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« Efficiency and coordination of fiscal policy in open economies »

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Abstract

Efficiency and coordination of fiscal policy in open economies by G. Koenig and I. Zeyneloglu

In this paper, we use a two country stochastic "new open economy macroeconomics" model with sticky wages and imperfect competition where public spending and private consumption appear in a non-separable way in individual preferences.

We use this setup to define optimal fiscal policy in the face of a productivity shock and to analyze the efficiency of this optimal fiscal policy as a stabilization tool. We also consider strategic games between fiscal authorities in the two countries in order to see if there are additional gains from fiscal cooperation. We find that optimal fiscal policy consists of a deviation in the same direction as the deviation of the shock and that this type of reaction reduces the negative effects of the shock. We find also that fiscal cooperation generates a higher level of welfare than under Nash. However, the gain from cooperation is very likely to be negligible.

Keywords: Fiscal policy, policy coordination, stabilization, new open economy macroeconomics

JEL : E62, F41, F42

Résumé

Efficacité et coordination des politiques budgétaires dans les économies ouvertes par G. Koenig et I. Zeyneloglu

L'analyse se place dans le cadre d'un modèle à deux pays qui possède les caractéristiques de ceux développés dans la nouvelle macroéconomie internationale. On suppose notamment que les salaires nominaux sont prédéterminés et que la concurrence sur le marché de biens et du travail est imparfaite. Le modèle retenu spécifie d'une façon particulière les préférences des agents introduisant dans les fonctions d'utilités des agents la non-séparabilité des dépenses publiques et des consommations privées et un coefficient d'aversion envers le risque.

Dans le cadre ainsi spécifié, on définit d'abord les politiques budgétaires optimales face à des chocs de productivité et l'efficacité de ces actions comme instruments de stabilisation. Puis, on envisage les stratégies budgétaires des deux pays afin d'évaluer les gains que pourrait apporter une coopération entre les autorités en termes de bien-être. Dans cette optique, on montre que les déviations des dépenses publiques par rapport à leurs moyennes évoluent dans le même sens que celles des chocs et qu'elles en réduisent les effets nets. De plus, la coopération budgétaire entraîne un niveau de bien-être supérieur à celui provenant d'une stratégie non-coopérative. Cependant le gain supplémentaire induit par la coopération est très faible.

Mots clés : politique budgétaire, coordination des politiques, stabilisation, nouvelle macroéconomie internationale

JEL : E62, F41, F42

Efficiency and coordination of fiscal policy in open economies

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1. Introduction

Because of increasing interdependence between the developed economies, the national macroeconomic policies can have undesirable effects on the foreign economies and to suffer from the consequences of these effects. Internationally coordination of these policies may help reduce or eliminate such externalities. This type of strategy has been analyzed since the 70s by various economists like Hamada (1974, 1979) and Oudiz and Sachs (1984), with a game theoretic approach based on aggregate models of structural interdependence. These models, for which Canzoneri and Henderson (1991) give a general over-view concerning the monetary policy, are now called "first generation" models of policy coordination.

Recently, Obstfeld and Rogoff (OR hereafter) suggested a "second generation" of policy coordination models (2002), based on the new Keynesian literature incorporating optimizing households, imperfect competition and nominal rigidities. Since the emergence of this framework which is developed by the seminal paper of OR (1995) and which is called "the new open economy macroeconomics" (NOEM hereafter), most of the contributions have chosen to focus on monetary policy issues while little attention has been paid to fiscal policy. The few exceptions which integrate fiscal policy, usually, analyze it together with monetary policy, searching for

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possible interactions and potential gains of coordination between monetary and fiscal policy. The literature focusing only on fiscal policy issues in the NOEM framework is yet even more limited.

The present paper aims to build on the existing literature by reconsidering the efficiency of fiscal policy as a tool for stabilization as well as possible additional gains from international fiscal policy coordination. Our analysis is based on the recent approach suggested by the NOEM framework for analyzing international policy coordination (e.g. OR (2000, 2002), Devereux and Engel (2000), Beetsma and Jensen (2002), Lombardo and Sutherland (2004)).

The NOEM literature takes a different approach that consists of deriving welfare functions using the individual utility function, for analyzing strategic games, against the first generation models which use social loss functions. These welfare functions overcome the lack of microeconomic justifications. However, in many of the models in the NOEM framework, a second order approximation of the utility function is necessary to solve the model which requires complex computational methods using special software.

This paper differs from the existing work on fiscal policy in the NOEM framework in two aspects. First, our model has the advantage of allowing analytical solutions without resorting to special softwares. Second, our model focuses only on fiscal policy issues considering that monetary policy is inactive.

For the supply side, the analytical framework uses a specification that is close to that of OR (2002) while it inspires from Ganelli (2003) for the utility function in adopting a non-separable specification between private and public spending. We use this set-up in order to study the role of fiscal policy as a stabilization tool as well as the potential gains of international fiscal policy cooperation.

In this framework consisting of two interdependent economies, we first analyze the efficiency of fiscal policy, in both countries, based on credible fiscal rules. For that, we derive the optimal values of reaction coefficients of fiscal authorities against productivity shocks, both for the cooperative game and the Nash game, as well as the impacts of the degree of risk aversion and openness on optimal reaction coefficients.

Then we show that optimal fiscal policy, defined as such under each regime, can improve welfare in both countries while it cannot achieve the pre-shock level of welfare. Moreover, although cooperation generates a higher level of welfare than Nash, due to spillover effects especially when countries are relatively open, the difference seems to be faint. Furthermore, these gains decrease with an increase in the risk aversion coefficient because of weaker spillover effects.

The paper is organized as follows: sections 2 and 3 describe the technical details of the model, section 4 derives the equilibrium values of prices and world demand, sections 5 and 6 define the expected utility and the optimal cooperative and non-cooperative fiscal policy response which maximize this utility and section 7 derives and compares welfare under cooperation and Nash policy. Finally section 8 concludes.

2. The Model: general features

The model is based on OR (2002) which is an extension of OR (1995) model. The latter is now familiar to researchers who work on the new open economy macroeconomics literature. The model of OR (2002) is a stochastic and static version of it incorporating sticky wages and non traded goods, focusing only on monetary policy leaving fiscal policy issues aside.

Our model is also static and stochastic and keeps the OR (2002) structure for the supply side (market structure, production and firm behavior). However, in order to be able to study fiscal policy issues we modified the demand side inspiring from Ganelli (2003).

2.1 Firms: production and labor demand

The world consists of two equally sized and identical countries, which we will call Home and Foreign. We also assume that there are two types of goods produced in each country: tradables indexed on the interval [0.1] and nontradables indexed on the interval (1.2]. To produce these two types of goods, the firms in each country use differentiated labor inputs. Goods prices are flexible but wages are fixed a period in advance by workers who, then, supply the amount of labor that firms demand at the posted nominal wage.

Let Y_i^H denote the home output of differentiated traded good *i* requiring $L_{i,j}^H$ units of labor of different types indexed by $j \in [0, 1]$. The production function for the traded goods produced at home is defined as in Blanchard-Kiyotaki (1987) :

$$Y_i^H = \left[\int_0^1 (L_{i,j}^H)^{\frac{\phi-1}{\phi}} dj \right]^{\frac{\phi}{\phi-1}} \quad (1)$$

where ϕ is defined as the elasticity of substitution between different traded goods produced at home.

The home nontraded goods production function is similar and given below:

$$Y_i^N = \left[\int_0^1 (L_{i,j}^N)^{\frac{\phi-1}{\phi}} dj \right]^{\frac{\phi}{\phi-1}} \quad (1')$$

We assume that different nontraded goods produced at home have the same elasticity of substitution ϕ as the traded goods.

The foreign production functions are the same with the difference that we use a star to indicate foreign variables.

As usual, firm i's demand for labor of type j necessary for the production of traded or nontraded goods Y_i is:

$$L_{ij} = \left[\frac{W_j}{W} \right]^{-\phi} Y_i \quad (2)$$

where W is the production-based index of wages[1] defined as $W = \left[\int_0^1 (W_j)^{1-\phi} dj \right]^{1/1-\phi}$

2.2. Individual preferences

A representative home individual of type i maximizes the expected value of the below expression of his utility:

$$U^i = \frac{\left(C^i G^i\right)^{1-\rho}}{1-\rho} + \chi \log \frac{M^i}{P} - KL^i \quad (3)$$

[1] The production-based aggregate wage index is defined as the minimum wage cost required for producing one unit of good with workers of quality $j \in (0,1)$

$$\min \left[\int_0^1 W_j L_{i,j} dj \right]$$
$$s.t \quad Y_i = 1$$

where $i \in [0, 1]$ and $\rho > 1$ is the constant coefficient of relative risk aversion. We consider values of ρ higher than one as it is more likely that this be the relevant case empirically (OR 2002, p.522). Note that this does not imply a negative marginal utility of consumption. The latter is always positive because of the denominator regardless of the value of ρ.

The function (3) implies that a typical domestic agent derives utility from private consumption C^i, from per-capita government spending G^i and from individual real money balances defined by M^i/P where P is the aggregate home currency price index while labor implies a certain disutility KL^i.

Each agent bears the disutility of work effort indicated by KL^i where L^i is total individual labor supplied by the worker of type i to home firms which produce traded ($\int_0^1 L_{ji}^H dj$) and nontraded goods ($\int_1^2 L_{ji}^N dj$). The marginal disutility of work effort is represented by K. A random shift in K can be interpreted as a productivity shock (OR 2000, p.4). In what follows, the productivity shock will be considered as an increase in the disutility of labor in both countries. The variation of the foreign marginal disutility K^* is also interpreted as resulting from a productivity shock.

In specifying the utility function as above, we follow Ganelli (2003) who introduces government spending in the utility function differently from OR (2002) who neglects fiscal policy issues. In doing so, Ganelli takes a different approach compared to papers that allow the public spending to appear in the utility function in a separable way as in Corsetti and Pesenti (2001), and Lombardo and Sutherland (2004) for example. He assumes that per-capita government spending and private consumption are non-separable which allows to consider a direct crowding-out effect of public spending on private consumption. However, our specification does not have the same form with Ganelli since we assume a multiplicative form with a risk aversion factor. In other words, we specify the total consumption component of utility to include a constant relative risk aversion coefficient differently from the log specification of consumption component which is widely used as in OR (2000).

We find it useful to include this attitude towards risk, because in a world of uncertainty agents would seek to insure themselves in terms of consumption units against a possible reduction in their relative consumption following a shock. Specifically, ex post, agents in both countries would like to derive the same marginal utility out of private consumption of tradable goods. Agents would also like to cover themselves against the possibility that this equality may not hold which we call as the consumption risk. We will show, later, that ex post in all states of nature, the total (private plus public) consumption of traded goods is equal across countries. However, due to some imperfections, the equality of marginal utilities of private consumption of tradables may not be achieved even in this case. These imperfections can be resumed in our case as incomplete financial markets and non-separabilities.

If we had a complete financial market then the existence of state contingent securities would assure the equality of consumption in both countries in any state and the risk sharing would be perfect. This is not the case in our model. Moreover, the non-separability between public and private consumption as well as between traded and nontraded goods imply that private consumption may be different in both countries.

When, $\rho = 1$ utility is separable in public and private consumption and moreover private consumption is separable in tradables and nontradables[2]. Thus the ex post equality of total consumption of traded goods across countries implies perfect international risk sharing of consumption in tradable goods because the marginal utility of tradable goods is independent of the consumption of nontraded goods, and the marginal utility of private consumption is independent of public consumption.

However, when $\rho \neq 1$ the equality of tradable goods across countries does not guarantee full risk sharing because the marginal utility of private consumption depends on public spending and the marginal utility of traded goods depends on the consumption of nontraded goods. Then it may be the case that private domestic consumption is different from foreign consumption implying that marginal utilities of traded goods are different even if total traded goods consumption is equal across countries. Thus the introduction of a non-separability when $\rho \neq 1$ implies an additional source of consumption risk.

2.3. Private and public demand of tradable and nontradable goods

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[2] In this case the consumption part of the utility takes the following form: $u(C,G) = \frac{(CG)^{1-\rho} - 1}{1-\rho}$ if we want it to converge to logarithmic as $\rho \to 1$. Applying L'Hopital's rule we get: $u(C,G) = \log(CG) = \log C + \log G = \gamma \log C_T + (1-\gamma)\log C_N + \log G$ since we define private consumption as $C = \frac{1}{\gamma^{\gamma}(1-\gamma)^{1-\gamma}} C_T^{\gamma} C_N^{1-\gamma}$.

For a representative individual of type *i*, the consumption C^i consists of tradable and non-tradable goods. For the home country, the aggregate private consumption index C is defined as following: $C = \frac{1}{\gamma^{\gamma}(1-\gamma)^{1-\gamma}} C_T^{\gamma} C_N^{1-\gamma}$.

This is a Cobb-Douglas specification where γ is the share of tradable goods (C_T) and 1-γ is the share of nontradable goods (C_N) implying a constant and unitary elasticity of substitution between tradable and nontradable goods.

Likewise, the aggregate traded goods consumption index is a Cobb-Douglas specification given as $C_T = 2C_H^{1/2} C_F^{1/2}$. This implies that domestic consumption of domestically produced traded goods C_H and domestic consumption of traded goods produced in the foreign country C_F have equal shares in the aggregate domestic consumption of traded goods.

Foreign indexes are identical with a star representing foreign variables.

The domestic consumption sub-indexes for C_H, C_F *and* C_N are constant elasticity aggregates with the same substitution elasticity θ as given below:

$$C_H = \left[\int_0^1 c_T(h)^{\frac{\theta-1}{\theta}} dh \right]^{\frac{\theta}{\theta-1}} \tag{4a}$$

$$C_F = \left[\int_1^2 c_T(f)^{\frac{\theta-1}{\theta}} df \right]^{\frac{\theta}{\theta-1}} \tag{4b}$$

$$C_N = \left[\int_0^1 c_N(h)^{\frac{\theta-1}{\theta}} dh \right]^{\frac{\theta}{\theta-1}} \tag{4c}$$

In equation (4a), C_H is defined as the aggregate home consumption of home traded goods where $c_T(h)$ is the consumption of a single domestic traded good h with $h \in [0,1]$ aggregated over home agents. Similarly, C_F and C_N are respectively the aggregate domestic consumption of foreign produced traded goods and the aggregate home consumption of home nontraded goods with $c_T(f)$ and $c_N(h)$ representing respectively the consumption of a single foreign produced traded good f with $f \in [1,2]$ and the consumption of a single home nontraded good h with $h \in [0,1]$.

Note that the unitary elasticity between home and foreign goods differs from the elasticity θ between the goods produced in one country.

The public demands for traded and nontraded goods are assumed to be the same as private consumptions defined in equations (4a) to (4c) with $G_H\ (g_H), G_F(g_f)$ and $G_N\ (g_N)$ replacing $C_H\ (c_H), C_F\ (c_F)$ and $C_N\ (c_N)$. They fall equally on home and foreign goods. In other words, there is no home bias.

The corresponding price indexes are defined as the minimum sum of money required to purchase one unit of consumption as defined by above equations. This gives the following domestic currency price indexes:

$$P_H = \left[\int_0^1 p_T(h)^{1-\theta} dh \right]^{\frac{1}{1-\theta}} \tag{5a}$$

$$P_F = \left[\int_1^2 p_T(f)^{1-\theta} df \right]^{\frac{1}{1-\theta}} \tag{5b}$$

$$P_N = \left[\int_0^1 p_N(h)^{1-\theta} dh \right]^{\frac{1}{1-\theta}} \tag{5c}$$

By the same logic, we have the following domestic currency price index for the total real consumption and for the tradable goods consumption respectively:

$$P = P_T^{\gamma} P_N^{1-\gamma} \tag{6a}$$

$$P_T = P_H^{1/2} P_F^{1/2} \tag{6b}$$

The foreign currency foreign price indexes are similar with a star denoting foreign currency prices.

Since we have defined the consumption and price indexes, we can now compute the individual and the aggregate demands for each type of good and all types of demand faced by a typical home or foreign producer.

Given the constant-elasticity of substitution consumption indexes (equations 4), the home individual's demands for a typical traded and a typical nontraded good *h* are respectively:

$$c_T(h) = \left(\frac{p_T(h)}{P_H} \right)^{-\theta} C_H \tag{7a}$$

$$c_N(h) = \left(\frac{p_N(h)}{P_N} \right)^{-\theta} C_N \tag{7b}$$

The public demands for traded ($g_T(h)$) or nontraded goods ($g_N(h)$) take the same form as the consumption of private goods $c_T(h)$ and $c_N(h)$.The foreign demand for public and private traded and nontraded goods are similar.

If all agents behave as the representative individual *i,* they determine private consumption demand for traded goods C_T and nontraded goods C_N by maximizing aggregate private consumption C defined as $C = \frac{1}{\gamma^\gamma (1-\gamma)^{1-\gamma}} C_T^\gamma C_N^{1-\gamma}$ making use the following relation $PC = P_T C_T + P_N C_N$:

$$C_T = \gamma \left(\frac{P_T}{P} \right)^{-1} C \tag{8a}$$

$$C_N = \gamma \left(\frac{P_N}{P} \right)^{-1} C \tag{8b}$$

Once C_T and C_N are determined, the domestic agents determine the following demands C_H and C_F by maximizing C_T with $C_T = 2C_H^{1/2} C_F^{1/2}$ making use of $P_T C_T = P_H C_H + P_F C_F$:

$$C_H = \frac{1}{2} \left(\frac{P_H}{P_T} \right)^{-1} C_T \tag{8c}$$

$$C_F = \frac{1}{2} \left(\frac{P_F}{P_T} \right)^{-1} C_T \tag{8d}$$

Public domestic demands (G_T, G_N, G_H, G_F) and foreign private ($C_T^*, C_N^*, C_H^*, C_F^*$) as well as public demands ($G_T^*, G_N^*, G_H^*, G_F^*$) are similar.

Given $C_T, G_T, c_T(h)$ and $g_T(h)$, the total demand for a typical home tradable good ($y_T^d(h)$) and for a single nontradable good produced at home ($y_N^d(h)$) facing each firm are :

$$y_T^d(h) = \frac{1}{2} \left(\frac{p_T(h)}{P_H} \right)^{-\theta} \left(\frac{P_H}{P_T} \right)^{-1} (C_T^w + G_T^w) \tag{9a}$$

$$y_N^d(h) = (1-\gamma) \left(\frac{p_N(h)}{P_N} \right)^{-\theta} \left(\frac{P_N}{P} \right)^{-1} (C^w + G^w) \tag{9b}$$

where the superscript *w* indicates world aggregates.

Demands addressed to the foreign producer are similar.

Note that these equations are slightly different from the one in the basic O-R model (1995). The reason is that, here the unitary elasticities of substitution between tradable and nontradable goods and between home and foreign traded goods are different from the elasticity of substitution θ between the goods produced in one country.

2.4. The demand for money

As in OR (2002), we assume that agents in both countries can trade internationally a real bond indexed to the composite traded good C_T. Since this is the only internationally traded asset, domestic firms are entirely domestically owned.

The demand for national currency by a representative agent i is determined by maximizing the utility function (3) under the following constraint defined in real terms:

$$\frac{M_d^i}{P} + C^i = \frac{M_o^i}{P} - T^i + \frac{W(i)L^i}{P} + \frac{\Pi(i)}{P} \tag{10}$$

where $\Pi(i)$ represents dividend payments by firms i which produce tradable ($\int_0^1 \Pi_{ji}^H dj$) and nontradable goods ($\int_1^2 \Pi_{ji}^N dj$) and pay the wage income $W(i)L^i$; M_o^i and M_d^i stand respectively for the money holdings at the beginning of the period and for the money demand; C^i and T^i denote respectively real consumption and tax payments.

Given the equations (3) and (10), the agent of type i solves the following Lagrangian:

$$\text{Max}\,\Lambda(C^i, L^i, M^i/P, \lambda) = \frac{(C^i G^i)^{1-\rho}}{1-\rho} + \chi \log\frac{M^i}{P} - KL^i + \lambda\left(\frac{M_d^i}{P} - \frac{M_o^i}{P} - C^i - T^i + \frac{W(i)L^i}{P} + \frac{\Pi(i)}{P}\right)$$

Taking the first derivatives gives us the following equation for money demand:

$$\frac{M_d^i}{P} = \chi (C^i)^{\rho} (G^i)^{\rho-1} \tag{11}$$

An analogous derivation gives the foreign money demand as similar to equation (11) where all the variables are denoted with a star.

Equation (11) deserves some explanation. The government spending appears in the money demand equation because private consumption and public spending enter in the utility function in a non-separable way. Therefore, when agents maximize utility with respect to money balances, public spending enters in the resulting money demand equation. The interpretation is the following: optimal money balances decision equates the marginal utility of money balances to the marginal utility of private consumption. Therefore, any decrease in the marginal utility of consumption can affect the decision of optimal money balances. Since an increase in public spending decreases the marginal utility of private consumption, agents substitute into money balances.

3. Equilibrium wages and prices

Workers set nominal wages a period in advance and supply ex post the amount of labor demand by firms at the fixed wage. Contrary to wages, prices are flexible.

3.1. Optimal preset wages

The individual agent determines his optimal wage by maximizing his expected utility EU^i where we introduce the value of C^i resulting from the budget constraint (10) and where we substitute for labor supply using the labor demand equation (2). This gives us the following maximization program:

$$EU^i = \frac{1}{1-\rho} E\left(\frac{W(i)}{P}\left[\frac{W(i)}{W}\right]^{-\phi} Y_i - G^i + \Pi(i) \right)^{1-\rho} (G^i)^{1-\rho} + E\left(\chi \log \frac{M^i}{P} \right) - E\left(K \left[\frac{W(i)}{W}\right]^{-\phi} Y_i \right) \quad (12)$$

where E is the expectations operator.

Taking the first derivative with respect to $W(i)$, remembering that total output Y_i is equal to total labor L^i used for production (where $Y_i = Y_i^N + Y_i^H$) and then rearranging gives the following equation for the optimal preset wage :

$$W(i) = \frac{\phi}{\phi - 1} \frac{E\left\{KL^i\right\}}{E\left\{(L^i / P)(C^i)^{-\rho}(G^i)^{1-\rho}\right\}} \quad (13a)$$

For a given elasticity ϕ, the optimal nominal wage increases when the expected value of disutility of work KL^i or price P increases, or when the expected marginal utility of consumption $\mathrm{E}((C^i)^{-\rho}(G^i)^{1-\rho})$ decreases. Since an increase in public spending decreases the marginal utility of private consumption it induces an increase in optimal wages for a given level of marginal disutility of work effort.

Without uncertainty the expectations operator disappears and equation (13a) takes the following form where the marginal utility of the real wage is a fixed mark-up over the marginal disutility of labor:

$$\frac{W(i)}{P} = \frac{\phi}{\phi - 1} \frac{K}{(C^i)^{-\rho}(G^i)^{1-\rho}} \tag{13b}$$

The markup rate $\phi/(\phi-1)$ indicates that workers have a negotiation power in the labor market. As the elasticity of substitution between different workers increase, the markup converges to unity which implies the elimination of negotiation power.

3.2. Equilibrium prices

A typical home traded good producer who faces the demand $y_T^d(h)$ defined by equation (9a) determines his optimal price $p_T(h)$ by maximizing his profit given as follows:

$$\Pi_T(h) = (p_T(h) - W)\frac{1}{2}\left(\frac{p(h)}{P_H}\right)^{-\theta}\left(\frac{P_H}{P_T}\right)^{-1}(C_T^w + G_T^w)$$

where W represents the wages paid for the production of a single good.

Taking the first derivative with respect to $p_T(h)$, then setting it to zero gives the optimal price as a fixed mark up over wage:

$$p_T(h) = \frac{\theta}{\theta - 1} W \tag{14a}$$

where the mark-up rate $\theta/\theta\text{-}1$ reduces when the elasticity of substitution θ between individual goods increases and it converges to unity when θ goes to infinity in the limit case of perfect substitutes without monopoly power of the firm.

Note that due to the symmetry of firms the individual price $p_T(h)$ is equal to the aggregate price index of home tradables P_H implying that:

$$P_H = \frac{\theta}{\theta - 1} W \tag{14b}$$

A similar profit maximization for the nontraded goods implies that the price of non-traded good is also a constant mark up over wage *W*.

The determination of the optimal price of a traded $p_T^*(f)$ and a nontraded good $p_N^*(f)$ by a foreign producer is similar: each price is a mark-up $\theta/\theta-1$ over wage W^*.

Since wages and mark-up rates are the same in all the firms of the two sectors, the price of the non-traded good is equal to the price of the traded good in both countries: $P_H = P_N = (\theta/\theta-1)W$ and $P_F^* = P_N^* = (\theta/\theta-1)W^*$.

We assume the law of one price and the purchasing power parity for the traded goods. Then the prices of tradable goods are equal across the two countries when expressed in the same currency with the nominal exchange rate ε: $P_T = \varepsilon P_T^*$.

Given the definitions of P and P_T in equations (6a) and (6b) and those of P^* and P_T^* which are expressed similarly, the real exchange rate is given by following equation:

$$\frac{\varepsilon P^*}{P} = \frac{\varepsilon P_T^{*\gamma} P_N^{*(1-\gamma)}}{P_T^{\gamma} P_N^{1-\gamma}} = \left(\frac{\varepsilon W^*}{W}\right)^{1-\gamma} \tag{15}$$

Since the aggregate foreign currency price P_F^* of foreign tradable goods and the aggregate home currency price P_H of home traded goods are a mark-up respectively over W^* and *W,* the terms of trade *t* can be expressed in the following way :

$$t = \frac{\varepsilon P_F^*}{P_H} = \frac{\varepsilon W^*}{W} \tag{16}$$

3.3. Output market clearing

The goods market must clear for both types of goods. For the traded goods market at home, total value of output must be equal to total value of demand. We can show this algebraically as follows:

$$P_H Y_H = P_H(C_H + G_H) + P_H(C_H^* + G_H^*)$$

The foreign analogue can be written as:

$$P_F Y_F^* = P_F(C_F + G_F) + P_F(C_F^* + G_F^*)$$

From the private demand equations (8c) and (8d) giving C_H and C_F and from the similar equations giving G_H and G_F, we know that $P_H(C_H+G_H)=\frac{1}{2}P_T(C_T+G_T)$ and $P_F(C_F+G_F)=\frac{1}{2}P_T(C_T+G_T)$. Introducing this equality as well as its foreign analogue and making use of the purchasing power parity we get:

$$P_H Y_H = \tfrac{1}{2}P_T(C_T+G_T)+\tfrac{1}{2}P_T(C_T^*+G_T^*)$$
$$P_F Y_F^* = \tfrac{1}{2}P_T(C_T+G_T)+\tfrac{1}{2}P_T(C_T^*+G_T^*)$$

Dividing these two equations gives:

$$\frac{P_H}{P_F}=\frac{Y_F^*}{Y_H}$$

This equality, together with our assumption that there is no international financial asset trading, implies that current account is always balanced. This means that countries have constant shares of income coming from the production of tradables.

Constant real income shares and our specification of isoelastic preferences over traded goods consumption imply that countries always consume exactly their production meaning that:

$$(C_T+G_T)=\frac{P_H Y_H}{P_T},\quad (C_T^*+G_T^*)=\frac{P_F Y_F}{P_T}$$

Combining the two previous relations gives:

$$(C_T+G_T)=(C_T^*+G_T^*) \tag{17}$$

The consumption of tradables is equal across countries in all states. Of course the overall consumption $(C+G)$ and (C^*+G^*) need not move together.

The total home spending can be measured in units of home tradable goods by:

$$Z=\frac{PC+PG}{P_T}=\frac{P_N}{P_T}(C_N+G_N)+C_T+G_T \tag{18a}$$

To define P_N/P_T in equation (18a), we made use of the fact that total consumption and price indexes are Cobb-Douglas aggregates over traded and non-traded goods with shares γ and $1-\gamma$ respectively. This implies that the ratio of home tradable consumption in value to that of home nontradables is equal to ${}^{1-\gamma}/_{\gamma}$ and that the relative price is defined as:

$$\frac{P_N}{P_T}=\frac{(1-\gamma)(C_T+G_T)}{\gamma(C_N+G_N)}$$

Plugging the above equation into (18a), we get:

$$Z = \frac{1}{\gamma}(C_T + G_T) \tag{18b}$$

An analogous expression can be defined for total foreign consumption Z^* measured in units of foreign traded goods. This equality together with the equality between $C_T + G_T$ and $C_T^* + G_T^*$ imply:

$$Z = \tfrac{1}{\gamma}\left(C_T + G_T\right) = Z^* = \tfrac{1}{\gamma}\left(C_T^* + G_T^*\right) \tag{18c}$$

The equality of home and foreign total spending measured in units of tradable goods will turn out to be very useful in solving the model.

From the definition of *Z* given in equation (18a) it is possible to derive the following definition for private consumption:

$$\frac{(P_T Z - PG)}{P} = C$$

Now, let us assume, for simplification purposes, that total public expenditure constitute a fraction *k* of total spending so that we have $PG = kP_T Z$. Then it is possible to rewrite private real consumption as following:

$$C = \frac{P_T}{P} Z(1-k) \tag{19}$$

Equation (19) states simply that home private consumption spending constitutes a fraction of $(1-k)$ of the total consumption spending in the home country.

4. Equilibrium values of terms of trade and the world demand

Having described the model as above, we can pass on to the solution process. For that, we have to compute the equilibrium value of relative wages. This will be necessary to determine the expected values of the terms of trade and of the total demand measured in units of tradables. These expected values, which will turn out to be useful in computing the expected utility of agents, are affected by the uncertainty over the major variables influencing wages and are represented by the variances and covariances of these major variables.

Once equilibrium wages are determined we can define the ex post values of expected total consumption and terms of trade as well as their relation with the exogenous shocks and the fiscal reactions that shocks bring about.

4.1. Relative Wages

The equilibrium wages at home and abroad will be determined using the equation for the optimal wage that maximizes the utility of each agent in both countries. We already defined optimal wages for the home country in equation (13a) where we drop the index *i* (since we consider that all agents are symmetric). The foreign counterpart is defined similarly. Dividing both sides of equation (13a) by W (remember that we dropped the index *i*), and then dividing and multiplying the left hand side by $\theta/(\theta-1)$, also making use of the mark-up equation ($P_H = [\theta/(\theta-1)]W$), we get the following expression for the home country:

$$1 = \frac{\phi\theta}{(\phi-1)(\theta-1)} \frac{E(KL)}{E[(P_H L/P)C^{-\rho}G^{1-\rho}]}$$

In the above equation, total production $P_H L/P$ requiring L units of labor is equal to total demand $(P_T Z/P=C+G)$ where $\frac{P_T}{P} = \left(\frac{\varepsilon W^*}{W}\right)^{(1-\gamma)/2}$. Moreover, according to (19), the private consumption represents a fraction $(1-k)$ of total production in real terms: $C = (1-k)P_H L/P$.

Introducing all these definitions in the above equation, yields the following expression:

$$\left(\frac{W}{W^*}\right)^{1-(1-\rho)(1-\gamma)/2} = \frac{\phi\theta}{(\phi-1)(\theta-1)} \frac{E\left(\mathrm{K}(\varepsilon)^{1/2}Z\right)(1-k)^{\rho}}{E\left((\varepsilon)^{(1-\rho)(1-\gamma)/2} Z^{1-\rho}G^{1-\rho}\right)} \tag{20a}$$

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 the opposite sign.

Dividing equation (20a) by its foreign analogue and rearranging yields:

$$\left(\frac{W}{W^*}\right)^{1-(1-\rho)(1-\gamma)} = \frac{E(\mathrm{K}\varepsilon^{1/2}Z)E(\varepsilon^{-(1-\rho)(1-\gamma)/2}Z^{1-\rho}G^{*1-\rho})}{E(\varepsilon^{(1-\rho)(1-\gamma)/2}Z^{1-\rho}G^{1-\rho})E(\mathrm{K}^*\varepsilon^{-1/2}Z)} \tag{20b}$$

4.2. Equilibrium value of expected terms of trade

The expected terms of trade in logs is defined, as follows, making use of equation (16): $E\tau = Ee + w^* - w$ where Ee represents the expected value of nominal exchange rate in log. To substitute for the gap between home and foreign nominal wages, w and w^* respectively, we introduce the log of equation (20b) into the definition of $E\tau$. The lognormal property of the variables allows us to write the log of (20b) in the following way which gives the expected terms of trade (see appendix):

$$E\tau = Ee + w^* - w = \frac{-1}{1-(1-\rho)(1-\gamma)}\left\{\sigma_{\kappa e} + (1-(1-\rho)^2(1-\gamma))\sigma_{ez} + \frac{(1-\rho)^2}{2}(\sigma^2_{g^*} - \sigma^2_g)\right.$$
$$\left. - \frac{(1-\rho)^2(1-\gamma)}{2}(\sigma_{eg^*} + \sigma_{eg}) + (1-\rho)^2\left(\sigma_{zg^*} - \sigma_{zg}\right)\right\} \quad (21)$$

where g, g^* and z represent respectively the domestic and foreign public spending and the global consumption in terms of traded goods, all in log form.

We assume that the two countries are affected by the same productivity shocks implying an equal random variation in κ et κ^* and that these random variables in log form have the same means and variances. Then we can define the world shock as $\kappa_w = (\kappa + \kappa^*)/2$ implying $E\kappa = E\kappa^* = E\kappa_w$, which we assume to be equal to zero, and $\sigma^2_\kappa = \sigma^2_{\kappa^*} = \sigma^2_{\kappa_w}$.

According to (21), the expected value of the terms of trade in logarithm is a function of the variances of public spending in logs σ^2_g and σ^2_{g*} and of the covariances of endogenous variables in logs that can be influenced by the fiscal policy.

These variances and co-variances are able to affect in the following way the terms of trade by influencing the log of relative wages defined by equation (20a):

-An increase in σ^2_g, $\sigma_{eg}, \sigma_{eg*}$ or σ_{zg} leads to an increase in the log of expected terms of trade, because it changes relative wages by increasing the log difference w^*-w.

For example, an increase in the variance of public home spending in logs σ^2_g leads to an increase in the expected marginal utility of consumption. Home agents are induced to decrease their wage claims, which bring about an increase in the terms of trade for a given value of w^*.

The impact of an increase in σ^2_g on Eτ is higher the higher is the risk aversion coefficient when ρ>1. Indeed, the increase in the expected marginal utility of consumption increases with ρ.

-An increase in σ^2_{g*}, $\sigma_{\kappa_w e}$ or σ_{zg*} reduces $E\tau$ by decreasing w^*-w.

If, for example, there is an increase in the covariance $\sigma_{\kappa_w e}$, home workers are induced to claim higher wages relative to foreign, because of higher disutility of work effort, while the demand of home tradable goods increases due to the variation in the exchange rate. This leads to a decrease in the expected terms of trade.

-An increase in σ_{ez} has a negative or positive impact on $E\tau$ depending on the effect of higher exchange rate and total consumption on home and foreign wages.

According to (21), an increase in the variances of the world shock σ_{κ_w} does not change the terms of trade. Indeed, an equal increase in the variances of the shocks leads to symmetric changes in w and w^*.

4.3. Equilibrium value of expected world demand

The log of world demand z^w is defined as the weighted sum of goods demand in both countries which are equal according to (18c): $z^w=(z + z^*)/2$ with $z = z^*$. According to this, the expected world demand in log can be expressed as follows: $E z^w = (Ez + Ez^*)/2$ with $Ez = Ez^* = E z^w$.

Taking the log of equation (20a), introducing the value of $E\tau$ and leaving $Ez = E z^w$ alone, we obtain the following expression of the expected level Ez of log of consumption spending measured in tradable goods (see appendix):

$$Ez_w = Ez = \tfrac{1}{2\rho}\begin{bmatrix} \frac{(1-\rho)^2}{2}(\sigma_{g^*}^2+\sigma_g^2)+\frac{(1-\rho)^2(1-\gamma)}{2}(\sigma_{eg}-\sigma_{eg^*})+(1-\rho)^2(\sigma_{zg^*}+\sigma_{zg})-2\sigma_{\kappa_w z}-\sigma_{\kappa_w}^2 \\ -\frac{1}{4}(1-(1-\rho)^2(1-\gamma)^2)\sigma_e^2-(1-(1-\rho)^2)\sigma_z^2 \end{bmatrix} \quad (22)$$

According to (22), a change in the following variances and covariances affects the anticipated consumption demand by changing relative wages as in the preceding analysis of the expected terms of trade (equation 21) :

-An increase in $\sigma_{\mathrm{g}}^2, \sigma_{eg}$ or σ_{zg} leads to an increase in the real goods consumption demand. Indeed, it reduces home wages for a given w^*, implying lower prices of tradables and nontradables at home for given foreign prices. This leads to an increase in the demand for home tradables and nontradables which is higher than the decrease in the demand for the foreign tradables.

-An increase in σ^2_{g*} or σ_{zg*} also determines an increase in the demand for home tradables and nontradables which is higher than the decrease in the demand for the foreign tradables.

-An increase of σ_{eg*} has the inverse effect because it generates an increase in w* for a given w, which implies higher foreign prices relative to home prices and hence a net decrease in the expected world demand.

According to (22), a change in the following variances and covariances affects the anticipated consumption without changing the terms of trade because they influence home and foreign wages leaving relative wages unchanged :

-An increase in the variance of the world shock $\sigma^2_{\kappa_w}$ or the covariance $\sigma_{\kappa_w z}$ generates unambiguously a decrease in global demand because of higher wages and prices in both countries.

-The increase in σ^2_e or in σ^2_z leads to an increase or a decrease in total consumption demand depending on whether it leads to a decrease or an increase in wages and prices in the two countries. This effect depends on the value of risk aversion coefficient ρ. Indeed, for σ^2_z the effect is positive when $\rho > 2$.

4.4. Equilibrium values of ex post exchange rate and world demand

Given preset wages, the equilibrium values of the exchange rate and the total demand can vary, unexpectedly, with the exogenous stochastic shocks defined as random increases in κ and κ^*. The equilibrium values of ex post exchange rate and world demand in log form are determined by the following equations in logs which define the money market equilibrium at home and abroad and where constants are omitted:

$$m - p = \rho(p_T + z - p) + (\rho - 1)g \tag{23a}$$

$$m^* - p^* = \rho(p^*_T + z^* - p^*) + (\rho - 1)g^* \tag{23b}$$

In the equations above the log values of home and foreign money supply and home and foreign prices are represented respectively by m, m^*, p and p^*. The right hand sides of these equations denote home and foreign money demand in log form which are defined using equation (11) and its foreign analogue where we aggregate across agents to specify the aggregate home and foreign money demand. Then we substitute for the log value of aggregate private consumption using equation (19) which defines private consumption as a fraction of total consumption measured in units of tradables. Adding equations (23a) and (23b), remembering that $z = z^*$ and omitting constants, it is possible to derive the following log value for the global consumption demand:

$$z_w = \frac{1}{2\rho}(m+m^*) - \frac{1-\rho}{2\rho}(p+p^*) + \frac{1-\rho}{2\rho}(g+g^*) - \frac{1}{2\rho}(p_T - p_T^*)$$

Then, using the definitions of the price indexes as well as the mark up equation (14b), we get the following equation for the ex post total consumption:

$$z_w = \frac{1}{2\rho}(m+m^*) - \frac{1}{2\rho}(w+w^*) + \frac{1-\rho}{2\rho}(g+g^*) \tag{24a}$$

Having defined the expected value of z_w we can compute the deviation of this variable from its expected value for given prices and wages following unanticipated shocks:

$$\hat{z}_w = z_w - Ez_w = \frac{1}{2\rho}(\hat{m}+\hat{m}^*) + \frac{1-\rho}{2\rho}(\hat{g}+\hat{g}^*) \tag{25a}$$

where carets over variables denote deviations: $\hat{m} = m - Em$ for money supply, $\hat{g} = g - Eg$ for the public spending, $\hat{z}_w = z_w - Ez_w$ for the total world spending.

From equation (25a) we see that a domestic or foreign public spending higher than its expected level generates a deviation of the total world spending from its expected level. Specifically, when $\rho > 1$, a deviation of public spending creates a deviation of world consumption in the opposite direction. Indeed, for example, a positive deviation in public spending increases Ez_w more than z_w and hence leads to a negative deviation of world spending.

A deviation in money supply creates a deviation of world spending in the same direction. For simplification purposes, in what follows, we will assume that monetary policy is inactive.

The expression for the nominal exchange rate is derived from the difference of money market equilibrium conditions at home and abroad. Subtracting (23a) from (23b) and noting that purchasing power parity holds for the traded goods, we get:

$$m - m^* + (1-\rho)(g-g^*) = \rho e + (1-\rho)(p-p^*)$$

Using the definitions of the price indexes, remembering again that purchasing power parity holds and then making use of the mark up equation (14b), we get the following solution for the ex post exchange rate:

$$e = \frac{(m-m^*) + (1-\rho)(g-g^*) - (1-\rho)(1-\gamma)(w-w^*)}{1-(1-\rho)(1-\gamma)} \tag{24b}$$

Having defined the expected value of the exchange rate, we can compute the deviation of this variable from its expected value for given wages following unanticipated shocks:

$$\hat{e} = \frac{1}{1-(1-\gamma)(1-\rho)}\left[(\hat{m}-\hat{m}^*)+(1-\rho)(\hat{g}-\hat{g}^*)\right] \tag{25b}$$

where $\hat{e} = e - Ee$.

Equation (25b) states that a higher level of domestic public spending, with respect to its expected value, appreciates the exchange rate while a deviation of foreign public spending from its expected level leads to a depreciation. This is because, an increase in public spending decreases the marginal utility of private consumption which induces agents to substitute into money balances. A higher money demand appreciates the exchange rate as long as it is not off-set by an increase in money supply. In short, public spending is able to create a deviation of total world spending and of the exchange rate from their expected levels.

5. Expected Utility

In dealing with welfare issues, we will restrict our attention to the "real" part of the utility function which depends only on consumption and work effort as this is a general convention in the literature. In other words, we will neglect the welfare effects of real balances. One can show that as long as the derived utility from real balances is not too large as a share of total utility, changes in the "real" utility will dominate total changes in utility. This will be true as long as χ is not too large. Note that this assumption does not eliminate the transmission channel implied by the money demand. Therefore, although the real balances will not have a direct effect on the utility, they will still have an impact on the utility through their effects on the expected terms of trade and total consumption.

The assumption above allows to define the expected utility as follows:

$$EU = E\left(\frac{(CG)^{1-\rho}}{1-\rho} - KL\right) \tag{26a}$$

The value of $E(KL)$ in the equation above can be expressed as below :

$$E(KL) = \Psi E\left(CG\right)^{1-\rho}$$

where $\Psi = \dfrac{(\theta-1)(\phi-1)}{\theta\phi(1-k)}$

In writing this equation, we made use of the goods market equilibrium condition ($P_T Z = P_H L$) and the mark up equation (14b) to substitute for P_H. In the resulting equation we introduce the certainty equivalent of the equilibrium wage given in equation (13b) where we drop the index *i.* Finally we use the definition of *C* defined in equation (19) to substitute for $Z\frac{P_T}{P}$.

After introducing the value of *E(KL)* into the expected utility in equation (26a) we get :

$$EU = E\left((\frac{1}{1-\rho} - \Psi)(CG)^{1-\rho} \right) \tag{26b}$$

Now, we can express (26b) in terms of total consumption and terms of trade. For this, we make use of the fact that C=$\frac{P_T}{P}Z(1-k)$ from equation (19). We also know, from the definition of price indexes, that $\frac{P_T}{P} = \left(\frac{\varepsilon W^*}{W} \right)^{(1-\gamma)/2} = t^{(1-\gamma)/2}$ where *t* stands for the terms of trade. Then we get the following expression for the expected utility:

$$EU = E\left((\frac{1}{1-\rho} - \Psi) G^{1-\rho} Z^{1-\rho} t^{(1-\gamma)(1-\rho)/2} (1-k)^{1-\rho} \right) \tag{26c}$$

It is possible to rewrite (26c) in terms of the variances and the covariances of its components. For that, we first take the log of (26c). Then we write it in exponential form and put it into expectations operator. Remembering that all variables are log normally distributed, we get:

$$EU = \exp\left\{ Ez + \tfrac{(1-\gamma)}{2} E\tau + \tfrac{(1-\rho)}{2}\sigma_g^2 + \tfrac{(1-\rho)}{2}\sigma_z^2 + \tfrac{(1-\rho)(1-\gamma)^2}{8}\sigma_e^2 + (1-\rho)\sigma_{zg} + \tfrac{(1-\rho)(1-\gamma)}{2}\sigma_{eg} + \tfrac{(1-\rho)(1-\gamma)}{2}\sigma_{ez} \right\} \tag{27a}$$

where we assume that *Eg*=0 for simplification purposes.

The expression for foreign expected utility is of the same form, except that $E\tau, \sigma_{ez}$ and σ_{eg^*} enter with opposite sign. Specifically, we have:

$$EU^* = \exp\left\{ Ez - \tfrac{(1-\gamma)}{2} E\tau + \tfrac{(1-\rho)}{2}\sigma_{g^*}^2 + \tfrac{(1-\rho)}{2}\sigma_z^2 + \tfrac{(1-\rho)(1-\gamma)^2}{8}\sigma_e^2 + (1-\rho)\sigma_{zg^*} - \tfrac{(1-\rho)(1-\gamma)}{2}\sigma_{eg^*} - \tfrac{(1-\rho)(1-\gamma)}{2}\sigma_{ez} \right\} \tag{27a$'$}$$

The expected terms of trade in logs and the covariance between the exchange rate and world demand in logs, which appear in the expected utility, constitute a potential source of conflict between the two countries, because their variation can induce an internationally asymmetric welfare distribution. The terms of trade are a source of conflict because an increase in its value increases demand for home goods while it generates a decrease in demand for foreign goods. A higher covariance between the exchange rate and the world demand implies that world demand is high when the exchange rate is high, that is when the exchange rate is shifting demand toward home workers while the inverse happens in the foreign country.

In equation (27a), we substitute the values of $E\tau$ and Ez given in equation (21) and (22) respectively we get for the home country:

$$EU = \exp\left\{\begin{array}{l} \frac{(1-\rho)(a-\rho)}{4\rho a}\sigma_{g^*}^2 + \frac{(1-\rho)(a+\rho)}{4\rho a}\sigma_g^2 + \frac{(1-a)(\rho-a)}{4\rho a}\sigma_{eg^*} + \frac{(1-a)(a+\rho)}{4\rho a}\sigma_{eg} + \frac{(1-\rho)(a-\rho)}{2\rho a}\sigma_{zg^*} \\ + \frac{(1-\rho)(a+\rho)}{2\rho a}\sigma_{zg} - \frac{(1-\gamma)}{2a}\sigma_{\kappa_w e} - \frac{1}{\rho}\sigma_{\kappa_w z} - \frac{1}{2\rho}\sigma_{\kappa_w}^2 - \frac{1-(1-\rho)(1-\gamma)^2}{8\rho}\sigma_e^2 - \frac{1}{2}\sigma_z^2 - \frac{\rho(1-\gamma)}{2a}\sigma_{ez} \end{array}\right\} \quad (27b)$$

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

The exponential form of the expected utility states that an increase in one of the variables in the brackets above, generates a more-than-proportional increase or decrease in the expected utility.

Equation (27b) states that while the variance of public spending has a positive impact on expected world consumption and terms of trade, it also has a negative impact on utility since it increases the disutility of work effort. The negative effect dominates overall. The variance of total consumption, exchange rate and the marginal disutility of labor as well as the covariances between the shock and exchange rate or world consumption generate also a decrease in the utility of agents.

Equation (27b) also describes the structural interdependence between the two countries. The covariance between foreign public spending and exchange rate has negative effects on expected home utility. This covariance increases the expected terms of trade $E\tau$ (see equation 21) while it decreases the expected total consumption (equation 22). Since agents attribute a higher importance on Ez than on $E\tau$ (equation 27a), the decrease in Ez dominates overall and home utility decreases with the covariance between foreign public spending and the exchange rate. The variance of foreign public spending has a positive effect since it increases Ez while decreasing $E\tau$ with t. he effect on Ez dominating. The same is true for the covariance between foreign public spending and world demand.

These externalities disappear when there are no tradable goods ($\gamma = 0$) because the countries represent a closed economy and there are no transmission possibilities between two countries which eliminates the interdependence.

For the foreign country, we introduce equations (21) and (22) into equation (27a′) to get the following expression for utility:

$$EU^{*} = \exp\left\{ \begin{array}{l} \frac{(1-\rho)(a-\rho)}{4\rho a}\sigma_{g}^{2} + \frac{(1-\rho)(a+\rho)}{4\rho a}\sigma_{g^{*}}^{2} + \frac{(1-a)(a-\rho)}{4\rho a}\sigma_{eg} - \frac{(1-a)(a+\rho)}{4\rho a}\sigma_{eg^{*}} + \frac{(1-\rho)(a-\rho)}{2\rho a}\sigma_{zg} \\ + \frac{(1-\rho)(a+\rho)}{2\rho a}\sigma_{zg^{*}} - \frac{(1-\gamma)}{2a}\sigma_{\kappa_w e} - \frac{1}{\rho}\sigma_{\kappa_w z} - \frac{1}{2\rho}\sigma_{\kappa_w}^{2} - \frac{1-(1-\rho)(1-\gamma)^{2}}{8\rho}\sigma_{e}^{2} - \frac{1}{2}\sigma_{z}^{2} + \frac{\rho(1-\gamma)}{2a}\sigma_{ez} \end{array} \right\} \qquad (27\text{b}')$$

6. Optimal Fiscal Policy Response

We assume that, in order to stabilize the economy, fiscal authorities react to exogenous shocks according to a fiscal rule whose optimal value changes according to the strategic behavior of the two fiscal authorities.

6.1. Fiscal rules

We assume that monetary authorities remain passive in the face of a shock affecting the disutility of labor in the two countries while fiscal authorities choose to react according to the following rules:

$$\hat{g} = g - Eg = \delta\hat{\kappa}_w = \delta(\kappa - E\kappa) \qquad (28\text{a})$$

$$\hat{g}^{*} = g^{*} - Eg^{*} = \delta^{*}\hat{\kappa}_w^{*} = \delta^{*}(\kappa^{*} - E\kappa^{*}) \qquad (28\text{b})$$

where $E\kappa = E\kappa^{*} = E\kappa_w = Eg = Eg^{*} = 0$.

Domestic and foreign fiscal authorities are free to choose the respective policy parameters δ and δ^{*} that maximize utility without committing to upper limits.

According to (28a) and (28b), a deviation of the domestic or foreign public spending from its expected level is a function of the deviation of the shock from its expected level. These rules imply that fiscal authority is not concerned with inflation, but only with economic activity. By altering public spending following a shock, the fiscal authority affects, both directly and indirectly, the goods demand through its effect on the exchange rate and also the goods supply through its effect on labor market.

These rules together with equations (25a) and (25b), lead to following expression for the relevant variances and covariances:

$$
\begin{aligned}
&\sigma_g^2 = \delta^2 \sigma_{\kappa_w}^2 \\
&\sigma_z^2 = \left[\tfrac{1-\rho}{2\rho}\right]^2 \left(\delta + \delta^*\right)^2 \sigma_{\kappa_w}^2 \\
&\sigma_e^2 = \left[\tfrac{1-\rho}{a}\right]^2 \left(\delta - \delta^*\right)^2 \sigma_{\kappa_w}^2 \\
&\sigma_{zg} = \tfrac{1-\rho}{2\rho} \delta^2 \sigma_{\kappa_w}^2 \\
&\sigma_{eg} = \tfrac{1-\rho}{a} \delta^2 \sigma_{\kappa_w}^2 \\
&\sigma_{ez} = \tfrac{(1-\rho)^2}{2\rho a} (\delta^2 - \delta^{*2}) \sigma_{\kappa_w}^2 \\
&\sigma_{\kappa_w e} = \tfrac{1-\rho}{a} \left(\delta - \delta^*\right) \sigma_{\kappa_w}^2 \\
&\sigma_{\kappa_w z} = \tfrac{1-\rho}{2\rho} \left(\delta + \delta^*\right) \sigma_{\kappa_w}^2
\end{aligned}
\tag{29}
$$

where $a = 1-(1-\rho)(1-\gamma)$. Foreign variances and covariances are similar except that σ_{eg^*} enters with opposite sign.

In computing the variances and covariances given in equations (29) we used the general definition $\sigma_{xy} = (x-Ex)(y-Ey) = \hat{x} \cdot \hat{y}$. Then, for example, according to equation (25b) we have $\sigma_{eg} = \hat{e} \cdot \hat{g} = \tfrac{1-\rho}{a} \sigma_g^2$ where $\sigma_g^2 = \delta^2 \sigma_{\kappa_w}^2$.

To find the optimal fiscal rules we need to introduce (29) into the expected utility given in equation (27b) for the home country. For the foreign country we do the same with corresponding equations. The choice of optimal fiscal policy depends on the choice of the strategic game.

6.2. Noncooperative Optimal Fiscal Policy

When both fiscal authorities choose not to cooperate, they decide their policy reaction against the shock by considering the choice of the other authority as given, neglecting the effects of this choice on their own decision.

To decide the optimal choice, each country maximizes its aggregate utility function with respect to its own policy parameter. The optimal behavior resulting from this program will give us the optimal value of the coefficients for each authority.

For the home country, plugging equation (29) in the expected utility given in equation (27b) gives the following expression in terms of policy parameters δ and δ^* as well as the variance of the shock $\sigma_{\kappa_w}^2$:

$$\mathrm{EU}(\delta,\delta^*,\sigma_{\kappa_w}^2)=\exp\left\{\begin{array}{l}\frac{(1-\rho)(a-\rho)}{4\rho a}\delta^{*2}\sigma_{\kappa_w}^2+\frac{(1-\rho)(a+\rho)}{4\rho a}\delta^2\sigma_{\kappa_w}^2+\frac{(1-\rho)(1-a)(a-\rho)}{4\rho a^2}\delta^{*2}\sigma_{\kappa_w}^2+\frac{(1-a)(a+\rho)(1-\rho)}{4\rho a^2}\delta^2\sigma_{\kappa_w}^2\\+\frac{(1-\rho)^2(a-\rho)}{4\rho^2 a}\delta^{*2}\sigma_{\kappa_w}^2+\frac{(1-\rho)^2(a+\rho)}{4\rho^2 a}\delta^2\sigma_{\kappa_w}^2-\frac{(1-\gamma)(1-\rho)}{2a^2}(\delta-\delta^*)\sigma_{\kappa_w}{}^2-\frac{1-\rho}{2\rho^2}(\delta+\delta^*)\sigma_{\kappa_w}{}^2-\frac{1}{2\rho}\sigma_{\kappa_w}^2\\-\frac{1-(1-\rho)(1-\gamma)^2}{8\rho}\left[\frac{1-\rho}{a}\right]^2(\delta-\delta^*)^2\sigma_{\kappa_w}^2-\frac{(1-\rho)^2}{8\rho^2}(\delta+\delta^*)^2\sigma_{\kappa_w}^2-\frac{\rho(1-\gamma)(1-\rho)^2}{4\rho a^2}(\delta^2-\delta^{*2})\sigma_{\kappa_w}^2\end{array}\right\} \quad (30)$$

Because of the exponential form of equation (30), in order to define the first order condition, it will suffice to take only the derivative of the expression in the brackets with respect to δ. This gives the following reaction function for the home fiscal authority concerning optimal fiscal authority when the economy is hit by the shock:

$$\delta=\frac{-(1-\rho)\left[\rho(1-(1-a)(1-\gamma))-a^2\right]\delta^*+2\rho^2(1-\gamma)+2a^2}{2\rho(a+\rho)+(1-\rho)\left[a(a+\rho)-\rho(1-(1-a)(1-\gamma))-2\rho^2(1-\gamma)\right]}$$

Following the same steps leads to the foreign reaction function below:

$$\delta^*=\frac{-(1-\rho)\left[\rho(1-(1-a)(1-\gamma))-a^2\right]\delta+2\rho^2(1-\gamma)+2a^2}{2\rho(a+\rho)+(1-\rho)\left[a(a+\rho)-\rho(1-(1-a)(1-\gamma))-2\rho^2(1-\gamma)\right]}$$

Solving the two equations above for the policy parameters, we can define the non cooperative response in the symmetric shock case in both countries as follows:

$$\delta^N=\delta^{*N}=\frac{\rho^2(1-\gamma)+a^2}{2a\rho}\succ 0 \quad (31)$$

The value of δ^N depends on the value of γ and ρ. The policy parameter increases with the degree of openness of the countries. For high values of γ the reaction coefficient decreases with an increase in risk aversion coefficient while for low values of γ the change is negligible.

6.3. Optimal Fiscal Policy under Cooperation

If policymakers could cooperate in choosing their domestic fiscal policy rules, then with equal weights on national welfares, they would maximize

$$EV=\tfrac{1}{2}EU^*+\tfrac{1}{2}EU \quad (32)$$

To do this, they would maximize over their own coefficient reaction which would give us a value for the policy response corresponding to a maximal utility in the cooperation case. The two countries place equal but opposite-signed weights on expected terms of trade $E\tau$, on the covariance σ_{ez} between world spending. Therefore, these two factors disappear at the global level. Then, substituting equation (27a) which gives home utility and its foreign analogue (27a′) into equation (32) and introducing the value of Ez_w given in equation (22), we get the following equation for the weighted world utility denoted as EV:

$$EV = \exp\left[\begin{array}{l} \frac{1-\rho}{4\rho}(\sigma_g^2+\sigma_{g^*}^2)-\frac{1-(1-\rho)(1-\gamma)^2}{8\rho}\sigma_e^2-\frac{1}{\rho}\sigma_{\kappa_w z}+\frac{1-\rho}{2\rho}(\sigma_{zg}+\sigma_{zg^*}) \\ +\frac{(1-a)}{4\rho}(\sigma_{eg}-\sigma_{eg^*})-\frac{1}{2\rho}\sigma_{\kappa_w}^2-\frac{1}{2}\sigma_z^2 \end{array}\right] \tag{33}$$

Again as in equations (27a) and (27a′), equation (32) gives us the global utility as a function of the variance of public spending but not as a function of the variance of the labor shock and again we use the definition of policy rules given in equations (28a and b) in order to express global utility in terms of policy parameters and the variance of the shock. Substituting the relevant variances and covariances as given in equations (29), we get the following expression for the global welfare which now depends on the reaction coefficients and the variance of the shock:

$$EV = \exp\left\{\begin{array}{l} -\frac{1}{2\rho}\sigma_{\kappa_w}^2-\frac{(1-\rho)}{2\rho^2}(\delta+\delta^*)\sigma_{\kappa_w}^2-\frac{(1-\rho)^2(1-(1-\rho)(1-\gamma)^2)}{8a^2\rho}(\delta-\delta^*)^2\sigma_{\kappa_w}^2+\frac{(1-\rho)(1-a)}{4a\rho}(\delta^2+\delta^{*2})\sigma_{\kappa_w}^2 \\ +\frac{(1-\rho)^2}{4\rho^2}(\delta^2+\delta^{*2})\sigma_{\kappa_w}^2-\frac{(1-\rho)^2}{8\rho^2}(\delta+\delta^*)^2\sigma_{\kappa_w}^2+\frac{1-\rho}{4\rho}(\delta^2+\delta^{*2})\sigma_{\kappa_w}^2 \end{array}\right\} \tag{34}$$

Fiscal authorities will maximize equation (34) with respect to the policy parameters. Again, because of the exponential form of equation (34), in order to define the first order condition, it will suffice to take only the derivative of the expression in the brackets with respect to coefficients of reaction. The resulting reaction function for the home country can be expressed as follows:

$$\delta = \frac{(1-\rho)\left[-\rho(1-(1-a)(1-\gamma))+a^2\right]\delta^*+2a^2}{(1-\rho)\left[-\rho(1-(1-a)(1-\gamma))+a^2\right]+2a\rho}$$

The reaction function for the foreign policy parameter is given as:

$$\delta^* = \frac{(1-\rho)\left[-\rho(1-(1-a)(1-\gamma))+a^2\right]\delta+2a^2}{(1-\rho)\left[-\rho(1-(1-a)(1-\gamma))+a^2\right]+2a\rho}$$

Solving for the parameters, we get the following value of policy parameters for the symmetric case:

$$\delta_C = \delta_C^* = \frac{a}{\rho} \succ 0 \tag{35}$$

The cooperative response decreases with an increase in γ for given values of ρ and with an increase in ρ for given values of γ. The impact of ρ is more important the higher is γ.

6.4. Implications of optimal fiscal responses

The inspection of equations (31) and (35) shows, first, that both the cooperative and the Nash responses are positive. Fiscal authority always chooses to increase public spending when there is an increase in the disutility of labor and to decrease when there is decrease in the marginal disutility of labor. For example, an increase in the marginal disutility of labor induces a reduction in labor supply for given real wages and for given marginal utility of private consumption. Fiscal authority aims to counteract this decrease by an increase in public spending since this decreases marginal utility of private consumption and increases total consumption. This, in turn, stimulates production and hence increases labor demand and supply. However, the increase in labor demand and supply induced by expansionary fiscal policy is not enough to offset the initial decrease.

Second, fiscal responses under both regimes decrease as ρ increases. Indeed, the crowding out effect of public spending is lower the higher is ρ. Hence, a lower fiscal reaction is sufficient for the same level of shock in order to create the same effect. However, this effect of ρ is lower when countries are rather closed. Especially under Nash the effect is negligible.

Equations (31) and (35) also give us information about the nature of international consumption risk sharing. We already said that the non-separability of public and private spending introduced an additional source of risk sharing. Indeed, in OR (2002), this imperfection of risk sharing disappears when we impose $\gamma=0$ implying that all goods are nontraded and there are no risks to share, or $\gamma=1$ implying that all goods are traded and their marginal utility no longer depends on other goods. Since this is the only non-separability in their model, in those extreme cases, the imperfection coming from non-separability is canceled. It is also the case for us that when $\gamma=0$, there are no risks to share and hence the policy parameters do not depend on the coefficient of risk aversion. However, when all goods are tradable, policy parameter always depends on the risk aversion coefficient in our model. Indeed, even if the consumption of tradable goods are independent of nontradables, as long as $\rho \neq 1$, marginal utility of private consumption still depends on public consumption which can introduce an asymmetry of the marginal utility of private consumption of tradables across countries.

Third, the cooperative response is higher than the Nash response ($\delta_C > \delta_N$) as long as $\rho \prec 3$. For higher values of ρ, cooperative response is higher than Nash response only if both economies are highly open.

Equation (30) shows the spillover effects coming from the impact of foreign fiscal policy on home variances and covariances which are of different sign. The net spillover effect depends on the values of ρ and γ. When economies are relatively open, net spillover effect is negative for plausible values of ρ while for low values of γ net spillover effect becomes positive for high values of ρ.

When negative spillover effects are internalized under cooperation, cooperative response is higher than under Nash while in the case of positive net spillover effect this result is reversed.

7. Welfare under Nash and Cooperative Solutions

This section compares welfare under cooperation to the welfare under Nash, in order to see if cooperation generates welfare gains, by evaluating equation (30) at the optimal response given by equation (31) for the Nash case and equation (34) by introducing the value of optimal policy response given in equation (35) for the cooperative case.

7.1. Welfare under Nash Regime

To evaluate welfare under Nash policy, we take the Nash welfare equation EU given in equation (30). Imposing symmetry across countries, introducing the value of policy parameter and making the necessary simplifications we get the following equation:

$$EU^N = \exp\left\{ \underbrace{\frac{1-\rho}{\rho^2}}_{-} \underbrace{\delta_N}_{+} \left[\underbrace{\frac{\rho^2(1-\gamma)-3a^2}{4a^2}}_{-} \right] \sigma^2_{\kappa_w} - \underbrace{\frac{1}{2\rho}}_{+} \sigma^2_{\kappa_w} \right\} \tag{36}$$

Suppose, first, that there no shocks ($\sigma^2_{\kappa_w} = 0$). From equation (36) we see that pre-shock welfare, denoted by EU_0, is equal to $EU_0 = \exp(0) = 1$. Then the economy is hit by a shock. Let us assume that fiscal authority does not react to the shock at first ($\delta_N = 0$). From equation (36), now welfare is equal to $EU_P = \exp\left(-\frac{1}{2\rho}\sigma^2_{\kappa_w}\right) \prec 1$ where P stands for passive. We see that welfare decreases with the occurrence of the shock. Suppose now that fiscal authority chooses to react to the shock. Since the expression in brackets in equation (36) is always negative for plausible values of ρ, welfare improves and we have $EU_0 \succ EU^N \succ EU_P$.

Fiscal policy is efficient under Nash regime in the sense that it is able to reduce the negative effects of the shock. However, the optimal fiscal reaction is not enough to return to the pre-shock level of welfare.

7.2. Welfare under Cooperation

As a first step we take the cooperative welfare equation EV given in equation (34). Imposing symmetry across countries and introducing the relevant value of policy parameter gives us the following equation:

$$EV^C = \exp\left\{ \underbrace{\frac{\rho-1}{2\rho^2}}_{+}\underbrace{\delta_C}_{+}\sigma^2_\kappa - \underbrace{\frac{1}{2\rho}}_{+}\sigma^2_\kappa \right\} \tag{37}$$

Again, we would like to compare, first, pre-shock welfare to welfare under passive fiscal policy and then to active fiscal policy. In the initial period there are no shocks and therefore all the variances and covariances are equal to zero. Then from equation (37), the initial welfare denoted by EV_0 is equal to $\exp\{0\} = 1$.

Now, both countries are hit by the shock. Suppose, first, that fiscal authorities choose not to react against the shock implying that δ_C is equal to zero. Then, from equation (37), welfare under passive fiscal policy, denoted by EV_P, after the occurrence of the shock is equal to $\exp\left\{\frac{-1}{2\rho}\sigma^2_\kappa\right\} \prec 1$

Now we suppose that fiscal policy decides to react to the shock. The first part in the brackets become positive and welfare improves which implies $EV_0 \succ EV^C \succ EV_P$.

Fiscal policy is efficient under cooperative regime in the sense that it is able to reduce the negative effects of the shock. However, the optimal fiscal reaction is not enough to return to the pre-shock level of welfare.

7.3. Implications of optimal fiscal policy and cooperation gains

The two preceding subsections show that fiscal policy is efficient under both regimes since it is able to reduce the negative effects of the shock. The fiscal authority can achieve this result through its effects on labor supply and demand. For example, an increase in the marginal disutility of labor induces a reduction in labor supply for given real wages and for given marginal utility of private consumption. An increase in public spending decreases marginal utility of private consumption and increases total consumption. This stimulates production and hence increases labor demand and supply, which improves welfare since it attenuates the decrease in consumption. However, the increase in labor demand and supply induced as such is not enough to offset the initial decrease and consumption decreases compared to pre-shock situation which induces a lower level welfare compared to the pre-shock welfare.

Having seen that fiscal policy is efficient, one could ask whether cooperation implies additional gains compared to Nash regime. First, we will evaluate equations (36) and (37) for the relevant values of policy parameters. Then we will subtract resulting equations to determine the sign of the gap between logEV^C and logEU^N. This is the equivalent of seeing if EV^C / EU^N is greater or less than one.

Subtracting log of equation (36) from log of (37) and introducing the relevant values of policy parameters gives the following expression:

$$\log EV^C - \log EU^N = \underbrace{\frac{\rho-1}{2\rho^2}}_{+}\underbrace{\left[\frac{\rho^4(1-\gamma)^2 - 2a^2\rho^2(1-\gamma) + a^4}{4a^3\rho}\right]}_{+} \succ 0$$

The expression in brackets above is always positive for all possible values of ρ and γ. There are additional gains from cooperation between two fiscal authorities because of the existence of spillover effects. However, these gains are very likely to be small. Especially when the degree of openness is low, the gain from cooperation approaches to zero and is eliminated completely when economies are closed. The gain from cooperation also decreases with an increase in ρ for plausible values ($\rho \le 4.5$).

8. Conclusion

In this paper we use a static and stochastic two country model which extends OR (2002) by introducing public spending and non-separability between private and public consumption way.

Conform to the NOEM literature, this model allows to display the role of not only variances, as in the first generation models, but also the role of covariances on welfare and hence provides a more detailed interdependence scheme across countries.

In this framework, we explore the optimal behavior of fiscal authority when faced to a productivity shock. We find that fiscal authority chooses to react positively under both regimes if there is an increase in the disutility of labor in both countries and chooses to react negatively in the opposite case. Moreover, the reaction of fiscal authority in both games decreases, as agents become more risk averse. Finally, the fiscal reaction under cooperation is higher than the one under Nash for relatively low values of risk aversion.

After analyzing the efficiency of fiscal policy under each regime, we focus on their welfare effects. Welfare analysis for both games shows that fiscal policy is able to improve welfare, under both regimes, with respect to welfare under passive fiscal policy. However, the fiscal response cannot re-attain the pre-shock welfare. We also find that cooperation is preferable to Nash, especially for high degree of openness. However, the gain from cooperation is likely to be very small especially for high values of risk aversion. Nevertheless, specific numerical simulations are necessary in order to have a more accurate insight about the importance of these gains.

In this model we choose to focus on fiscal policy issues neglecting the role of monetary policy and the implications on inflation. However it is possible to extend the model to include a role for monetary policy in order to study the interactions between them. This would introduce another potential line for future research.

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APPENDIX

The expected terms of trade

We will define the terms of trade in log form. Remember that the terms of trade is defined in equation (16). Taking the log of this equation and putting it in the expectations operator, without forgetting that wages are fixed, gives: $Ee + w^* - w$. Indeed, this is what we are looking for. For this, we take equation (13a) in the text and divide both sides of the equality by W_i, multiply and divide the left hand side by $\frac{\theta}{\theta-1}$ and make use of the mark-up equation (14b) to get the following expression:

$$1 = \frac{\phi\theta}{(\phi-1)(\theta-1)} \frac{E(KL)}{E\left(\frac{LP_H}{P} C^{-\rho} G^{1-\rho}\right)}$$

Now remember that we can write the goods market equilibrium as $P_T Z = P(C+G) = P_H L$. Then making use of our assumption that tradable public consumption constitutes a fraction k of the total spending, we can show that $\frac{LP_H}{P} = C\frac{1}{1-k}$. Then making use of equation (19) in the text and the fact that $\frac{P_T}{P} = \left(\frac{\varepsilon W^*}{W}\right)^{(1-\gamma)/2}$ we can transform the above equation as follows:

$$1 = \frac{\phi\theta}{(\phi-1)(\theta-1)} \frac{E\left(K(\frac{\varepsilon W^*}{W})^{\frac{1}{2}} Z\right)(1-k)^{\rho}}{E\left((\frac{\varepsilon W^*}{W})^{(1-\rho)(1-\gamma)/2} Z^{1-\rho} G^{1-\rho}\right)}$$

Rearraging yields equation 6:

$$\left(\frac{W}{W^*}\right)^{\frac{1-(1-\rho)(1-\gamma)}{2}} = \frac{\phi\theta}{(\phi-1)(\theta-1)} \frac{E\left(K(\varepsilon)^{\frac{1}{2}} Z\right)(1-k)^{\rho}}{E((\varepsilon)^{(1-\rho)(1-\gamma)/2} Z^{1-\rho} G^{1-\rho})} \qquad \#$$

The foreign analogue is:

$$\left(\frac{W^*}{W}\right)^{\frac{1-(1-\rho)(1-\gamma)}{2}} = \frac{\phi\theta}{(\phi-1)(\theta-1)} \frac{E\left(K^*(\varepsilon)^{-\frac{1}{2}} Z\right)(1-k)^{\rho}}{E((\varepsilon)^{-(1-\rho)(1-\gamma)/2} Z^{1-\rho} G^{*1-\rho})}$$

Dividing the two equations above and rearranging yields:

$$\left(\frac{W}{W^*}\right)^{1-(1-\rho)(1-\gamma)} = \frac{E\left(K(\varepsilon)^{\frac{1}{2}} Z\right) E((\varepsilon)^{-(1-\rho)(1-\gamma)/2} Z^{1-\rho} G^{*1-\rho})}{E((\varepsilon)^{(1-\rho)(1-\gamma)/2} Z^{1-\rho} G^{1-\rho}) E\left(K^*(\varepsilon)^{-\frac{1}{2}} Z\right)}$$

Taking logs yields:

$$[1-(1-\rho)(1-\gamma)](w-w^*) = \log E\left(K(\varepsilon)^{\frac{1}{2}} Z\right) + \log E((\varepsilon)^{-(1-\rho)(1-\gamma)/2} Z^{1-\rho} G^{*1-\rho}) - \log E((\varepsilon)^{(1-\rho)(1-\gamma)/2} Z^{1-\rho} G^{1-\rho}) - \log E\left(K^*(\varepsilon)^{-\frac{1}{2}} Z\right)$$

This equation may seem a little bit confusing so let us take the logs of expectations operator step by step: suppose that $A = K(\varepsilon)^{\frac{1}{2}} Z$.

Then $logA = \kappa + \frac{1}{2}e + z$.

Then $A = \exp\left[\kappa + \frac{1}{2}e + z\right]$.

This implies: $EA = E\left[\exp\left[\kappa + \frac{1}{2}e + z\right]\right]$. Then, applying the general formula giving the expected value of the exponential of a normal variable, we get
$EA = \exp\left[E(\kappa) + \frac{1}{2}Ee + +Ez + \sigma_\kappa^2 + \frac{1}{4}\sigma_e^2 + \sigma_z^2 + \frac{1}{2}\sigma_{\kappa e} + \sigma_{\kappa z} + \frac{1}{2}\sigma_{ez}\right]$

Taking the log of the above expression gives:

$logE\left[K(\varepsilon)^{\frac{1}{2}}Z\right] = \left[E(\kappa) + \frac{1}{2}Ee + +Ez + \sigma_\kappa^2 + \frac{1}{4}\sigma_e^2 + \sigma_z^2 + \frac{1}{2}\sigma_{\kappa e} + \sigma_{\kappa z} + \frac{1}{2}\sigma_{ez}\right]$

Doing the same with the other expressions in expectations operator and placing the expected value of the exchange rate on the left hand side of the equality gives equation (21´) in the text as follows:

$$E\tau = Ee + w^* - w = \frac{-1}{1-(1-\rho)(1-\gamma)}\left[\begin{array}{c}\sigma_{\kappa_w e} + (1-(1-\rho)^2(1-\gamma))\sigma_{ez} + \frac{(1-\rho)^2}{2}(\sigma_{g^*}^2 - \sigma_g^2) \\ -\frac{(1-\rho)^2(1-\gamma)}{2}(\sigma_{eg^*} + \sigma_{eg}) + (1-\rho)^2(\sigma_{zg^*} - \sigma_{zg})\end{array}\right]$$

Finally we would like to remind that we focus our attention only on unanticipated shocks so that from the definition of fiscal spending in eqaution (28) in the text, we have $E\kappa = 0 = Eg$

The expected total consumption spending (**symmetric case**):

Take the log of ref: Eq6 above:

$$\begin{aligned}\frac{[1-(1-\rho)(1-\gamma)]}{2}(w-w^*) = {} & \frac{(1-(1-\rho)(1-\gamma)}{2}Ee + \rho Ez + \frac{1}{2}\sigma_{\kappa_w}^2 + \frac{[1-(1-\rho)^2(1-\gamma)^2]}{8}\sigma_e^2 \\ & + \frac{\left(1-(1-\rho)^2\right)}{2}\sigma_z^2 + \frac{1}{2}\sigma_{\kappa_w e} + \sigma_{\kappa_w z} + \frac{[1-(1-\rho)^2(1-\gamma)]}{2}\sigma_{ez} \\ & - \frac{(1-\rho)^2}{2}\sigma_g^2 - \frac{(1-\rho)^2(1-\gamma)}{2}\sigma_{eg} - (1-\rho)^2\sigma_{zg}\end{aligned}$$

Then place the expected level of the exchage rate on the left-hand side of the above equation and combine it with the expected terms of trade as given above and leave Ez alone at the left-hand side. This gives equation (22´) in the text as follows:

$$Ez = \frac{1}{2\rho}\left[\begin{array}{c}\frac{(1-\rho)^2}{2}(\sigma_g^2 + \sigma_{g^*}^2) + \frac{(1-\rho)^2(1-\gamma)}{2}(\sigma_{eg} - \sigma_{eg^*}) + (1-\rho)^2(\sigma_{zg^*} + \sigma_{zg}) - 2\sigma_{\kappa_w z} - \sigma_{\kappa_w}^2 \\ -\frac{\left[1-(1-\rho)^2(1-\gamma)^2\right]}{4}\sigma_e^2 - \left(1-(1-\rho)^2\right)\sigma_z^2\end{array}\right]$$

Note that we have omitted constants in both the expected level of the terms of trade and the expected level of the world spending.

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