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International consumption risk sharing and fiscal policy

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Abstract

The present paper uses a two-country stochastic general equilibrium model assuming incomplete financial markets and non-separable consumer preferences to show how optimal fiscal responses to an asymmetric productivity shock can mitigate the worsening of the international consumption risk sharing following the shock. It also identifies the conditions under which the gains from fiscal stabilization can be improved by cooperative responses.

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1. Introduction

A large majority of empirical studies which evaluate the correlations between the rate of consumption growth among countries or between an individual-country consumption growth rate and the world consumption growth rate show that the international consumption risk due to economic fluctuations is unequally shared across countries[1]. The incomplete structure of financial markets, imperfections in international trade (shipping costs, biased preferences, sticky wages or prices) and non-separable consumer preferences are among the possible reasons for the lack of risk sharing suggested by empirical research.

This imperfection raises the question of whether a welfare maximizing fiscal reaction to a shock can also have desirable effects on the international consumption risk sharing. This question is especially for macroeconomic policies in countries with fixed relative wages which are hit by idiosyncratic shocks inducing consumption asymmetries across countries. Obstfeld and Rogoff (2002) consider this question by introducing imperfect international consumption risk sharing into the stochastic version of Obstfeld and Rogoff (1995). However, the authors exclude fiscal policy issues. Since monetary instruments have turned out to be less efficient in several countries due to the interest rates that are already close to zero, several researchers have attempted to extend Obstfeld and Rogoff (2002) to analyze fiscal policy, but few papers study the link between fiscal policy and international consumption risk sharing. Lombardo and Sutherland (2004) analyze the relation between international consumption risk sharing and fiscal and monetary policy by relating the relative prices of assets to relative real disposable income. Similarly, Andersen and Spange (2006) and Spange (2007) also assume separable preferences but exclude any possibility of asset trading in order to capture the imperfect risk sharing and introduce a link between risk sharing and fiscal policy through distortionary income taxes.

Similarly to Andersen and Spange (2006), the present paper assumes passive monetary policy and concentrates on the effect of fiscal policy on international consumption risk sharing with build-in responses to shocks. It excludes the possibility of risk diversification through financial markets. In contrast to Andersen and Spange (2006), we assume non-separable consumption preferences for traded and non-traded goods and we introduce fiscal policy through a cash-in-advance constraint which is particularly convenient for the analysis of a tax-financed public spending. Our model is close to Obstfeld and Rogoff (2002) in all other aspects. In contrast to the latter, we restrict our attention to the case of country-specific shocks, since common shocks do not alter the international consumption risk sharing pattern.

We find that under wage rigidity and non unitary coefficient of relative risk aversion, fiscal reactions against country-specific productivity shocks can mitigate the deterioration of international consumption risk sharing following the shock. Indeed, the optimal responses to an asymmetric shock determine a variation of the terms of trade which reduces the transfer of tradable goods between the countries. Hence they offer a kind of insurance against the worsening of the risk sharing across the countries. However, this insurance is not complete. Indeed, if the asymmetric shock leads to a deviation from perfect international consumption risk sharing, the fiscal reactions do not allow to return to the initial situation. The partial insurance offered by non cooperative responses to the shock is not necessarily improved by cooperation between fiscal authorities. Indeed, the terms of trade variation necessary for maximum welfare, which is the main purpose of the optimal fiscal cooperative policies, can

[1] See Canova (1996), Lewis (1996), Olivei (2000), Corsetti et al. (2008) and Hoffman (2008) among others.

be inconsistent with the one necessary to improve the consumption risk sharing more than the non cooperative policy.

The paper is organized as follows. Section 2 describes the technical details of the setup. Section 3 defines the deviations from the flexible wage welfare and from the perfect international consumption risk sharing due to an asymmetric productivity shock in the case of preset wages. This allows to see how fiscal policy can influence these deviations. Section 4 explores the interaction between the welfare efficiency of fiscal policy and the international consumption risk sharing. Section 5 concludes.

2. The model

The model keeps the Obstfeld and Rogoff structure (2002) for the supply side, but it differs for the demand side by introducing public spending through cash-in-advance (CIA) constraint.

2.1 Production

The world consists of two equally sized identical countries, Home and Foreign. Each country produces traded and non-traded goods with labor as the only input, according to CES functions where the elasticity of substitution ϕ between different types of labor employed is the same across the two sectors. At home, a firm i's demand for labor of type j is given by $L_{i,j} = \left[W_j / W\right]^{-\phi} Y_{i,j}$. A representative foreign firm has a similar demand for labor.

2.2. Individual Preferences and Private Consumption

The preferences of a representative home household i is defined by the following expected utility function which is similar in the foreign country :

$$U_i = E\left[\frac{C_i^{1-\rho}}{1-\rho} - KL_i\right] \tag{1}$$

where $\rho \succ 0$ is the constant coefficient of relative risk aversion and E is the expectations operator. The utility depends on work effort L_i and consumption bundle C_i of non-traded as well as home and foreign traded goods. The aggregate consumption C is of Cobb-Douglas form and depends on traded and non traded goods, C_T and C_N, respectively. The traded goods consumption C_T has the same form and depends on home and foreign traded goods, C_H and C_F, respectively. The corresponding price indexes are $P = P_T^{\gamma} P_N^{1-\gamma}$ and $P_T = P_H^{1/2} P_F^{1/2}$ where γ is the share of traded goods.

2.3 Fiscal policy

Home and foreign public spending (G and G^*) which have the same structure as the private consumptions are financed by lump sum taxes (T and T^*). We assume that the fiscal authorities react to an asymmetric productivity shock according to the following contingency rules where lowercase letters denote logs and a tilde over any variable represents the deviation of that variable from its expected value while an asterisk denote foreign variables:

$$\tilde{g} = \delta_d \tilde{\kappa}_d \text{ and } \tilde{g}^* = -\delta_d^* \tilde{\kappa}_d \tag{2}$$

As in Corsetti and Pesenti (2001), g and g^* are the logs of the ratio between the public spending and the private consumption in both countries and κ_d is the log of the asymmetric shock defined as $\kappa_d = (\kappa - \kappa^*)/2$ where κ (κ^*) represents the log of K (K^*). Finally, δ_d and δ_d^* represent the home and foreign coefficients in the fiscal policy feedback rules.

2.4 The cash-in-advance constraint

In contrast to Obstfeld and Rogoff (2002), we introduce money via a cash-in-advance (CIA) constraint on private agents who need cash to carry out consumption and tax payments. Aggregating the individual CIA constraint across home (foreign) agents and combining with the home (foreign) government budget constraint yields home and foreign money demand M and M^* as follows:

$$M = PC + PT \quad \text{and} \quad M^* = P^*C^* + P^*T^* \tag{3}$$

Equation (3) implies that government spending influences the overall price index and therefore the exchange rate through its direct impact on money demand for given money supplies.

2.5 Wage and Price Setting

Goods prices are flexible but wages are fixed a period in advance by workers who supply the amount of labor that firms demand at the posted nominal wage. The optimal home preset wage below which is the same for all workers follows from the maximization of (1) with respect to wages, taking account of labor demand under the household budget constraint:

$$W = \frac{\phi}{\phi - 1} \frac{E(KL)}{E[(L/P)C^{-\rho}]} \tag{4}$$

The optimal preset foreign wage is defined similarly.

Profit maximization implies that prices are a mark-up over wages in each country: $\phi/(\phi-1)$

$P_H = P_N = (\theta/\theta - 1)W$ and $P_F^* = P_N^* = (\theta/\theta - 1)W^*$. Assuming the law of one price for traded goods and the same preferences in both countries leads to the purchasing power parity where S is the nominal exchange rate: $P_T = SP_T^*$. Given the Cobb-Douglas form of P and P_T and the same elasticity of substitution θ between goods across the world, the terms of trade are given by $Q = SP_F^*/P_H = SW^*/W$.

2.6 Output Market Clearing

Home and foreign output market clearing of traded goods where the demand in each country is half of the total demand implies $P_H Y_H = P_F Y_F^*$. Moreover, the assumption of constant real income shares and isoelastic preferences over traded goods implies: $C_T + G_T = C_T^* + G_T^*$. Then, given the Cobb-Douglas forms for the overall price index, it turns out that total nominal spending measured in units of tradables in both countries, Z and Z^*, are equal.

We assume that the ratio between public spending and private consumption is fixed in a non stochastic equilibrium. Therefore, home public spending constitutes a fraction k of the total home spending measured in tradables: $PG = kP_T Z$. This implies:

$$C = (1-k)\frac{P_T}{P} Z \tag{5}$$

A similar expression holds for the foreign country.

3. Welfare and international consumption risk sharing

A productivity shock leads to a deviation of the welfare from its flexible-wage level under wage rigidity. The fiscal authorities are assumed to aim at reducing or eliminating this gap by manipulating the terms of trade through public spending, which, in turn, affects international consumption risk sharing.

3.1 The welfare cost of wage rigidity

Following Obstfeld and Rogoff (2002), we express home welfare under sticky wages EU in terms of the expected flexible-wage welfare $E\overline{U}$ which is considered as the benchmark case, by applying a second order approximation to the individual utility function. For this, we introduce the expected terms of trade Eq and total spending Ez defined in appendix B, together with the flexible wage level of expected home utility given in appendix A, into the utility under fixed wages (A4) to get:

$$EU = E\overline{U} \exp[(1-\rho)\Lambda] \tag{6}$$

where Λ is defined as follows:

$$\Lambda = \frac{1}{\rho}\lambda - \frac{1}{2}\left(\frac{\sigma_{\kappa_d}^2}{\rho^2} + \sigma_z^2\right) - \frac{1-(1-\rho)(1-\gamma)^2}{8\rho}\sigma_s^2 - \frac{1}{2\rho}\sigma_{\kappa_d s} - \frac{(1-\gamma)}{a}\left(\frac{\rho}{2}\sigma_{sz} + \sigma_{\kappa_d z}\right) \tag{7}$$

with $\lambda = \dfrac{(1-\rho)\gamma[\gamma/2 + \rho(1-\gamma)]}{\rho a^2}\sigma_{\kappa_d}^2$

The welfare component Λ depends, like its foreign analogue Λ^*, on the second moments of the variables and it may bring about a welfare cost due to wage rigidity since a non zero value of Λ creates a deviation from the flexible wage level of utility.

3.2 The impact of fiscal policy on welfare

Fiscal spending affects welfare through its impact on the second moments given in (7). This impact results from the effect of fiscal policy on total spending and the exchange rate through the money demand. In order to see this, we start by log-linearizing the money demand (3) where g is an approximation of the ratio between public spending and private consumption and combine with the log-linear version of (4). Adding up the resulting equation with its foreign analogue and introducing the prices as markups over wages yields the following expression where the constant parameters are omitted, remembering that $z = z^*$ and assuming passive monetary policy:

$$\tilde{z} = -0{,}5(\tilde{g} + \tilde{g}^*) \tag{8}$$

Again, we log-linearize the money demand and combine it with the log-linear version of (4).We subtract the result from its foreign counterpart taking account of the purchasing power parity for the traded goods and assuming passive monetary policy. This yields:

$$\tilde{s} = -(\tilde{g} - \tilde{g}^*) \tag{9}$$

The fiscal rules given in (2) together with the definitions of $\tilde{s}$ and $\tilde{z}$ defined in (8) and (9) allow to express the second moments in (7) as functions of the fiscal policy coefficients:

$$\sigma_z^2 = \sigma_{z^*}^2 = \tfrac{1}{4}[(\delta_d - \delta_d^*)^2\sigma_{\kappa_d}^2]; \sigma_{sz} = \sigma_{sz^*} = \tfrac{1}{2}(\delta_d^2 - \delta_d^{*2})\sigma_{\kappa_d}^2;\ \sigma_{\kappa_d z} = \sigma_{\kappa_d z^*} = -\tfrac{1}{2}(\delta_d - \delta_d^*)\sigma_{\kappa_d}^2 \tag{10a}$$

$$\sigma_s^2 = (\delta_d + \delta_d^*)^2\sigma_{\kappa_d}^2;\ \sigma_{\kappa_d s} = -(\delta_d + \delta_d^*)\sigma_{\kappa_d}^2 \tag{10b}$$

The optimization of Λ and Λ^* after introducing (10a) and (10b) allows to determine the optimal fiscal policy. Once the latter is known, one can analyze its impact on international risk sharing.

3.3 The international consumption risk sharing

The international risk sharing in tradable goods consumption is efficient if the following marginal utilities of home and foreign traded goods are equalized across countries.

$$\frac{\partial U}{\partial C_T} = \left(\frac{SW^*}{W}\right)^{\frac{(1-\gamma)(1-\rho)}{2}} Z^{-\rho}(1-k)^{-\rho} \text{ and } \frac{\partial U^*}{\partial C_T^*} = \left(\frac{SW^*}{W}\right)^{\frac{-(1-\gamma)(1-\rho)}{2}} Z^{*-\rho}(1-k)^{-\rho} \tag{11}$$

Introducing C defined in (5) and the ratio C_N/C_T along the markup prices in the derivative of home and foreign utility with respect to C_T expresses home marginal utility as in (11). Following the same steps for the foreign country yields the foreign marginal utility as in (11).

Given that $Z = Z^*$, the equality $\partial U/\partial C_T = \partial U^*/\partial C_T^*$ which implies perfect international consumption risk sharing is achieved when tradable and non-tradable goods are separable in the consumption bundle ($\rho = 1$), when all goods are tradable ($\gamma = 1$) or when the terms of trade SP_F/P_H are equal to one implying $SW^*/W = 1$.

4. The impact of optimal fiscal policy on international consumption risk sharing

We assume that the initial state of the economy is characterized by perfect consumption risk sharing and welfare is equal to its flexible-wage level in both countries regardless of the value of ρ. Then, an asymmetric productivity shock increases the marginal disutility of labor at home and decreases it in the foreign country. This induces welfare losses and deteriorates international consumption risk sharing at the same time. Fiscal responses to the shock can mitigate this deterioration at least partially. The size of the effect on risk sharing depends on whether the fiscal authorities in both countries decide or not to cooperate.

4.1 Non cooperative Fiscal rules as an insurance for international consumption risk sharing

Since wages are fixed, restoring the optimality condition between consumption and leisure in each country following an asymmetric shock requires an increase (decrease) in home (foreign) consumption of tradable and non-tradable goods. The resulting higher (lower) marginal utility of tradable goods consumption at home (abroad) requires a home currency depreciation when $\rho < 1$ and an appreciation when $\rho > 1$ in order to satisfy equation (11). This creates a deviation from the perfect risk sharing scheme since it causes a gap between the marginal utilities of home and foreign tradable goods. The extent of the mitigation effect of the fiscal policy on the worsening of risk sharing depends on the nature of the optimal non cooperative fiscal reaction to the productivity shock.

In the absence of cooperation, home and foreign fiscal authorities determine the optimal reaction coefficients, δ_d^N and $\delta_d^{N^*}$, by minimizing the gap between the fixed and flexible wage welfare defined by Λ given in (7) and its foreign analogue Λ^* after introducing (10a) and (10b):

$$\delta_d^N = \delta_d^{*N} = \frac{a + \rho(1-\gamma)}{a - (1-\gamma)(a - a^2 - \rho^2)} \succ 0 \qquad (12)$$

where $a = 1 - (1-\rho)(1-\gamma)$.

According to (12), the optimal Nash responses to asymmetric shocks are positive and depend on the degree of openness γ as long as $\rho \neq 1$. They take a unit value regardless of the value of γ when $\rho = 1$. They decrease when the risk aversion ρ increases.

When $\rho \neq 1$, the welfare maximizing optimal fiscal reaction has a positive effect on the international consumption risk sharing through its effects on the exchange rate. Indeed, the positive fiscal responses to the asymmetric shock imply higher taxes at home and lower abroad, which implies higher (lower) home (foreign) money demand. This induces an appreciation of the home currency. On the other hand, the fall in home consumption of traded goods lowers the money demand in the home country which brings about a depreciation of the home currency. When the second effect dominates the first so that we have a net depreciation of the home currency, the ratio of home marginal utility to foreign is higher than one if $\rho < 1$ and lower if $\rho > 1$. The inverse is true for the net appreciation case. This helps restore the equality given in (11). Therefore, the optimal fiscal reaction mitigates the deviation from perfect risk sharing while maximizing welfare.

Because of the positive effect of the fiscal reaction on risk sharing, the optimal fiscal policy can be seen as an insurance against the deterioration of the international consumption risk sharing following an asymmetric shock when financial markets cannot, for some reason, achieve this task. However, this insurance is not complete.

The inability of the fiscal policy to restore the perfect risk sharing is not entirely due to wage rigidity. Indeed, the shock worsens the risk sharing even in the flexible wage case without fiscal policy, which implies that the deterioration of the risk sharing can not be absorbed by simply pushing wages to their post-shock optimal level. This can be seen by comparing equations (11) and (A6) in appendix A. According the equality between the marginal utilities defined in (11), full risk sharing requires a unit value of the terms of trade as long as $\rho \neq 1$ or $\gamma \neq 1$. However, it is obvious from equation (A6) that this cannot be achieved under flexible wages unless the shocks are symmetric across countries implying that $K = K^*$.

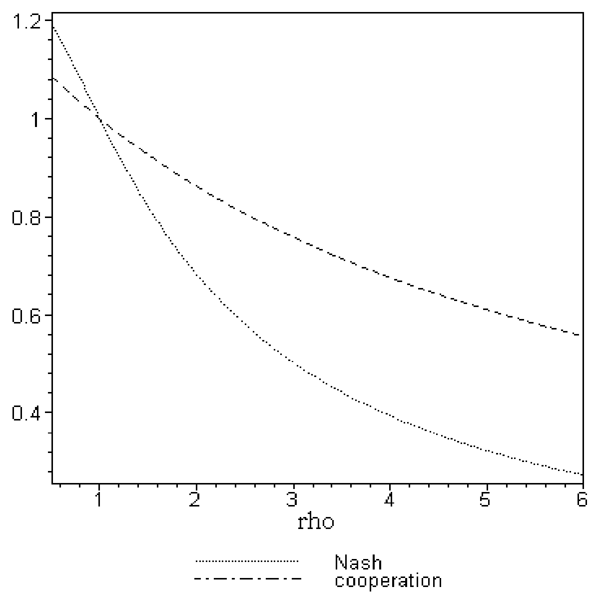
4.2 The effects of cooperative fiscal policy

The fiscal authorities which react cooperatively to an asymmetric shock aim at minimizing the equally weighed average of Λ given in (7) and its foreign analogue Λ^* after introducing (10a) and (10b). This yields the following policy coefficients:

$$\delta_d^C = \delta_d^{*C} = \frac{1}{1-(1-\rho)(1-\gamma)^2} \succ 0 \tag{23}$$

Similarly to the Nash case, the optimal cooperative responses to asymmetric shocks are positive and they increase as the coefficient of risk aversion falls. They are unitary when $\rho = 1$. Figure 1 allows to compare the policy coefficients on the y-axis under both regimes for various degrees of risk aversion assuming $\gamma = 0{,}6$.

Fig. 1 optimal fiscal reaction coefficients



According to Figure 1 cooperative responses are higher than Nash responses when ρ>1, lower when $\rho < 1$ and are both equal to one when $\rho = 1$.

Internalizing the cross-border spillover effects through policy cooperation does not necessarily imply gains on the improvement of risk sharing following the shock. Indeed, the terms of trade adjustment necessary to improve welfare through cooperative policy may be inconsistent with the one that allows to improve the risk sharing more than under non cooperative policy.

Table 1 first gives the deviation of the ratio of home consumption of tradables to foreign tradable consumption (UmC_T / UmC_T^*) from the unit value (implying perfect risk sharing across countries) depending on the impact of the optimal policy on the exchange rate. Then, it compares that deviation to the one that results from policy cooperation.

Table 1 The effect of fiscal policy on the ratio between home and foreign marginal utilities of tradable goods

Exchange rate	Non cooperative fiscal policy		Cooperative fiscal policy	
	$\rho < 1$	$\rho > 1$	$\rho < 1$	$\rho > 1$
depreciation	$\left(\frac{UmC_T}{UmC_T^*}\right)_N > 1$	$\left(\frac{UmC_T}{UmC_T^*}\right)_N < 1$	$\left(\frac{UmC_T}{UmC_T^*}\right)_C > \left(\frac{UmC_T}{UmC_T^*}\right)_N$	$\left(\frac{UmC_T}{UmC_T^*}\right)_C < \left(\frac{UmC_T}{UmC_T^*}\right)_N$
appreciation	$\left(\frac{UmC_T}{UmC_T^*}\right)_N < 1$	$\left(\frac{UmC_T}{UmC_T^*}\right)_N > 1$	$\left(\frac{UmC_T}{UmC_T^*}\right)_C < \left(\frac{UmC_T}{UmC_T^*}\right)_N$	$\left(\frac{UmC_T}{UmC_T^*}\right)_C > \left(\frac{UmC_T}{UmC_T^*}\right)_N$

Figure 1 shows that when ρ>1, the optimal fiscal reaction is higher than the one under Nash policy. This implies that taxes increase (fall) more at home (abroad) compared to the non cooperative case, which in turn leads to a stronger (lower) increase (fall) in home (foreign) money demand. Therefore cooperative fiscal response causes a higher home currency appreciation with respect to the Nash policy. Remember that the greater (lower) traded goods consumption at home (abroad) necessary to restore the optimality condition between consumption and leisure leads to a home currency depreciation following the shock. Therefore, the cooperative responses may lead either to a net home currency depreciation (dS>0) or appreciation (dS<0) just like the non cooperative reactions. However, if the net effect is a depreciation, it is lower under cooperation. When the net effect is an appreciation, it is higher in the cooperative case. Therefore the ratio between the domestic and foreign utilities of tradable goods under cooperation $(UmC_T/UmC_T^*)_C$ is lower than the one resulting from non cooperative policy $(UmC_T/UmC_T^*)_N$ in the case of a net depreciation and higher in the case of a net appreciation. This implies that in the first case, fiscal cooperation mitigates more the worsening of the risk sharing with respect to the non cooperative policy because $(UmC_T/UmC_T^*)_C$ is closer to unit value than $(UmC_T/UmC_T^*)_N$. In contrast, non cooperative policy has a better performance on the risk sharing when the net effect on the exchange rate is a net appreciation.

A similar logic implies that when $\rho<1$, non-cooperative fiscal policy leads to a lower home currency appreciation. Thus, if the net impact on the exchange rate is a depreciation, it is higher under cooperation. In contrast, the cooperative response implies a higher net appreciation with respect to Nash policy. This, in turn, implies that the ratio between the domestic and foreign utilities of tradable goods is higher under cooperative policy in the first case and lower in the second. Therefore, the risk sharing performance of the cooperative response is worse in the first case and better in the second compared to non-cooperative fiscal reaction.

5. Conclusion

We introduce imperfect international consumption risk-sharing in a two-country stochastic model through non-separable preferences and financial market imperfections (modeled simply as the absence of asset trading) as suggested by Lewis (1996) in order to study the interactions between the imperfect character of international risk sharing and optimal fiscal policy. Under wage rigidity, a welfare-maximizing fiscal reaction to an asymmetric productivity shock mitigates the deterioration of international risk sharing due to the shock by acting on the terms of trade. This implies a reallocation of traded goods consumption across the countries whose size depends on the impact of fiscal policy on the exchange rate through money demand.

Therefore fiscal cooperation does not necessarily lead to a higher international risk sharing compared to non-cooperative policy. In both cases, the international reallocation of traded goods consumption following the fiscal reaction is less efficient than the one that occurs in a complete financial markets environment. This suggests that increasing financial integration could contribute to the positive impact of fiscal policies on risk sharing. Another way to analyze the link between risk sharing and fiscal policy could consist of introducing investment and public debt, which would allow consumption smoothing within a country when international trade fails to do so.

The present setup can not evaluate explicitly the effect of a higher risk sharing on welfare similarly to the empirical research which generally tests only the deviations from the perfect consumption risk sharing[2]. The perspective developed recently by Flood and al. (2009) could

[2] Obstfeld and Rogoff (1996, p. 329-332) give an overview of the controversies on these tests.

be used to develop a welfare-based measure of the deviations from the perfect consumption risk sharing in an extension of the present setup.

Appendix A

Expected utility under fixed wages

Introducing the value of L derived from the goods market equilibrium condition $P_T Z = P_H L$ in the utility function (1) gives the following home expectation utility:

$$U_i = E\left[\frac{C^{1-\rho}-1}{1-\rho} - K\frac{P_T Z}{P_H}\right] \tag{A1}$$

where W, $P_T Z$ and P_H are respectively defined by the certainty equivalent of the preset wage (4), the relation between C and $P_T Z$ in (5) and the mark up equation $P_H = \theta(\theta-1)^{-1}W$

Introducing these values in (A1) leads to:

$$EU = E\left([(1-\rho)^{-1} - \Psi]C^{1-\rho}\right) \tag{A2}$$

where $\Psi = (\phi-1)(\theta-1)/\phi\theta$

The equation (A2) can be expressed in terms of total spending Z and terms of trade Q. For this, we introduce in (A2) the equation (8) in which $P_T / P = (SW^* / W)^{(1-\gamma)/2}$ $= Q^{(1-\gamma)/2}$ $P_T/P = (\varepsilon W^*/W)^{(1-\gamma)/2} = t^{(1-\gamma)/2}$. Then we get the following expression for the fixed home wage expected utility:

$$EU = E\left([(1-\rho)^{-1} - \Psi)](1-k)^{1-\rho} Z^{1-\rho} Q^{(1-\gamma)(1-\rho)/2}\right) \tag{A3}$$

where $Q = SP_F^* / P_H = SW^* / W$.

Taking the log of (A3) and assuming that all variables are log normally distributed, we express the expected sticky-wage utility at home in following exponential form:

$$EU = E\left((1-\rho)^{-1} - \Psi\right)(1-k)^{1-\rho}\exp[(1-\rho)Ez + \frac{(1-\rho)(1-\gamma)}{2}Eq + \frac{(1-\rho)^2}{2}\sigma_z^2$$

$$+\frac{(1-\rho)^2(1-\gamma)^2}{8}\sigma_s^2 + \frac{(1-\rho)^2(1-\gamma)}{2}\sigma_{sz}] \tag{A4}$$

where Ez and Eq are the expected log values of the private spending and terms of trade, σ_z^2 and σ_s^2 are the variances of the spending and the exchange rate in log, and σ_{sz} is the covariance between the log values of exchange rate and the spending.

The expression for foreign expected utility under fixed wages is of the same form, except that Eq and σ_{sz} which enter with opposite sign.

Utility under flexible Wages

As in the case of fixed wages, the consumption depends on the terms of trade and the spending.

To define the terms of trade, we consider the certain equivalent version of the optimal wage given in (4). We introduce in this equation the price index $P = P_H^{\gamma/2} SP_F^{*\gamma/2} P_N^{1-\gamma}$, the consumption $C = (1-k)P_H L / P$ given in (5) where $P_T Z = P_H L$ and the mark up equation $P_H = P_N = \theta(\theta-1)^{-1}W$. We deduce the following expression from the resulting equation and its foreign equivalent similarly defined:

$$\left(\frac{W}{SW^*}\right)^{\frac{(1-\rho)\gamma}{2}} = \frac{1}{\Psi}K(1-k)^\rho L^\rho \quad \text{and} \quad \left(\frac{SW^*}{W}\right)^{\frac{(1-\rho)\gamma}{2}} = \frac{1}{\Psi}K^*(1-k)^\rho L^{*\rho} \tag{A5}$$

Introducing the definition of traded goods price and the markup equation in the home resource constraint $P_T Z = P_H L$ and the foreign analogue leads to: $L = (SW^*/W)^{1/2} Z$ and

$L^* = (W / SW^*)^{1/2} Z^*$. Combining these values with (A5) yields the flexible wage level of terms of trade as follows:

$$\left(\frac{W}{SW^*}\right)^{1-(1-\rho)(1-\gamma)} = \frac{K}{K^*} \tag{A6}$$

Introducing (A6) into (A5) where L and L^* are defined above gives the flexible wage solution of total home spending as follows:

$$Z = \Psi^{1/\rho}\left(\frac{1}{\mathrm{KK}^*}\right)^{1/2\rho} \tag{A7}$$

Introducing (A6) and (A7) into (A3) leads to the following home utility under flexible wages where $a = 1-(1-\rho)(1-\gamma)$:

$$E\overline{U} = \left(\frac{1}{1-\rho} - \Psi\right)(1-k)\left(\frac{K}{K^*}\right)^{\frac{-(1-\rho)(1-\gamma)}{2a}}\left(\frac{1}{KK^*}\right)^{\frac{1-\rho}{2\rho}}\Psi^{\frac{1-\rho}{\rho}} \tag{A8}$$

The equation (A9) can be written in the following exponential form:

$$E\overline{U} = \left(\frac{1}{1-\rho} - \Psi\right)(1-k)\Psi^{\frac{1-\rho}{\rho}}\exp\left(\frac{(1-\rho)^2}{2\rho^2}\sigma^2_{\kappa_d} - \frac{1-\rho}{\rho}\lambda\right) \tag{A9}$$

where $\lambda = \dfrac{(1-\rho)\gamma[y/2+\rho(1-\gamma)]}{\rho a^2}\sigma^2_{\kappa_d}$ and $\sigma^2_{\kappa_d}$ is the variance of the asymmetric shock in log.

The foreign flexible wage expected utility is derived similarly.

Appendix B
Equilibrium values of the expected terms of trade and spending

To compute the expected values of the terms of trade and the total home demand one first has to rearrange the optimal wage (7). Start by dividing both sides of (7) by W, dividing and multiplying the left side of (7) by $\theta/(\theta-1)$ and using $P_H = \theta(\theta-1)^{-1}W$ inserting. Knowing that $P_T / P = (SW^*/W)^{(1-\gamma)/2}$ according to the Cobb-Douglas form of P_T, we insert (5) in the resulting equation, which leads to the following expression

$$\left(\frac{W}{W^*}\right)^{\frac{1-(1-\rho)(1-\gamma)}{2}} = \frac{(1-k)^\rho}{\Psi}\frac{E(KS^{1/2}Z)}{E(S^{(1-\rho)(1-\gamma)/2}Z^{1-\rho})} \tag{B1}$$

where $\Psi = (\phi-1)(\theta-1)/\phi\theta$

Doing the same for the foreign country with the relevant equations leads to a similar equation with the exception that the exchange rate enters with opposite sign.

Dividing equation (B1) by its foreign analogue and rearranging, remembering that $Z^* = Z$ $Z^* = Z$ yields:

$$\left(\frac{W}{W^*}\right)^{\frac{1-(1-\rho)(1-\gamma)}{2}} = \frac{E(KS^{1/2}Z)E(S^{-(1-\rho)(1-\gamma)/2}Z^{1-\rho})}{E(S^{(1-\rho)(1-\gamma)/2}Z^{1-\rho})E(K^*S^{-1/2}Z)} \tag{B2}$$

According to (B1) and (B2), the preset relative wage depends on the expected levels of the productivity shock, the demand and the exchange rate.

Using the expected terms of trade is defined in logs as $Eq = Es + w^* - w$ and assuming that all variables are log-normally distributed, it is possible to get the following expression by taking the log of (B2) and rearranging:

$$Eq = Es + w^* - w = -\frac{1}{1-(1-\rho)(1-\gamma)}[2\sigma_{\kappa_d z} + (1-(1-\gamma)(1-\rho)^2)\sigma_{sz}] \tag{B3}$$

Taking the log of (B1) and combining the result with (B3) allows to derive the expected spending in terms of tradable goods as follows:

$$Ez = \frac{1}{\rho}\log\Psi - \log(1-k) - \frac{1}{2\rho}\sigma_{\kappa_d s} - \frac{1}{2\rho}\left(\frac{\sigma_\kappa^2}{\rho} + (1-(1-\rho)^2)\sigma_z^2 + \frac{1-(1-\rho)^2(1-\gamma)^2}{4}\sigma_s^2\right) \qquad \text{(B4)}$$

An analogous expression for Ez^* can be defined using the foreign counterpart of (B1).

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