it is roughly of the same proportion as the change observed in the symmetric equilibrium case. The similar response from the small economy and the very small response of the large economy explain why the gain in trade volume is marginally smaller than in the symmetric equilibrium.

The less obvious results concern the effects on welfare. A general result is that the relative gain for the asymmetric economies, both large and small, is less than that for the symmetric economies. A further general result is that the large economy fares better (in terms of relative gain) than the small economy except for the high risk aversion case ($R$ = 10). The other results of interest concern the non-monotonic behaviour of the relative gains for the small economy as $\theta$ gets larger and the fact that for the larger value of $\rho$ we consider, domestic welfare actually declines when moving from a exible to a fixed exchange rate.

To understand what is going on, first recall that there are four states of the world. State one is a positive demand shock for domestic, state four a positive demand shock for foreign. States two and three are positive global supply shocks for both countries, states one and four negative global shocks. The supply shocks are included, recall, to ensure that the economies have some degree of positive correlation consistent with observed data. With symmetry, the supply shocks play no real role in terms of transfers between economies. With differently sized economies, these shocks do play a role and it is to the disadvantage of the small economy.

Now consider the situation where there are no demand shocks, $(\gamma(s) = 0, \forall s)$, just the symmetric productivity shocks. We use the change in the expected composite commodity index $d\bar{C}$ under this situation, reported at the bottom of Table 2, to gauge the effects of the fixed exchange rate system. Notice that in all cases, the small (domestic) economy is worse off while the large economy is seemingly unaffected. In fact, the welfare effects for the large economy in this case are positive, just very small.

These welfare results when there is no demand uncertainty can be explained as follows. Because of the difference in country size, for a given allocation of labour across sectors, the variation in output for the small economy, $I_x$ or $I_y$, is less than the variation in aggregate output, $I_x^W$ and $I_y^W$. The exact opposite is true for the large economy. Now recall that the difference between the flexible and fixed exchange rate equilibrium is that in the former the allocations depend only upon domestic output while for the latter they depend upon aggregate output. With no demand uncertainty, there is very little change in labour allocations across the two regimes; consequently, there is very little difference in the measures of output $I_x$, $I_y$ and the terms of trade variables across regimes. So all that moving to the fixed exchange rate system involves for both economies is a greater dependence upon aggregate output rather than own output. For domestic this rise in variance is welfare lowering across all parameterizations, as reported in the table. For foreign, this index rises slightly but with the level of precision we use in the table it is zero.

This then explains why, when there is demand uncertainty, the small economy generally gains less compared to the large economy: they are disadvantaged by the global supply shocks, which tend to increase the variation of their consumption. Only when risk aversion is high do the gains from increased specialization through risk sharing better advantage the small economy.[15] Further, this explains why the small economy gains less than it did under the symmetric arrangement, where the global supply shocks do not play any significant role. As far as why the large economy gains less in relative terms than it does under the symmetric arrangement, presumably this reflects the small size of its trading partner, which limits the scope of any co-insurance.

The fact that the small economy gains less than the large economy (due to the effects of the global supply shocks) points to an important feature of the way the fixed exchange rate system redistributes resources between economies. In essence, it is a very blunt instrument not designed ex ante to improve welfare as a state contingent asset does. It is just a feature of the pricing system. In the situation here, the small economy is disadvantaged by participating and being subsequently dependent upon global shocks rather than own country shocks.

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15 Notice that when $R$ = 10, the degree of specialization by the small domestic economy is low under flexible rates with a significant increase under fixed rates.

Notice that explanation given for the different welfare effects is consistent with other results in the table. As $\rho$ becomes larger, our previous results tell us that the gains from risk sharing get smaller. So what dominates is the effect of the supply shocks and these are sufficient to lower our welfare measure for the small domestic economy, to the point the effect of the fixed exchange rate, even with demand shocks, lowers welfare. Finally, this might also explain the non-monotonicity result over the parameter $\theta$. As $\theta$ gets larger, the role for the fixed exchange rate mechanism diminishes. This mechanism has both positive and negative welfare effects for the small economy and it is possible the relative strength of these effects adjusts as $\theta$ changes, leading to the non-monotonic results we observe in Table 2.

### 3.2 Supply Shocks and Symmetric Economies

We now focus briefly on supply shocks. For space considerations, we only consider the benchmark economy under three different situations of varying sources of uncertainty. It turns out that while there are some non-trivial welfare gains from moving to a fixed exchange rate, the effect on labour allocations and hence trade is considerably less than those arising when we consider preference shocks. The reason, noted previously, is that the terms of trade for this economy does a very good job in redistributing the country-specific effects of supply shocks, as described in Cole and Obstfeld (1991). This is in contrast to preference shocks where the terms of trade serves exactly the opposite role.

As before, the probability is equal across all states. The distribution for the productivity parameters is now specified as, for $i = x, y$ :

$$\begin{aligned} a_i(s) &= \mu_i + \eta(s) + \epsilon_i(s) \\ a_i^*(s) &= \mu_i^* + \eta^*(s) + \epsilon_i(s) \end{aligned}$$

The $\eta$ shocks are country specific sector independent mean zero productivity shocks while the $\epsilon_i$ are country independent sector specific mean zero shocks. The mean values for the productivity parameters are set to the same values as the previous section. We consider three possible sets of shocks, named and defined as follows:

| | | |
|---|---|---|
| Industry | $\eta,\ \eta^* \in \{\ 0.00,\ 0.00\}$ | $\epsilon_x,\ \epsilon_y \in \{-0.15,\ 0.15\}$ |
| Country | $\eta,\ \eta^* \in \{-0.15,\ 0.15\}$ | $\epsilon_x,\ \epsilon_y \in \{\ 0.00,\ 0.00\}$ |
| Country & Industry | $\eta,\ \eta^* \in \{-0.15,\ 0.15\}$ | $\epsilon_x,\ \epsilon_y \in \{-0.15,\ 0.15\}$ |

As each shock can take on two values and there are four different shocks there are in total sixteen states of the world. Notice that the industry shocks will lead to a positive correlation between the two economies while the country shocks tend to leave the two economies uncorrelated (there are just as many states of the world where the country shocks move in unison as when they are out of synchronization).

The results for the benchmark economy for these three different stochastic structures are presented in Table 3. As before, we present descriptive statistics for the economy though because we are interested in examining how the different nature of the shocks work with the exchange rate systems, we have not specified the shocks to calibrate the economy as we did in Table 1 (though we return to this issue briefly below).

The first set of results consider the model where there are only industry specific shocks. Because of the nature of the shocks, domestic and foreign output are (near) perfectly correlated under both exchange rate regimes.[16] In part this is due to the terms of trade adjustments that occur; in states of the world where productivity of $x$ rises and $y$ falls, say, $\rho$ rises which reduces domestic real income and raises foreign. Because the terms of trade adjustments are sufficient to ensure this high degree of correlation between the two economies, there is no scope for the fixed exchange rate system to reduce consumption based risk. Consequently, there is no change in specialization, trade or welfare.

When we introduce country based risk (the second column of results), however, differences emerge between the flexible and fixed exchange rate system because these shocks reduce the correlation between the two economies. With just country based risk, we observe a fall in specialization and trade and an increase in welfare. Using our measure of relative gain in risk adjusted consumption, the fixed exchange rate system captures 32 percent of the gains from no uncertainty at all. When we include both country specific and industry specific shocks (the third column of results), specialization and trade fall by a similar amount while the welfare gain is lessened to roughly 18 percent. The welfare gains in both cases arise because the fixed exchange rate system makes consumption allocations depend upon, in part, aggregate income $I_C^W$ . This reduces exposure to country specific shocks and consequently reduces the variation of the composite commodity bundle. As the mean levels are almost identical between the fixed and flexible exchange rate, this means welfare is higher under the fixed exchange rate system.

The decreased specialization is a little more difficult to understand. We offer the following tentative explanation. Consider the country specific shocks as we have defined them but in the extreme situation where each country is specialized in production. In this case, these shocks act as industry specific shocks and the terms of trade will work to redistribute the effects of these shocks between the two countries. Consequently, specialization provides rewards both in terms of comparative advantage as well as in providing a clean role for the terms of trade to redistribute the country specific shocks. Under fixed exchange rates, however, there is less incentive to reap the second benefit because there is already a means of redistributing the country specific shocks through the price system. This may explain the very slight decline in specialization. In support of this argument, consider what happens under flexible exchange rates as we let $\rho$ approach one. As the goods become very close substitutes, the ability of the terms of trade to redistribute supply shocks disappears (for $\rho = 1$, the terms of trade is constant). Consequently, if our argument is correct, the level of specialization should be less, which is in fact what we observe.[17]

We view these results concerning supply shocks as suggestive only with the primary role to contrast them with the demand shock results. With multiple sectors and the possibility for both country and industry specific supply shocks (and possibly global supply shocks), it is much more difficult to identify a reasonable and focal distribution of these shocks. There are just too many free parameters which significantly influence the results. This seems to require direct modelling of these underlying shocks and

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16 The correlation reported in the table has been rounded.

17 The exact numbers are as follows. Under the Country & Industry specification, the share of labour in the production of good $x$ in the home economy is $L_x$ = 0.7717 when $\rho = 1/3$. When $\rho$ = 0.99, the share is marginally less, $L_x$ = 0.7648.

then introducing these into the analysis; unfortunately, this is beyond the scope of this paper. We suspect, however, that in the sort of framework considered here, supply side shocks are not going to play as large or as interesting a role as demand shocks, particularly with respect to specialization decisions, because the terms of trade does too good of a job of redistributing their effects.

## 4. Concluding Remarks

We present a general equilibrium monetary model of trade and endogenous specialization that depends upon the exchange rate system in place. Under flexible exchange rates, money is neutral; under a system of coordinated fixed exchange rates with fixed money supplies (equivalent to a common currency), the exchange rate system works to redistribute the effects of country specific shocks between the participating countries.

When we consider an environment with both demand and global supply shocks and the economies are symmetric, the model predicts an increase in specialization, trade and welfare under a fixed exchange rate system relative to a flexible exchange rate. When there are asymmetries in country size, we still observe a tendency toward increased specialization and trade but the welfare effects are ambiguous, largely because the global supply shocks can serve to disadvantage the small economy under the fixed exchange rate system. When we consider an environment with just supply shocks, the model predicts small trade and specialization effects though the welfare effects are positive and similar in magnitude to those under the demand shocks.

A possible limitation of our analysis is that we exclude any trade in state contingent assets that might reduce consumption risk. In this regard, our results tend to overstate the effects of the exchange rate system since it is the only means of pooling risk we allow. That said, our framework is not inconsistent with much of the optimal currency literature, based on the initial work of Mundell (1961). This analysis argues (loosely) that only countries that are highly correlated are suitable candidates for a common currency since otherwise exchange rate adjustments are needed in response to country specific shocks (this literature usually focuses on demand shocks). The implicit assumption is that it is not possible to reduce these risks through asset trade, just as we are considering here.

We motivated our theoretical analysis by the empirical results of Rose (2000) and others, which find a large effect of a common currency on trade volumes. Rose's (2000) original estimates were of a magnitude of a factor of about three, that is trade volumes would increase by 300%; in his meta-analysis of the subsequent literature, Rose (2004), he argues for a figure between 30 and 90%. Whatever the case, our results are clearly some ways from the empirical literature. Nonetheless, we are able to provide a theoretical model which makes an explicit prediction about the effects of a common currency on trade volume which is qualitatively correct and with magnitudes that while small are non-trivial.

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**Table 1. Preference Shocks, Symmetric Economies**

| Parameters | Variation in Parameter | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $\theta$ | | | | $\rho$ | | | $R$ | | |
| | | BM | | | | | | | | |
| $\theta$ | 0.33 | 0.50 | 0.67 | 0.83 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| $\rho$ | 0.33 | 0.33 | 0.33 | 0.33 | 0.50 | 0.67 | 0.99 | 0.33 | 0.33 | 0.33 |
| $R$ | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 4.00 | 10.00 | 30.00 |
| **Descriptive Statistics** | | | | | | | | | | |
| $E(p)$ | 1.03 | 1.03 | 1.03 | 1.03 | 1.02 | 1.01 | 1.00 | 1.03 | 1.03 | 1.03 |
| $\sigma(p)$ | 0.24 | 0.24 | 0.24 | 0.24 | 0.18 | 0.12 | 0.00 | 0.24 | 0.24 | 0.24 |
| *Flexible:* | | | | | | | | | | |
| $\rho(p^{-1}, I_C)$ | 0.30 | 0.30 | 0.30 | 0.30 | 0.25 | 0.18 | 0.01 | 0.28 | 0.23 | 0.16 |
| $\rho_(I_C, I_C^*)$ | 0.66 | 0.66 | 0.66 | 0.66 | 0.78 | 0.89 | 1.00 | 0.69 | 0.76 | 0.85 |
| $\sigma(a)/\sigma(I_C)$ | 0.81 | 0.81 | 0.81 | 0.81 | 0.85 | 0.90 | 0.97 | 0.82 | 0.84 | 0.87 |
| *Fixed:* | | | | | | | | | | |
| $\tilde{L}_x/\tilde{L}_y$ | 0.30 | 0.30 | 0.30 | 0.30 | 0.25 | 0.18 | 0.01 | 0.28 | 0.23 | 0.16 |
| $\hat{L}_x/\hat{L}_y$ | 0.65 | 0.65 | 0.65 | 0.66 | 0.77 | 0.88 | 1.00 | 0.66 | 0.70 | 0.81 |
| $E(\hat{T})/E(\tilde{T})$ | 0.80 | 0.81 | 0.81 | 0.81 | 0.85 | 0.90 | 0.97 | 0.81 | 0.82 | 0.86 |
| **Trade** | | | | | | | | | | |
| $\tilde{L}_x/\tilde{L}_y$ | 3.00 | 3.00 | 3.00 | 3.00 | 3.12 | 3.21 | 3.29 | 2.75 | 2.09 | 1.50 |
| $\hat{L}_x/\hat{L}_y$ | 3.19 | 3.14 | 3.09 | 3.05 | 3.20 | 3.25 | 3.29 | 3.04 | 2.59 | 1.75 |
| $E(\hat{T})/E(\tilde{T})$ | 1.04 | 1.03 | 1.02 | 1.01 | 1.02 | 1.01 | 1.00 | 1.06 | 1.15 | 1.15 |
| **Welfare** | | | | | | | | | | |
| $d\bar{W}_C$ | 0.012 | 0.007 | 0.004 | 0.002 | 0.004 | 0.002 | 0.000 | 0.015 | 0.032 | 0.033 |
| Rel. Gain | 0.251 | 0.211 | 0.155 | 0.085 | 0.173 | 0.126 | 0.005 | 0.325 | 0.467 | 0.657 |

Notes: BM denotes the benchmark parameter settings discussed in the text. $E(x)$ and $\sigma(x)$ denote mean and standard deviation of $x$, the latter expressed as a percentage of the mean; $\rho(x, y)$ denotes correlation of $x$ and $y$. $I_C$ and $I_C^*$ denote output measured in composite commodity terms, domestic and foreign. a is a labour share weighted index of the productivity shocks $a_x$ and $a_y$. T denotes trade volume, sum of exports and imports measured in composite commodity terms. Rel. Gain denotes the change in $EC^{1-R}/(1-R)$ from the fixed exchange rate relative to the change arising from no variation in $\gamma$.

**Table 2: Preference Shocks, Asymmetric Economies**

| | Variation in Parameter | | | | | | |
|---|---|---|---|---|---|---|---|
| **Parameters** | $\theta$ | | | $\rho$ | | $R$ | |
| | **BM** | | | | | | |
| $\theta$ | 0.50 | 0.67 | 0.83 | 0.50 | 0.50 | 0.50 | 0.50 |
| $\rho$ | 0.33 | 0.33 | 0.33 | 0.50 | 0.67 | 0.33 | 0.33 |
| $R$ | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 4.00 | 10.00 |
| **Trade** | | | | | | | |
| $\tilde{L}_x/\tilde{L}_y$ | 5.59 | 5.59 | 5.59 | 5.40 | 4.97 | 4.98 | 3.43 |
| $\tilde{L}_x^*/\tilde{L}_y^*$ | 0.61 | 0.61 | 0.61 | 0.55 | 0.48 | 0.64 | 0.75 |
| $\hat{L}_x/\hat{L}_y$ | 6.00 | 5.86 | 5.72 | 5.63 | 5.07 | 5.82 | 4.78 |
| $\hat{L}_x^*/\hat{L}_y^*$ | 0.61 | 0.61 | 0.61 | 0.55 | 0.48 | 0.62 | 0.69 |
| $E(\hat{T})/E(\tilde{T})$ | 1.02 | 1.02 | 1.01 | 1.01 | 1.01 | 1.05 | 1.12 |
| **Welfare** | | | | | | | |
| $d\bar{C}$ | 0.003 | 0.004 | 0.003 | 0.001 | -0.000 | 0.122 | 253.055 |
| $d\bar{C}^*$ | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 |
| Rel. Gain | 0.053 | 0.063 | 0.045 | 0.023 | -0.016 | 0.189 | 0.371 |
| Rel. Gain* | 0.166 | 0.112 | 0.057 | 0.140 | 0.110 | 0.230 | 0.325 |
| $\gamma(s) = 0, \forall s$ | | | | | | | |
| $d\bar{C}$ | -0.002 | -0.002 | -0.001 | -0.002 | -0.002 | -0.046 | -38.973 |
| $d\bar{C}^*$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Notes: BM denotes the benchmark parameter settings discussed in the text. $T$ denotes trade volume, sum of exports and imports measured in composite commodity terms. $d\bar{W}_C$ measures the change in expected utility measured in composite commodity terms as a fraction of total output under flexible exchange rates (for both home and foreign). Rel. Gain denotes the change in $EC^{1-R}/(1-R)$ from the fixed exchange rate relative to the change arising from no variation in $\gamma$ ; the asterisk denotes a foreign variable.

**Table 3: Supply Shocks**

**Benchmark Economy $\theta$ = 0.5, $\rho$ = 0.33, $R$ = 2**

| | Source of Shocks | | |
|---|---|---|---|
| | **Industry** | **Country** | **Country & Industry** |
| **Descriptive Statistics** | | | |
| $E(p)$ | 1.01 | 1.00 | 1.01 |
| $\sigma(p)$ | 0.11 | 0.04 | 0.11 |
| *Flexible:* | | | |
| $\rho(p^{-1}, I_C)$ | -0.02 | -0.66 | -0.20 |
| $\rho_(I_C, I_C^*)$ | 1.00 | 0.14 | 0.45 |
| $\sigma(a)/\sigma(I_C)$ | 1.10 | 1.04 | 1.06 |
| *Fixed:* | | | |
| $\rho(p^{-1}, I_C)$ | -0.02 | -0.66 | -0.20 |
| $\rho_(I_C, I_C^*)$ | 1.00 | 0.14 | 0.45 |
| $\sigma(a)/\sigma(I_C)$ | 1.10 | 1.03 | 1.06 |
| **Trade** | | | |
| $\tilde{L}_x/\tilde{L}_y$ | 3.25 | 3.30 | 3.38 |
| $\hat{L}_x/\hat{L}_y$ | 3.25 | 3.25 | 3.33 |
| $E(\hat{T})/E(\tilde{T})$ | 1.00 | 0.99 | 0.99 |
| **Welfare** | | | |
| Rel. Gain | 0.00 | 0.315 | 0.183 |

Notes: As for previous tables.