International Risk-Sharing and the Exchange Rate: Re-evaluating the Case for Flexible Exchange Rates

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Abstract

A classic argument for flexible exchange rates is that the exchange rate plays a 'shock-absorber' role in an open economy vulnerable to country-specific shocks. This paper presents a sharp counter-example to this argument within a very conventional open economy model. Countries are subject to unpredictable shocks to world demand for their goods. Efficient adjustment is prevented, both by sticky nominal wages and by the absence of a market for hedging consumption risk internationally. A flexible exchange rate policy acts perfectly as a 'shock-absorber', fully stabilizing output and replicating the flexible wage outcome. Despite this, a policy that fixes the exchange rate may be welfare superior, even though fixed exchange rates cause output to deviate from the flexible wage outcome. Moreover, an optimal monetary rule in this environment would always dampen exchange rate movements, and may even be a fixed exchange rate.

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Introduction

A classic argument for flexible exchange rates is that an economy with nominal wage or price rigidities can use the exchange rate as a 'shock-absorber' in face of external, country-specific shocks. This argument is central to Friedman's (1953) case for flexible exchange rates, as well as in Mundell's (1961) analysis of the benefits of separate national currencies. More recently, 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 (e.g. Alesina and Barro 2000, Bayoumi and Eichengreen 1998, Sachs 1999, Murray 1999, Thiessen 2000). The logic of this argument for flexible exchange rates is simple and compelling. As stated by Mundell (1961):

"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."

This paper develops a theoretical analysis of the case for the adjustment benefits of flexible exchange rates within a welfare-based model.[1] The results provide a sharp counter-example to the argument of Mundell, within a very simple model that is set up along conventional lines. In the model, countries specialize in particular goods, and face unpredictable shifts in world preferences for their products. Wage rates are pre-set, and cannot adjust in response to shifts in world demand. Our question is whether it is desirable from a welfare perspective to allow nominal exchange rates to adjust to random shifts in world demand. Nominal exchange rates may play a useful role because they allow for adjustment in the terms of trade.[2]

The new feature of the analysis here is to emphasize the role of international financial markets. Financial markets are important in our model because they allow residents of a country to engage in consumption risk-sharing, diversifying away some of the risk associated with unpredictable demand disturbances.[3]

Policies of 'flexible' and 'fixed' exchange rates are not uniquely defined; there are many ways to achieve each outcome. Our working definition of flexible exchange rates is one where the monetary authorities in each country follow a constant money supply rule, independent of the exchange rate. A fixed exchange rate is defined as a 'cooperative peg' whereby authorities in each country design monetary policy to keep the exchange rate from responding to world demand shocks. But the key results of the paper are not sensitive to these definitions of flexible and fixed exchange rate regimes, and we also consider alternative rules.

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

2 We assume that there is full exchange rate pass-through to prices of imported goods. While the literature has argued that, empirically, there is limited pass-through (Engel, 1999), it is also possible that the exchange rate plays a useful role in adjusting relative prices, even if pass-through is absent at the consumer price level (Obstfeld 2000). To keep our analysis simple, and to stay with the framework of the traditional argument for flexible exchange rates in so far as is possible, we assume that pass-through is immediate.

3 While there are clear theoretical arguments for welfare gains from consumption risk-sharing, much empirical evidence has questioned the extent of such risk-sharing in the international economy (e.g. Backus, Kydland and Kehoe 1995). A fair degree of consensus seems to exist among economists that there are at best incomplete opportunities to share risk among countries.

Our results show that the case for flexible exchange rates depends on the structure of international financial markets. With full international risk-sharing the exchange rate regime is irrelevant. For constant money supply in each country, the exchange rate does not respond at all to shifts in demand, so the exchange rate does not play a direct role in the adjustment process. But an optimal (welfare-maximizing) monetary rule under full risk-sharing requires a counter-cyclical monetary stance, which means that the monetary authority should always increase exchange rate volatility, relative to a passive monetary rule.

When risk-sharing is absent, however, the results are quite different. In the economy without risk-sharing, a flexible exchange rate acts perfectly as a shock-absorber. In response to a negative world demand shock for a country's good, under flexible exchange rates, the home currency will depreciate, output (and employment) is perfectly stabilized. In fact this policy perfectly replicates the flexible wage allocation, undoing the effects of nominal rigidities. With a fixed exchange rate, by contrast, the fall in world 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.

The key factor behind this welfare result is the absence of complete risk-sharing in international financial markets. In a first-best outcome for the world economy, 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. This achieves an efficient allocation of world resources, maximizing world GDP in an environment where all income risk is hedged away.

Without full risk-sharing, however, a country's consumption must equal its ex-post income, so that the wealth effects of demand shocks cannot be hedged away. The perfect correlation between consumption and income reduces the response of output (employment) to changes in the relative price of the country's good. If there were fully flexible wages (but no risk-sharing) a rise in world demand would improve the terms of trade and raise income by so much that in equilibrium, there would be no positive response of output at all. When wages rates are sticky, monetary policy determines the response of output. But a flexible exchange rate monetary rule prevents aggregate demand from responding at all (and mimics the flexible wage economy). This does ensure a stable level of output at the flexible wage outcome, but it does not maximize welfare; it would be better in expected utility terms to have output respond to demand shocks. This means that it may be better to have a fixed exchange rate, and trade off some welfare triangles in the labor market for a more efficient response of output to world demand shocks.

These results are not sensitive to the particular way in which fixed and flexible exchange rate monetary rules are defined. We show that a fixed exchange rate supported by a unilateral peg may still raise welfare, for all countries. In addition, if instead of defining flexible exchange rates as a constant money target, we assumed a constant price level, the results would be unchanged in the no risk-sharing case. In the case of full risk-sharing, a price stability rule stabilizes output (but not at the flexible wage outcome), but it may still be welfare-dominated by a fixed exchange rate rule.

We also define a welfare-maximizing response of monetary policy in the environment without complete risk-sharing. Here the results are also quite striking. It is always optimal for monetary policy to cause output to deviate from the flexible wage equilibrium. The optimal monetary rule is pro-cyclical, which means that the monetary authority should always *dampen* exchange rate variability. Moreover, in a non-trivial case, the optimal monetary rule is a pegged exchange rate.

Our results draw into question the conventional wisdom on the benefits of exchange rate adjustment, or equivalently, the costs of dollarization or single currency areas. Conventionally, it is argued that the benefits of dollarization or a single currency area are primarily microeconomic (reducing transactions costs), while the costs come from the loss of the exchange rate in macroeconomic stabilization. But when it is acknowledged that in reality monetary policy cannot be designed to perfectly respond to macroeconomic shocks, but must choose between broad objectives such as inflation rate stability or exchange rate stability, then the results suggest that it is not clear even on stabilization grounds, that there are any costs to eliminating the exchange rate as part of the macro adjustment process.

Section 1 outlines the model. Section 2 defines a benchmark optimum, as well as solving the model in the case of full risk-sharing and no risk-sharing. Section 3 compares flexible and fixed exchange rates. Section 4 outlines an optimal monetary policy, Section 5 discusses extensions, and Section 6 concludes.

Section 1: The Model

Take a model of a 'home' and 'foreign' country. There are two goods; the home country specializes in producing good 1 and the foreign country specializes in good 2. In addition, there is only one period (we discuss the extension to a dynamic model in the conclusions). Wages must be set in advance before the state of the world is known. This is a highly simplified environment, but it suffices in illustrating our main result on the welfare benefits of exchange rate adjustment.

1.1 Firms

The final-goods firm in the home country uses labor to produce output. As in Obstfeld and Rogoff (2000a), labor is differentiated across households. Define the composite labor supply in the home country as H, where $H = \left(\int_0^1 H(i)^{\frac{(\rho-1)}{\rho}} di \right)^{\frac{\rho}{(\rho-1)}}$, and $H(i)$ represents labor supply of individual i. The elasticity of substitution between types of labor is $\rho>1$. The final-good firm has the production function

$$Y=H^{(1-\alpha)}, \ \alpha\leq 1. \tag{1.1}$$

Final-good firms are price-takers. The firm chooses employment to maximize profits, given the set of wage rates it faces. Profits are defined as $\Pi = P_1 Y - \int_0^1 W(i)H(i)di$, where P_1 is the price of the home good, and $W(i)$ is household i's wage. The implicit labor demand schedule is:

$$P_1(1-\alpha)\frac{Y_1}{H}\left(\frac{H(i)}{H}\right)^{-\frac{1}{\rho}} = W(i)\ . \tag{1.2}$$

1.2 Households

Within each country, there is a unit measure of 'households'. A household supplies labor to the final-goods firm, receiving profits from ownership of the firm. In addition, the individual consumes some of the final good, and holds real balances. Home country consumer i maximizes the following utility function:[4]

$$EU = E(\ln(C(i)) + \gamma \ln(\frac{M(i)}{P}) - \eta(\frac{H(i)^{1+\psi}}{1+\psi})\ . \tag{1.3}$$

$C(i)$ 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. Implicitly, we are assuming that the 'law of one price' holds for each good. $M(i)$ is the quantity of domestic money held.

The variable γ 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, and centered at 0.5. The idea is that there are random preference shocks, shifting world demand either towards or away from the good of the home country relative to the foreign country.[5] We commonly refer to this as a 'demand shock'.

1.3 Financial Market Structure

We can think of there being different types of financial market arrangements available to consumers. Under all arrangements, the household sets the wage in advance, and then chooses consumption and money balances *after* the state of the world has been revealed. But financial markets can also allow for ex-ante consumption insurance. Imagine a situation where households were able to trade ex-ante in a full set of state-contingent nominal securities. Then since preferences are identical and there is additive separability between consumption and labor supply, there is full consumption risk-sharing:

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4 Here preferences exhibit additive separability between consumption and labor. Bachetta and Van Wincoop (2000) show that non-separability in preferences affect the comparison of exchange rate regimes.

5 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).

$$C = C^*. \tag{1.4}$$

The polar opposite case is when there is no risk-sharing at all. Households must meet their ex-post budget constraints without any asset flows across countries, given the prices and income that they face. The ex-post budget constraint for household i is

$$PC(i) + M(i) = W(i)H(i) + \tilde{\Pi}(i) + M_0 + T \tag{1.5}$$

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 transfer from the monetary authority (common across households). Given wages, and taking prices, profit income and transfers as given, the household optimally divides income between consumption and money holdings. Optimal consumption will equal:

$$C(i) = \frac{1}{1+\chi}\frac{W(i)H(i) + \Pi(i) + M_0 + T}{P}. \tag{1.6}$$

Optimal money holdings results from trading off the benefits from holding real balances, relative to the consumption sacrifice. For both types of financial market arrangements, we have

$$\frac{M(i)}{P} = \chi C(i). \tag{1.7}$$

1.4 Wage Setting

Each worker *i* faces a downward sloping labor demand curve, given by (1.4). The worker chooses the wage to maximize expected utility. Whatever the financial market structure, the optimal wage will satisfy

$$W(i) = \frac{\rho}{\rho - 1}\eta\frac{EH(i)^{1+\psi}}{E(\frac{H(i)}{PC(i)})}. \tag{1.8}$$

Expression (1.8) indicates that the worker will set the expected utility gain from a small reduction in the wage, given by $E(\frac{(\rho-1)H(i)}{PC(i)})$, equal to the expected utility cost implied by the higher work effort, given by $\eta\frac{E(H(i)^{\psi}\rho H(i))}{W(i)}$. The wage is higher, the lower is the elasticity of demand for labor ρ.

Given the wage, employment is determined by the demand for labor (1.2). Finally, individual demand for the two goods is $C_1(i) = \gamma\frac{PC(i)}{P_1}$, and $C_2(i) = (1-\gamma)\frac{PC(i)}{SP_2^*}$. Since each individual within a country is alike, we dispense with the individual-specific subscripts, so we must have $H(i) = H$.

The conditions pertaining to the foreign economy are analogous. The foreign firm has a production function for good 2 identical to (1.1). In addition, foreign preferences are identical to (1.3), and foreign consumers receive the same preference shocks that affect home consumers' preferences.

1.5 Equilibrium

An equilibrium, for either type of risk-sharing, and 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 as described in (1.8), c) utility maximization by home and foreign households, d) satisfaction of government budget constraints; $M = M_0 + T$, $M^* = M_0 + T^*$ and e) market clearing in goods and money.

With full risk-sharing, goods market clearing is represented by the two equations:

$$Y = \gamma \frac{2PC}{P_1} . \tag{1.9}$$

$$Y^* = (1-\gamma) \frac{2PC}{SP_2^*} . \tag{1.10}$$

Without risk-sharing, on the other hand, goods market clearing is represented by the two equations:

$$Y = \gamma \frac{P}{P_1} \left(C + C^* \right), \tag{1.11}$$

$$Y^* = (1-\gamma) \frac{P}{SP_2^*} \left(C + C^* \right). \tag{1.12}$$

Either from equations (1.9) and (1.10), or from (1.11) and (1.12), we have

$$\left(\frac{P_1}{SP_2^*} \right) = \frac{\gamma}{1-\gamma} \frac{Y^*}{Y} . \tag{1.13}$$

Equation (1.13) is very familiar (e.g. Cole and Obstfeld 1990). It says that the terms of trade is inversely related to relative output. This result holds independently of assumptions about nominal rigidities, monetary policies, or financial markets.

Section 2: Comparison of Alternative Outcomes

2.1 A Benchmark Optimum

A natural outcome on which to focus is the first best. Define a benchmark optimum where a social planner, weighting each country equally in the social welfare function, chooses consumption and employment without being restricted by financial markets, monopolistic competition, or nominal rigidities.[6]

The problem faced by the social planner can be described easily. The social planner's optimal choices are intuitive:

$$C = C^* = \frac{1}{2}\left[\frac{Y}{\gamma}\right]^{\gamma}\left[\frac{Y^*}{(1-\gamma)}\right]^{(1-\gamma)}, \tag{2.1}$$

$$H = \left[\frac{2\gamma(1-\alpha)}{\eta}\right]^{\frac{1}{1+\psi}} \qquad H^* = \left[\frac{2(1-\gamma)(1-\alpha)}{\eta}\right]^{\frac{1}{1+\psi}}. \tag{2.2}$$

The social planner would equalize consumption, but not employment (or output), across countries. Home country output should be higher when there is a swing in world demand towards the home good ($\gamma > \frac{1}{2}$), and at the same time foreign output should be lower. The sensitivity of output to movements in world demand will depend on the elasticity of labor supply. The parameter Ψ is the inverse of the constant-consumption elasticity of labor supply. When labor supply is very elastic ($\Psi \to 0$), output should move proportionally to the demand shock. But when labor supply is highly inelastic ($\Psi \to \infty$), optimal output should be constant.

From (1.13), the terms of trade under the benchmark optimum will be

$$\frac{P_1}{SP_2^*} = \left[\frac{\gamma}{1-\gamma}\right]^{\frac{\psi+\alpha}{1+\psi}}. \tag{2.3}$$

The higher the elasticity of labor supply, the less volatile should be the terms of trade.

6 For this exercise, and the rest of the paper, we follow the practise 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 χ becomes arbitrarily small.

There are three reasons why equilibrium outcomes diverge from the social planning optimum: the presence of monopolistic competitive distortions in wage setting; the presence of nominal wage rigidities; and the absence of international risk-sharing. In order to focus exclusively on the last two issues, and because the first distortion is essentially irrelevant for the comparison of monetary policy/exchange rate rules, we assume henceforth that governments in each country offer a lump-sum tax financed optimal wage subsidy to firms in the amount $\frac{1}{\rho-1}$. This cancels the distortion due to market power of wage setters.[7]

2.2 Full Risk-Sharing

Now assume that households can engage in full ex-ante risk-sharing. Nominal wages are pre-set however, according to (1.8). In setting nominal wages, workers must forecast both the aggregate demand parameter γ as well as the money supplies. For the present, assume that money supplies are i.i.d, and independent of the demand parameter. In the next section, we make specific assumptions about the distribution of money supplies pertaining to alternative monetary policies/exchange rate rules.

From the market clearing conditions under full risk-sharing, (1.9) and (1.10), we can establish that the formula for consumption given by (2.1) still obtains; conditional on output levels, consumption risk is shared optimally across countries. But employment is now in general different from (2.2). To derive the solution for employment, note that profit maximization rules imply that

$$P_1\varepsilon(1-\alpha)H^{-\alpha}=W$$

(where $\varepsilon=1+\frac{1}{\rho-1}$ is the gross employment subsidy). Combine this with the market clearing condition (1.9), and the money market equilibrium condition (1.7), to get

$$H=2\gamma\frac{M\varepsilon(1-\alpha)}{W\chi}. \tag{2.4}$$

Employment depends positively on the relative preference for home country goods and the money supply, and negatively on the nominal wage. For a constant money supply, employment would respond by more to a demand shock than under the social planner's solution, since if wages were flexible ex-post they would increase in response to a demand shock. Thus, although there is full risk-sharing, output is not generally at the efficient level.

Now using the solution (2.4), and noting that with a symmetric distribution for γ and i.i.d. monetary shocks, the pre-set nominal wages will be identical in the home and foreign countries, we can solve for the terms of trade under full risk-sharing as

$$\frac{P_1}{SP_2^*}=\left[\frac{\gamma}{1-\gamma}\right]^{\alpha}\left[\frac{M^*}{M}\right]^{(1-\alpha)}. \tag{2.5}$$

7 See Woodford (2001) for a discussion of this procedure.

Holding the money supplies constant, the terms of trade will respond by less than the benchmark optimum, in response to a tilt in world demand towards the home country good. This is because output responds by more than the benchmark optimum. An unanticipated home country monetary expansion, on the other hand, will generate a terms of trade deterioration.

Now, putting together (1.2) and (2.5), the solution for the nominal exchange rate is given by

$$S = \frac{M}{M^*} . \tag{2.6}$$

The exchange rate depends only on relative money supplies, and not directly on the demand disturbance. All the response in the terms of trade to demand shocks is accounted for by nominal price adjustment rather than exchange rate adjustment.

Finally, we can use the wage-setting condition (1.8) to determine the equilibrium pre-set wage under full risk-sharing as

$$W = \left(\eta\left[2(1-\alpha)\right]^{\psi}\right)^{\frac{1}{1+\psi}} \left[\frac{E(\gamma M)^{1+\psi}}{E(\gamma)}\right]^{\frac{1}{1+\psi}} \frac{\varepsilon}{\chi} . \tag{2.7}$$

If both γ and M were known in advance, or wages were flexible ex-post, then a combination of (2.4) and (2.7) shows that employment would be equal to the benchmark optimum.

The impact of wage stickiness depends upon the elasticity of labor supply. If the elasticity is very high ($\psi \to 0$) , then the nominal wage does not depend at all on the distribution of γ (assuming that γ and M are independent), and employment responds to demand shocks in a way which replicates the benchmark optimum. In this circumstance, wage stickiness is costly in welfare terms only because of unanticipated money shocks. On the other hand, when $\psi > 0$, the nominal wage is increasing in the volatility of money supply and the demand shock. Then nominal wage stickiness reduces *expected* employment below that of the benchmark optimum.

2.3 No Risk-Sharing

When there are no financial markets at all to hedge against income risk, households face the ex-post budget constraint given by (1.6). Without transfers of money across countries, this means that nominal spending equals nominal income for each country. Hence, for the home country:

$$PC = P_1 Y. \tag{2.8}$$

Now combine this with the profit maximization rule for the home country firm, and the money market equilibrium condition, to get the following solution for employment

$$H = \left(\frac{M\varepsilon(1-\alpha)}{W\chi}\right). \tag{2.9}$$

The key difference between this and its counterpart (2.4) for the economy with full international risk-sharing is that employment is *not* influenced by the world demand shock γ. The explanation is intuitive. With pre-set nominal wages, employment can only increase in response to a positive demand disturbance if the nominal price of the domestic good P_1 rises. This means that nominal income $P_1 Y$ must rise. Under both financial market arrangements, nominal spending PC is tied down by the domestic money supply. While with full risk-sharing, nominal spending and nominal income may differ, without financial markets, nominal spending and nominal income must be the same. Thus, for a given value of the money supply, nominal income and therefore P_1 is independent of the demand shock, and so must be employment.

From (1.13) and (2.9) we may solve for the terms of trade:

$$\frac{P_1}{SP_2^*} = \frac{\gamma}{1-\gamma}\left[\frac{M^*}{M}\right]^{(1-\alpha)} . \tag{2.10}$$

Without risk-sharing, the terms of trade responds by *too much* to a demand disturbance (relative to the benchmark optimum), for given values of the money stock. Again, a home monetary expansion will cause a fall in the terms of trade. The exchange rate is then obtained by using expression (1.2), (2.9), and their counterparts for the foreign country in (2.10):

$$S = \frac{1-\gamma}{\gamma}\frac{M}{M^*} . \tag{2.11}$$

A rise in demand for the home country good leads to an exchange rate appreciation. In the previous case, all terms of trade adjustment to a demand shock was achieved by nominal price movement. But here all adjustment is done by the exchange rate.

Consumption without risk-sharing is given by

$$C = \gamma\left[\frac{Y}{\gamma}\right]^{\gamma}\left[\frac{Y^*}{1-\gamma}\right]^{1-\gamma}, \; C^* = (1-\gamma)\left[\frac{Y}{\gamma}\right]^{\gamma}\left[\frac{Y^*}{1-\gamma}\right]^{1-\gamma} . \tag{2.12}$$

Consumption risk is no longer pooled. Since nominal spending and income must be equated, home country consumption rises relative to foreign consumption in face of a positive demand shock for the home good.

Finally, using (2.8), (2.9), and the money market clearing condition in the wage setting equation (1.8), we obtain the solution for the wage in the economy without risk-sharing:

$$W = \left(\eta(1-\alpha)^{\psi}\right)^{\frac{1}{1+\psi}}\left[E(M)^{1+\psi}\right]^{\frac{1}{1+\psi}}\frac{\varepsilon}{\chi} . \tag{2.13}$$

Because employment does not depend on the demand shock, neither does the optimal pre-set wage. Apart from constant parameters, the wage depends only on the distribution of the money supply. A rise in the volatility of the money supply will raise the equilibrium pre-set wage, and hence reduce *expected* employment, as before. The extent to which the volatility of the money supply affects the wage again depends on the elasticity of labor supply. When labor supply is highly elastic, the wage depends only on the expected money supply, but as the elasticity of labor supply falls, the wage becomes more and more sensitive to monetary volatility.[8]

From (2.13), it is apparent that without risk-sharing, if the money supply is held constant, there is no consequence at all of nominal wage stickiness. The pre-set wage and the ex-post flexible wage are the same. The allocation of resources is then identical to that which would obtain in a flexible wage environment.

Section 3: Fixed versus Flexible Exchange Rates

Now we examine the support given in this model for the shock-absorber role of a floating exchange rate. We compare a policy of 'flexible' exchange rates to 'fixed' exchange rates. We define a flexible exchange rate as a policy rule whereby the monetary authority pays no attention to the exchange rate. The most simple way to represent this is to assume a constant value of the money supply of each country. On the other hand, a fixed exchange rate is one where both home and foreign countries adjust the money supply continually in order to prevent the exchange rate from moving. Alternative definitions are possible, however, and we also consider some different monetary rules for flexible and fixed exchange rates below.

Of course, we might expect that neither fixed nor flexible exchange rates policies (as defined) would be optimal from a welfare point of view. But a central pillar in the case for flexible exchange rates relies on the idea that the exchange rate acts as an automatic adjustment device, independently of any specific response of monetary policy. In the next section, we will investigate optimal monetary rules.

3.1 Full Risk-Sharing

It is apparent that under the definitions considered, the comparison of fixed and flexible exchange rates is only relevant to the economy without full risk-sharing. With full risk-sharing, the exchange rate is unaffected by demand shocks. Hence a constant money supply in each country keeps the exchange rate constant, and the monetary stance for a fixed and flexible exchange rate policy is the same. In a sense, the exchange rate is irrelevant to the adjustment process under full risk-sharing (although, as seen below, optimal monetary policy under full risk-sharing requires exchange rate movements).

8 Some further intuition for this result can be given. In the case of no risk-sharing, the worker wishes to set the wage so as to keep the expectation $EH^{1+\psi}$ constant (cf. 1.8). 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.

3.2 No Risk-Sharing

Without risk-sharing, a flexible exchange rate is described by the solution to equation (2.11) with $M = M^*$. A fixed exchange rate is defined as a *co-operative peg*, supported by the following monetary rules for the home and foreign monetary authorities:

$$M = 2\gamma M_0,\ M^* = 2(1-\gamma)\ M_0\ . \tag{3.1}$$

where the value of M_0 is arbitrary. 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. From (2.8), employment under a fixed exchange rate is:

$$H = \frac{2\gamma M_0 \varepsilon(1-\alpha)}{W\chi},\quad H^* = \frac{2(1-\gamma)M_0\varepsilon(1-\alpha)}{W\chi}, \tag{3.2}$$

and the terms of trade is

$$\frac{P_1}{P_2^*} = \left[\frac{\gamma}{1-\gamma}\right]^{\alpha}\ . \tag{3.3}$$

Employment rises in response to a tilt in world demand towards the domestic good. This leads to a lesser response of the terms of trade than under floating exchange rates. Hence, fixed exchange rates de-stabilize output in response to world demand shocks. Moreover, because employment is variable, a fixed exchange rate implies that the economy is generically away from the flexible wage equilibrium.

It may seem natural to conclude therefore that fixed exchange rates must be inferior, in welfare terms, to flexible exchange rates. A flexible exchange rate stabilizes output at the 'natural rate' (i.e. the flexible employment level), while a fixed exchange rate does not, and moreover, reduces expected output. But this conclusion is not in general correct. In the flexible exchange rate economy (or equivalently, the economy without wage rigidities, but also without risk-sharing), employment does not respond to world demand shocks. But in the benchmark optimum economy, employment should increase when there is a tilt in world demand towards the home good. While flexible exchange rates keep employment at its 'natural rate', the natural rate is generically inefficient, due to the absence of international risk-sharing.

By contrast, a fixed exchange rate is pro-cyclical; it leads to a rise in demand and output precisely at the time that world demand tilts towards the home good. Relative to the flexible wage economy, it means that there are 'output gaps'; i.e. employment is above the natural rate in periods of high demand, and below the natural rate under low demand. But at the same time, the fixed exchange rate ensures that employment and output do respond in the right direction, compared with the benchmark optimum.

3.3 Welfare Trade-Off

Hence, there is a welfare trade-off between fixed and flexible exchange rates. The appendix shows that the impact of monetary policy is felt only with respect to the expected utility of consumption (the expected utility of employment is independent of monetary policy). Therefore, the welfare comparison of fixed and flexible exchange rates turns on the difference for expected log consumption. From equation (2.12), without risk-sharing $\ln(C)$ is proportional to

$$\ln\left[\frac{M}{W}\right]^{(1-\alpha)\gamma}\left[\frac{M^*}{W^*}\right]^{(1-\alpha)(1-\gamma)} . \tag{3.4}$$

There are two differences between fixed and flexible exchange rates in their impact on the expected value (3.4). First, when money supplies are responsive to the shifting in preference weights, then the expected value of (3.4) is higher, so fixed exchange rates tend to do better. But at the same time, greater volatility in the money supply will raise the wage set by home and foreign consumers (c.f. 2.13), lowering average employment and thus reducing the expected value (3.4). The net effect depends on the elasticity of labor supply. With a low value of ψ, the wage is quite insensitive to monetary volatility, and the first effect dominates. But when ψ is high, the wage increases a lot in response to monetary volatility, and the second effect dominates.

Figure 1 illustrates the trade-off, assuming a distribution of γ with standard deviation 0.1, α = 0.3, and η = 0.1. In this example, fixed exchange rates dominate flexible exchange rates (expected log consumption is higher) whenever the elasticity of labor supply is above 0.96. This elasticity is well within the range used in calibrated general equilibrium models (e.g. Backus, Kydland and Kehoe 1995).

3.4 Alternative Exchange Rate Rules

Unilateral Peg

From expression (3.4) it is apparent that the way in which the exchange rate is fixed is not important for the results. Say that the foreign country kept M^* constant. Then to keep the exchange fixed, the home country would need to use the rule $M = \gamma/(1-\gamma)M_0$. In this case, only the first element in (3.4) would be affected. But it is easy to show that utility (of both home *and* foreign countries) would be higher under fixed exchange rates, if ψ was low enough. Thus, even a unilateral peg may be in a country's interest.

Price Stability Rule

We have defined flexible exchange rates as a policy, which keeps the money supply in each country constant. An alternative definition would be a policy rule designed to keep the price of the domestic good constant (a price stability rule). How would this alternative definition change our results? Without risk-sharing, there is no difference at all, since a constant money supply implies a constant price of the domestic good. In the case of full risk-sharing, however, a price stability rule would require an active monetary response to prevent prices from adjusting to demand shocks. From Section 2, it is easy to show that the following monetary rules will maintain price stability under full risk-sharing:

$$M = \gamma^{-1} M_0, \quad M^* = (1-\gamma)^{-1} M_0.$$

With these rules, the terms of trade would adjust through nominal exchange rate movement rather than domestic price adjustment. But since domestic prices do not adjust, neither does employment or output. A price stability rule under full risk-sharing would fully stabilize output.[9] But this may still be welfare-dominated by a fixed exchange rate, for the same reasons that we have described above. It is not optimal to stabilize output in response to demand shocks. For a high labor supply elasticity, both countries would still prefer a fixed exchange rate.

Section 4: Optimal Monetary Rules

Neither a fixed nor flexible exchange rate policy as described above is likely to maximize consumer welfare. Here we investigate 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.[10]

4.1 Full Risk-Sharing

With full risk-sharing, the rule maximizes expected utility taking into account the wage setting equation (2.7). The appendix describes the derivation of the rule:

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

9 But this rule would *not* replicate the flexible wage outcome under full risk-sharing, since under flexible wages and full risk-sharing, output would respond to demand shocks. In the next section, we show that the optimal rule under full risk-sharing does sustain the flexible wage outcome.

10 A discretionary monetary policy rule is not well defined in this setting, since, as shown in Corsetti and Pesenti (2001a), and Tille (2000), the monetary authorities in any individual country have a continuing incentive to precipitate a surprise *deflation*, thereby reducing home country output and raising the terms of trade. Since, in a rational expectations equilibrium, we cannot have a surprise deflation, then there is no lower bound on the money stock. To avoid these problems, we restrict our attention to monetary policy rules chosen under commitment.

Under full risk-sharing, the optimal monetary rule for each country is counter-cyclical. Since with sticky nominal wages and full risk-sharing, employment responds to a demand shock by more than is efficient, the monetary policy rule is used to dampen the response. The rule (4.1) in fact replicates the benchmark optimum, (equivalent to the flexible wage outcome with full risk-sharing). Output and the terms of trade respond to a demand shock as in (2.2) and (2.3). Under full risk-sharing, the only deviation from the benchmark optimum is the presence of nominal wage rigidity.

As a corollary, the optimal monetary rule under full risk-sharing must create exchange rate volatility. Any passive monetary rule (for instance the flexible exchange rate policy of constant money supplies from Section 3) would involve no exchange rate volatility at all in this economy. An optimal monetary rule produces the exchange rate given by

$$S = \left[\frac{1-\gamma}{\gamma}\right]^{\frac{\psi}{1+\psi}}. \tag{4.2}$$

With a perfectly elastic labor supply, the exchange rate should be fixed, and monetary policy need not respond to demand shocks at all.

4.2 No Risk-Sharing

The optimal monetary rule without risk-sharing is designed to increase output in face of a positive demand shock. The monetary rule is pro-cyclical:

$$M = \gamma^{\frac{1}{1+\psi}} M_0, \quad M^* = (1-\gamma)^{\frac{1}{1+\psi}} M_0 . \tag{4.3}$$

So monetary policy is expansionary in 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. From a welfare view, exchange rate volatility under flexible exchange rates is excessive.

The exchange rate resulting from this rule is the same as (4.2). Again, the higher is the elasticity of labor supply, the closer the optimal monetary policy rule approximates a fixed exchange rate. But unlike the economy with full risk-sharing, a fixed exchange rate is a non-trivial rule here since it requires an active response of money to demand shocks. On the other hand, as the elasticity of labor supply falls, the monetary policy more closely resembles the flexible exchange rate policy.

Unlike the optimal rule under full risk-sharing, in this case the monetary rule cannot achieve the benchmark optimum. This is easy to see from equation (2.12). No matter how a monetary rule is designed, it can affect only the realizations of employment/output, since monetary policy only works by reacting to a demand shock faster than nominal wages can react. It cannot facilitate consumption risk-sharing.

Finally, we note that 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.[11]

Section 5: Discussion and Extensions

The model is highly simplified, offering the most transparent framework within which to compare exchange rate policies. How sensitive are the results to the particular specification of the model? Many variations in the specification would not matter. For instance if instead of consumption, output entered money demand (perhaps 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 2000a). If instead prices were sticky in our setting, the exchange rate equation (2.11) would still hold, and the same welfare results would hold, since domestic output would still be pinned down by monetary policy under flexible exchange rates, and would respond positively to demand shocks under fixed exchange rates.

Many other extensions of the model could be undertaken. We could introduce different types of shocks; for instance technology shocks could be allowed for. But in this model the exchange rate regime plays no role at all in handling technology shocks. Intuitively, a domestic technology shock will generate a fall in prices in exact proportion to the shock, and does not require any response in the exchange rate. More generally, it would be important in a more fully specified model to quantitatively assess the extent to which fixed exchange rates may be desirable. To do this, we would need to allow for more risk aversion than in log utility, and to construct a fully dynamic model with limited asset trade, such as trade in non-contingent international bonds. Though this would complicate the analysis by introducing current account dynamics into consideration, it is unlikely to eliminate the basic welfare conclusions.

Section 6: Conclusions

Our results throw some doubt on the conventional defence of flexible exchange rates. The model is not contrived towards obtaining these results. There are no problems of monetary policy credibility that might increase the desirability of a ‘hard peg’, and no distortions in the financial system that might limit the benefits of exchange rate adjustment (Krugman 1999). In addition, there is complete ‘pass-through’ of the exchange rate to domestic prices of imports, so the traditional ‘expenditure-switching’ role of the exchange rate is still operative. Rather, 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. The traditional argument for flexible exchange rates relies on undoing the second distortion. While flexible exchange rates in our model do a perfect job of eliminating this distortion, there is no guarantee that eliminating one distortion makes you better off.

11 For a similar result, see Obstfeld and Rogoff (2000b).

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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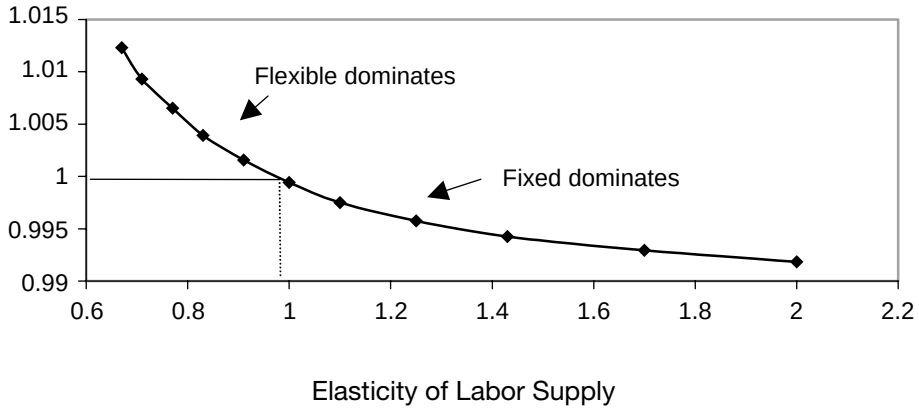
Figure 1: Ratio of E(ln(C))



Appendix

A. Solving the Model

Full Risk-Sharing

The model with full ex-ante risk-sharing can be described by the following equations:

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

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

$$C=C^* \tag{A.3}$$

$$\frac{M}{P} = \chi C \tag{A.4}$$

$$\frac{M^*}{P^*} = \chi C^* \tag{A.5}$$

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

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

$$H^{1-\alpha} = \gamma\frac{2PC}{P_1} \tag{A.8}$$

$$H^{*1-\alpha} = (1-\gamma)\frac{2PC}{SP_2^*} \tag{A.9}$$

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 $\sigma=\{\gamma,M,M^*\}$ represents the realization of demand and monetary shocks. From (A.8) and (A.9) we obtain equation (1.13) of the text. Substituting back into either (A.8) or (A.9) gives us (2.1) of the text (which, recall, holds under full risk-sharing). Equations (A.1), (A.4) and (A.8) give the employment solution

(2.4) of the text, and a (A.2), (A.5), and (A.9) give the solution for foreign employment. The exchange rate solution (2.6) is obtained from (2.1) of the text, (A.1), (A.2), and the solutions for employment. Finally, the wage, (2.7) (and the counterpart for the foreign country), is obtained by simply substituting the employment solutions into (A.6) and (A.7), and using (A.4) and (A.5).

No Risk-Sharing

Without risk-sharing, the model can be described by the equations:

$$P_1\varepsilon(1-\alpha)H^{-\alpha} = W \tag{A.10}$$

$$P_2^*\ \varepsilon(1-\alpha)H^{*-\alpha} = W^* \tag{A.11}$$

$$PC=P_1H^{(1-\alpha)} \tag{A.12}$$

$$\frac{M}{P} = \chi C \tag{A.13}$$

$$\frac{M^*}{P^*} = \chi C^* \tag{A.14}$$

$$W = \frac{\rho}{\rho-1}\eta\frac{EH^{1+\psi}}{E(\frac{H}{PC})} \tag{A.15}$$

$$W^* = \frac{\rho}{\rho-1}\eta\frac{EH^{*1+\psi}}{E(\frac{H^*}{P^*C^*})} \tag{A.16}$$

$$H^{1-\alpha} = \gamma\frac{P(C+C^*)}{P_1} \tag{A.17}$$

$$H^{*1-\alpha} = (1-\gamma)\frac{P(C+C^*)}{SP_2^*} \tag{A.18}$$

Again, these nine equations can be solved for the nine variables:

$$W, W^*,\ H(\sigma), H^*(\sigma), P_1(\sigma), P_2^*(\sigma), S(\sigma), C(\sigma), C^*(\sigma)\ .$$

Equation (2.1) follows as before. Substituting equation (2.1) into equation (A.12) gives (2.12) of the text. Home employment is obtained by using (A.10) and (A.12), and similarly for foreign employment. The nominal exchange rate (2.11) is obtained by using (A.10), (A.11), equation (2.1), (2.8) (and its foreign counterpart), and the money market clearing conditions (A.13) and (A.14). Finally the home and foreign

wage is obtained by substituting for employment and the money market clearing conditions in equations (A.16) and (A.17).

B. Optimal Monetary Policy

Full Risk-Sharing

We wish to evaluate expected utility under full risk-sharing. Note that employment, from equations (2.4) and (2.7), is given by

$$H = \frac{2(1-\alpha)\varepsilon}{\chi}\frac{\gamma M}{W} = \left[\frac{2(1-\alpha)}{\eta}\right]^{\frac{1}{1+\psi}} \cdot \frac{(\gamma M)(E\gamma)^{\frac{1}{1+\psi}}}{(E(\gamma M)^{1+\psi})^{\frac{1}{1+\psi}}} \quad . \tag{B.1}$$

Then consumption is given by:

$$C = \left(\frac{H^{1-\alpha}}{\gamma}\right)^{\gamma}\left(\frac{H^{*(1-\alpha)}}{(1-\gamma)}\right)^{1-\gamma} =$$
$$\Phi\gamma^{-\gamma}(1-\gamma)^{-(1-\gamma)}\left[\frac{(\gamma M)(E\gamma)^{\frac{1}{1+\psi}}}{(E(\gamma M)^{1+\psi})^{\frac{1}{1+\psi}}}\right]^{(1-\alpha)\gamma}\left[\frac{((1-\gamma)M^{*})(E(1-\gamma))^{\frac{1}{1+\psi}}}{(E((1-\gamma)M)^{1+\psi})^{\frac{1}{1+\psi}}}\right]^{(1-\alpha)(1-\gamma)} \tag{B.2}$$

where $\Phi = \left[\frac{2(1-\alpha)}{\eta}\right]^{\frac{(1-\alpha)}{1+\psi}}$.

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. The evaluation of expected utility for the home country monetary authority when choosing optimal monetary policy with commitment, with full risk-sharing, is given by:

$$EU = E\ln(C) - \frac{\eta}{1+\psi}EH^{1+\psi}$$
$$= E(1-\alpha)\gamma\ln\left[\frac{(\gamma M)E(\gamma)^{\frac{1}{1+\psi}}}{(E(\gamma M)^{1+\psi})^{\frac{1}{1+\psi}}}\right] - E(1-\alpha)(1-\gamma)\ln\left[\frac{((1-\gamma)M^{*})E(1-\gamma)^{\frac{1}{1+\psi}}}{(E((1-\gamma)M)^{1+\psi})^{\frac{1}{1+\psi}}}\right] \tag{B.3}$$

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

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 (B.1) into $\frac{\eta}{1+\psi}EH^{(1+\psi)}$, and the result is independent of the monetary rule.)

Now, without loss of generality, assume γ takes on a finite set of realizations $\gamma = \{\gamma_1..\gamma_N\}$ with probabilities $\{\pi_1..\pi_N\}$. Then the first order condition for the monetary authority maximizing (B.3) is

$$\frac{\gamma_i}{M_i} = \frac{E(\gamma)}{M_i}\frac{(\gamma_i M_i)^{1+\psi}}{E(\gamma M)^{(1+\psi)}} \ . \tag{B.4}$$

Rearranging this gives expression (4.1) of the text for the home country. The expression for the foreign country can be similarly obtained. Note that it is apparent from examining the expression for expected utility that there are no gains from international policy co-ordination here.

No Risk-Sharing

Without risk-sharing, employment may be written as

$$H = \left[\frac{(1-\alpha)}{\eta}\right]^{\frac{1}{1+\psi}} \frac{M}{(E(M)^{1+\psi})^{\frac{1}{1+\psi}}} \ . \tag{B.5}$$

and consumption as

$$\begin{aligned} C &= \gamma\left(\frac{H^{1-\alpha}}{\gamma}\right)^{\gamma}\left(\frac{H^{*(1-\alpha)}}{(1-\gamma)}\right)^{(1-\gamma)} \\ &= \Theta\left(\frac{\gamma}{1-\gamma}\right)^{1-\gamma}\left[\frac{M}{(E(M)^{1+\psi})^{\frac{1}{1+\psi}}}\right]^{(1-\alpha)\gamma}\left[\frac{M^*}{(E(M^*)^{1+\psi})^{\frac{1}{1+\psi}}}\right]^{(1-\alpha)(1-\gamma)} \ . \end{aligned} \tag{B.6}$$

where $\Theta = \left[\frac{(1-\alpha)}{\eta}\right]^{\frac{(1-\alpha)}{1+\psi}}$. Expected utility for the monetary authority, when choosing policy with full commitment, is given by

$$\begin{aligned} EU &= E(\ln C - \frac{\eta}{1+\psi} H^{1+\psi}) \\ &= E(1-\alpha)\gamma \ln\left[\frac{M}{(E(M)^{1+\psi})^{\frac{1}{1+\psi}}}\right] + E(1-\alpha)(1-\gamma)\ln\left[\frac{M^*}{(E(M^*)^{1+\psi})^{\frac{1}{1+\psi}}}\right] \\ &+ E\ln(\Theta\left(\frac{\gamma}{1-\gamma}\right)^{1-\gamma}) - \frac{(1-\alpha)}{1+\psi}. \end{aligned} \tag{B.7}$$

Again, it is easy to see from (B.5) that the disutility of employment is independent of money. Now, using the same assumption about the distribution of demand shocks, the first order condition for maximizing (B.7) is

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

Rearranging gives (4.3) of the text. Again, it is clear that there are no gains to international monetary policy co-ordination.

Note that, using the monetary rules defined as flexible and fixed exchange rates from Section 3 of the text, we can arrange (B.7) 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 ψ=0, with a symmetric distribution for γ 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.