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# Should the exchange rate be a shock absorber?

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## Abstract

This paper examines the welfare case for the exchange rate as a shock “absorber”, cushioning an economy in face of shocks to world demand for its good. We provide an example in which, although the exchange rate acts perfectly as a shock absorber, stabilizing output around the natural rate, and eliminating the impact of nominal rigidities, it may in fact be better to prevent the exchange rate from adjusting at all. The explanation for this is that, with incomplete international financial markets, the natural rate is inefficient; it does not respond enough to demand shocks. While fixing the exchange rate increases the *volatility* of consumption, the pro-cyclical nature of monetary policy under a fixed exchange rate allows for a more efficient *composition* of consumption between home and foreign goods. Furthermore, for the shocks examined, a welfare maximizing monetary rule always dampens exchange rate volatility relative to that of a free float, and in some cases may imply a fixed exchange rate.

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## 1. Introduction

*“In the international trade example, if demand shifts from the products of country B to the products of country A, a depreciation by country B or an appreciation by country A would correct the external imbalance and also relieve unemployment in country B and restrain inflation in country A. This is the most favorable case for flexible exchange rates based on national currencies.” Mundell (1961).*

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A central part of the case for flexible exchange rates, as stated by [Friedman \(1953\)](#) and [Mundell \(1961\)](#), is that the exchange rate acts as a shock absorber, cushioning the economy in face of external shocks. Conversely, the sacrifice of the adjustment role of the exchange rate is taken as one of the major costs of a single currency area or a policy of dollarization. For instance, in face of a negative external shock, a fixed exchange rate regime requires the central bank to follow a contractionary policy so as to maintain the peg, forcing all the adjustment to take place in the real economy rather than the exchange rate.

This paper illustrates a stark counter-example to the “shock-absorber” case for exchange rate adjustment, in a model constructed exactly as in [Friedman and Mundell](#), but using a utility-based evaluation of exchange rate regimes.<sup>1</sup> We show that, in the presence of world demand shocks, although a flexible exchange rate acts perfectly as a shock absorber, in welfare terms it may in fact be better to prevent the exchange rate moving at all.

Exchange rate policy matters in the model only because of nominal wage rigidities. If the exchange rate is flexible, then in face of a negative world demand shock for a country's good, the currency depreciates, and output is stabilized. In fact, a flexible exchange rate replicates the flexible wage allocation, i.e. output is stabilized at the natural rate. With a fixed exchange rate, by contrast, the fall in demand leads to a fall in output and a rise in unemployment. Despite this, we find that when evaluating exchange rate regimes in expected utility terms, flexible exchange rates may be welfare-dominated by fixed exchange rates, for a wide range of parameter values.

Why is it better not to allow the exchange rate to adjust, even when it attains the flexible wage allocation? The answer is that, due to the absence of full international financial markets, the flexible wage equilibrium is not efficient. In a symmetric first-best outcome, a shift in world demand away from one country's good towards that of another country would lead to a fall in output of the first country and a rise in output for the second country. But when international financial markets are incomplete, output will in general not respond efficiently to world demand shocks.<sup>2</sup> With fully flexible wages (but incomplete financial markets) the terms of trade adjust to a demand shock by so much that, in equilibrium, output is fully stabilized.

By contrast, when wage rates are sticky, monetary policy determines the response of output. A flexible exchange rate ensures that the terms of trade adjust just as in the flexible wage equilibrium. This maintains a stable level of output, but it does not maximize welfare; it would be better in expected utility terms to have output respond to demand shocks. It may be better to have a fixed exchange rate, pushing output away from its natural rate, to obtain a more efficient response of output to world demand shocks. Even though flexible exchange rates provide a more stable con-

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<sup>1</sup> Our model follows many recent papers in the literature, including [Bacchetta and Wincoop \(2000\)](#), [Devereux and Engel \(2000\)](#), [Corsetti and Pesenti \(2001a,b\)](#), [Monacelli \(2000\)](#), [Parrado and Velasco \(2001\)](#), and [Obstfeld and Rogoff \(1995, 2000\)](#). See [Lane \(2001\)](#) for a survey.

<sup>2</sup> [Obstfeld and Rogoff \(2002\)](#) also construct a model where the flexible wage equilibrium level of output is inefficient, due to the absence of international financial markets. But they do not examine the effect of demand shocks as described in this paper, nor do they contrast the effects of fixed relative to flexible exchange rates.

sumption of home and foreign goods, a fixed exchange rate provides a better composition of consumption (between home and foreign goods), and so may be more desirable. In fact, it is the often-criticized *pro-cyclical feature of monetary policy* under a fixed exchange rate that makes it desirable.

The results do not depend on the way in which a fixed exchange rate regime is defined. Whether the exchange rate is fixed by both countries in a cooperative peg, or by one country in a unilateral peg, it may still enhance welfare (of both countries) relative to a flexible exchange rate.

These results therefore question the proposition that the exchange rate should move freely as an automatic shock absorber. But, rather than following a passive monetary policy, we can also investigate the role of the exchange rate in an *optimal*, welfare-maximizing monetary policy. Doing this, we show that it is *always* optimal for monetary policy to cause output to deviate from the flexible wage equilibrium. Moreover, the optimal monetary rule is pro-cyclical, which means that the monetary authority should always *dampen* exchange rate variability relative to that of a freely floating exchange rate. Furthermore, in a non-trivial case, the *optimal* monetary rule is a fixed exchange rate.

Although the benefit of a fixed exchange rate here is tied closely to the absence of international financial markets, it is not because a fixed exchange enhances international risk sharing. Mundell (1973) shows how a single currency area might facilitate risk sharing when full international financial markets are missing, because it allows for money transfers across states of the world. But the fixed exchange rate rule studied here does not allow *any risk sharing*, since each country must remain bound by its ex post budget constraint, and there are no money transfers across countries.<sup>3</sup> Rather than risk sharing, the (potential) advantage of a fixed exchange rate in this model is that it generates more efficient adjustment to shocks. Ironically, this is precisely the conventional argument for flexible exchange rates.

The results provide an example which questions the benefit of exchange rate adjustment, or equivalently, the cost of dollarization or single currency areas. It is often said that the benefits of a single currency area are primarily microeconomic (reducing transactions costs), while the costs come from the loss of the exchange rate in macroeconomic stabilization (e.g. Alesina and Barro, 2000). But when it is acknowledged that, in reality, monetary policy cannot perfectly respond to shocks, but must choose between broad objectives such as inflation rate stability or exchange rate stability, the results may lead us to ask whether there are *any* welfare costs to eliminating exchange rate adjustment.

The central model of the paper is very simple, so as to draw out the essential features of the argument. In a concluding section, we show that the main arguments can be extended to a more a general model specification.

Section 2 outlines the model. Section 3 compares flexible and fixed exchange rates. Section 4 outlines an optimal monetary policy. Section 5 discusses extensions, and Section 6 concludes.

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<sup>3</sup> See Ching and Devereux (2002) for an analysis of the risk-sharing effects of a single currency area.

## 2. The model

Take a model of a “home” and “foreign” country, where the home country specializes in production of good 1 and the foreign country specializes in good 2. In addition, there is only one period. Wages are set in advance, before the state of the world is known. Although extremely simple, this framework is sufficient to illustrate the key results of the paper. Moreover, as shown below, the results are robust to generalization.

### 2.1. Firms

Final goods are produced using labor, which is differentiated across households. The production function is

$$Y = \left( \int_0^1 H(i)^{(\rho-1)/\rho} di \right)^{\rho(1-\alpha)/(\rho-1)},$$

where  $H(i)$  represents labor supply of individual  $i$ , the elasticity of substitution between types of labor is  $\rho > 1$ , and there are diminishing returns to overall labor, so that  $\alpha < 1$ . Final good firms are price takers. The firm chooses employment to maximize profits, given the set of wage rates it faces. Profits are written as

$$\Pi = P_1 Y - \int_0^1 W(i)(1 - \varepsilon)H(i) di,$$

where  $P_1$  is the price of the home good, and  $W(i)$  is household  $i$ 's wage. The expression  $\varepsilon$  represents a wage subsidy paid to firms by the home government. This subsidy offsets the inefficiency due to the market power of wage setters.<sup>4</sup> Defining composite labor as

$$H = \left[ \int_{i=0}^1 H(i)^{1-(1/\rho)} di \right]^{1/[1-(1/\rho)]},$$

the firms implicit labor demand schedule is

$$P_1(1 - \alpha)H^{-\alpha} \left( \frac{H(i)}{H} \right)^{-1/\rho} = W(i)(1 - \varepsilon). \quad (2.1)$$

### 2.2. Households

In each country, there is a unit measure of households. The home country consumer  $i$  maximizes the following utility function:

$$EU = E \left\{ \ln(C(i)) + \chi \ln \left( \frac{M(i)}{P} \right) - \eta \frac{H(i)^{1+\psi}}{1+\psi} \right\}. \quad (2.2)$$

<sup>4</sup> In our model, the efficiency loss due to market power is independent of the exchange rate regime, so it is convenient to abstract from it.

$C(i)$  is aggregate consumption, given by

$$C = \left( \frac{C_1(i)}{\gamma} \right)^\gamma \left( \frac{C_2(i)}{(1-\gamma)} \right)^{1-\gamma},$$

and  $P$  is the price index, given by  $P = P_1^\gamma (SP_2^*)^{1-\gamma}$ , where  $S$  is the exchange rate and  $P_2^*$  is the foreign currency price of good 2. The “law of one price” holds for each good.  $M(i)$  is the quantity of domestic money held.

The variable  $\gamma$  represents the relative preference for good 1, the home good. Let this be common across households and countries, and stochastic. Also, let the distribution be symmetric, bounded between 0 and 1, with mean 0.5. The process represents random preference shocks, shifting world demand for the good of the home country relative to the foreign country.<sup>5</sup> We commonly refer to this as a “demand shock”. This is a concise method of capturing the shocks described by Mundell.

### 2.3. Budget constraint

Households set the wage in advance, and then choose consumption and money balances *after* the state of the world has been revealed. There is no ex-ante trade across countries in state contingent assets. Empirical evidence (e.g. Lewis, 1995) motivates this assumption. But we return to this issue below.

The ex-post budget constraint for household  $i$  is

$$PC(i) + M(i) = W(i)H(i) + \tilde{\Pi}(i) + M_0 + T, \quad (2.3)$$

where  $W(i)$  is the nominal wage for household  $i$ ,  $\tilde{\Pi}(i)$  is the total profit income of the household, and  $M_0 + T$  represents original money holdings, plus any tax or transfer from the monetary or fiscal authority (common across households).

### 2.4. Household choices

Each worker  $i$  faces a downward-sloping labor demand curve, given by (2.1). The expected utility maximizing wage is

$$W(i) = \frac{\rho\eta}{\rho-1} \frac{EH(i)^{1+\psi}}{E[H(i)/PC(i)]}. \quad (2.4)$$

Expression (2.4) indicates that the worker will set the expected utility gain from a small reduction in the wage, given by  $E\{[(\rho-1)H(i)]/PC(i)\}$ , equal to the expected utility cost implied by the higher work effort, given by  $\eta\{[E(H(i)^\psi \rho H(i)]/W(i)\}$ . Given the wage, employment is determined by the demand for labor (2.1). We set the wage subsidy such that  $\varepsilon = 1/\rho$ . This eliminates the distortion due to monopoly wage setting.

<sup>5</sup> Preference shocks have been used in many contexts in the recent dynamic general equilibrium literature. A well-known example in open economy macroeconomics is the paper of Stockman and Tesar (1995).

Given wages, profit income and transfers, the household optimally divides income between consumption and money holdings. Optimal money holdings are

$$\frac{M(i)}{P} = \chi C(i). \quad (2.5)$$

Demand for each of the two goods is  $C_1(i) = \gamma[PC(i)/P_1]$ , and  $C_2(i) = (1 - \gamma)[PC(i)/SP_2^*]$ . Since each individual within a country is alike, we dispense with the individual-specific notation hereafter, so we must have  $H(i) = H$ .

Conditions pertaining to the foreign economy are analogous. The foreign firm has an identical production function. In addition, foreign preferences are identical to (2.2), and foreign consumers receive the *same* preference shocks that affect home consumers' preferences. Foreign variables are denoted with an asterisk.

### 2.5. Equilibrium

An equilibrium, for any monetary policy rule, is defined by: (a) profit maximization by home and foreign firms, (b) optimal wage setting by home and foreign workers, (c) utility maximization by home and foreign households, (d) consolidated public sector budget constraints, given by  $M - M_0 = T + \varepsilon WH$ ,  $M^* - M_0^* = T^* + \varepsilon^* W^* H^*$ ,<sup>6</sup> and (e) market clearing in goods and money.

Goods market clearing is represented by the two equations

$$Y = \gamma \frac{P}{P_1} (C + C^*). \quad (2.6)$$

$$Y^* = (1 - \gamma) \frac{P}{SP_2^*} (C + C^*). \quad (2.7)$$

From (2.6) and (2.7), we have

$$\left( \frac{P_1}{SP_2^*} \right) = \frac{\gamma}{1 - \gamma} \frac{Y^*}{Y}. \quad (2.8)$$

The terms of trade is inversely related to relative output, but positively related to demand shocks (e.g., see [Cole and Obstfeld, 1990](#)). This condition holds independently of assumptions about nominal rigidities, or monetary policies.

The closed form solution of the model is simple to construct. [Table 1](#) gives the solution, for arbitrary monetary policy rules. Given the simple preference specification and the terms of trade equation (2.8), equilibrium consumption in each country is given by a weighted geometric average of national output (employment). From a

<sup>6</sup> The right-hand side of each of these expressions represents government revenue from money creation. The left-hand side describes government outlays on net transfers and the wage subsidy.

Table 1  
Model solution for given monetary rules

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$C = \gamma \left[ \frac{Y}{\gamma} \right]^\gamma \left[ \frac{Y^*}{1-\gamma} \right]^{1-\gamma}$	$C^* = (1-\gamma) \left[ \frac{Y}{\gamma} \right]^\gamma \left[ \frac{Y^*}{1-\gamma} \right]^{1-\gamma}$
$H = \frac{M(1-\alpha)}{W(1-\varepsilon)\chi}$	$H^* = \frac{M^*(1-\alpha)}{W^*(1-\varepsilon)\chi}$
$Y = H^{1-\alpha}$	$Y^* = H^*(1-\alpha)$
$P_1 = \left( \frac{W(1-\varepsilon)}{(1-\alpha)} \right)^{1-\alpha} \left( \frac{M}{\chi} \right)^\alpha$	$P_2^* = \left( \frac{W^*(1-\varepsilon)}{(1-\alpha)} \right)^{1-\alpha} \left( \frac{M^*}{\chi} \right)^\alpha$
$W = \left( \frac{\rho\eta(1-\alpha)^\psi}{(\rho-1)(1-\varepsilon)^\psi} \right)^{1/(1+\psi)} [E(M)^{1+\psi}]^{1/(1+\psi)} \frac{1}{\chi}$	$W = \left( \frac{\rho\eta(1-\alpha)^\psi}{(\rho-1)(1-\varepsilon)^\psi} \right)^{1/(1+\psi)} [E(M^*)^{1+\psi}]^{1/(1+\psi)} \frac{1}{\chi}$
$S = \frac{1-\gamma}{\gamma} \frac{M}{M^*}$	

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combination of the household and government budget constraint, we get the economy's balance of payments condition  $PC = P_1 Y$ . Combine this with (2.1), and money market clearing, we obtain an expression for employment which depends positively on the domestic money stock, and negatively on the nominal wage. Note that, holding the money stock constant, output is *independent of the demand shock*. Table 1 also shows that the optimal wage depends only on the distribution of the money supply. When  $\psi > 0$  a rise in the volatility of the money supply will raise the equilibrium nominal wage, and hence reduce *expected* employment.<sup>7</sup> Finally, since goods prices depend only on nominal wages and the money stock in each country, holding money stocks constant, *all* the adjustment in the terms of trade to a demand shock has to be done through the nominal exchange rate.

### 3. Comparison of exchange rate regimes

#### 3.1. Social planning outcome

As a reference point, it is useful to know what the *first-best* outcome looks like. Imagine a social planner who weights each country equally and could choose consumption and employment to maximize utility in each state of the world. Appendix A establishes the following proposition.

<sup>7</sup> Some further intuition for this result can be given. The worker wishes to set the wage so as to keep the expectation  $EH^{1+\psi}$  constant. Since employment will increase linearly with the money supply, when  $\psi > 0$  the worker puts more weight on high values of the money supply than on low values. This leads her to set the fixed wage higher, the more volatile is money.

**Proposition 1.**

(a) *The social planner equalizes ex-post consumption so that*<sup>8</sup>

$$C = C^* = \frac{1}{2} \left[ \frac{Y}{\gamma} \right]^\gamma \left[ \frac{Y^*}{(1-\gamma)} \right]^{1-\gamma}. \quad (3.1)$$

(b) *The social planner makes output responsive to demand shocks*

$$Y = \left[ \frac{2\gamma(1-\alpha)}{\eta} \right]^{(1-\alpha)/(1+\psi)} Y^* = \left[ \frac{2(1-\gamma)(1-\alpha)}{\eta} \right]^{(1-\alpha)/(1+\psi)}. \quad (3.2)$$

The social planner would equalize consumption across countries, but not output. Home country output should be higher when there is a swing in world demand towards the home good ( $\gamma > 1/2$ ), and at the same time foreign output should be lower. Output is more responsive to shifts in world demand, the higher is the elasticity of labor supply (the lower is  $\psi$ ). Knowing this, we note from (2.8) that the terms of trade implied by the social planner solution should be

$$\left( \frac{P_1}{SP_2^*} \right) = \left[ \frac{\gamma}{1-\gamma} \right]^{\psi/(1+\psi)}. \quad (3.3)$$

As the elasticity of labor supply rises (falls), the desired variability in the terms of trade falls (rises).

### 3.2. Monetary rules

Now let us look at the outcome under alternative exchange rate regimes. There is no one-to-one correspondence between the exchange rate regime and the monetary rule. Many alternative monetary rules are consistent with flexible or fixed exchange rates. But we have to make some assumption about the monetary policy rules. We describe the two alternative monetary rules as follows.

Assumption 1. (flexible exchange rates). Each country maintains a fixed level of the money stock.

Assumption 2. (fixed exchange rates). Each country follows a cooperative peg, adjusting its money stock in response to the home demand shock as follows:

$$M = 2\gamma M_0, \quad M^* = 2(1-\gamma)M_0. \quad (3.4)$$

<sup>8</sup> For this exercise, and the rest of the paper, we follow the practice originated by Obstfeld and Rogoff (1995) and many others, of ignoring the utility of real money balances in the evaluation of expected utility. Implicitly, we are focusing on a case where  $\chi$  becomes arbitrarily small.

Assumption 1 most closely approximates the characteristic of freely floating exchange rates. The exchange rate responds to demand shocks, but domestic prices are constant. We could think of this as an inflation targeting monetary rule. Under Assumption 2, the exchange rate is independent of demand shocks. But domestic prices are pro-cyclical.

### 3.2. Flexible versus fixed exchange rates

#### Proposition 2.

- (a) Under flexible exchange rates, output is independent of the demand shock.  
 (b) The equilibrium under flexible exchange rates replicates the equilibrium of a flexible wage economy.

Proposition 2 says that the nominal exchange rate acts so as to completely stabilize GDP from the effects of shocks to world demand. Moreover, as a result of this, the flexible exchange rate monetary rule completely eliminates the effect of nominal wage rigidities. The intuition behind the proposition is easy to see. From Table 1, equilibrium output is given by

$$Y = \left[ \frac{M(1-\alpha)}{W(1-\varepsilon)\chi} \right]^{1-\alpha}. \quad (3.5)$$

With pre-set nominal wages, output can only increase in response to a positive demand disturbance if the price  $P_1$  rises. This means that nominal income  $P_1Y$  must rise. But by money market equilibrium, nominal spending  $PC$  (and therefore nominal income) is tied down by the domestic money supply. The flexible exchange rate monetary rule keeps the money supply constant, so output must be constant.

The second part of the proposition is established by looking at the equilibrium wage from Table 1. If nominal income and employment are both independent of  $\gamma$ , then there is no uncertainty with respect to the ex-post *market clearing* nominal wage. This means that the sticky-wage outcome is equivalent to an economy where wages are flexible ex post.

The exchange rate response under flexible exchange rates is illustrated in Table 1. A rise in demand for the home country good leads to an exchange rate appreciation. This explains the sense in which the nominal exchange rate acts as a “shock absorber”. All the response in the terms of trade is performed by the exchange rate, without any movement in prices, so the real economy is unaffected by the shock. But in comparison with (3.3), the exchange rate responds too much to the demand shock, since the movement in the terms of trade exceeds that of the social planning outcome.

Why is the flexible wage equilibrium different from the social planning solution? The answer is that, in the market equilibrium, there is no cross-country risk sharing. Without international financial markets, the income effects of demand shocks are fully absorbed by domestic households. For a positive demand shock, home consumption

rises so much that home labor supply schedule is pushed backwards. The negative income effect exactly offsets the positive substitution effect of the terms of trade, and employment is unchanged.

Now turn to the equilibrium under fixed exchange rates. When the monetary rules in the two economies are represented by (3.4), then it is clear that output will no longer be independent of demand shocks, since nominal income in each country moves in a pro-cyclical direction. We can establish the following proposition.

**Proposition 3.**

- (a) Under fixed exchange rates, output in each country depends positively upon the demand shock.
- (b) The equilibrium under fixed exchange rates does not replicate the equilibrium of a flexible wage economy.

Under a fixed exchange rate regime, a monetary authority must follow an expansionary policy in response to a rise in demand for the domestic good; monetary policy must be pro-cyclical. Using the expressions from Table 1, output under a fixed exchange rate is

$$Y = \left[ \frac{2\gamma M_0(1 - \alpha)}{W\chi(1 - \varepsilon)} \right]^{1-\alpha}, \quad Y^* = \left[ \frac{2(1 - \gamma)M_0(1 - \alpha)}{W^*\chi(1 - \varepsilon)} \right]^{1-\alpha}. \tag{3.6}$$

Output responds positively to a demand shock, because monetary policy in each country is expanded to keep the exchange rate constant. Since output rises (falls) when there is a shift in demand towards (away from) the home country good, the terms of trade must adjust less. Using (2.8) and (3.6), the terms of trade response is described by

$$\frac{P_1}{P_2^*} = \left[ \frac{\gamma}{1 - \gamma} \right]^\alpha. \tag{3.7}$$

It is no surprise that a fixed exchange rate rule reduces the variability of the terms of trade, as it increases the variability of output. While a flexible exchange rate policy stabilizes output at the natural rate, under a fixed exchange rate output is pushed away from the natural rate.

It is tempting to conclude from this that a flexible exchange rate must always give higher expected utility than fixed exchange rates. But in fact this conclusion is incorrect. We may summarize the welfare evaluation of the two regimes as follows.

**Proposition 4.** *Expected utility is higher under fixed exchange rates than flexible exchange rates when*

$$E(\gamma \ln(\gamma)) - \frac{E\gamma}{1 + \psi} \ln(E(\gamma)^{1+\psi}) \geq 0.$$

Given the distribution of  $\psi$ , this condition depends only on one parameter, the elasticity of labor supply ( $\psi^{-1}$ ). When labor supply elasticity is high (low), then fixed (flexible) exchange rates tend to dominate.

**Corollary.** *When the marginal disutility of labor is constant ( $\psi=0$ ), expected utility is higher under fixed exchange rates.*

The intuition may be given as follows. It is shown in Appendix A that the expected utility comparison between the two exchange rate policies depends only on the expected value of log consumption, in each case. From Table 1, recall that expected log consumption (for the home country) may be written as

$$E \ln C = E\gamma \ln Y + E(1 - \gamma) \ln Y^* + \Theta,$$

where  $\Theta = E(1 - \gamma) \ln[\gamma/(1 - \gamma)]$ . The first two expressions are in fact equal, by the symmetry of the  $\gamma$  distribution. Hence, the comparison between flexible and fixed exchange rates depends only on the value of  $E\gamma \ln Y$ . Decomposing this we get

$$\frac{E \ln Y}{2} + \text{cov}(\gamma, \ln Y). \quad (3.8)$$

In comparison with a flexible exchange rate, a fixed exchange rate rule reduces the first expression, because it reduces the expected value of log output. This happens for two reasons. First, under fixed exchange rates, fluctuations in the real wage cause a gap between the marginal product of labor and the marginal disutility of labor. This leads to a higher volatility in the *level* of output, reducing the expected value of log output. Secondly, since a fixed exchange rate implies a more volatile aggregate demand, we saw from Table 1 that when  $\psi > 0$ , this causes a higher nominal wage, thereby reducing the mean level of employment and output. On this count alone, flexible exchange rates are more desirable, in welfare terms. Moreover, this accords with the traditional shock absorber property of flexible exchange rates—by stabilizing aggregate demand and output, a flexible exchange rate can increase welfare.

The second expression introduces a countervailing force, however. A positive covariance between the demand shock and log output will increase welfare, because it increases (decreases) output of the country whose good is in high (low) worldwide demand. By stabilizing the exchange rate, monetary authorities are following a procyclical rule, leading output to move in the same direction that would be chosen by a social planner. What is more, this goes counter to the traditional argument, because it calls for output to be *more volatile* than it would be in a regime of freely flexible exchange rates.

Hence, a flexible exchange rate may offer welfare benefits from stabilizing consumption, but by the same token may impose welfare costs because the composition of consumption (between home and foreign output) is insensitive to world demand. When the condition of Proposition 4 is met, then the second factor dominates the first, and fixed exchange rates are more desirable. The critical

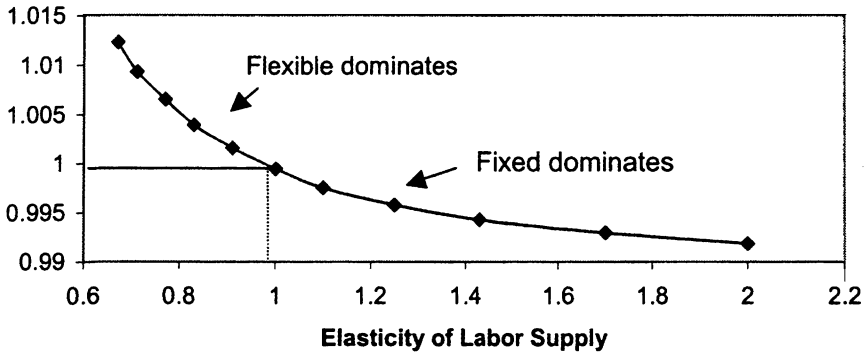


Fig. 1. Ratio of  $E(\ln(C))$ .

parameter is the elasticity of labor supply. Fig. 1 illustrates the trade-off. With a very high elasticity of labor supply, a fixed exchange rate dominates, because it leads output to be highly responsive to demand shocks, as would be chosen by a social planner. But when labor supply is very inelastic, flexible exchange rates dominate, because in this case a social planner would choose a stable level of output.

**4. Optimal monetary rules**

Neither a fixed nor flexible exchange rate policy rule as described above is likely to maximize consumer welfare. Here we identify optimal monetary rules when the authorities can adjust the money supply to ex-post realizations of the demand shock. We assume that monetary authorities are benevolent and choose a policy rule to maximize the expected utility of domestic residents. We also assume that monetary policy is chosen under *commitment*, whereby the authorities choose a set of contingent rules for policy, taking into account the way in which the monetary policy rule impacts on wage setting.

**Proposition 5.**

(a) *The welfare maximizing monetary rules are*

$$M = \gamma^{1/(1+\psi)} M_0, \quad M^* = (1 - \gamma)^{1/(1+\psi)} M_0. \tag{4.1}$$

(b) *The exchange rate under the optimal monetary rules is*

$$S = \left[ \frac{1 - \gamma}{\gamma} \right]^{\psi/(1+\psi)}.$$

**Corollary.** When  $\psi = 0$ , the optimal monetary policy rule is a fixed exchange rate.

Monetary policy is expansionary in the face of positive demand shocks towards the domestic economy. This means that optimal monetary policy should *always dampen* exchange rate movements, compared with the flexible exchange rate policy. Under flexible exchange rates, exchange rate volatility is excessive. As  $\psi$  tends to zero, the optimal policy is to eliminate exchange rate movements completely.

Note that the optimal monetary rule cannot achieve the social planning optimum. No matter how a monetary rule is designed, it can affect only the realizations of employment and output, since monetary policy only works by reacting to a demand shock faster than nominal wages can react. It cannot facilitate consumption risk-sharing.<sup>9</sup>

There are no strategic interactions between monetary authorities when determining optimal policy under commitment. Optimal monetary policy for individual monetary authorities is identical to that which would be chosen were the two authorities co-operating.<sup>10</sup>

## 5. Discussion and extensions

### 5.1. Financial markets

In the model, the flexible wage equilibrium is Pareto inefficient, due to the absence of international financial markets. Although a fixed exchange rate leads GDP to deviate from its natural rate, it may still be a better policy rule, because the natural rate is inefficient. Clearly, the results are different when there are markets for international risk sharing. But this does not mean that a flexible exchange rate is more desirable in an economy with risk sharing. With full financial markets, a flexible exchange rate no longer stabilizes output, nor does it ensure output is equal to the flexible wage output level. In fact, the flexible wage level of output under full financial markets is no longer constant. It responds to demand shocks in an equivalent way to that chosen by a social planner, described in the previous section.

Table 2 describes the solution of the model under complete financial markets, for arbitrary monetary policies. Consumption is equalized across countries, in all states of the world. The key difference between this and Table 1 is that the exchange rate is no longer directly dependent on demand shocks. In fact, a constant money rule maintains a constant value of the exchange rate. This means that, in welfare terms, fixed and flexible exchange rates are equivalent.

<sup>9</sup> In the case where there are full financial markets, an optimal monetary rule would attain the social planning outcome. It is easy to show (see Devereux, 2001) that an optimal monetary rule in this case would generate *more* exchange rate volatility than under the flexible exchange rate rule.

<sup>10</sup> For a similar result, see Obstfeld and Rogoff (2001).

Table 2  
Model solution for given monetary rules: full financial markets

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$C = \frac{1}{2} \left[ \frac{Y}{\gamma} \right]^\gamma \left[ \frac{Y^*}{(1-\gamma)} \right]^{1-\gamma}$	$C^* = \frac{1}{2} \left[ \frac{Y}{\gamma} \right]^\gamma \left[ \frac{Y^*}{1-\gamma} \right]^{1-\gamma}$
$H = 2\gamma \frac{M(1-\alpha)}{W\chi(1-\varepsilon)}$	$H^* = 2\gamma \frac{M^*(1-\alpha)}{W\chi(1-\varepsilon)}$
$Y = H^{1-\alpha}$	$Y^* = H^* 1 - \alpha$
$P_1 = (2\gamma)^\alpha \left( \frac{W(1-\varepsilon)}{(1-\alpha)} \right)^{1-\alpha} \text{fen} > \left( \frac{M}{\chi} \right)^\alpha$	$P_2^* = (2\gamma)^\alpha \left( \frac{W^*(1-\varepsilon)}{(1-\alpha)} \right)^{1-\alpha} \left( \frac{M^*}{\chi} \right)^\alpha$
$W = \left( \frac{2\rho[(1-\alpha)]^\psi}{(\rho-1)[1+\varepsilon]^\psi} \right)^{1/(1+\psi)} \left[ \frac{E(\gamma M)^{1+\psi}}{E(\gamma)} \right]^{1/(1+\psi)} \frac{1}{\chi}$	$W^* = \left( \frac{2\rho[(1-\alpha)]^\psi}{(\rho-1)[1+\varepsilon]^\psi} \right)^{1/(1+\psi)} \left[ \frac{E(\gamma M^*)^{1+\psi}}{E(\gamma)} \right]^{1/(1+\psi)} \frac{1}{\chi}$
$S = \frac{M}{M^*}$	

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Note also that although the welfare benefits of a fixed exchange rate rule arise because of missing international financial markets, a fixed exchange rate does not itself enhance risk sharing. In fact, the fixed exchange rate rule studied here does not allow any risk sharing, since each country must remain bound by its ex post budget constraint, and there are no money transfers across countries.<sup>11</sup>

### 5.2. Alternative exchange rate rules

Assumption 2 describes one policy which maintains a fixed exchange rate. How would our results (under incomplete financial markets) differ if the exchange rate was fixed by a unilateral peg, instead of a cooperative peg? Say that the foreign country kept  $M^*$  constant. Then to keep the exchange fixed, the home country would need to use the rule  $M = \gamma/(1-\gamma)M_0$ . Then, only domestic output would respond to a demand shock. Foreign output would be stabilized, as under flexible exchange rates. But we can use the same procedure as in Proposition 4 to show that expected utility (of both countries) is higher under fixed exchange rates, if  $\psi$  is low enough. Thus, even a unilateral peg may be in a country's interest.

### 5.3. Extending the model

The model is highly simplified, offering the most transparent framework within which to compare exchange rate policies. How sensitive are the results to the

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<sup>11</sup> From Table 1 it is clear that the cross-country correlation of consumption is independent of the exchange rate rule.

particular specification of the model? Many assumptions do not matter critically. For instance, if instead of consumption, output entered money demand (due to a cash in advance motive for money holding), the results would be unchanged, since, without full risk sharing, consumption and output are equal in value terms. Similarly, we have assumed that nominal rigidities enter into the wage setting process (as in Obstfeld and Rogoff, 2000). If instead prices were sticky in our setting, the exchange rate equation from Table 1 would still hold, and the same welfare results would hold, since output would still be pinned down by monetary policy under flexible exchange rates, and would respond positively to demand shocks under fixed exchange rates.

The results in the paper examine the case for exchange rate adjustment in face of country-specific demand shocks. In the case of technology shocks, the welfare case for exchange rate adjustment would be greater (see Devereux and Engel, 2000). Nevertheless, when we simply compare fixed and flexible exchange rate rules as described by Assumptions 1 and 2, we find that the exchange rate plays no role at all in adjusting to technology shocks. This is because, in face of a unitary elasticity of substitution between home and foreign goods, there is no impact of technology shocks on the exchange rate.

## 6. Conclusions

Our results throw some doubt on the shock absorber case for flexible exchange rates in face of fluctuations in relative demand for a country's good. The results are due to the combination of multiple deviations from efficiency in the international economy. There is both a failure of full international risk sharing, and the failure of wages to be flexible enough. While flexible exchange rates can deal perfectly with the second distortion, keeping output at its natural rate, this may be undesirable, relative to a fixed exchange rate, which would ensure output more closely approximates that of an economy without nominal rigidities and with complete financial markets.

More generally, the results have implications for the debate about the consequences of sacrificing exchange rate adjustment in single currency areas and "dollarized" economies. If we accept that, in reality, monetary policy cannot be perfectly designed, but must choose between general rules such as inflation targeting compared with a hard pegged exchange rate, then it is not necessarily true that giving up the possibility of exchange rate adjustment is costly, even if the economy is vulnerable to country-specific shocks which require relative price adjustment.

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## Appendix A

The model can be described by the equations

$$P_1 \varepsilon (1 - \alpha) H^{-\alpha} = W, \quad (\text{A.1})$$

$$P_2^* \varepsilon (1 - \alpha) H^* - \alpha = W^*, \quad (\text{A.2})$$

$$PC = P_1 H^{1-\alpha}, \quad (\text{A.3})$$

$$\frac{M}{P} = \chi C, \quad (\text{A.4})$$

$$\frac{M^*}{P^*} = \chi C^*, \quad (\text{A.5})$$

$$W = \frac{\rho}{\rho - 1} \eta \frac{EH^{1+\psi}}{E(H/PC)}, \quad (\text{A.6})$$

$$W^* = \frac{\rho}{\rho - 1} \eta \frac{EH^{*1+\psi}}{E(H^*/P^*C^*)}, \quad (\text{A.7})$$

$$H^{1-\alpha} = \gamma \frac{P(C + C^*)}{P_1}, \quad (\text{A.8})$$

$$H^{*1-\alpha} = (1 - \gamma) \frac{P(C + C^*)}{SP_2^*}. \quad (\text{A.9})$$

These nine equations can be solved for the nine variables:  $W$ ,  $W^*$ ,  $H(\sigma)$ ,  $H^*(\sigma)$ ,  $P_1(\sigma)$ ,  $P_2^*(\sigma)$ ,  $S(\sigma)$ ,  $C(\sigma)$ ,  $C^*(\sigma)$ , where  $\sigma$  designates the ex post state. Eqs. (A.3), (A.8) and (A.9) may be solved for the consumption solutions in Table 1. (A.1), (A.3) and (A.4) may be combined to obtain the employment solution for the home country, and (A.2), (A.5) and (A.9) give the foreign employment solution. (A.6) and (A.7) may then be used to obtain the wage equations. (A.1) and (A.2) may be solved then for prices, using the employment solutions. Finally, the terms of trade equation (2.8) is used to obtain the exchange rate solution.

**Proof of Proposition 1.** The social planning solution is derived by maximizing the equal weighted sum of home and foreign expected utility, subject to the production and resource constraints,  $H^{1-\alpha} = C_1 + C_1^*$ ,  $H^{*1-\alpha} = C_2 + C_2^*$ . The social planner chooses state contingent consumption and employment levels for each country, subject to these constraints. It is easily established that the social planning solution coincides with (3.1) and (3.2).

**Proof of Proposition 2.** From the results of Table 1, using Assumption 1, it is clear that employment and output in each country are independent of demand shocks. Similarly, given a constant money supply the wage setting equations in Table 1 show that the market clearing wages are known ex ante, so the second part of the proposition follows.

**Proof of Proposition 3.** From the results of Table 1, using Assumption 2, employment and output in each country are increasing in country demand shocks. Since the money supply in each country is stochastic by Assumption 1, the ex-post market clearing money wage is not known in advance. Hence, with pre-set nominal wages, the flexible wage allocation is generically not obtained.

**Proof of Proposition 4.** Employment may be written as

$$H = \left[ \frac{1 - \alpha}{\eta} \right]^{1/(1+\psi)} \frac{M}{(E(M)^{1+\psi})^{1/(1+\psi)}}, \tag{A.10}$$

and consumption as

$$\begin{aligned} C &= \gamma \left( \frac{H^{1-\alpha}}{\gamma} \right)^\gamma \left( \frac{H^{*1-\alpha}}{1 - \gamma} \right)^{1-\gamma} \\ &= \Theta \left( \frac{\gamma}{1 - \gamma} \right)^{1-\gamma} \left[ \frac{M}{(E(M)^{1+\psi})^{1/(1+\psi)}} \right]^{(1-\alpha)\gamma} \left[ \frac{M^*}{(E(M^*)^{1+\psi})^{1/(1+\psi)}} \right]^{(1-\alpha)(1-\gamma)}, \end{aligned} \tag{A.11}$$

where  $\Theta = [(1 - \alpha)/\eta]^{(1-\alpha)/(1+\psi)}$ . Expected utility is given by

$$\begin{aligned} EU &= E \left( \ln C - \frac{\eta}{1 + \psi} H^{1+\psi} \right) = E(1 - \alpha)\gamma \ln \left[ \frac{M}{(E(M)^{1+\psi})^{1/(1+\psi)}} \right] \\ &\quad + E(1 - \alpha)(1 - \gamma) \ln \left[ \frac{M^*}{(E(M^*)^{1+\psi})^{1/(1+\psi)}} \right] \\ &\quad + E \ln \left( \Theta \left( \frac{\gamma}{1 - \gamma} \right)^{1-\gamma} \right) - \frac{1 - \alpha}{1 + \psi}. \end{aligned} \tag{A.12}$$

Note that the second expression on the right-hand side of the first line, capturing the disutility of employment, is independent of monetary policy (to see this, substitute (A.10) into  $[\eta/(1+\psi)]EH^{1+\psi}$ , and the result is independent of the monetary rule).

Using the monetary rules defined by Assumptions 1 and 2 of the text, we can arrange (A.12) to obtain the condition for flexible exchange rates to be superior, in welfare terms, to fixed exchange rates, as

$$E\gamma \ln(\gamma) - \frac{E\gamma}{1+\psi} \ln(E(\gamma)^{1+\psi}) \leq 0.$$

For  $\psi = 0$ , with a symmetric distribution for  $\gamma$  centred at 0.5, this is not satisfied. Hence, for high values of the elasticity of labor supply, fixed exchange rates will dominate in welfare terms.

**Proof of Proposition 5.** Without loss of generality, assume  $\gamma$  takes on a finite set of realisations  $\gamma = \{\gamma_1 \dots \gamma_N\}$  with probabilities  $\{\pi_1 \dots \pi_N\}$ . Optimal monetary with commitment involves the monetary authority choosing a monetary rule  $M(\gamma)$ , taking into account that the expectations of this rule will determine pre-set wage rates. Then the first-order condition for the monetary authority maximizing (A.12) is

$$\frac{\gamma_i}{M_i} = \frac{E(\gamma)}{M_i} \frac{(M_i)^{1+\psi}}{E(M)^{1+\psi}}.$$

Rearranging gives (4.1) of the text. Note that it is apparent from examining the expression for expected utility that there are no gains from international policy co-ordination here.

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