WELFARE AND MACROECONOMIC INTERDEPENDENCE

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ABSTRACT

The paper develops a simple choice-theoretic model suitable for carrying out welfare analyses of the international transmission of monetary and fiscal policies. The model can be solved in closed form and illustrated in terms of the simplest graphical apparatus, so as to provide the analysis of macroeconomic interdependence, structural spillovers, policy links and strategic complementarities with rigorous but intuitive micro-foundations. In contrast with the traditional literature, our findings emphasize the positive externalities of foreign monetary expansions and foreign fiscal contractions on domestic welfare, while highlighting the ambiguous welfare effects of domestic policy shocks.

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"What we 'need' to know is how to evaluate the microeconomics of international monetary systems. Until we can do that, we are making policy advice by the seat of our pants."[1]

1 Introduction

This paper develops a simple choice-theoretic model suitable for carrying out welfare analyses of the international transmission of monetary and fiscal policies. The optimization-based approach pursued in this paper provides a unifying theoretical framework for the study of both positive and normative aspects of macroeconomic interdependence. The model can be solved in closed-form and illustrated in terms of the simplest graphical apparatus, so as to provide the analysis of structural spillovers and international policy links with rigorous but intuitive micro-foundations.

In terms of the number and quality of recent analyses that build upon its theoretical foundations, the classic Mundell-Fleming-Dornbusch model appears remarkably vital in the policy literature. Yet, despite its popularity as intellectual reference for international policy evaluation, the traditional approach has long been subject to widespread criticism, on both methodological and practical grounds. The following quote is a representative synthesis of such criticism: "virtually all of the literature [on macroeconomic policy interdependence] is based on obsolete Keynesian models, which lack the microfoundations needed for proper welfare analysis... Many effects often emphasized in *ad-hoc* policy analyses may be offsetting when taken together... The standard approach adopted in Keynesian analyses, which treat output and the current account balance as measures of welfare, can be very misleading".[2]

In support of the traditional approach to normative issues, it is commonly argued that 'microeconomic correctness' is a requirement of somewhat second-order importance in this area of research. *Ad-hoc* models are typi-

[1]Krugman [1993], p.22.

[2]Obstfeld and Rogoff [1996], pp.656, 686 and 688. Similarly, Rotemberg and Woodford [1997] write "the analysis of the deadweight losses associated with alternative policies in terms of the individual preferences that account for the predicted responses to a policy change is by now the standard method of the public finance literature. But this method has been little applied to problems of monetary policy... Analyses of optimal monetary policy — or at least those that are based upon econometric models — consider instead the problem of minimizing one *ad hoc* loss function or another."

cally presented in the literature as stylized approximations of more complex analyses. Despite their acknowledged arbitrariness, small, easily managed, 'tractable' models are useful to focus on empirically relevant issues, without resorting to the cumbersome analytical apparatus often associated with rigorously 'micro-founded' theories.[3]

At the current stage of development of the literature, however, the gap between micro-foundations of welfare analysis and tractability in modelling international macroeconomics may be narrower than commonly thought, and this paper suggests a way to bridge it. It should be stressed that our main goal is not to show how a general-equilibrium intertemporal model with monopolistic competition and nominal rigidities can be made as (analytically and graphically) simple as a standard open-economy IS-LM model. Rather, the objective of our paper is to show, with the help of a stylized model, how recent directions of research in international macroeconomics[4] are already relevant — and applicable — for policy purposes. The analysis of Sections 5 and 6 provides three examples by addressing costs and benefits of exchange rate devaluations, the nature of monetary spillovers, and the international repercussions of fiscal contractions.[5]

The exercise we consider throughout the paper focuses on the impact of unanticipated monetary and fiscal policy shocks on output, consumption and welfare. Such a 'textbook' policy experiment allows for a close scrutiny of the merits of the new approach to international macroeconomics (as captured by our setup) in relation to the traditional framework.

Consider for instance the effects of monetary shocks. As discussed in

[3]As Blanchard and Fischer [1989, p.558] write, "the costs and benefits of deriving a model from first principles — explicit utility and profit maximization, and explicit treatment of market structure — must be weighed case by case. Explicit derivation forces one to think more precisely about the specification one intends to use. It may lead, however, for reasons of analytical tractability, to specifications which are unpleasantly contorted and leave out important complexities of the issues at hand."

[4]A partial list includes Svensson and van Wijnbergen [1989], Obstfeld and Rogoff [1995 and 1996], Betts and Devereux [1996], Hau [1996], Kollmann [1996], Chari, Kehoe and McGrattan [1997]. The literature builds upon closed-economy models of imperfect competition with sticky prices (see among others Blanchard and Kiyotaki [1987] and Ball and Romer [1990]; recent contributions include Kimball [1995] and Rotemberg and Woodford [1997]).

[5]It is not a coincidence that these three issues are currently at the core of the policy debate — on both sides of the Atlantic — on the take-off of European Monetary Union and the effects of the Stability Pact embedded in the Treaty of Amsterdam.

Section 5 of the paper, the welfare impact of a domestic monetary expansion in the short run has an ambiguous sign, since an excessive depreciation of the terms of trade might offset the gain in output and consumption. Conversely, a foreign monetary expansion unambiguously raises welfare in the home country, as it improves its terms of trade and increases consumption towards its first-best level. These results stem from a coherent — albeit stylized — specification of both the welfare function and the transmission mechanism. They stand in contrast with traditional models that emphasize the negative impact on domestic welfare of monetary shocks and exchange rate devaluations abroad, because of 'beggar-thy-neighbor' displacement of domestic aggregate demand. The above results also provide an important qualification to a central conclusion by Obstfeld and Rogoff [1995], that in the presence of monopolistic distortions small expansionary monetary policies — no matter where they originate — have qualitatively similar effects on national welfare levels through their impact on global consumption.

While perfectly consistent with the theoretical construction by Obstfeld and Rogoff [1995], our modelling strategy presents several analytical advantages: 1) a closed-form solution can be attained, making it possible to analyze the impact of large shocks — thus enhancing analytical malleability and empirical applicability of the model; 2) the solution does not require strong assumptions of symmetry across countries, so that it is possible to trace the role of country-specific features in the mechanism of international policy transmission; and 3) the optimal policy at a national level can be determined as a function of structural parameters and the policy stance of the rest of the world, therefore providing a fresh approach to the welfare analysis of strategic interdependence and policy games. The latter point is emphasized in Section 5.3 of the paper, that revisits the traditional literature on the central banks reaction functions within a choice-theoretic setup.

The paper is structured as follows. Section 2 briefly describes the building blocks of our model and compares our framework with the relevant literature; Appendix A provides a complete description of the model and the optimization process. Section 3 discusses the solution strategy (the interested reader will find a generalization of a key result in Appendix B). Non-specialist readers might skim over these sections — or refer to them when needed — and move immediately to Section 4, that presents the closed-form solution of the model in both graphical and analytical terms. Sections 5 and 6 analyze different dimensions of international interdependence — monetary and fiscal — in the light of our results. A few concluding remarks appear in Section 7.

2 Building blocks of the model

In this section we briefly outline the key building blocks of our model. To make the comparison with the existing literature easier, when possible we use the same notation and parameterization adopted by Obstfeld and Rogoff [1996, ch.10].

2.1 Preferences

The model includes two countries, Home and Foreign, each specialized in the production of a traded good. In each country there is a continuum of economic agents, with population size normalized to 1/2. Home agents are indexed by $j \in [0, 1/2]$, Foreign agents by $j^* \in (1/2, 1]$.

The lifetime utility of Home agent j is given by

$$U_t(j) = \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left[\frac{C_\tau(j)^{1-\rho}}{1-\rho} + \chi \ln \frac{M_\tau(j)}{P_\tau} + V(G_\tau) - \frac{\kappa}{2} \ell_\tau(j)^2 \right]$$

Here β is the discount rate, equal to $(1+\delta)^{-1}$ where δ is the rate of time preference; $1/\rho$ is the elasticity of intertemporal substitution; C is a consumption index (to be defined below); ℓ denotes the amounts of labor supplied by the agent. In providing public goods G, the government spends exclusively on domestically produced goods; the function V is individual utility from public goods.

Home agents' wealth is allocated among two assets, real money holdings, M/P, and an internationally traded bond denominated in composite consumption units (denoted B in what follows). Home money is exclusively held by Home agents, and it provides liquidity services that enter the utility function. The international bond is in zero net-supply worldwide.

Within countries, agents have symmetric preferences and constraints. Across countries, individuals preferences are only symmetric over consumption goods, so that the elasticity of substitution $1/\rho$, and the rate of time preference δ are identical. Domestic and foreign agents are otherwise dissimilar as far as preferences towards liquidity, leisure and public goods are concerned.

In what follows, it will be notationally convenient to introduce two indexes of fiscal stance, g and g^*, defined as the ratio of total output to output net of spending. We can therefore write $Y - G = Y/g$ and $Y^* - G^* = Y^*/g^*$.

Note that g and g^* are equal to one when government spending is zero, and they are increasing in the spending to output ratios G/Y and G^*/Y^*.

2.2 Consumption and price indexes

The Cobb-Douglas consumption index for the Home agent is defined as

$$C_t(j) \equiv (C_{H,t}(j))^\gamma (C_{F,t}(j))^{1-\gamma} \qquad 0 < \gamma < 1$$

where $C_H(j)$ and $C_F(j)$ are domestic consumption of the Home good and the Foreign good by individual j. Preferences on the two goods are identical across countries:

$$C_t^*(j^*) \equiv \left(C_{H,t}^*(j^*)\right)^\gamma \left(C_{F,t}^*(j^*)\right)^{1-\gamma}$$

The consumption-based price indexes that correspond to the above specification of preferences[6] are

$$\begin{aligned} P_t &\equiv \frac{1}{\gamma_W} (P_{H,t})^\gamma \left(E_t P_{F,t}^*\right)^{1-\gamma} \\ P_t^* &\equiv \frac{1}{\gamma_W} (P_{H,t}/E_t)^\gamma \left(P_{F,t}^*\right)^{1-\gamma} \end{aligned} \tag{1}$$

where $\gamma_W \equiv \gamma^\gamma (1-\gamma)^{(1-\gamma)}$. In equations (1), P_H is the price of Home good in domestic currency, P_F^* is the price of Foreign good in local currency, and E is the nominal exchange rate (domestic currency per unit of foreign currency). The mechanism of adjustment in the model hinges upon the fluctuations of the terms of trade, P_H/EP_F^*, that affect both real exchange rates and real wages in the global economy. Consumption-based PPP holds ($P = EP^*$) as a straightforward implication of the assumptions on preferences ($\gamma = \gamma^*$).

2.3 Production and market structure

Production of the domestic good requires a continuum of differentiated labor inputs that are supplied by domestic agents. Technology is described by a

[6]The consumption-based price index P is defined as the minimum expenditure that is necessary to buy one unit of the composite good C, given the price of the Home good and the Foreign good.

linear-homogeneous CES production function. For the Home country, we have

$$Y_t = \left(2\int_0^{1/2} \ell_t(j)^{\frac{\phi-1}{\phi}} dj\right)^{\frac{\phi}{\phi-1}} \qquad \phi > 1$$

where Y denotes output per capita — so that $Y/2$ is aggregate output — and the parameter ϕ is the elasticity of input substitution. Note that in a symmetric equilibrium where $\ell(j) = \ell$, output is a linear function of labor: $Y = \ell$.

While national firms act competitively, each economic agent is a monopoly supplier of one type of labor input.[7] As agents use their market power, economic efficiency is reduced by monopolistic distortions and output is suboptimally low.[8] Clearly, the higher the degree of substitutability among inputs (the larger ϕ), the lower the market power of workers. Thus, the elasticity of input substitution ϕ is also a (decreasing) index of imperfect competition.

From the Home firms' profit maximization problem, we derive the labor demand for each type of labor

$$\ell_t(j) = \left(\frac{W_t(j)}{P_{\mathrm{H},t}}\right)^{-\phi} Y_t \qquad (2)$$

where $W(j)$ is the nominal wage rate. Acting as a monopolistic supplier of productive inputs, each Home agent takes into account the labor demand above when maximizing her lifetime utility. The condition (2) implies that, in a symmetric equilibrium with $Y = \ell$, nominal wages must be equal to product prices ($W = P_{\mathrm{H}}$). Note that this equality holds whether wages are sticky or flexible. Similar relations hold for the Foreign country.

In the short run, the economies of both countries are characterized by nominal rigidities that we introduce in the form of predetermined nominal wages. Nominal wages are assumed to be fixed for one period (short run);[9]

[7] In the literature, the source of monopoly power on the supply of each type of labor service is typically identified with factors such as the presence of unions or specific knowledge in performing production tasks. Note that, in either case, the issue arises as of how such monopoly power evolves over time.

[8] In deciding her optimal labor supply, each agent is assumed to take the price of the national good as given. In an economy with a large number of workers, individual decisions can only have a negligeable effect on goods prices.

[9] As discussed later on in the text, in our analysis we only consider policy scenarios in which the predetermination of nominal wages does not empair the logical consistency of

after one period, they are fully flexible so that — provided no new shock occurs — they adjust to their steady state level (long run).

While such an assumption is commonly adopted in the literature, any arbitrary specification of nominal rigidities is of course unwarranted from a theoretical point of view, and potentially problematic. The way nominal rigidities are modelled is crucial in determining the consistency of the theory, let alone the construction of empirical tests. In general, the theoretical analysis of the effectiveness of demand policies, as well as of the dynamic implications of policy shocks, can be significantly affected by the specific hypotheses regarding the mechanism of wage and price adjustment.

Nevertheless, we stress an important characteristic of our setup: the model can be solved in closed-form for a general time-contingent mechanism of price adjustment, and the normative implications of the analysis are qualitatively similar across particular specifications of such mechanism. Thus, for the purpose of this paper, one-period fixed nominal wages should be considered as a working hypothesis leading to results that hold for more general dynamic structures of price adjustment.

2.4 Remarks on the specification

Before we proceed, it is useful to emphasize a few key differences and similarities between our model and the model by Obstfeld and Rogoff [1995 and 1996, section 10.1]. In the latter, the consumption indexes are defined over a continuum of differentiated goods, which enter the index with a common elasticity of intratemporal substitution. The same parameter (θ in their notation, with $\theta > 1$ and $\theta = \theta^*$) plays the double role of elasticity of substitution between foreign and domestic goods, and index of monopolistic distortion. The intertemporal elasticity of substitution is assumed to be one (*i.e.*, consumption preferences are logarithmic).

In our framework, the elasticity of substitution between foreign and domestic goods, which is determined by preferences, is kept separated from the degree of monopolistic competition, which is determined by technology. The Home and Foreign consumption indexes are defined over two traded goods that are produced with a continuum of differentiated national labor inputs. While the two goods are not necessarily symmetric in the utility function (*i.e.*

the model. In particular, we rule out monetary expansions that could lead — for given nominal wages — to a reduction of real wages below the marginal rate of substitution.

γ can be different from $1/2$), the consumption indexes are Cobb-Douglas, so that the elasticity of intratemporal substitution is equal to one. This elasticity is smaller than the elasticities of substitution among factors of production in the labor markets (ϕ and ϕ^*). Most of the enhanced tractability of our model — including the possibility of closed-form solutions — stems precisely from these assumptions.[10]

Moreover, consumption utility is not restricted to the logarithmic case. This is not a simple generalization: as we will see below, the logarithmic case is the only special case in which there are no strategic or structural links across countries: in general, *i.e.* if ρ is different from 1, *global* policy stances and macroeconomic distortions influence consumption, output and welfare in *each* country.

Finally, we need not impose symmetry upon the economic structure of the two countries. Specifically, the degree of Home monopolistic competition, ϕ, Home utility from money holdings, χ, and Home utility from leisure, κ, need not be equal to the corresponding foreign parameters ϕ^*, χ^*, κ^*. The model can therefore be used in tracing the implications of structural differences for the world equilibrium allocation and policy spillovers.

3 Solving the model

We now describe the optimality conditions and constraints that determine the world-wide equilibrium in the model, and discuss the solution strategy. For our purposes, the model is fully described by the seven blocks of equations presented in the next section — to which one should add the definitions (1). A presentation of the analytical details of the optimization process can be found in Appendix A. In order to save on unnecessary notation, in what follows we drop time subscripts: steady-state variables are indexed by upperbars, while short-run variables are not indexed at all.

[10] Recent models with nominal wage rigidities that are not solvable in closed-form include the model by Hau [1996] and Obstfeld and Rogoff [1996, section 10.4.2]. These models assume a continuum of differentiated consumption goods, so that there is no separation between the degree of monopolistic distortion and the elasticity of goods substitution.

3.1 Policy shocks and equilibrium relations

In our analysis we consider an initial steady-state equilibrium in which neither country is a net debtor (or creditor), and study the impact of permanent, unanticipated changes in domestic or foreign money, as well as in domestic or foreign government spending, expressed as percentages of GDP.[11] We will denote the new steady-state levels of these variables with $\bar{M}$, $\bar{M}^*$, $1 - 1/\bar{g}$ and $1 - 1/\bar{g}^*$ respectively.[12] Note that, when all policy shocks are permanent, there is no difference between short-run and long-run values of these policy variables, *i.e.* $g = \bar{g}$, $g^* = \bar{g}^*$, $M = \bar{M}$ and $M^* = \bar{M}^*$. The extension of our analysis to temporary shocks is straightforward; we will illustrate the effects of temporary shocks in Section 4 with the help of our graphical apparatus.

The familiar Euler equations describe the optimal intertemporal allocation of consumption:

$$C^{-\rho} = \beta(1+r)\bar{C}^{-\rho} \qquad (C^*)^{-\rho} = \beta(1+r)\left(\bar{C}^*\right)^{-\rho} \tag{3}$$

where r is the short-run real interest rate, namely the rate of return on an international bond indexed to the composite consumption good.

In the short run, equilibrium in the money markets requires

$$\frac{\bar{M}}{P} = \chi\frac{1+i}{i}C^{\rho} \qquad \frac{\bar{M}^*}{P^*} = \chi^*\frac{1+i^*}{i^*}(C^*)^{\rho} \tag{4}$$

These equations are standard: Home demand for real money balances M/P is a function of consumption and the nominal interest rate $1 + i$, defined by the 'Fisher equation' as the product of the real return on the bond $(1 + r)$ and the CPI inflation rate $(\bar{P}/P)$.

In the long run, the money market equilibrium conditions become:

$$\frac{\bar{M}}{\bar{P}} = \chi\frac{1+\delta}{\delta}\bar{C}^{\rho} \qquad \frac{\bar{M}^*}{\bar{P}^*} = \chi^*\frac{1+\delta}{\delta}\left(\bar{C}^*\right)^{\rho} \tag{5}$$

where the long-run nominal interest rate in both countries is equal to the rate of time preference δ. This is because the steady-state CPI inflation rate

[11]Note that the fiscal shock is defined as an unanticipated permanent shock to the ratio of government spending to output, rather than to the level of expenditure. While the analyses of shocks to G and to G/Y are substantially similar, our specification is analytically simpler and, arguably, more relevant on empirical grounds.

[12]Recall that $Y - G = Y/g$, so that a change in G/Y is also a change in g.

is zero, and (3) implies that the steady-state real interest rate is equal to the rate of time preference.

Next, consider the short-run current account identities:

$$\bar{B} \equiv \frac{P_{\mathrm{H}}(Y-G)}{P} - C \qquad -\bar{B} \equiv \frac{P^*_{\mathrm{F}}(Y^*-G^*)}{P^*} - C^* \tag{6}$$

Here B is the net bond position of the Home country (if B is positive, Home is a net lender and Foreign is a net borrower), with the international bond indexed to the composite consumption good. Initially, B is zero, so that the short-run current account flow is equivalent to the long-run asset position $\bar{B}$. The right hand side of the two current account identities (6) is output minus absorption, both measured in units of the composite consumption good.

In the long run, the net asset position of each country is constant and the steady-state consumption level is equal to output net of government spending plus net interest payments to (or from) the rest of the world:

$$\bar{C} = \delta\bar{B} + \frac{\bar{P}_{\mathrm{H}}\left(\bar{Y}-\bar{G}\right)}{\bar{P}} \qquad \bar{C}^* = -\delta\bar{B} + \frac{\bar{P}^*_{\mathrm{F}}\left(\bar{Y}^*-\bar{G}^*\right)}{\bar{P}^*} \tag{7}$$

where δ is the steady-state real interest rate.

A standard result in models where the consumption index is characterized by a constant elasticity of substitution, is that world demand for each good (net of government spending) is a function of world consumption $(C+C^*)$ *and* the relative price of the good (P_{H}/P or P^*_{F}/P^*).[13] Thus, the short-run and long-run aggregate equilibrium conditions in the goods markets can be written as follows:

$$\begin{aligned} \frac{P_{\mathrm{H}}(Y-G)}{P} &= \gamma(C+C^*) \qquad \frac{P^*_{\mathrm{F}}(Y^*-G^*)}{P^*} = (1-\gamma)(C+C^*) \\ \frac{\bar{P}_{\mathrm{H}}\left(\bar{Y}-\bar{G}\right)}{\bar{P}} &= \gamma\left(\bar{C}+\bar{C}^*\right) \qquad \frac{\bar{P}^*_{\mathrm{F}}\left(\bar{Y}^*-\bar{G}^*\right)}{\bar{P}^*} = (1-\gamma)\left(\bar{C}+\bar{C}^*\right) \end{aligned} \tag{8}$$

The above equations show that real net income in each country is a constant share of real world consumption spending.

The last equilibrium condition refers to the optimal trade-off between labor and leisure:

$$\bar{Y} = \frac{\phi-1}{\kappa\phi}\frac{\bar{P}_{\mathrm{H}}}{\bar{P}}\bar{C}^{-\rho} \equiv \Phi\frac{\bar{P}_{\mathrm{H}}}{\bar{P}}\bar{C}^{-\rho}$$

[13] Recall that, in our parameterization, the constant elasticity of substitution is equal to one.

$$\bar{Y}^{*} = \frac{\phi^{*}-1}{\kappa^{*}\phi^{*}}\frac{\bar{P}_{\mathrm{F}}^{*}}{\bar{P}^{*}}\left(\bar{C}^{*}\right)^{-\rho} \equiv \Phi^{*}\frac{\bar{P}_{\mathrm{F}}^{*}}{\bar{P}^{*}}\left(\bar{C}^{*}\right)^{-\rho} \tag{9}$$

where we have used the fact that, when agents are symmetric within a country, per-capita output (Y) is equal to per-capita labor (ℓ). Equations (9) guarantee that, at the margin, the utility cost of foregoing leisure is equal to the benefit from consumption financed with the income generated by supplying additional labor. Note that labor supply will be higher (other things equal) when consumption is lower or the real wage ($\bar{P}_{\mathrm{H}}/\bar{P}$ or $\bar{P}_{\mathrm{F}}^{*}/\bar{P}^{*}$) is higher.

Equations (9) also relate labor supply to a (decreasing) index of domestic market distortions, denoted by Φ and Φ^{*}. When labor inputs are very poor substitutes for each other (ϕ is close to 1), workers have a high market power and Φ is close to zero. Thus, low values of Φ correspond to low equilibrium levels employment and output, due to distortions associated with monopolistic competition.

As nominal wages are predetermined (implying that P_{H} and P_{F}^{*} are also predetermined) in the short run, workers optimally adjust their labor supply as to meet labor demand. Thus, conditions (9) may not hold in the short run. They always holds, however, in the long run, when wages (and goods prices) fully adjust to their equilibrium levels. Since our analysis focuses on unanticipated policy shocks, it is logically consistent to assume that wages in the short run are set at the level consistent with the pre-shock steady-state equilibrium.

3.2 'Exchange rate dynamics redux' redux

The solution strategy of the model is remarkably simple. The starting point in solving the model is to observe that the Home and Foreign Euler equations (3) imply that there cannot be anticipated changes in the ratio of Home to Foreign consumption. Thus, in our policy experiment, this ratio is the same in the short and in the long run:

$$C/C^{*} = \bar{C}/\bar{C}^{*} \tag{10}$$

Consider then the ratios of the Home to Foreign money market equilibrium condition in the short run (4) and in steady-state (5). Since in the resulting expressions the Home to Foreign consumption ratios are identical, using the PPP condition and the Fisher equation we derive an equation for the rate of nominal exchange rate depreciation,

$$\frac{E}{\bar{E}} = \frac{(1+r)\,\bar{P}^* - \left(E/\bar{E}\right) P^*}{(1+r)\,\bar{P}^* - P^*} \tag{11}$$

that is solved by $E = \bar{E}$.

With a permanent unanticipated monetary expansion, the exchange rate completely adjusts on impact, that is, it does not overshoot (or undershoot) its long run level.[14] Intuitively, suppose that E were above $\bar{E}$ (the overshooting case). Given PPP, this would imply that the Home inflation rate is below its Foreign counterpart: $\bar{P}/P < \bar{P}^*/P^*$. As real interest rates are identical across countries, the anticipated inflation differential would lower the Home nominal interest rate below its Foreign counterpart ($i < i^*$). Other things being equal (the consumption ratio C/C^* is constant over time), the ratio between real money demand at Home and abroad would rise in the short run because of the fall in $i - i^*$, and it would be expected to fall in the long run when both i and i^* are equal to δ. But this would only be possible if expected inflation in the Home country were higher than abroad, that is a contradiction.

As regards the equilibrium current account, we rearrange its definition in both the short run (6) and the long run (7) using the equilibrium conditions in the goods markets (8). We obtain

$$\frac{C + \bar{B}}{C^* - \bar{B}} = \frac{\gamma}{1-\gamma} \tag{12}$$

for the short run and

$$\frac{\bar{C} - \delta\bar{B}}{\bar{C}^* + \delta\bar{B}} = \frac{\gamma}{1-\gamma} \tag{13}$$

for the long run. Since the international consumption ratios are the same in the short and in the long run, comparing (12) and (13) we conclude that $\bar{B} = 0$. Policy shocks do not lead to international redistribution of wealth

[14] It is worth stressing that this result does not depend on the log-specification of utility from money holdings. For instance, if the functional form describing utility of real balances were $(1-\varepsilon)^{-1}\chi\,(M/P)^{1-\varepsilon}$, the left hand side of (11) would become $\left(E/\bar{E}\right)^{\varepsilon}$. The solution would be, once again, $E = \bar{E}$. The no-overshooting result also characterizes the 'redux' model by Obstfeld and Rogoff [1995]). A similar result can be derived by assuming PPP in a two-country extention of the original Dornbusch model holding output fixed (Dornbusch [1976], sections 1-3).

through current account changes. Note also that, with $\bar{B} = 0$, the ratio of Home to Foreign consumption is constant and equal to $\gamma / (1 - \gamma)$.

This result undoubtedly represents the crucial difference between our model and the model by Obstfeld and Rogoff [1995]. For an intuitive explanation, it is useful to focus on (8). Observe that the elasticity of net output demand with respect to relative prices is equal to one, which is also the elasticity of intratemporal substitution among goods in our consumption index. In the 'redux' model these elasticities are larger than one: world demand for goods is more sensitive to changes in relative prices than is in our setup.

By way of example, consider an increase in the relative price of the Foreign good in the short run. *Ceteris paribus*, demand for Home goods increases relative to Foreign goods. When this effect is strong enough — as is in the 'redux' model — relative output $(P_{\mathrm{H}}Y/P_{\mathrm{F}}^{*}Y^{*})$ increases more than relative consumption $(PC/P^{*}C^{*})$: Home agents desire to lend resources abroad for consumption-smoothing purposes, thus becoming net creditors *vis-à-vis* the Foreign country $(\bar{B} > 0)$. In our model, instead, relative consumption and relative output rise just as much as the relative price. Home agents labor incomes increase relative to Foreign agents, but their purchasing power declines proportionally, so that there is no scope for international lending. The adjustment process underlying this result is based on terms of trade movements, and is essentially analogous to the mechanism described by Stockman [1987] and Cole and Obstfeld [1991] in relation to the role of relative prices in international risk sharing.

Our result is robust with respect to alternative specifications of the wage (price) adjustment mechanism. In Appendix B, we assume that the adjustment takes a number T of periods, and we leave unspecified the precise dynamics of the adjustment. As we show, it remains true that permanent policy shocks have no impact on the net international asset position. The key features of our analysis — including its formal tractability — remain unaltered under these very general conditions.

4 Tools for positive and normative analysis of interdependence

In this section, we first build a simple graphical apparatus that is suitable for carrying out both positive and normative policy analysis. Then, we provide the complete closed-form solution of the model. To proceed, we introduce two useful notational conventions.[15] We will denote with the subscript R (for 'ratio' or 'relative') the ratio between Home and Foreign variables. For instance,

$$\bar{M}_R \equiv \frac{\bar{M}}{\bar{M}^*} \qquad \bar{g}_R \equiv \frac{\bar{g}}{\bar{g}^*}$$

Also, we will denote with the subscript W (for 'world') a geometric average of Home and Foreign variables, using γ and $1-\gamma$ as weights. So, for example, the world money stock and the world fiscal stance index are defined as follows

$$\bar{M}_W \equiv \bar{M}^\gamma \left(\bar{M}^*\right)^{1-\gamma} \qquad \bar{g}_W \equiv \bar{g}^\gamma \left(\bar{g}^*\right)^{1-\gamma}$$

4.1 A graphical apparatus for long-run and short-run analysis

In what follows, our model will be described — and illustrated graphically — in terms of three equilibrium relations between domestic consumption and domestic output/employment, both in the short run and the long run. Before delving into the analysis, it is important to clarify the reason why we choose to characterize the equilibrium allocation in terms of two arguments in the utility function (C and Y), as opposed to using more familiar spaces such as quantities and prices (Y and i or E), or world aggregates and ratios. Working in the YC space (or ℓC space) makes it possible to carry out joint graphical analyses of both positive and normative aspects of policy interdependence. In other words, the choice of the YC space is mainly motivated by the possibility of superimposing a map of indifference curves to the equilibrium analysis, in order to illustrate and visualize the welfare implications of policy shocks.

While the analysis below focuses on the relations between *domestic* variables, it should be clear that all equilibrium relations are derived from the optimality conditions and resource constraints describing the equilibrium for

[15]This notation is reminiscent of the traditional 'sums' *vs* 'differences' approach in general equilibrium open-economy models. See for instance Aoki [1981].

the *world* economy as a whole. Thus, they include all international spillovers and repercussions effects of domestic and foreign policy variables, as well as the external implications of domestic market distortions.

For simplicity of exposition, in the derivation of the equilibrium *loci* we will generally ignore the constants of proportionality. A complete description of the equilibrium relations appears in Table 1 in the next section.

We start with the analysis of the long-run equilibrium. To derive the first schedule, observe that — with zero external debt — the current account identity (7) yields:

$$\bar{C} = \frac{\bar{P}_{\mathrm{H}}}{\bar{P}\bar{g}}\bar{Y}$$

Solving for the relative price in the long run, $\bar{P}_{\mathrm{H}}/\bar{P}$,[16] we can rewrite the previous expression as

$$\bar{Y} \propto (\bar{g}^{*})^{\frac{1-\gamma}{2}} \bar{g}^{\frac{1+\gamma}{2}} \bar{C} \tag{14}$$

where $\propto$ denotes 'proportional to'. When Home agents increase their steady-state consumption $\bar{C}$, demand for Home goods $\bar{Y}$ increases proportionally. Changes in the relative price bring about an *expenditure-switching* effect on the demand of Home goods. Namely, a fiscal expansion abroad increases the relative price of the Foreign goods and shifts demand toward Home goods. A fiscal expansion at Home increases demand for local goods but also raises their price: the second effect reduces — without offsetting — the first effect. In Figure 1, where $\bar{C}$ is on the y-axis, $\bar{Y}$ is on the x-axis, the *locus* (14) draws a ray from the origin and is labelled GE — a shorthand for goods (market) equilibrium. The GE schedule tilts downward when $\bar{P}_{\mathrm{H}}/\bar{P}\bar{g}$ falls.

A second relation between consumption and output is derived by rearranging the labor-leisure trade-off as[17]

$$\bar{Y} \propto (\bar{g}_R)^{\frac{1-\gamma}{2}} \bar{C}^{-\rho} \tag{15}$$

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[16]Using the definition (1), note that $\bar{P}_{\mathrm{H}}/\bar{P} = \gamma_W \left(\bar{P}_{\mathrm{H}}/\bar{E}\bar{P}^{*}_{\mathrm{F}}\right)^{1-\gamma}$. Taking the ratio of (8) in the long run, we obtain $\bar{P}_{\mathrm{H}}/\bar{E}\bar{P}^{*}_{\mathrm{F}} = [\gamma/(1-\gamma)]\left(\bar{g}_R/\bar{Y}_R\right)$. To determine $\bar{g}_R/\bar{Y}_R$, solve equations (7) for, respectively, $\bar{P}_{\mathrm{H}}/\bar{P}$ and $\bar{P}^{*}_{\mathrm{F}}/\bar{P}^{*}$; then, substitute the expressions for Home and Foreign real wages into equations (9); finally, take the ratio of expressions (9), obtaining $\bar{Y}_R = \Phi_R \left(\bar{C}_R\right)^{1-\rho} \bar{g}_R \bar{Y}_R^{-1}$. Recalling that $\bar{C}_R$ is equal to $\gamma/(1-\gamma)$, solve for $\bar{Y}_R^2$ as a function of the relative fiscal policy $\bar{g}_R$, so that $\bar{g}_R/\bar{Y}_R$ is proportional to $(\bar{g}_R)^{1/2}$.

[17]Consider a weighted average of conditions (9), namely $\bar{Y}_W = \Phi_W \gamma_W \bar{C}_W^{-\rho}$. Observe that, from (7) and (8), world consumption $\bar{C}_W$ is proportional to $\bar{C}$. To solve for $\bar{Y}_W$ as a function of $\bar{Y}$ and fiscal variables, rewrite $\bar{Y}_W$ as $\bar{Y}\left(\bar{Y}_R\right)^{\gamma-1}$ and solve for $\bar{Y}_R$ as a function of $\bar{g}_R$ (see previous footnote).

Interpreting (15), an increase in steady-state consumption $\bar{C}$ makes Home agents more willing to enjoy leisure, thus reducing output. For any levels of $\bar{C}$, a fiscal expansion at Home and/or a fiscal contraction abroad lead to a real appreciation of the Home currency. The associated increase in real wages provides Home agents with an incentive to supply more labor. The *locus* (15) is plotted in Figure 1 as the negatively-sloped curve LE, that is shorthand for labor (market) equilibrium. The LE locus shifts to the right when $\bar{g}_R$ increases.

A third locus is derived by rearranging the money market equilibrium equations so as to write Home consumption as a function of world real balances:[18]

$$\bar{C}^{\rho} \propto \frac{\bar{M}_W}{\left(\bar{P}_{\mathrm{H}}\right)^{\gamma}\left(\bar{P}_{\mathrm{F}}^{*}\right)^{1-\gamma}} \tag{16}$$

In Figure 1, this equation draws a horizontal line. We label this locus with ME, for money (market) equilibrium. The ME locus shifts upwards when world real balances increase.

Looking at equations (14) and (15), we observe that monetary shocks do not affect $\bar{C}$ and $\bar{Y}$. In the long run, consumption and output are determined exclusively by the intersection of the GE locus with the LE locus. With long-run money neutrality, the ME locus (16) only determines the level of goods prices.

Our graphical apparatus can be readily adapted to describe the short-run (world and) Home equilibrium. We first re-label the axes of Figure 1 replacing long-run consumption and output with their short-run counterparts. Then, as was the case with long-run variables, we note that the current account identities provide the equilibrium relation between consumption and output ($C = P_{\mathrm{H}}Y/P\bar{g}$) that defines the GE locus. Since P_{H} and P_{F}^{*} are predetermined in the short run, the relative price is only affected by the nominal exchange rate, so that the GE locus can be written as[19]

$$Y \propto \bar{g}\left(\bar{M}_R\right)^{1-\gamma} C \tag{17}$$

In Figure 1, the slope of the short-run GE locus is now a function of

[18]To obtain (16), take the world average of Home and Foreign long-run money market equilibrium conditions and recall that $\bar{C}_W$ is proportional to $\bar{C}$.

[19]Recall that $P_{\mathrm{H}}/P = \gamma_W \left(P_{\mathrm{H}}/EP_{\mathrm{F}}^{*}\right)^{1-\gamma}$. With a constant ratio between Home and Foreign consumption, money market equilibrium in the short and the long run implies $E = \bar{E} = \chi^{*}\chi^{-1}\left[\gamma/\left(1-\gamma\right)\right]^{-\rho}\bar{M}_R$.

domestic fiscal policy and the relative money supply $\bar{M}_R$. A domestic fiscal expansion translates one-to-one into higher demand for domestic goods, but does not affect the short-run terms of trade. Conversely, changes in relative money supply $\bar{M}_R$ affect the short-run terms of trade, through their effect on the exchange rate.

Since goods prices are sticky, the short-run ME locus can be simply written in terms of Home consumption and world money supply:

$$C^{\rho} \propto \bar{M}_W \tag{18}$$

The short-run equilibrium levels of consumption and output level correspond to the intersection point between GE and ME. In the presence of short-run nominal rigidities and monopolistic competition in the labor market, agents do not necessarily operate on their labor supply schedule, so that the LE locus is irrelevant in determining the short-run equilibrium allocation.

4.2 Welfare analysis with the closed-form solution

The analytical details of the closed-form solution of the model are shown in Table 1, which focuses on the Home country with the understanding that similar relations hold for Foreign country. In this table, we express all endogenous variables as functions of (unanticipated and permanent) policy innovations $\bar{M}$, $\bar{M}^*$, $\bar{g}$ and $\bar{g}^*$. In most cases, the policy variables affect the endogenous variables either as ratios of Home to Foreign policy stances ($\bar{M}_R$ and $\bar{g}_R$), or as world averages ($\bar{M}_W$ and $\bar{g}_W$). The constant terms are functions of the other parameters of the model, of the indices of structural distortion (Φ and Φ_W), as well as of the pre-shock policy stance.

Welfare analysis can be carried out by using equation (19) below, expressing the lifetime utility of the Home representative agent:

$$\begin{aligned} U \;&=\; \frac{C^{1-\rho}}{1-\rho} + \chi \ln \frac{\bar{M}}{P} + V\left(G\right) - \frac{\kappa}{2} Y^2 + \\ &\quad \frac{1}{\delta}\left[\frac{\bar{C}^{1-\rho}}{1-\rho} + \chi \ln \frac{\bar{M}}{\bar{P}} + V(\bar{G}) - \frac{\kappa}{2}\bar{Y}^2\right] \end{aligned} \tag{19}$$

The closed-form expressions provided by Table 1, together with the above expression, makes welfare analysis in our model remarkably tractable. The advantages are apparent: we need not resort to log-linearizations and other

Table 1: Solution of the model

	Determinants of Home welfare	
C	$= a_1 \left(\bar{M}_W\right)^{\frac{1}{\rho}}$	Short-run consumption
Y	$= a_2 \left(\bar{M}_R\right)^{1-\gamma} \left(\bar{M}_W\right)^{\frac{1}{\rho}} \bar{g}$	Short-run output
$\bar{M}/P$	$= a_3 \bar{M}_W$	Short-run real balances
$\bar{C}$	$= a_4 \left(\bar{g}_W\right)^{-\frac{1}{1+\rho}}$	Long-run consumption
$\bar{Y}$	$= a_5 \bar{g}^{\frac{1}{2}} \left(\bar{g}_W\right)^{-\frac{1-\rho}{2(1+\rho)}}$	Long-run output
$\bar{M}/\bar{P}$	$= a_6 \left(\bar{g}_W\right)^{-\frac{\rho}{1+\rho}}$	Long-run real balances
	Prices	
$1+r$	$= a_7 \left(\bar{M}_W\right)^{-1} \left(\bar{g}_W\right)^{-\frac{\rho}{1+\rho}}$	Short-run real interest rate
$EP^*_{\mathrm{F}}/P_{\mathrm{H}}$	$= a_8 \bar{M}_R$	Short-run terms of trade
$E = \bar{E}$	$= a_9 \bar{M}_R$	Nominal exchange rate
$\bar{E}\bar{P}^*_{\mathrm{F}}/\bar{P}_{\mathrm{H}}$	$= a_{10} \left(\bar{g}_R\right)^{-\frac{1}{2}}$	Long-run terms of trade
$\bar{P}_{\mathrm{H}}$	$= a_{11} \bar{M} \left(\bar{g}_W\right)^{-\frac{1-\rho}{2(1+\rho)}} \bar{g}^{\frac{1}{2}}$	Long-run Home good price

Notes : The index R refers to ratios of Home to Foreign variables. The index W refers to geometric averages of Home and Foreign variables with weights γ and $1-\gamma$. The constants are defined below, where the subscript 0 indexes pre-shock levels, and $\Gamma \equiv [\gamma/(1-\gamma)]^{1-\gamma} (\gamma_W)^{\frac{2}{1+\rho}}$.

$$a_1 = \Gamma \left(g_{W_0}\right)^{-\frac{1}{1+\rho}} \left(M_{W_0}\right)^{-\frac{1}{\rho}} \left(\Phi_W\right)^{\frac{1}{1+\rho}};$$

$$a_2 = \Gamma^{\frac{1-\rho}{2}} \left(g_{W_0}\right)^{-\frac{1-\rho}{2(1+\rho)}} \left(g_0\right)^{-\frac{1}{2}} \left(M_{R_0}\right)^{-(1-\gamma)} \left(M_{W_0}\right)^{-\frac{1}{\rho}} \Phi^{\frac{1}{2}} \left(\Phi_W\right)^{\frac{1-\rho}{2(1+\rho)}};$$

$$a_3 = \chi \left[(1+\delta)/\delta\right] \Gamma^{\rho} \left(g_{W_0}\right)^{-\frac{\rho}{1+\rho}} M_{W_0}^{-1} \left(\Phi_W\right)^{\frac{\rho}{1+\rho}};$$

$$a_4 = \Gamma \left(\Phi_W\right)^{\frac{1}{1+\rho}};$$

$$a_5 = \Gamma^{\frac{1-\rho}{2}} \Phi^{\frac{1}{2}} \left(\Phi_W\right)^{\frac{1-\rho}{2(1+\rho)}};$$

$$a_6 = \chi \left[(1+\delta)/\delta\right] \Gamma^{\rho} \left(\Phi_W\right)^{\frac{\rho}{1+\rho}};$$

$$a_7 = \beta^{-1} \left(g_{W_0}\right)^{\frac{\rho}{1+\rho}} M_{W_0};$$

$$a_8 = \left[\gamma/(1-\gamma)\right]^{-\frac{1+\rho}{2}} \left(g_{R_0}\right)^{-\frac{1}{2}} M_{R_0}^{-1} \left(\Phi_R\right)^{\frac{1}{2}};$$

$$a_9 = \chi^* \chi^{-1} \left[\gamma/(1-\gamma)\right]^{-\rho};$$

$$a_{10} = \left[\gamma/(1-\gamma)\right]^{-\frac{1+\rho}{2}} \left(\Phi_R\right)^{\frac{1}{2}};$$

$$a_{11} = \left(a_4\right)^{\rho} a_5 \left(a_6\right)^{-1} \Phi^{-1}.$$

approximation techniques, we need not rely on numerical simulations, we need not be confined to the study of marginal policy shocks.

The latter point requires an important qualification. While our analysis is not confined to local deviations from the initial steady state, it should be clear that — within the logical framework of our model — policy shocks cannot be unbounded. In response to policy shocks, both in the short and long run the representative Home agent will be willing to increase her work effort only to the extent that the marginal utility from it is non-negative. If the derived utility from real holdings is a relatively small component of total utility (χ is not too large), we have:

$$C^{-\rho}\frac{\partial C}{\partial \ell} - \kappa\ell \geq 0 \quad \text{and} \quad \bar{C}^{-\rho}\frac{\partial \bar{C}}{\partial \bar{\ell}} - \kappa\bar{\ell} \geq 0 \tag{20}$$

If these conditions did not hold — for instance, because of 'excessively' expansionary shocks in the short run — agents would be better off by refusing to supply the additional labor requested to meet the demand. In such a situation, the behavioral assumption underlying our model would no longer be tenable: heuristically, a free market economy cannot operate beyond the standard of perfect competition.

Now, in equilibrium labor can be transformed into consumption at the real wage rate (adjusted for fiscal effects):

$$C = \frac{P_{\mathrm{H}}}{P\bar{g}}\ell \quad \text{and} \quad \bar{C} = \frac{\bar{P}_{\mathrm{H}}}{\bar{P}\bar{g}}\bar{\ell}$$

Replacing $\partial C/\partial \ell$ with $P_{\mathrm{H}}/P\bar{g}$ in the expression above, and recalling $Y = \ell$, the inequalities (20) simplify to

$$\frac{P_{\mathrm{H}}}{P} \geq \kappa Y C^{\rho}\bar{g} \quad \text{and} \quad \frac{\bar{P}_{\mathrm{H}}}{\bar{P}} \geq \kappa\bar{Y}\bar{C}^{\rho}\bar{g} \tag{21}$$

implicitly defining the range of policy shocks over which our analysis is meaningful.[20] Put simply, these conditions state that real wages must be sufficiently high (not lower that the marginal rate of substitution between consumption and leisure) to provide Home agents with an incentive to work.

Finally, we note that the graphical apparatus of Figure 1 can be readily extended to include and complement welfare analysis. Holding constant

[20]Using the results of Table 1, it is possible to translate the conditions above into constraints on the domain of the policy shocks.

utility from real balances and public goods, it is easy to show that, in the YC space, the short-run and long-run indifference curves of the representative agents are upward sloping and convex: utility increases when moving North-West. Figure 2 shows a map of these curves.

Since the utility function is additive separable in real balances and public goods, a change in these variables only affects the utility *level* associated with each curve, but not the shape of the curves shown in Figure 2. A thorough welfare analysis should include changes in the metric of the indifference curves due to liquidity effects or a change in the supply of public good. As will be apparent below, in many cases such changes in metric will reinforce the welfare impact of the policy effects on consumption and employment.

5 Monetary interdependence

5.1 A positive analysis of monetary shocks

Our first exercise in policy analysis focuses on the effects on the Home economy of a domestic monetary expansion. The monetary transfer raises Home agents' nominal incomes but depreciates the nominal exchange rate, increasing the Home currency price of Foreign goods. As the nominal exchange rate moves one-to-one with the money supply while P_{H} and P^*_{F} are fixed, the Home currency depreciation only raises the Home CPI by a fraction $1-\gamma$ of the increase in money supply. Thus, Home agents' incomes increase in real terms, boosting demand for consumption goods.

Abroad, the Home currency depreciation improves the purchasing power of Foreign incomes, leading to higher consumption expenditure. Note that, since Home and Foreign agents face the same real interest rate, consumption grows symmetrically in the two countries.[21] A higher world consumption coupled with a higher relative price of Foreign goods unambiguously increases the demand for Home goods, raising Y.

The above scenario is illustrated in Figure 3. The economy starts off at point 0, at the intersection between GE, LE and ME. A monetary expansion in the Home country shifts the ME locus upward, as the domestic monetary transfer raises real money balances at Home and abroad, requiring higher

[21] Real money balances also grow in the same proportion (*i.e.*, by a fraction γ): in the Home country P raises by a fraction $1-\gamma$ of the increase in $\bar{M}$, in the Foreign country $\bar{M}^*$ is constant but P^* falls by a fraction γ.

levels of consumption to maintain equilibrium in the national money markets. At the same time, the nominal depreciation of the exchange rate reduces the relative price of Home goods: the demand for Home goods increases for any level of Home consumption, and the GE locus tilts downward. The new equilibrium is at point 1, corresponding to higher consumption and output in the Home country. Since prices do not adjust instantaneously to the new fundamentals, the short-run allocation does not lie along the LE curve.

As the monetary shock does not affect the current account, monetary policy has no long-run effects. In the long run, world real balances as well as the real exchange rate move back to their original equilibrium levels. Both LE and GE return to their initial positions, so that the long-run equilibrium (point 2) coincides with the original steady state allocation (point 0).

We should note here that the analysis of *temporary* shocks is qualitatively similar to the above analysis of *permanent* shocks. Consider an unexpected increase in the money supply lasting one period only. Referring once again to Figure 3: in the short run the economy moves North-East from 0 to 1, returning in the long run to the initial steady state. The key difference relative to the case of a permanent shock is the dynamics of the exchange rate and the nominal interest differential. While in the short run the nominal exchange rate depreciates to clear the money market, it is expected to appreciate in the long run, and move back to the initial level. Expectations of an appreciation then lower the Home nominal interest rate *vis-à-vis* its Foreign counterpart, raising demand for Home money and dampening the effects of the monetary expansion on the exchange rate (as well as the global expansionary impact of the policy shock). Real money holdings grow faster at Home than abroad, but the adjustment of the nominal interest rates guarantees that consumption grows at the same rate in both countries.

Consider now the effects of a *permanent* monetary expansion originating abroad. In Figures 4a and 4b, the increase in $\bar{M}^*$ shifts the ME locus upward and tilts the GE locus to the left (as the Foreign shock appreciates the domestic terms of trade). The result is an unambiguous increase in Home consumption, while the effects on Home output can be positive (Figure 4a) or negative (Figure 4b).

To interpret the latter result, observe that Home output is subject to two contrasting forces: a higher world consumption tends to increase the demand of Home goods (by a fraction $1/\rho$), while the real appreciation of the Home currency tends to reduce it (with unit elasticity). Thus, a Foreign monetary expansion has a positive impact on Home output when $\rho < 1$, and a negative effect when $\rho > 1$.

Another way of interpreting the previous result focuses on the complementarity of Home and Foreign goods in the utility function. With CES consumption indices and power utility, two goods are complements — that is, the marginal utility of one good increases with the consumption of the other good — when the elasticity of intertemporal substitution is larger than the elasticity of intratemporal substitution, and substitutes otherwise. In our specification, the intertemporal elasticity is $1/\rho$ while the intratemporal elasticity is 1. Since world consumption of the Foreign good is unambiguously higher after the Foreign monetary expansion, world demand for Home good (and Home employment) increases only insofar as Home and Foreign goods are complements (when $\rho < 1$), and falls otherwise.[22]

5.2 A normative analysis of monetary shocks

An important result of Obstfeld and Rogoff [1995] is that country-specific monetary expansions have positive repercussions worldwide, as national welfare levels depend only on the average monetary stance across countries.[23] As acknowledged explicitly by the authors, however, their analysis applies exclusively to marginal deviations from the steady-state, and the solution strategy based on local log-linearizations might 'break down' when employed to study the impact of large shocks. Using the closed-form solution to our model, we face no such technical restrictions. We can therefore delve into the welfare analysis of large shocks, provided — as we have explained above — they do not lower the marginal rate of substitution below the real wage.

Figure 3 and 4 — employed so far to analyze the mechanism of policy transmission — also allow us to carry out a stylized analysis of the welfare effects of monetary shocks. Consider first Figure 3, that illustrates the effects of a Home expansion. When the economy moves from 0 to 1, it moves North-East: the benefits from higher consumption (as well as from higher liquidity services) are reduced by the costs of rising disutility of work effort. Formally, we can differentiate the indirect utility of a representative Home agent with

[22]The nature of international links in relation to intertemporal and intratemporal substitution is discussed in Svensson and Van Vijnbergen [1987] within the context of a model with complete markets and perfect pooling. Our analysis suggests that these highly restrictive assumptions are not necessary in deriving the above results.

[23]This result need not hold in the presence of country-specific inefficiencies unrelated to monopolistic competition, such as distortionary taxation.

respect to $\bar{M}$:

$$sign\left(\frac{\partial U}{\partial \bar{M}}\right) = sign\left[\frac{C^{1-\rho}}{\rho} + \chi - \kappa Y^2\left(\frac{1}{\rho} + \frac{1-\gamma}{\gamma}\right)\right] \qquad (22)$$

The expression above confirms that the sign of the impact of a monetary expansion on domestic welfare is ambiguous. What can be said about the net welfare effect?

Because of the presence of structural monopolistic distortions, in the initial steady-state equilibrium real wages are excessively high while world output and consumption are suboptimally low. With a small monetary innovation, the welfare benefit from a higher level of domestic consumption dominates the disutility of the additional work effort. Thus, for relatively small shocks, the net welfare effect of monetary policy is positive.

As the size of monetary shocks increases, however, the rising utility costs of foregone leisure tends to dominate the benefits from additional consumption, driving (22) to zero and eventually turning it negative. This consideration brings forth two important questions. Is the size of the shocks necessary to turn (22) negative consistent with the boundary on admissible monetary innovations (21)? If so, is it possible for suboptimally large monetary shocks to reduce welfare below the initial steady state level?

As regards the first question, consider the problem of maximizing the indirect utility of the Home representative consumer (19) with respect to $\bar{M}$, thus equating (22) to zero. Disregarding liquidity effects, we can write the first order condition for a maximum as

$$\frac{P_{\mathrm{H}}}{P} = \kappa Y C^{\rho} \bar{g}\left(1 + \frac{1-\gamma}{\gamma}\rho\right) \; > \; \kappa Y C^{\rho} \bar{g}$$

Clearly, the size of the policy shock associated with the optimal monetary policy never violates the constraint (21): at the optimum, after the inflationary shock has raised aggregate demand at preset prices, agents' real wages are strictly above their marginal cost in terms of utility. But this implies that monetary expansions slightly larger than the optimal stance will turn expression (22) negative, yet will not violate (21). Even though agents are still exchanging their labor services for consumption at a rate above the competitive standard, they now work more and get less relative to the allocation supported by the optimal monetary policy.

The main issue, then, is whether suboptimally large policy shocks that turn expression (22) negative could reduce Home welfare below its initial steady-state level. It turns out that, depending on the relative magnitude of structural parameters, there are cases in which no shock is better than large shocks, and cases in which the opposite is true.

To show this, we keep $\bar{M}^*$, $\bar{g}$ and $\bar{g}^*$ constant at their initial steady-state levels M_0^*, g_0 and g_0^*, and evaluate the welfare function (19) at two levels of $\bar{M}$: the initial steady-state level ($\bar{M} = M_0$), and the level consistent with competitive output (that is, the monetary shock such that $P_H/P = \kappa Y C^\rho g_0$). Note that the competitive output level is supported by the largest domestic monetary shock that is consistent with (21). Disregarding liquidity effects, simple algebra[24] shows that Home agents are worse off after a large shock if the following expression holds true, and better off otherwise:[25]

$$\left(\frac{1}{1-\rho} - \frac{1}{2}\right)\left(\frac{\phi}{\phi - 1}\frac{1}{g_0}\right)^{\frac{\gamma(1-\rho)}{2\rho+\gamma(1-\rho)}} < \frac{1}{1-\rho} - \frac{\phi - 1}{2\phi} g_0$$

An important conclusion from the analysis above is that the optimal Home monetary policy is less expansionary than required to raise output to its efficient level. It is worth stressing the reason underlying this result. For a given Foreign policy stance, the domestic monetary expansion required to raise output to its efficient level leads to an 'excessive' loss of purchasing

[24] As monetary policies have no long-run effects, focus exclusively on short-run welfare and assume without loss of generality that $M_0 = M_0^* = \bar{M}^* = 1$. In the absence of Home monetary shocks ($\bar{M} = M_0$), Home short-run welfare is

$$\frac{a_1^{1-\rho}}{1-\rho} - \frac{\kappa}{2} a_2^2 g_0^2$$

In contrast, the Home monetary stance consistent with the efficient level of output is

$$\bar{M} = \left(\frac{a_1^{1-\rho}}{\kappa a_2^2 g_0^2}\right)^{\frac{\rho}{2\rho+\gamma(1-\rho)}}$$

so that the short-run welfare level after the largest admissible policy shock is

$$\left(\frac{1}{1-\rho} - \frac{1}{2}\right) a_1^{1-\rho} \left(\frac{a_1^{1-\rho}}{\kappa a_2^2 g_0^2}\right)^{\frac{\gamma(1-\rho)}{2\rho+\gamma(1-\rho)}}$$

To obtain the expression in the text, compare the two welfare levels above, observing that $a_1^{1-\rho}/a_2^2 = g_0/\Phi$.

[25] As a numerical example, if $g_0 = 1$, $\phi = 2$, and $\gamma = 0.5$, the inequality is true when $\rho > 0.37$.

power of Home incomes. The case in which the deterioration of the terms of trade offsets the efficiency gains from reducing the monopolistic gap is reminiscent of 'immiserizing growth' in the international trade literature. Only if the optimal expansion were jointly implemented ($\bar{M} = \bar{M}^*$), the exchange rate distortions would disappear and output would rise to its efficient level, both domestically and abroad.[26]

Consider now the impact on Home welfare of a monetary expansion originating abroad. When consumption grows and work effort falls (Figure 4b) the impact on welfare is obviously positive, and it is reinforced by liquidity effects. The welfare impact is less obvious in the case shown by Figure 4a, as the economy moves North-East. The ambiguity nonetheless disappears when we consider the partial derivative of the indirect utility of wealth with respect to $\bar{M}^*$

$$sign\left(\frac{\partial U}{\partial \bar{M}^*}\right) = sign\left[\frac{C^{1-\rho}}{\rho} + \chi - \kappa Y^2\left(\frac{1}{\rho} - 1\right)\right]$$

It is straightforward to show that, as long as (21) holds, the sign of the resulting expression is always positive. Intuitively, an expansion abroad unambiguously raises domestic welfare, as the gains from higher consumption utility are strengthened by the gains from an improved terms of trade. This result stands in contrast with popular analyses of policy interdependence, in which monetary expansions and exchange rate devaluations abroad can have negative ('beggar-thy-neighbor') repercussions on domestic welfare, by shifting aggregate demand toward Foreign goods. The key policy implication of our analysis is that no country has a welfare incentive to 'retaliate' to foreign expansions by engaging in 'competitive devaluations': regardless of whether policies abroad boost or squeeze domestic employment, their external effect on national welfare is overall positive.

[26]Comparing our results with the 'redux' model, in both models short-run Home welfare depends positively on the global money stance $\bar{M}_W$ and negatively on the relative money stance $\bar{M}_R$. A key difference is that in our model monetary policies have no welfare effects in the long run. In the 'redux' model, instead, $\bar{M}_R$ affects steady-state variables, in such a way that the welfare effects of (a small change in) $\bar{M}_R$ in the long run and the short run exactly offset each other. Therefore, the net effect of monetary policy on welfare depends only on $\bar{M}_W$.

5.3 Strategic policy interaction revisited

The absence of a welfare incentive to engage in competitive devaluations does not mean that the Home government should not react to policy shocks originating abroad. While we leave to future contributions the detailed game-theoretic analysis of international strategic interactions, in this section we briefly touch upon the issue of determining the 'reaction function' of national monetary authorities in response to policies implemented in the rest of the world.

The reaction function is obtained by setting equation (22) equal to zero and rewriting it explicitly in terms of the Home and Foreign monetary stances.[27] If χ is relatively small, or if monetary authorities do not take into account liquidity effects when determining the optimal monetary policy, we obtain

$$[2\rho(1-\gamma)+\gamma(1+\rho)]\log\bar{M} = \Psi - (1-\gamma)(1-\rho)\log\bar{M}^{*} \tag{23}$$

where Ψ is a constant independent of $\bar{M}$ and $\bar{M}^{*}$.

The *look* of this equation is extremely familiar from the literature on policy coordination (Hamada [1985], Canzoneri and Henderson [1991]): it is a log-linear reaction function expressing the optimal monetary policy in one country as a function of structural parameters and the optimal monetary policy of the other country. This reaction function, derived in the standard literature from *ad-hoc* quadratic objective functions (in which typical arguments are employment and inflation), is now endogenously obtained within a choice-theoretic framework.

Are monetary policy instruments strategic *complements* or *substitutes*? That is, is the reaction function positively or negatively sloped? In our analysis, we can study policy spillovers using the insights gained from the analysis of the international transmission mechanism. Consider a monetary expansion in the Foreign country, that brings about an increase in consumption in the Home country. The impact on Home output is ambiguous: equation (23) reveals that monetary policies are strategic substitutes if goods are complements in utility, while monetary policies are strategic complements if goods

[27]This yields

$$(a_1)^{1-\rho}\left(\bar{M}_W\right)^{\frac{1-\rho}{\rho}}+\rho\chi=\left(1+\frac{1-\gamma}{\gamma}\rho\right)(a_2)^2\,\bar{g}^2\bar{M}^{2\left(1-\gamma+\frac{\gamma}{\rho}\right)}\kappa\left(\bar{M}^{*}\right)^{2(1-\gamma)\frac{1-\rho}{\rho}}$$

are substitutes in utility.

We can shed further light on the logic underlying this result by reinterpreting the case in which $\rho < 1$ as an 'overheating' scenario, and the case in which $\rho > 1$ as an 'underemployment' scenario. Start with an initial allocation that corresponds to the implementation of the optimal monetary policy by Home authorities when $\bar{M}^* = M_0^*$. In the overheating scenario, an expansion abroad — for given prices — boosts world demand for domestic goods, raising domestic employment above its initial (optimized) level. Although the CPI actually falls on impact, the economy of the Home country is overheated in terms of a suboptimally large 'wage-inflationary gap', measured by the difference between the current real wage and the shadow price of forgone leisure. While the expansion abroad increases Home welfare, an additional appreciation of the Home currency can raise it even further by reducing the high disutility of work effort. This is why the monetary authority of the Home country finds it optimal to react by adopting a contractionary monetary policy that 'cools down' the economy.

In the 'underemployment' scenario, the story is reversed: an expansion abroad increases not only Home consumption but also Home leisure — or, less euphemistically, Home unemployment — because of the *expenditure-switching* effects associated with the Foreign real exchange rate depreciation. In this case, the optimal reaction by the Home monetary authorities is a monetary expansion that generates employment and additional consumption. This is because Home labor disutility does not grow as fast as consumption utility when Home monetary authorities expand. Note that the reaction by Home policy-makers to the foreign shock should not be mistaken for a competitive ('beggar-thy-neighbor') devaluation: the domestic monetary expansion actually increases welfare also in the Foreign country.

In the case in which $\rho = 1$, consumption preferences are additively separable, and Home monetary policies are strategically independent of Foreign policies. This does not rule out the presence of international spillovers: for instance, a monetary contraction abroad reduces world production leading to a fall in consumption and utility at Home. However, there is nothing that the authorities of the Home country can do to offset this fall in utility: any policy reaction (either expansionary or contractionary) to foreign policy shocks would be counterproductive domestically.

6 Fiscal interdependence

The effects of fiscal shocks in our model are to a large extent the mirror image of the effects of monetary policy shocks. A permanent fiscal expansion changes the new steady state allocation of employment and consumption at the world level, whereas a permanent monetary expansion is neutral in the long run. A monetary expansion increases short-run consumption both domestically and abroad, whereas a fiscal expansion does not have any short-run effect on consumption: in analogy with the Keynesian balanced budget multiplier, an increase in public demand for domestic goods is accommodated by an equal expansion in domestic supply.[28]

We visualize the effects of an unexpected permanent fiscal expansion in Figure 5. The economy starts off at point 0. In the short run, a fiscal expansion by the Home country tilts the GE locus downward and to the right. Note that the lower slope of the GE does not reflect a real depreciation (the terms of trade remain in fact unchanged in the short run),[29] but rather the increase in public demand at given prices. The economy moves along the ME line to point 1. In the short run, the equilibrium allocation lies above the labor-leisure schedule LE. This analysis also characterizes the effects of temporary fiscal shocks.

In the long run, Home wages adjust upward to reflect the permanent increase in demand for Home goods. The relative price of Home goods rises and the Home currency appreciates in real terms. The increase in real wages implies that in the long run Home output increases by less than public spending, so that the world supply of consumption goods falls while prices increase

[28]As $Y - G$ remains unaltered, the amount of resources available for world private consumption is unchanged. The terms of trade also remain unchanged, as no crowding out of net export is necessary to make room for a higher level of domestic demand. The situation would be different if utility were not additive separable in private and public consumption: in that case, changes in government spending would affect the marginal utility of private consumption leading to a change in relative prices.

[29]In our setup, the nominal exchange rate only depends on relative money supply. Government spending can nonetheless be included among the determinants of the nominal exchange rate with a simple extension of the model, that is, by modelling aggregate money demand as a function of both private and public consumption. Then, given money supply, a fiscal expansion would bring about an appreciation of the exchange rate in both nominal and real terms. In the light of this observation, the policy experiment considered in the main text could be interpreted as the result of a fiscal expansion that is accommodated by monetary policy.

in both countries.

In Figure 5, the long-run GE locus lies somewhere in between the old steady-state and the short-run schedules. This is because the real appreciation offsets in part the impact of the fiscal expansion. At the same time, the higher real wages in the Home country shift the LE line to the right: for any level of consumption, Home agents are now willing to supply more labor. It is straightforward to show that the horizontal distance between new and old LE curves is never larger than the horizontal distance between new and old (steady-state) GE schedules. Thus, the economy reaches an equilibrium such as point 2, corresponding to lower consumption and higher output levels relative to the initial steady-state allocation (point 0).

Consider now the effects of a Foreign expansion on the Home economy, illustrated in Figures 6a and 6b. In the short run, nothing happens: the Foreign expansion neither reduces world consumption nor modifies the terms of trade, so that there are no international repercussions: the short-run equilibrium 1 coincides with the old steady state 0. In the short run, the only global variable that responds to a permanent fiscal shock is the real interest rate: it falls in anticipation of lower world consumption (and higher inflation) in the future.

In the long run, the expansion abroad depreciates the Home terms of trade and the GE locus tilts downward. At the same time, the real depreciation reduces Home real wages, and the LE locus moves downward and to the left. The new equilibrium is at point 2, corresponding unambiguously to a lower level of consumption. Output, instead, can fall (Figure 6a) or increase (Figure 6b) relative to the initial equilibrium. Since the Foreign fiscal shock reduces the availability of Foreign goods to world consumers ($\bar{Y}^* - \bar{G}^*$ falls), world demand for Home goods increases if the two national goods are substitutes, and falls otherwise.[30]

The mechanism of transmission described so far holds regardless of the nature of public expenditure. Government spending at home and abroad may be purely dissipative ($V = V^* = 0$), or fall on public goods that increase agents' utility ($V' > 0$, $V^{*\prime} > 0$). Trivially, when Home public spending is purely dissipative, the impact on Home welfare of a fiscal expansion is unambiguously negative: this can be visualized in Figure 5 by observing that

[30] From a different point of view, Home output increases if the labor supply boost following the fall in consumption more than offsets the negative effects of the real wage squeeze.

both points 1 and 2 lies South-East of the initial equilibrium point 0.[31] In our framework, steady-state levels of $\bar{g}$ larger than one are therefore desirable only to the extent that the government is able to raise Home agents utility by transforming private into public goods.[32] At an optimum, a benevolent government chooses $\bar{g}$ so as to maximize over the trade-off between direct utility gains and the welfare costs described so far.

The welfare impact on the Home country of an increase in Foreign spending is ambiguous *prima facie*, as the economy need not move South-East relative to the initial equilibrium (Figure 6a shows the case in which it moves South-West). Thus, we need to check whether it is possible that — within the admissible range of shocks in our analysis — Foreign expansions have positive spillovers on the Home economy. Formally, taking the derivative of the welfare function with respect to $\bar{g}^*$ and disregarding second-order liquidity effects, we obtain

$$sign\left(\frac{\partial U}{\partial \bar{g}^*}\right) = sign\left(\frac{\phi - 1}{\phi}\frac{1 - \rho}{2}\bar{g} - 1\right) \tag{24}$$

This expression is clearly negative in the case depicted in Figure 6b ($\rho > 1$), whereas a Foreign fiscal expansion determines a drop in Home consumption of both leisure and final goods. It turns out to be always negative also for the case depicted in Figure 6a. The reason is that, with $\rho < 1$, the above expression is positive only for very high values of Home fiscal spending, $\bar{g}$.[33] At such high values of $\bar{g}$, however, the home fiscal pressure on production raises the marginal rate of substitution between Home consumption and leisure above the real wage, a scenario that we have ruled out by defining the upper boundary for policy shocks (21).

In conclusion, a stylized analysis of fiscal interdependence within our setup shows that, while fiscal contractions abroad generate positive international externalities raising domestic welfare, a generalized world fiscal contraction need not improve global welfare. This result concerns steady-state equilibrium allocations, and is therefore independent of short-run nominal rigidities and sluggishness in price adjustment.

[31] When the utility of real holdings is considered as well, the negative welfare effects of lower consumption are reinforced.

[32] An alternative analytical route to rationalize steady-state levels of $\bar{g}$ above one is to treat public goods (spending) as an input in production.

[33] More precisely, provided that $\bar{g} > 2\phi\,(1 - \rho)^{-1}\,(\phi - 1)^{-1}$.

7 Conclusions

This paper has been devoted to a thorough but simple welfare analysis of international monetary and fiscal interdependence. In our optimization-based setup we let the terms of trade play a central role in the process of adjustment to external shocks and de-emphasize the role of current account fluctuations, as a deliberate modeling strategy to abstract from technical complexities and focus directly on the substance of the transmission mechanism. The model can thus be solved in closed form, and the analysis of policy shocks does not require approximation techniques or numerical simulations. Yet, the model is rather general in several dimensions. No strong assumption of symmetry across countries is required, and the solution is robust to alternative specifications of the price-adjustment mechanism.

National welfare, consumption and employment are determined in the model as functions of world-wide indices of policy stance and structural monopolistic distortion. At the core of the international transmission mechanism lie income and substitution effects in the trade-off between labor and leisure, and complementarity and substitutability of domestic and foreign goods in consumption. Our findings emphasize the potential drawbacks of monetary policy in increasing output towards its efficient level, as the exchange rate depreciation required to boost domestic demand also reduces the purchasing power of domestic incomes. They point out that large monetary shocks may be welfare-reducing relative to an initial status quo with no policy intervention. They stress the positive externalities of foreign monetary expansions and foreign fiscal contractions on domestic welfare, in contrast with popular analyses of policy interdependence.

A modern theoretical paradigm in international macroeconomics — based on choice-theoretic analysis in models with imperfect competition and nominal rigidities — is currently under construction. The new literature has so far been unable to meet standards of simplicity and malleability that have played a major role in determining the success and longevity of the traditional apparatus. In the present stage of development of a new intellectual synthesis in international economics, small, tractable models such as the one presented in this paper may provide valuable tools to understand and popularize the welfare implications at the core of the new approach, while bridging the gap with the traditional paradigm. This is perhaps the most useful aspect of our construction — and, we believe, its appeal as a launching pad for further threads of policy-oriented research.

Appendix A

This Appendix presents in detail the structure of the model underlying our analysis. Preferences and technology have already been described in the main text. The constraints faced by economic agents are as follows.

In the Home country, the individual budget constraint is

$$\begin{aligned} P_t B_{t+1}(j) + M_t(j) &= P_t(1+r_t)B_t(j) + M_{t-1}(j) + W_t(j)\ell_t(j) \\ &\quad -P_t T_t(j) - \left(P_{\mathrm{H},t}C_{\mathrm{H},t}(j) + E_t P^*_{\mathrm{F},t}C_{\mathrm{F},t}(j)\right) \end{aligned}$$

where B is the international bond and T non-distortionary (lump-sum) net taxes; both B and T are denominated in composite consumption units. In the Foreign country we have

$$\begin{aligned} P^*_t B^*_{t+1}(j^*) + M^*_t(j^*) &= P^*_t(1+r_t)B^*_t(j^*) + M^*_{t-1}(j^*) + W^*_t(j^*)\ell^*_t(j^*) \\ &\quad -P^*_t T^*_t(j^*) - \left(\frac{P_{\mathrm{H},t}}{E_t}C^*_{\mathrm{H},t}(j^*) + P^*_{\mathrm{F},t}C^*_{\mathrm{F},t}(j^*)\right) \end{aligned}$$

The government budget constraints in the two countries are

$$\begin{aligned} &\int_0^{1/2} \frac{M_t(j) - M_{t-1}(j)}{P_t}dj + \int_0^{1/2} T_t(j)dj \\ =\ & \frac{M_t - M_{t-1}}{2P_t} + \frac{T_t}{2} = \frac{P_{\mathrm{H},t}G_t}{2P_t} \end{aligned}$$

and

$$\begin{aligned} &\int_{1/2}^1 \frac{M^*_t(j^*) - M^*_{t-1}(j^*)}{P^*_t}dj^* + \int_{1/2}^1 T^*_t(j^*)dj^* \\ =\ & \frac{M^*_t - M^*_{t-1}}{2P^*_t} + \frac{T^*_t}{2} = \frac{P^*_{\mathrm{F},t}G^*_t}{2P^*_t} \end{aligned}$$

Note that G and G^* are the per-capita levels of government spending, $G/2$ and $G^*/2$ the aggregate levels.

The resource constraints for the world economy are

$$\begin{aligned} \frac{Y_t}{2} &\geq \frac{G_t}{2} + \int_0^{1/2} C_{\mathrm{H},t}(j)dj + \int_{1/2}^1 C^*_{\mathrm{H},t}(j^*)dj^* \\ \frac{Y^*_t}{2} &\geq \frac{G^*_t}{2} + \int_0^{1/2} C_{\mathrm{F},t}(j)dj + \int_{1/2}^1 C^*_{\mathrm{F},t}(j^*)dj^* \end{aligned}$$

(which hold with equality sign if an interior equilibrium exists). The international bond is in zero net-supply:

$$\int_0^{1/2} B_t(j)dj + \int_{1/2}^{1} B_t^*(j^*)dj^* = 0$$

Finally, the standard transversality conditions hold

$$\begin{aligned}
\lim_{\tau\to\infty} \frac{1}{\Pi_{s=t+1}^{t+\tau}(1+r_s)}\left(B(j)_{t+\tau+1} + \frac{M(j)_{t+\tau}}{P_{t+\tau}}\right) &= 0 \\
\lim_{\tau\to\infty} \frac{1}{\Pi_{s=t+1}^{t+\tau}(1+r_s)}\left(B^*(j^*)_{t+\tau+1} + \frac{M^*(j^*)_{t+\tau}}{P^*_{t+\tau}}\right) &= 0
\end{aligned}$$

To characterize the Home country equilibrium, recall equation (2), the demand for labor supplied by individual j, so that her labor incomes are

$$W_t(j)\ell_t(j) = \ell_t(j)^{1-\frac{1}{\phi}} P_{\mathrm{H},t} Y_t^{\frac{1}{\phi}}$$

The individual maximization problem can now be written in terms of the following Lagrangian:

$$\begin{aligned}
\mathcal{L}_t(j) = {} & \sum_{\tau=t}^{\infty} \beta^{\tau-t}\left[\frac{C_\tau(j)^{1-\rho}}{1-\rho} + \chi \ln\frac{M_\tau(j)}{P_\tau} + V(G_\tau) - \frac{\kappa}{2}\ell_\tau(j)^2\right] + \\
& \sum_{\tau=t}^{\infty} \beta^{\tau-t}\lambda_\tau(j)\left[-P_\tau B_{\tau+1}(j) + P_\tau(1+r_\tau)B_\tau(j) - M_\tau(j) + M_{\tau-1}(j) + \right. \\
& \left. (\ell_\tau(j))^{1-\frac{1}{\phi}} P_{\mathrm{H},\tau}(Y_\tau)^{\frac{1}{\phi}} - P_\tau T_\tau(j) - P_{\mathrm{H},\tau}C_{\mathrm{H},\tau}(j) - E_\tau P^*_{\mathrm{F},\tau}C_{\mathrm{F},\tau}(j)\right]
\end{aligned}$$

The first order conditions with respect to $C_{\mathrm{H},t}(j)$, $C_{\mathrm{F},t}(j)$, $B_{t+1}(j)$, $M_t(j)$, and $\ell_\tau(j)$ are, respectively,

$$C_t(j)^{1-\rho}\frac{\gamma}{C_{\mathrm{H},t}(j)} = \lambda_t(j) P_{\mathrm{H},t}$$

$$C_t(j)^{1-\rho}\frac{1-\gamma}{C_{\mathrm{F},t}(j)} = \lambda_t(j) E_t P^*_{\mathrm{F},t}$$

$$\lambda_t(j) P_t = \beta\lambda_{t+1}(j) P_{t+1}(1+r_{t+1})$$

$$\frac{\chi}{M_t(j)} = \lambda_t(j) - \beta\lambda_{t+1}(j)$$

$$\ell_t(j) = \lambda_t(j)\frac{\phi - 1}{\kappa\phi}(\ell_t(j))^{-\frac{1}{\phi}} P_{H,t}(Y_t)^{\frac{1}{\phi}}$$

With symmetric agents, the previous equations can be rewritten in terms of the following equilibrium conditions. The consumption index is characterized by:

$$P_t C_t = P_{H,t}C_{H,t} + E_t P^*_{F,t} C_{F,t} = \frac{1}{\gamma} P_{H,t} C_{H,t} = \frac{1}{1-\gamma} E_t P^*_{F,t} C_{F,t}$$

The Euler equation determines the optimal intertemporal allocation of consumption:

$$C_t^{-\rho} = \beta(1 + r_{t+1}) C_{t+1}^{-\rho} \tag{A.1}$$

Equilibrium in the money market requires:

$$\frac{M_t}{P_t} = \chi \frac{1 + i_{t+1}}{i_{t+1}} C_t^{\rho} \tag{A.2}$$

In the previous expression, we have used the definition of the nominal interest rates i:

$$1 + i_{t+1} \equiv (1 + r_{t+1}) \frac{P_{t+1}}{P_t}$$

Finally, the labor-leisure trade-off can be written as

$$\ell_t = Y_t = \frac{\phi - 1}{\kappa\phi} \frac{P_{H,t}}{P_t C_t} C_t^{1-\rho} \tag{A.3}$$

Aggregating the individual budget constraints, the current account relation can be written as:

$$B_{t+1} - B_t = r_t B_t + \frac{P_{H,t}(Y_t - G_t)}{P_t} - C_t \tag{A.4}$$

Equilibrium in the Foreign country can be characterized by following the same steps, introducing stars where appropriate, and the aggregate resource constraints are now:

$$\begin{aligned} \frac{Y_t - G_t}{2} &= \frac{C_{H,t}}{2} + \frac{C^*_{H,t}}{2} = \frac{\gamma P_t}{2P_{H,t}}(C_t + C^*_t) \\ \frac{Y^*_t - G^*_t}{2} &= \frac{C_{F,t}}{2} + \frac{C^*_{F,t}}{2} = \frac{(1-\gamma) P^*_t}{2P^*_{F,t}}(C_t + C^*_t) \end{aligned} \tag{A.5}$$

In the main text, equations (3) derive from (A.1), (4) and (5) from (A.2), (6) and (7) from (A.4), (8) from (A.5), and (9) from (A.3).

Appendix B

Suppose that the adjustment of prices and wages takes more than one period. What happens to the current account during the transition to the new steady-state? Nothing. If $B_t = 0$ at the time of the shock and the adjustment occurs at time $t + T$, it is still true that $B_t = B_{t+1} = B_{t+2}... = B_{t+T} = 0$.

To see this, observe that the expressions for the current account and the equilibrium in the goods market at time $t + 1$ imply

$$\frac{B_{t+1} + C_t}{-B_{t+1} + C_t^*} = \frac{\gamma}{1-\gamma}, \tag{B.1}$$

at time $t + 2$ imply

$$\frac{B_{t+2} - B_{t+1}(1 + r_{t+1}) + C_{t+1}}{-B_{t+2} + B_{t+1}(1 + r_{t+1}) + C_{t+1}^*} = \frac{\gamma}{1-\gamma}, \tag{B.2}$$

and so on. At time $t + T$ we have

$$\frac{C_{t+T} - \delta B_{t+T}}{C_{t+T}^* + \delta B_{t+T}} = \frac{\gamma}{1-\gamma} \tag{B.3}$$

Note that the previous equations hold regardless of the specific mechanism of price adjustment.

Now, define as x the time-invariant consumption ratio across countries:

$$\frac{C_t}{C_t^*} = \frac{C_{t+1}}{C_{t+1}^*} = ... = \frac{C_{t+T}}{C_{t+T}^*} \equiv x$$

and rewrite expression (B.1) as

$$B_{t+1} = C_t^* \left[\gamma - (1-\gamma) x\right],$$

and expression (B.2) as

$$B_{t+2} = \left\{C_t^* (1 + r_{t+1}) + C_{t+1}^*\right\} \left[\gamma - (1-\gamma) x\right].$$

In general, we can write

$$B_{t+T} = \left\{\sum_{\tau=0}^{T-1} C_{t+\tau}^* \prod_{s=\tau+1}^{T-1} (1 + r_{t+s})\right\} \left[\gamma - (1-\gamma) x\right] \tag{B.4}$$

Observe that expression (B.3) implies

$$B_{t+T} = -\frac{C^*_{t+T}}{\delta}\left[\gamma - (1-\gamma)\, x\right] \tag{B.5}$$

Comparing (B.4) and (B.5) yields

$$\left\{\sum_{\tau=0}^{T-1} C^*_{t+\tau} \prod_{s=\tau+1}^{T-1} (1 + r_{t+s}) + \frac{C^*_{t+T}}{\delta}\right\}\left[\gamma - (1-\gamma)\, x\right] = 0$$

and since the expression in curly brackets is strictly positive, it is the case that

$$x = \frac{\gamma}{1-\gamma}$$

which implies

$$B_t = B_{t+1} = ... = B_{t+T} = 0.$$

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Figure 1. Steady-state equilibrium

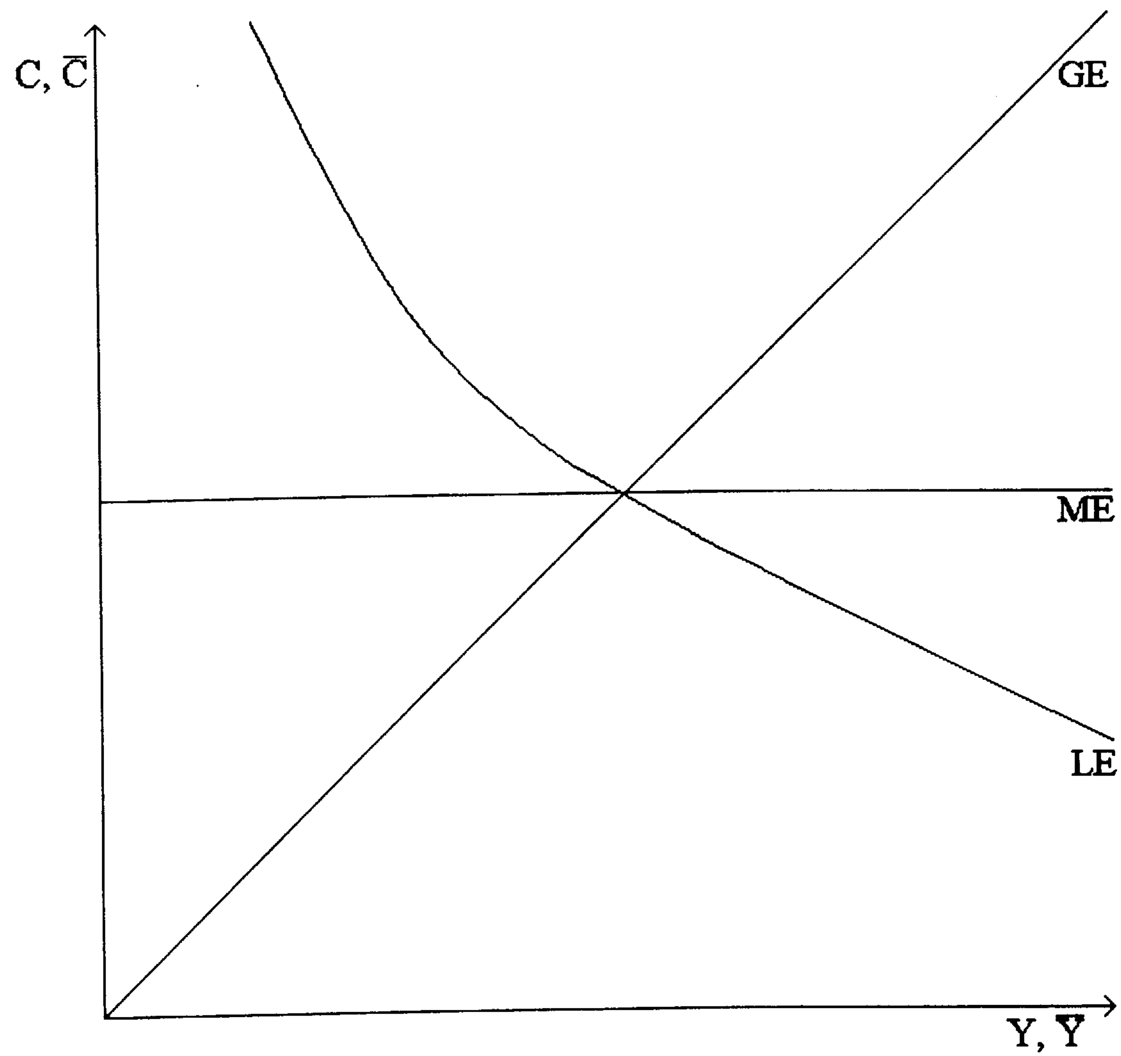

Figure 2. Indifference curves

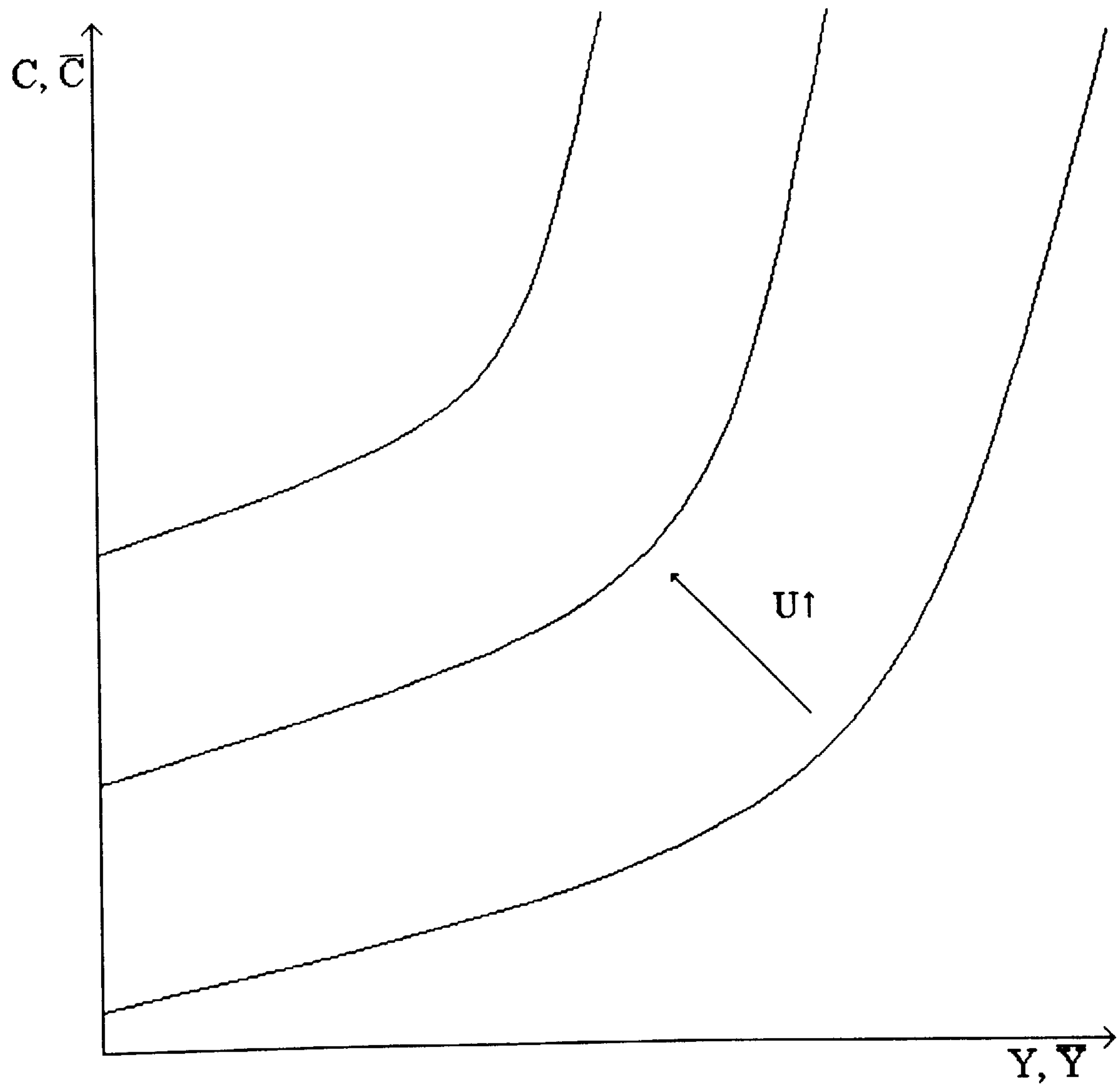

Figure 3. Effects of Home monetary expansions

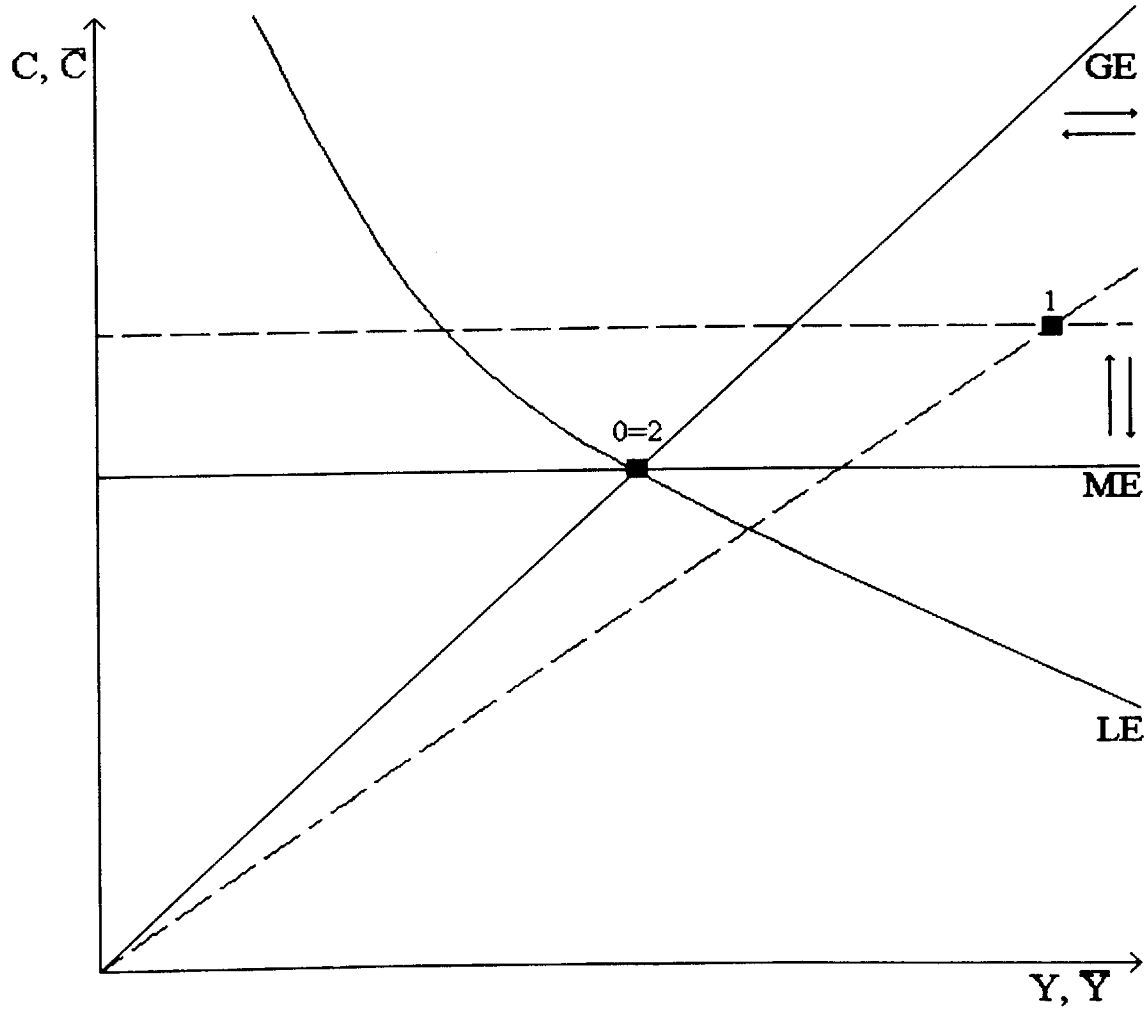

Figure 4a. Effects of Foreign monetary expansions: positive output spillovers

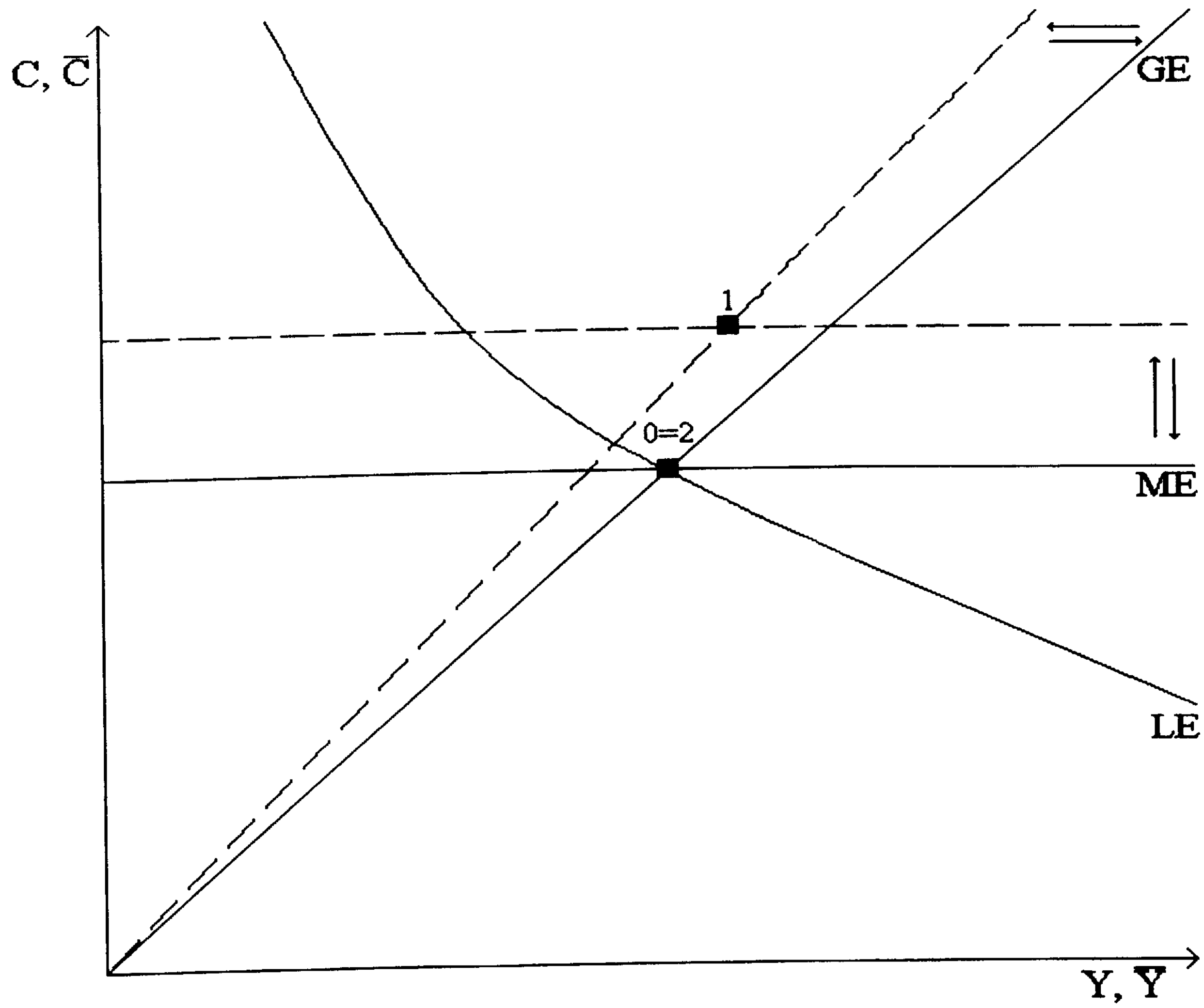

Figure 4b. Effects of Foreign monetary expansions: negative output spillovers

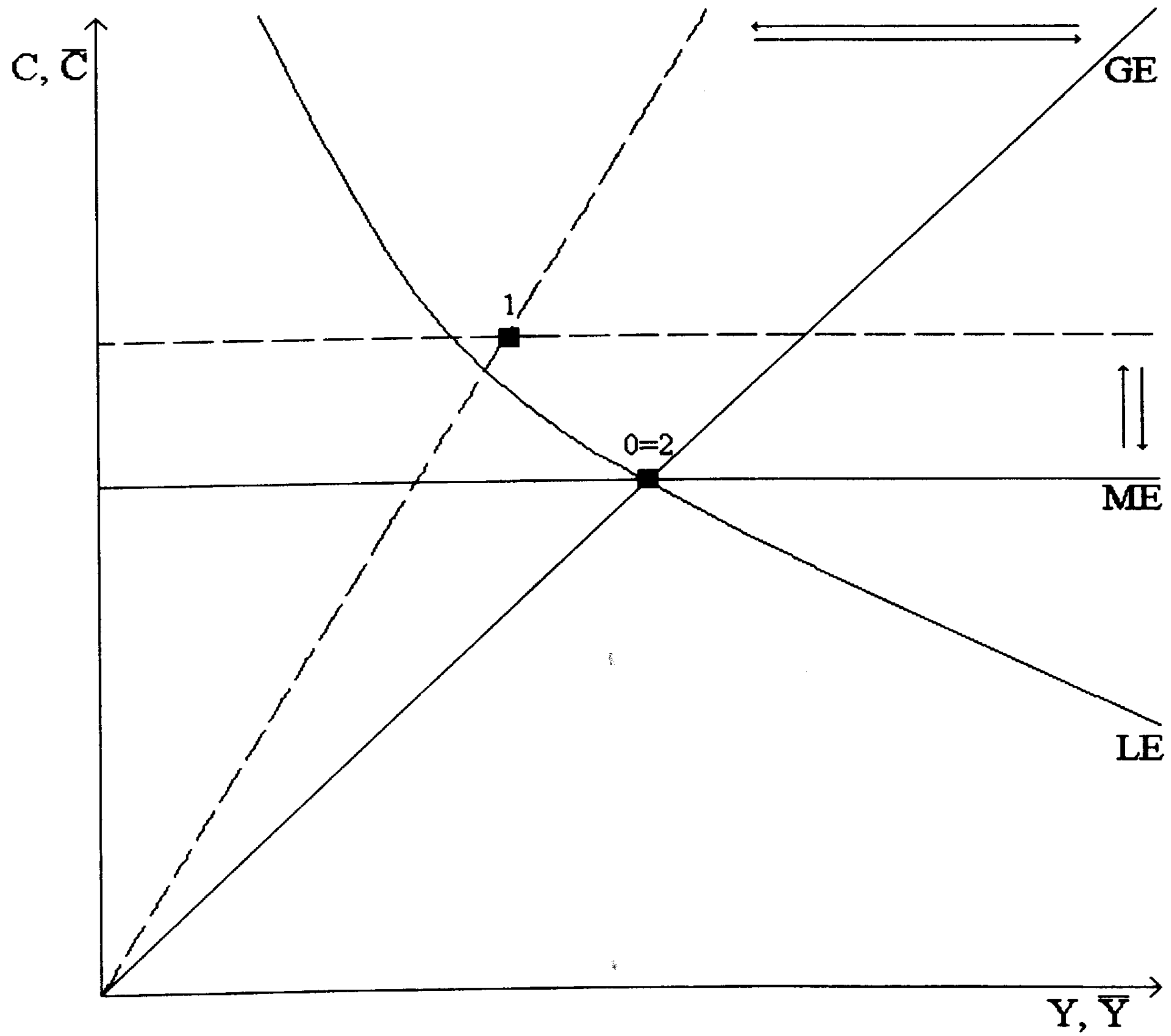

Figure 5. Effects of Home fiscal expansions

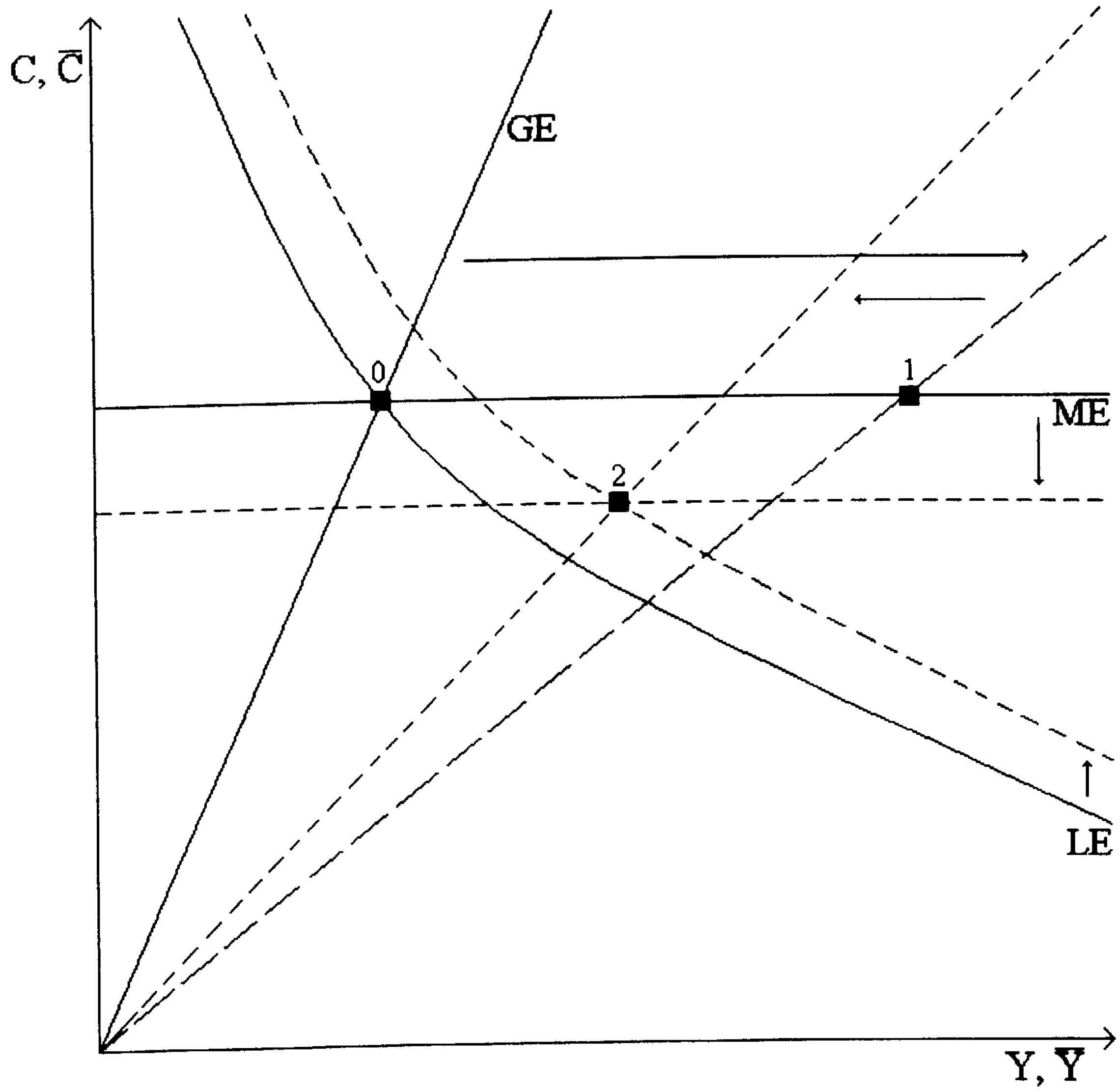

Figure 6a. Effects of Foreign fiscal expansions: negative output spillovers

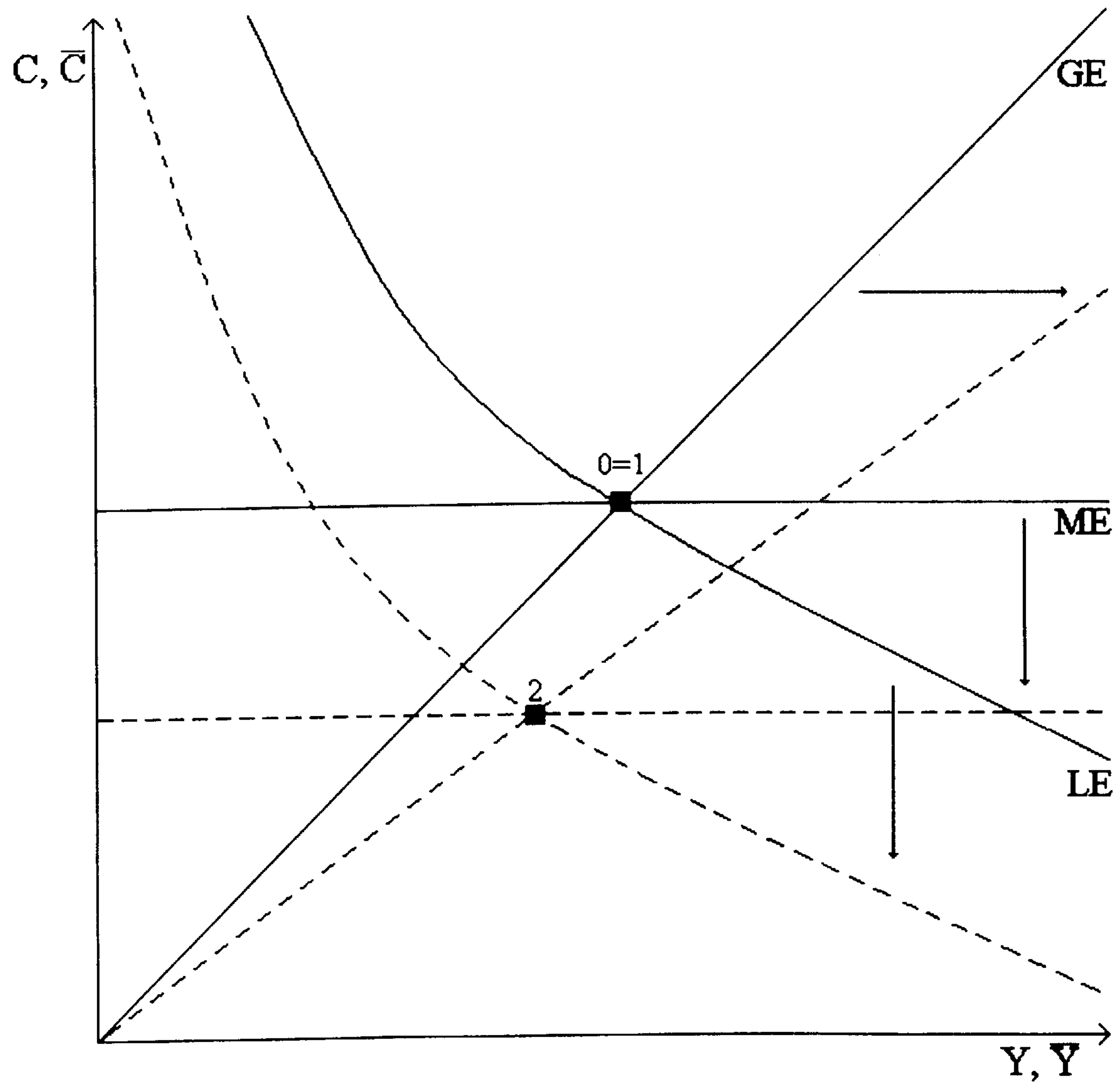

Figure 6b. Effects of Foreign fiscal expansions: positive output spillovers