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of Cooperative and
Noncooperative Fiscal Policy

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The welfare economics of cooperative and noncooperative fiscal policy

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In the absence of Ricardian equivalence, lump-sum transfers between households within a country can alter the pattern of national saving and consumption, allowing the government to exploit the country's size in world trade and in international borrowing and lending. Redistribution across generations through unfunded social-security retirement schemes or public-sector deficit finance with lump-sum taxes and transfers enables a national planner to affect both the static and intertemporal terms of trade when trade restrictions or discriminatory taxation of asset income are unavailable due to international agreements. The case for cooperative fiscal-policy formation by governments of interdependent economies is examined in an overlapping-generations economy with internationally perfectly mobile capital and a single relative price, the world interest rate. The optimum unfunded social-security scheme when no distortionary tax instruments are allowed is derived for a government with nationalistic social preferences. This policy targets both intergenerational-distribution objectives and interest-rate objectives. The absence of distortionary taxes implies that no overall loss in world surplus need result from the strategic use of lump-sum transfers, so that coordination of intergenerational transfers is unnecessary for Pareto optimality. When internationally enjoyed public goods are introduced, allocational efficiency requires cooperative selection of national exhaustive public-spending programs, but it does not demand that the financing of public expenditures be coordinated.

1. Introduction

Full international integration of commodity and financial markets appears to leave little scope for countries to adopt policies to gain national advantage in world markets. Under free trade and unified tax regimes the set of fiscal policies available to national policy makers is severely limited. In the absence of Ricardian equivalence, however, lump-sum transfers between households within a country can alter the pattern of national saving and consumption, allowing a government to exploit the country's size in world trade and international lending and borrowing.

The use of intergenerational transfers between citizens for pursuing nationalistic welfare objectives is studied in an overlapping-generations economy. Redistribution across generations either through balanced-budget un-

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funded social-security retirement schemes or public-sector deficit finance with lump-sum taxes and transfers allows a national planner to affect the country's static and intertemporal terms of trade when trade restrictions or discriminatory taxation of asset income by source or residence are unavailable, say, due to international agreements.

A major issue is whether cooperative-policy formation by governments of interdependent economies is desirable for allocational efficiency. The absence of distortionary taxes implies that no overall loss in world surplus need result from the strategic use of lump-sum transfers. Lump-sum intergenerational-transfer schemes designed to attain national welfare goals do not create departures from Pareto optimality in the world economy. Such policies do effect redistributions of total surplus between foreign residents and home-country citizenry.

We adopt an utilitarian objective for each policy maker in a two-country model which implies that the global command optimum is time-consistent. It also implies that the national command optimum for a single country facing a passive second country will be time-consistent provided a sufficient set of distortionary tax instruments can be used. The utility of all currently alive and yet to be born generations is discounted exponentially to the present. For simplicity, in all but one of our examples, we assume that the social rate of discount is constant. This utilitarian social-welfare function which is used by Calvo and Obstfeld (1988) is similar to ones proposed by Samuelson (1967, 1968), but requires no constraints on government behavior to assure time consistency of the command optima.

The adoption of a social-welfare function for the government in each country introduces a distinction between intertemporal allocations which are Pareto-optimal with respect to all household preferences (in the usual sense) and ones which are Pareto-optimal with respect to national policy makers' preferences. Because the national social-welfare functions are strictly utilitarian, optima with respect to planners' preferences are a subset of the full set of Pareto optima. Lump-sum redistribution schemes under free trade and capital mobility chosen by utilitarian planners are shown to assure that a competitive equilibrium allocation is a Pareto optimum. Because it does not benefit either social planner, dynamic inefficiency of the equilibrium plan can be avoided using noncooperative national lump-sum tax policies without international side-payments. However, a noncooperative equilibrium in lump-sum tax and transfer plans does not assure Pareto optimality with respect to national social planners' preferences. Therefore coordination is not necessary for allocational efficiency in the standard Pareto sense but is required to attain efficiency with respect to policy makers' preferences.

In our analysis we allow only intertemporal international trade, that is, borrowing and lending or international trade in claims on capital stocks (these are equivalent in this model). The generalization to study the effects of

lump-sum tax policies on the commodity terms of trade in each period is contained in Buiter and Kletzer (1990b). The impact of lump-sum taxation in the absence of Ricardian equivalence on key relative prices is demonstrated with only one relative price, the world interest rate, each period. We assume that capital is perfectly mobile internationally. We also assume away any ability of individual governments to use national seigniorage to finance fiscal deficits by studying a nonmonetary economy.

In the second section the two-country model and notation are introduced. The welfare economics of coordinated and uncoordinated fiscal policies are discussed in the third section. Three criteria are presented. The first is Pareto optimality with respect to household preferences, the second is Pareto optimality with respect to the two national planners' preferences, and the third is optimality with respect to a global utilitarian social-welfare objective. If only lump-sum taxes and transfers between households within each country separately are allowed (that is, each national authority is subject to a national solvency constraint without any international side-payments), then a noncooperative equilibrium choice of policies achieves a Pareto-optimal allocation of resources with respect to individual household preferences. Coordination between governments in the selection of these fiscal policies is necessary in general to attain a Pareto optimum with respect to the two national planners' objectives in a competitive equilibrium with free capital mobility. While separate but coordinated fiscal policies are necessary to achieve nationalistic-planner Pareto efficiency, optimization of global objectives requires international lump-sum transfers. If these are infeasible, there are two sets of policies that can be used to pursue the global second-best. The first involves the use of lump-sum national intergenerational redistribution to influence the world rate of interest and thus the international distribution of income between debtors and creditors. In addition, the international distribution of income can be altered by policies which affect the payments to the internationally immobile factor, labor in this model. Wage differentials are created by subsidizing investment in one country and taxing it in the other in the presence of perfect capital mobility.

Throughout this paper, we allow unrestricted age-dependent lump-sum national tax and transfer schemes in our analysis. In Buiter and Kletzer (1990a) we show that in an infinite-horizon economy fiscal policies composed of age-independent lump-sum taxes and transfers with deficit finance subject to a suitable public-sector solvency constraint are entirely equivalent to (balanced budget) unfunded social-security retirement schemes. That is each set of policies supports the same set of intertemporal consumption plans. As Calvo and Obstfeld (1988) show, age-independent transfer schemes which are optimal for the utilitarian planner require an infinite-horizon economy to ensure that they are also time-consistent [see also Hillier and Malcomson (1984)]. Following Wilson (1981) and O'Connell and Zeldes (1988), Calvo and

Obstfeld demonstrate that in the case of the optimal lump-sum tax policy with age-independent transfers the usual form of the government-solvency constraint does not hold. Therefore, as in Buiter and Kletzer (1990a), we modify the solvency constraints to allow deficit-financed age-independent transfer and tax schemes.

The fourth section analyzes optimum policy for a single country with national chauvinistic utilitarian objectives facing a passive country. With unrestricted distortional and lump-sum fiscal instruments, the national first-best is attained through a combination of a tax on interest received by residents from foreigners or interest paid by residents to foreigners and an unfunded social-security retirement scheme (or its equivalent with age-independent transfers). The borrowing/lending tax is the intertemporal equivalent of the optimum tariff in this model. The optimum policy package is time-consistent for the national utilitarian planner because distortional taxes are introduced in addition to unrestricted lump-sum tax and transfer policies. In this model, the national command optimum is achieved so that the standard time-inconsistency problem in the overlapping-generations economy with potential capital levies does not arise [see Fischer (1980), Kydland and Prescott (1980), Turnovsky and Brock (1980), and Chamley (1985)]. We next derive the optimal unfunded social-security policy when no distortional tax instruments are allowed and show that lump-sum tax policies can target both intergenerational-distribution objectives and interest-rate objectives. The trade-off between these two objectives targeted by a single instrument is discussed. The (constrained) national optimum in this case is not in general time-consistent.

In the fifth section, we introduce technological externalities in public-policy formation by adding internationally enjoyed public goods. A world Pareto optimum with respect to household preferences requires cooperative exhaustive public-spending programs. Public-goods provision is inefficient under noncooperative behavior by national chauvinistic social planners in general. However, attainment of a Pareto optimum does not require that the financing of public expenditures be coordinated, just the level of such expenditures at each date. As before, a Pareto-optimal plan with respect to planners' preferences does in general require cooperation in financing plans as well.

2. The model

The model economy is a two-country version of the Diamond (1965) overlapping-generations model with capital accumulation following Buiter (1981). A country is defined by two characteristics. First there is a factor of production (labor) that is immobile between countries. Second each country has a fiscal authority whose ability to tax residents may differ from its ability to tax nonresidents and/or whose ability to tax domestic sources of income

may differ from its ability to tax foreign sources of income. These very general 'boxes' will be filled with specific examples in what follows.

Each generation survives for two periods, and the economy has an infinite horizon. The populations of the two countries, home and foreign, are equal in size, growing at the same constant proportional rate n . Within each country the households are homogeneous, but tastes and initial wealth differ across borders. A constant returns-to-scale technology, which may be country-specific, is available to perfectly competitive firms producing a single output.

There is a public sector in each country which can effect intergenerational transfers between members of its own population (currently alive or yet to be born), levy distortionary taxes, and provide publicly consumed goods. Each government is represented by a single player possessing a national social-welfare function which it seeks to maximize observing a suitable solvency constraint (discussed below). There is no sovereign default risk. Taxes and subsidies can be levied on domestic investment, foreign-asset income received by domestic residents, or payments to foreign investors. There also can be lump-sum transfers to and taxes on domestic households that do not represent immediate direct intergenerational transfers. Any budget deficits or surpluses are financed by issuing or retiring one-period real government debt.

The utility function for a representative household of each generation in both countries is assumed to be intertemporally additively separable, and, without loss of generality, the single-period felicity functions are assumed identical between periods and generations within a country. The utility for a household in the home country which is young at time t is

$$U_t(c_t^1, c_t^2) = u(c_t^1) + \beta u(c_t^2), \quad (1)$$

where c_t^1 is consumption at time t of the household when young, c_t^2 is consumption at time $t + 1$ of the household when old, and the discount rate β is between zero and one. Collective consumption is not considered in the next two sections, as reflected in (1). Public goods are introduced in an additively separable manner in section 5. The utility function for the counterpart household in the foreign country is

$$U_t^*(c_t^{*1}, c_t^{*2}) = u^*(c_t^{*1}) + \beta^* u^*(c_t^{*2}),$$

where asterisks indicate foreign variables and parameters. The felicity functions $u(c)$ and $u^*(c^*)$ are twice continuously differentiable, increasing, and

strictly concave. Further, we assume that

$$\lim_{c \rightarrow 0} u'(c) = \infty \quad \text{and} \quad \lim_{c \rightarrow \infty} u'(c) = 0, \quad (2)$$

with corresponding Inada conditions for u^* . The home-country production function in intensive form is given by

$$y_t = f(k_t),$$

where y and k denote per capita output and capital, respectively, for the home country. f is twice continuously differentiable, increasing, and strictly concave, and the Inada conditions are assumed to hold. The foreign production function, assumed to have the same properties as f , is

$$y_t^* = f^*(k_t^*).$$

National wealth for the home country is the sum of the domestic capital stock and net claims on foreigners h minus home government debt b . We do not need to distinguish between direct foreign investment and foreign lending because they are perfect substitutes in this model.

At time t , total world output is divided between current consumption and capital stocks for period $t + 1$. Either country's output can be used to form capital for the next period in either country. However, existing capital stocks cannot be reallocated across borders for producing current outputs.

The budget constraint for a young household at time t in the home country under free capital mobility is

$$w(k_t) - \tau_t^1 - \frac{\tau_t^2}{1 + r_{t+1}} \geq c_t^1 + \frac{c_t^2}{1 + r_{t+1}}, \quad (3)$$

where r_{t+1} is the world rate of interest, $w_t = w(k_t) = f(k_t) - k_t f'(k_t)$ is the wage rate, τ_t^1 is the lump-sum tax paid while young, and τ_t^2 is the lump-sum tax paid while old. The competitive household maximizes (1) with respect to its consumption plan c_t^1 and c_t^2 subject to (3), taking as given w_t , r_{t+1} , τ_t^1 , and τ_t^2 . Household saving by the young and consumption by the old in the home country are given by

$$(1 + n)(h_{t+1} + b_{t+1} + k_{t+1}) + c_t^1 = w(k_t) - \tau_t^1 \quad (4)$$

and

$$c_t^2 = (1 + n)(1 + r_{t+1})(h_{t+1} + b_{t+1} + k_{t+1}) - \tau_t^2. \quad (5)$$

The equilibrium conditions for the home private sector are

$$u'(c_t^1) - (1 + r_{t+1})\beta u'(c_t^2) = 0 \quad (6)$$

and

$$f'(k_{t+1}) = r_{t+1}, \quad (7)$$

in addition to (4) and (5). The equilibrium conditions for the foreign private sector can be obtained by attaching asterisk superscripts to home-country functions and variables.

In the presence of home-country taxes on borrowing or lending abroad, r must be replaced by the sum of the world interest rate and the tax rate on foreign investment income or payments in both (6) and (7). If fixed capital formation in the home country receives a subsidy, then r must be replaced by the world interest rate minus the subsidy rate in (7) alone.

A national income accounting identity yields

$$(1 + r_t)h_t - x_t = (1 + n)h_{t+1}, \quad (8)$$

where x_t is the per capita primary external deficit (or trade deficit) for the home country.

The material balance constraint for the world economy is

$$f(k_t) + f^*(k_t^*) + k_t + k_t^* \geq (1 + n)(k_{t+1} + k_{t+1}^*) + c_t^1 + \frac{c_{t-1}^2}{1 + n} + c_t^{*1} + \frac{c_{t-1}^{*2}}{1 + n}. \quad (9)$$

Under the assumptions made, a competitive equilibrium for this economy exists given h_0 and positive initial capital stocks k_0 and k_0^* , and given that all distortionary taxes are linear.

3. Pareto-optimal policies

In the two-country overlapping-generations model, a competitive equilibrium allocation is Pareto-optimal unless the equilibrium growth path is dynamically inefficient. In Buiter and Kletzer (1990a) it is shown that fiscal policy using only nondistortionary instruments can assure a Pareto optimum. If arbitrary age-dependent lump-sum transfers are feasible, then efficiency can be achieved through the use of separate balanced-budget fiscal policies in each country. That is, balanced-budget intergenerational transfer schemes for each country separately suffice. Under free capital mobility, unfunded social-

security retirement schemes in each country do not need to be coordinated to assure a Pareto optimum with respect to household preferences.

When arbitrary unfunded social-security policies are available, relaxing the constraint that the public-sector budget be balanced in every period provides no additional ability to either government for achieving national welfare objectives. However, if restrictions are placed on the contemporaneous intergenerational transfers that can be made, then deficit-financing (or surplus accumulations) increases the instruments available to policy makers.

It is important to note that the proposition that free international capital mobility and uncoordinated, unfunded social-security programs for each of the two countries are capable of ensuring that a competitive economy attains a Pareto-optimal equilibrium allocation refers to Pareto optimality with respect to the individual household's preferences. In what follows the expressions 'Pareto-optimal' or 'Pareto-efficient' when used without qualification will always mean 'Pareto-optimal' (or Pareto-efficient) with respect to the utility functions of current and future individual households. In this paper, we introduce a utilitarian objective function for the social planner in each country and show that with free capital mobility and separate unfunded social-security retirement schemes a Pareto optimum with respect to the nationalistic preferences of the two planners can be achieved provided these separate¹ tax-transfer schemes are coordinated. A noncooperative equilibrium using only lump-sum instruments will still yield a Pareto optimum with respect to household preferences, but not with respect to national chauvinistic utilitarian planners' preferences. None of these policies will, in general, be time-consistent.

In an unrestricted, unfunded social-security scheme the budget constraint for the home-country government each period is given by

$$\tau_t^1 + \frac{\tau_{t-1}^2}{1+n} = 0. \quad (10)$$

The effect of age-dependent lump-sum transfers is to change the saving of the current young, altering the level of wealth for the next period. In the open economy, a reduction in aggregate (world) saving is required if the equilibrium path for the competitive *laissez-faire* economy is dynamically inefficient. This is achieved by taxing the young and subsidizing the consumption of the old in at least one of the countries (possibly it is necessary in both).

¹Separate tax-transfer schemes are tax-transfer schemes that are balanced nation-by-nation, i.e., that do not involve direct international transfers. We can widen this definition to include unbalanced public-sector budgets as long as one nation's public debt is serviced with taxes on that nation's residents only. Separate tax-transfer schemes can either be coordinated or uncoordinated.

The following result is proved in Buiter and Kletzer (1990a):

Proposition 1. A Pareto-optimal plan can be attained as a competitive equilibrium allocation under free capital mobility and unfunded social-security schemes. Coordination of the latter is unnecessary.

Note that Proposition 1 does not say that a competitive equilibrium allocation under perfect capital mobility will be Pareto-efficient for any set of national unfunded social-security schemes. Clearly, there may be unfunded national social-security schemes that support a dynamically inefficient equilibrium. It does say that there exist uncoordinated unfunded national social-security schemes that support a Pareto optimum.

Suppose that a national planner possesses an utilitarian welfare function of the following form over the consumption plans of the home country's residents:

$$S_t = \sum_{i=0}^{\infty} \left(\frac{1+n}{1+\rho} \right)^i (u(c_{t+i}^1) + \beta u(c_{t+i}^2)) + \left(\frac{1+\rho}{1+n} \right) \beta u(c_{t-1}^2), \quad (11)$$

where ρ is the social generational discount rate of the planner. This function is analogous to the social-welfare objective used by Calvo and Obstfeld (1988) in the closed economy.

The foreign planner seeks to maximize

$$S_t^* = \sum_{i=0}^{\infty} \left(\frac{1+n}{1+\rho^*} \right)^i (u^*(c_{t+i}^{*1}) + \beta^* u^*(c_{t+i}^{*2})) + \left(\frac{1+\rho^*}{1+n} \right) \beta^* u^*(c_{t-1}^{*2}). \quad (12)$$

In each of these functions the felicity of the currently old is included and discounted at exactly the same rate as felicity while old of the currently young or unborn. This is necessary if an unrestricted national command optimum is to be time-consistent [compare with Samuelson (1967, 1968)]. Free international capital mobility and balanced-budget age-dependent transfer schemes for each country are adequate policy instruments to attain a Pareto optimum with respect to these national welfare criteria.

Proposition 2. A Pareto optimum is achievable with respect to the national social-welfare objectives S and S^ under perfect competition and free capital mobility using separate national unfunded social-security retirement schemes (that is, schemes that are balanced nation-by-nation without international transfers).*

Proof. A Pareto optimum with respect to S and S^* , given initial capital stocks and initial net foreign assets, is found by maximizing the Lagrangean given below for some $\lambda \geq 0$,

$$S_0 + \lambda S_0^* + \sum_{t=0}^{\infty} \psi_t \left[f(k_t) + f^*(k_t^*) + k_t + k_t^* - (1+n)k_{t+1} - (1+n)k_{t+1}^* - (c_t^1 + c_t^{*1}) - \frac{(c_{t-1}^2 + c_{t-1}^{*2})}{(1+n)} \right].$$

This yields the interior first-order conditions given in eqs. (13a) through (14c), the restrictions on the values of the Lagrange multipliers along an optimal path given in (15a)–(15c), and the transversality conditions ensuring dynamic efficiency given in (15d)–(15e),

$$u'(c_t^1) - \beta(1 + f'(k_{t+1}))u'(c_t^2) = 0, \quad (13a)$$

$$u^*(c_t^{*1}) - \beta^*(1 + f^{*'}(k_{t+1}^*))u^*(c_t^{*2}) = 0, \quad (13b)$$

$$f'(k_{t+1}) = f^{*'}(k_{t+1}^*), \quad (13c)$$

$$u'(c_t^1) = \frac{(1 + f'(k_{t+1}))}{1 + \rho} u'(c_{t+1}^1), \quad (14a)$$

$$u^*(c_t^{*1}) = \frac{(1 + f^{*'}(k_{t+1}^*))}{1 + \rho^*} u^*(c_{t+1}^{*1}), \quad (14b)$$

$$\left(\frac{1+n}{1+\rho} \right)^i u'(c_{t+i}^1) = \lambda \left(\frac{1+n}{1+\rho^*} \right)^i u^*(c_{t+i}^{*1}), \quad (14c)$$

$$\psi_t(1 + f'(k_{t+1})) = (1+n)\psi_{t-1}, \quad (15a)$$

$$\psi_t(1 + f^{*'}(k_{t+1}^*)) = (1+n)\psi_{t-1}, \quad (15b)$$

$$\psi_t \geq 0 \quad \text{for all } t, \quad (15c)$$

$$\lim_{t \rightarrow \infty} \psi_t \geq 0, \quad (15d)$$

$$\lim_{t \rightarrow \infty} \psi_t k_t = 0. \quad (15e)$$

Competitive individual lifetime optimization in both countries and perfect international financial capital mobility ensure that eqs. (13a)–(13c) hold. National intergenerational transfers satisfying $\tau_t^1 + \tau_{t-1}^2/(1+n) = 0$ and $\tau_t^{*1} + \tau_{t-1}^{*2}/(1+n) = 0$ are enough to ensure that eqs. (14a)–(14b) hold, since from the two household budget constraints it follows that there are always two instruments, τ_{t+1}^2 and τ_{t+1}^{*2} , to use to satisfy (14a)–(14b) given prior choices of τ_{t+1}^1 and τ_{t+1}^{*1} . There will also be some nonnegative Pareto weight or national distributional weight λ that satisfies (14c). It is easily checked that this Pareto weight will be constant over time. Dynamic inefficiency is obviously ruled out with cooperative behavior. It would in fact be ruled out even with Nash behavior, as it will always be in the interest of each national policy maker to transfer more resources to its own old (even unilaterally) if the interest rate were permanently below the growth rate. \square

The policy choices for the home and foreign government are interdependent and must be made cooperatively to attain a Pareto optimum with respect to the two national social-welfare functions. This point can be seen by noting that (14c) is obtained from the following two first-order conditions for optimization of the Lagrangean in the above proof:

$$\left(\frac{1+n}{1+\rho} \right)^t u'(c_t^1) = \psi_t,$$

$$\lambda \left(\frac{1+n}{1+\rho^*} \right)^t u^*(c_t^{*1}) = \psi_t \quad \text{for all } t \geq 0.$$

With noncooperative behavior (for instance with Nash behavior) these equations will not hold in general, because the two national players will not be facing the same shadow prices of capital. They will hold if the two national social-welfare functions and the two national private-sector production functions and utility functions are identical, if the initial values of k and k^* are the same and if the initial value of h is zero. Note that in Proposition 2 the weight on foreign social welfare λ is constant over all generations. In the individual Pareto problem (referred to in Proposition 1), there can be a separate weight for every generation in each country. We summarize this discussion as follows:

Corollary. Under free capital mobility, separate national unfunded social-security retirement schemes must be chosen cooperatively to ensure that a Pareto optimum with respect to the national social-welfare functions is attained as a competitive equilibrium allocation.

The alternative of deficit-financed lump-sum transfer payments to households currently alive or budget surpluses to finance future transfers will only add to government's effective arsenal of fiscal instruments if restrictions are imposed on the scope of age-dependent transfer plans. In the closed infinite-horizon economy, Calvo and Obstfeld (1988) show that if the transfers made to (or taxes paid by) the two generations living at any date must be equal, then public debt management is capable of ensuring that a competitive equilibrium allocation is Pareto-efficient. In Buiter and Kletzer (1990a) we extend this proposition to a two-country setting. We show that if there always is a next period (that is, if the economy goes on forever), the ability of each government to transfer from the currently old to the currently young with national balanced budgets is an adequate policy instrument to attain a Pareto-efficient global capital-accumulation path. However, the sign of the transfer to the private sector from the public sector can switch back and forth between periods in an efficient age-independent lump-sum tax and transfer scheme, implying that discounted government debt at each date may form a nonconvergent sequence. An adequate reformulation of the government-solvency constraint is the following. With just lump-sum taxes and transfers the budget identity of the home government is

$$(1+n)b_{t+1} \equiv (1+r_t)b_t - \tau_t^1 - (1+n)^{-1}\tau_{t-1}^2.$$

Here b_t is home-country government debt per member of home-country generation t . Therefore, for $T \geq 0$, we have²

$$b_T \equiv (1+n)^{-1} \sum_{t=0}^{T-1} \left(\tau_t^1 + \frac{\tau_{t-1}^2}{(1+n)} \right) \left(\prod_{i=1}^t (1+n)^{-1}(1+r_i) \right) + \prod_{i=1}^{T-1} (1+n)^{-1}(1+r_i)b_0.$$

We require that the sequence $\{b_T\}_{T=0}^\infty$ possesses a convergent infinite subsequence $\{b_{T_j}\}_{T_j=0}^\infty$ such that the limit, as j goes to infinity of $b_{T_j}(1+n)^{T_j-1}[\prod_{i=0}^{T_j-1}(1+r_i)]^{-1}$, is nonpositive. The following proposition follows immediately:

Proposition 3. Under free capital mobility, age-independent transfer schemes which observe the modified public-sector solvency constraint in each country can be found to assure that a competitive equilibrium allocation is a Pareto optimum with respect to the two national planners' preferences.

² We adopt the notational convention that

$$\prod_{t=1}^0 (1+n)^{-1}(1+r_t) = 1 \quad \text{and} \quad \sum_{t=0}^{-1} x_t = 0.$$

Proof. The argument is almost identical to that for Proposition 2 and to the argument in Buiter and Kletzer (1990a) showing that age-independent lump-sum transfers can support a Pareto optimum with respect to individual household preferences. The revised public-sector solvency constraint is satisfied if the net discounted transfers to each generation (discounted to birth) do not grow faster than the interest rate. Dynamic efficiency can be assured without violating this restriction. \square

Corollary. The public-sector deficit-financing policies of the two governments require coordination, in general, to assure that a national social-welfare Pareto optimum is attained for the planners as a competitive equilibrium with free capital mobility.

Another question which might be asked is what policy instruments are required to maximize a global utilitarian planner's objectives? In this case, a single function is defined over the utilities of successive generations in both countries which can be written:

$$S_t^G = \left[\sum_{i=0}^\infty \left\{ (1+n)^i \prod_{j=0}^i \Omega_j \right\} (u(c_{t+i}^1) + \beta u(c_{t+i}^2)) \right. \\ \left. + \left(\frac{\Omega_{-1}}{1+n} \right) (\beta u(c_{t-1}^2)) \right] \\ + \left[\sum_{i=0}^\infty \left\{ (1+n)^i \prod_{j=0}^i \Omega_j^* \right\} (u^*(c_{t+i}^*) + \beta^* u^*(c_{t+i}^{*2})) \right. \\ \left. + \left(\frac{\Omega_{-1}^*}{1+n} \right) (\beta^* u^*(c_{t-1}^{*2})) \right], \tag{16}$$

where $\{\Omega_j\}$ and $\{\Omega_j^*\}$ are weights on the utilities of every household in the two populations, respectively. These weights can be different for each generation in each country. We assume that

$$0 < \sum_{i=0}^\infty \left\{ (1+n)^i \prod_{j=0}^i \Omega_j \right\}, \quad \sum_{i=0}^\infty \left\{ (1+n)^i \prod_{j=0}^i \Omega_j^* \right\} < \infty.$$

For time consistency of the global command optimum, it is also required that generational discount factors $(1+n)^i \prod_{j=0}^i \omega_j$ and $(1+n)^i \prod_{j=0}^i \Omega_j^*$ decline exponentially with i . This implies $0 < (1+n)\Omega_j, (1+n)\Omega_j^* < 1$ for $j \geq 0$.

Clearly maximization of S_t^G (for given household weights Ω_j and Ω_j^*), subject to the global material-balance constraint in general requires lump-sum transfers between the two populations. A global social-welfare command

optimum can only be supported as a competitive equilibrium with perfect international capital mobility if the fiscal authorities use both intergenerational transfers within each country (for example, either balanced-budget age-dependent lump-sum transfers or age-independent lump-sum transfers with deficits and surpluses observing the modified public-sector solvency constraints) and lump-sum international transfers.

The necessary conditions for a global social-welfare optimum include – in addition to the conditions governing the behavior of the shadow price of capital given in (15a)–(15e) – the following:

$$f'(k_{t+i}) = f^*(k_{t+i}^*), \tag{17a}$$

$$u'(c_{t+i}^1) = (1 + f'(k_{t+i+1+i}))\beta u'(c_{t+i}^2), \tag{17b}$$

$$u^*(c_{t+i}^{*1}) = (1 + f^*(k_{t+i+1+i}^*))\beta^* u^*(c_{t+i}^{*2}), \tag{17c}$$

$$\Omega_{t+i+1+i} u'(c_{t+i+1+i}^1) = (1 + f'(k_{t+i+1+i}))^{-1} u'(c_{t+i}^1), \tag{17d}$$

$$\Omega_{t+i+1+i}^* u^*(c_{t+i+1+i}^{*1}) = (1 + f^*(k_{t+i+1+i}^*))^{-1} u^*(c_{t+i}^{*1}), \tag{17e}$$

$$\left(\prod_{j=0}^i \Omega_j \right) u'(c_{t+i}^1) = \left(\prod_{j=0}^i \Omega_j^* \right) u^*(c_{t+i}^{*1}) \text{ for all } i. \tag{17f}$$

The first three of these are satisfied in any competitive equilibrium with perfect international capital mobility. The fourth condition characterizes optimality with respect to the global social-welfare function of the intergenerational distribution of resources within the home country. The fifth characterizes optimality of the intergenerational distribution of resources within the foreign country. The last condition characterizes optimality (in terms of the global social-welfare function) of the international (or intragenerational) distribution of resources. This last condition implies that an international lump-sum transfer plan is, in general, required in addition to individual national unfunded social-security policies to assure that competitive equilibrium allocations are global social-welfare optima. There must be scope for lump-sum redistribution between all economic agents alive at the same time, not just among the economic agents belonging to disjoint (national) subsets of the total world population. Only in rather uninteresting special cases [such as identical private utility functions and production functions, identical initial capital stocks, zero initial net foreign assets, and equal valuation of home and foreign consumers in the global social-welfare function ($\Omega_{t+i} = \Omega_{t+i}^*$ for all i)] will the achievement of the global command optimum not require lump-sum international redistribution.

When the global planner is restricted to follow national balanced-budget policies using lump-sum intergenerational redistribution only, neither the

first-order condition for (unrestricted) international distributional optimality (17f) nor the two first-order conditions for (unrestricted) national intergenerational distributional optimality (17d)–(17e) will in general be satisfied. Policies that influence the intergenerational distribution of resources inevitably influence the world rate of interest. Typically, as shown in Buiter and Kletzer (1990a), redistribution towards the old will raise the rate of interest. Even in an endowment economy without endogenous capital formation, an increase in the rate of interest will redistribute resources from borrowers to lenders.

Therefore, unless the two countries happen to be in financial autarky in each period, an increase in the rate of interest will redistribute resources from one of them (the borrower) to the other (the lender). The restricted global planner will in general trade off at the margin the intergenerational-distribution objectives within each country against the international-distribution objectives. In our model, the endogeneity of the capital stock means that direct intergenerational redistribution in period t will also influence the wage income of agents born in period $t + 1$. If the two national production functions differ, this may provide another means through which the restricted global planner can pursue its international distributional objectives.

The ability to effect international lump-sum transfers is indeed likely to be limited. We already discussed the possibility of using national intergenerational redistribution through lump-sum taxes and transfers to influence capital formation and thus the wages paid to labor, the internationally immobile factor. A second-best approach to maximizing global social-welfare objectives without the ability to effect lump-sum international transfers may well involve the use of any available distortionary tax and transfer instruments to influence the competitive payments to internationally immobile factors of production. Since in our model labor is immobile across borders while new capital can be located in either country, a tax on or subsidy to investment in one country will cause the two countries' wage rates to diverge. Shifting capital between countries redistributes income between the young of the two countries through the payments to labor. Country-specific fiscal policies (e.g., lump-sum intergenerational redistribution, if available) which observe suitably modified public-sector solvency constraints can then be used to distribute these altered national wages across generations within each population. The use of distortionary instruments to achieve 'indirect' net international wealth transfers is of course at most second-best and would not be resorted to if lump-sum international redistribution were an option.

We now derive the constrained optimal policy combination for the global social planner without direct international redistribution (whether through lump-sum or distortionary taxes or transfers) but with country-specific taxes on or subsidies to the rentals of capital and with country-specific residence-based taxation of nonwage income. Note that we wish to rule out all direct international redistribution between home-country and foreign-country resi-

dents. Since residents of either country can own capital in both countries, we impose the restriction that all net capital-tax revenue collected from home-country residents is redistributed in lump-sum fashion only to home-country residents and similarly for the net capital-tax revenue collected from foreign residents. The constraints to be observed by the global planner are those of a competitive economy with perfect international capital mobility.

The restricted global welfare optimum is achieved by maximizing S^G in (16) by influencing investment and consumption in both countries through the choice each period of the four lump-sum taxes τ_t^1 , τ_{t-1}^2 , τ_t^1 , and τ_{t-1}^2 , the two capital-income tax rates θ_t and θ_t^* , and the two residence-based interest-income tax rates μ_t and μ_t^* subject to the following set of constraints:

$$\begin{aligned} f(k_{t+i}) + k_{t+i} + f^*(k_{t+i}^*) + k_{t+i}^* - (1-n)(k_{t+i+i} + k_{t+i+i}^*) \\ \geq c_{t+i}^1 + c_{t+i}^{*1} + \frac{c_{t+i-1}^2}{1+n} + \frac{c_{t+i-1}^{*2}}{1+n}, \end{aligned} \quad (18)$$

$$\begin{aligned} f(k_{t+i}) - k_{t+i} f'(k_{t+i}) - \tau_{t+i}^1 - \frac{\tau_{t+i}^2}{1+r_{t+i+i} - \mu_{t+i+i}} \\ \geq c_{t+i}^1 + \frac{c_{t+i}^2}{1+r_{t+i+i} - \mu_{t+i+i}}, \end{aligned} \quad (19)$$

$$\begin{aligned} f^*(k_{t+i}^*) - k_{t+i}^* f'(k_{t+i}^*) - \tau_{t+i}^{*1} - \frac{\tau_{t+i}^{*2}}{1+r_{t+i+i} - \mu_{t+i+i}^*} \\ \geq c_{t+i}^{*1} + \frac{c_{t+i}^{*2}}{1+r_{t+i+i} - \mu_{t+i+i}^*}, \end{aligned} \quad (20)$$

$$\begin{aligned} \tau_{t+i}^1 + \frac{\tau_{t+i-1}^2}{1+n} + \theta_{t+i} a_{t+i} k_{t+i} + \theta_{t+i}^* (1-a_{t+i}^*) k_{t+i}^* \\ + \mu_{t+i} ((1-a_{t+i}^*) k_{t+i}^* + a_{t+i} k_{t+i}) = 0, \end{aligned} \quad (21)$$

$$\begin{aligned} \tau_{t+i}^{*1} + \frac{\tau_{t+i-1}^{*2}}{1+n} + \theta_{t+i}^* a_{t+i}^* k_{t+i}^* + \theta_{t+i} (1-a_{t+i}) k_{t+i} \\ + \mu_{t+i}^* ((1-a_{t+i}) k_{t+i} + a_{t+i}^* k_{t+i}^*) = 0, \end{aligned} \quad (22)$$

$$r_{t+i} = f'(k_{t+i}) - \theta_{t+i} = f''(k_{t+i}^*) - \theta_{t+i}^*, \quad (23)$$

$$u'(c_{t+i}^1) = (1+r_{t+i+i} - \mu_{t+i+i}) \beta u'(c_{t+i}^2), \quad (24)$$

$$u^{**}(c_{t+i}^{*1}) = (1+r_{t+i+i} - \mu_{t+i+i}^*) \beta^* u^{**}(c_{t+i}^{*2}). \quad (25)$$

Eqs. (21) and (22) represent balanced-budget constraints for the public sectors. Since there are assumed to be lump-sum taxes and transfers for national intergenerational redistribution (that is, arbitrary unfunded national social-security programs), no generality is lost with the assumption of a balanced budget. The proportion of the capital stock employed in the home country owned by home residents is a_t , and the proportion of the capital stock employed in the foreign country owned by foreign citizens is a_t^* . Eqs. (21) and (22) reflect the restriction that all tax revenue collected from home-country residents is redistributed in lump-sum fashion to this population only, and similarly for foreign tax revenues. Wedges between the rates of interest received by foreign and home households can be imposed. The before-tax interest rate r is the same in both countries through the assumption of perfect international capital mobility. It equals the marginal product of capital net of capital-income taxes in the two countries: $r_t = f'(k_t) - \theta_t = f''(k_t^*) - \theta_t^*$. Private residents in the home country get an after-tax rate of return on their financial assets of $r_t - \mu_t$, while foreign residents earn $r_t - \mu_t^*$.

For this economy, we establish the following proposition:

Proposition 4. In the absence of feasible international lump-sum transfers, the second-best policy for the global utilitarian planner with access to country-specific taxes on capital income and residence-based interest taxes is to set a nonnegative tax on the returns to capital located in one country and a nonpositive tax on the returns to capital located in the other country, along with separate unfunded social-security schemes or their equivalent in each country. Residence-based interest taxes are not used.

Proof. Solve the Lagrange problem for the maximization of S^G given in (16) using constraints (18)–(25). The necessary conditions for an optimum include eqs. (26) through (31). ψ_t , η_t , and η_t^* are the Lagrange multipliers for constraints (18), (21), and (22), respectively.

$$\mu_{t+i} = \mu_{t+i}^* = 0, \quad (26)$$

$$\begin{aligned} [\varphi_{t+i} + a_{t+i} \eta_{t+i} + (1-a_{t+i}) \eta_{t+i}^*] \theta_{t+i} \\ = (1-a_{t+i}) (\eta_{t+i} - \eta_{t+i}^*) k_{t+i} f''(k_{t+i}), \end{aligned} \quad (27)$$

$$\begin{aligned} [\varphi_{t+i} + a_{t+i}^* \eta_{t+i}^* + (1-a_{t+i}^*) \eta_{t+i}] \theta_{t+i}^* \\ = (1-a_{t+i}^*) (\eta_{t+i}^* - \eta_{t+i}) k_{t+i}^* f''(k_{t+i}^*), \end{aligned} \quad (28)$$

$$\eta_{t+i+i} = (1+n)(1+r_{t+i+i})^{-1} \eta_{t+i}, \quad (29)$$

$$\eta_{t+i+i}^* = (1+n)(1+r_{t+i+i}^*)^{-1} \eta_{t+i}^*, \quad (30)$$

$$\varphi_{t+i+i} = (1+n)(1+r_{t+i+i})^{-1} \varphi_{t+i}. \quad (31)$$

Eq. (26) says that residence-based taxes on asset income are not used in the restricted global optimum program. They obviously cannot effect any direct international transfer. In addition they cannot be used to move the two national capital intensities and thus the two national wage rates in opposite directions. They can be used to influence the before-tax world interest rate and thus the distribution of income between a debtor and a creditor nation, but that same objective can be achieved more effectively using the other fiscal instruments. There is no case for distorting the global allocation of saving.

Because the three multipliers ψ , η , and η^* must be all nonnegative at the constrained optimum, there will in general be a nonzero tax or subsidy to investment in at least one country. This follows from eqs. (27) and (28) which imply

$$\begin{aligned} & [a\eta + (1-a)\eta^*]\theta + (1-a)(\eta^* - \eta)k\eta' \\ & = [a^*\eta^* + (1-a^*)\eta]\theta^* + (1-a^*)(\eta - \eta^*)k^*\eta^{*'} \end{aligned}$$

The two capital tax rates will therefore never have the same signs (unless they are both zero). \square

There are two reasons why a global planner without access to lump-sum international redistribution instruments may want to influence capital formation using distortionary taxes. First, such policies will influence the world rate of interest; to the extent that there is net foreign investment, such changes in the world rate of interest will redistribute income between residents of the debtor country and the creditor country. Second, changes in the national capital stocks influence the wages received by the future young generation in the two countries.

From eqs. (27) and (28) it can be seen that a distortionary tax will not be imposed on the income from capital located in a country when that country's capital stock is wholly owned by domestic residents: $\theta_t = 0$ if $a_t = 0$ and $\theta_t^* = 0$ if $a_t^* = 0$. Thus if $a_t = a_t^* = 1$ for all t we have $r_t = f'(k_t) = f^{*'}(k_t^*)$ for all t , and the unrestricted command optimum will prevail. If there is never any *net* ownership of foreign assets, real or financial (which is implied by - but does not imply - the absence of gross foreign ownership), there is no argument for changing the world rate of interest in order to alter the global distribution of income between debtors and creditors. If there is no gross foreign ownership of real capital, there also is no social return to trying to change wages (the income of the internationally immobile factor) by influencing physical capital formation through distortionary taxes on the income from capital. With perpetual financial autarky (gross and net) all domestic capital formation must be financed out of domestic saving, and the excess burden of the distortion associated with the domestic capital-forma-

tion process in a country is borne exclusively by residents of that country. In a closed economy distortionary taxes would not be used, and neither will they be used in this formally open but effectively closed economy.

The second case where distortionary taxes will not be used in the restricted global optimum is where the shadow values of the separate national public-sector budget constraints are equal ($\eta_t = \eta_t^*$ for all t). This represents the case in which, in the unrestricted global optimum, there never are any net lump-sum international transfers.

The remaining necessary conditions for the restricted global optimum are given below:

$$\begin{aligned} \frac{u(c_{t+i}^1)}{\Omega_{t+1}u^1(c_{t+i+1}^1)} &= 1 + r_{t+i+1} = \frac{u^*(c_{t+i+1}^{*1})}{\Omega_{t+1}^*u^{*1}(c_{t+i+1}^{*1})}, \\ (1+n)^i \prod_{j=0}^i \Omega_j u^1(c_{t+i}^1) &= (1+n)^i \prod_{j=0}^i \Omega_j^* u^{*1}(c_{t+i}^{*1}) + \eta_{t+i} - \eta_{t+i}^*, \end{aligned}$$

plus the usual transversality conditions.

They are easily seen to reduce to the first-order conditions for the unrestricted global optimum given in (17b) through (17d) when $\eta_t = \eta_t^*$ for all t . When $a_t^* = 1$ for all t , the equations of motion for the shadow prices are the same as in the unrestricted optimum, but the initial conditions for η and η^* need not be the same.

As noted in the earlier discussion, a 'distortionary' tax/subsidy program is useful for global utilitarian social-welfare optimization when there is foreign ownership of capital in at least one country in competitive equilibrium and the special case that no international lump-sum transfers are desired in the unrestricted optimization exercise does not hold.

A tax on the earnings of home capital (with or without the feature that any revenue collected from foreign owners of domestic capital is returned to them as lump-sum payments) reduces the capital stock in the home country, depressing home wages and raising foreign wages. This imperfect-substitute policy for international lump-sum transfers creates a distortion by breaking the equality of the marginal productivities of capital across borders. In equilibrium, a least distortionary policy will entail a positive subsidy to capital in one country and a positive tax on capital earnings in the other, in the general case.

4. Policies for achieving national welfare objectives

While the policies necessary for a competitive equilibrium growth path for the two-country economy under free financial capital mobility to be a Pareto

optimum do not need to be coordinated between governments, a Pareto optimum with respect to two utilitarian national planners' preferences and a global social-welfare optimum are attained only through coordinated policy selection. In this section we study the national optimal behavior of a single national planner who takes as given current and future policy choices of the other national planner. We can look at this as an intertemporal version of the familiar static trade-policy analysis which considers the interaction of an active, optimizing national policy maker who exploits the country's size in the world market and a passive policy maker who neither responds to the other country's policy measures nor attempts to exploit his country's market power. The passive country (labeled 'foreign' in what follows) is assumed not to have imposed any distortionary taxes or subsidies. It may have an internal lump-sum intergenerational-redistribution scheme, but this is assumed independent of the policies pursued by the active home-country policy maker. We can of course interpret the behavior of our 'active' home-country government as noncooperative open-loop Nash behavior. To characterize a full Nash equilibrium, the foreign government's behavior will have to be specified analogously: like the home-country policy maker, it will not take world market prices as parametric.

For the open-loop Nash equilibrium when both governments have access to instruments for national lump-sum intergenerational redistribution and to distortionary instruments such as capital rental taxes, interest taxes or subsidies, and taxes or subsidies on foreign lending (borrowing), we state the following proposition without proof:

Proposition 5. As in the static trade model, a noncooperative (open-loop Nash) equilibrium under nationalistic policy making when national policy makers have access to distortionary instruments yields a Pareto-suboptimal world allocation of resources, in this case capital.

If in the one active and one passive country scenario the home-country planner takes the lump-sum transfer scheme between foreign-country residents chosen by the foreign government as given, then the optimal choice of policies by the home planner with preferences defined only over domestic residents' utilities as in eq. (11) will include distortionary taxes. In conventional static multicountry trade theory, the optimal policy intervention for national welfare objectives is an optimum tariff. In this model all international trade is intertemporal so the analogue of the optimum tariff is a tax on private foreign lending or borrowing. Such a tax equates the domestic rate of intertemporal product transformation ($1 +$ the home-country marginal productivity of capital) with ($1 +$ the rate of return to domestic residents from claims on foreign capital). The tax (the capital-market equivalent to a tariff or export tax) raises the foreign rate of interest paid to home-country residents

by foreigners if the home country is a net creditor, or lowers the rate of interest paid by domestic residents to foreigners if the home country is a net debtor.

The optimum policy package for the home-country utilitarian planner is easily derived. A convenient way of characterizing the optimum problem of the domestic planner maximizing S_t [given in eq. (11)] is by viewing her as being able to choose directly for all $i \geq 0$ the domestic consumption streams $\{c_{t+i}^1, c_{t+i-1}^2\}$ and the stream of trade deficits $\{x_{t+i}\}$ subject to the following constraints:

$$f(k_{t+i}) + k_{t+i} - (1+n)k_{t+i+1} + x_{t+i} - c_{t+i}^1 - (1+n)^{-1}c_{t+i-1}^2 = 0, \quad (32)$$

$$f^*(k_{t+i}^*) + k_{t+i}^* - (1+n)k_{t+i+1}^* - x_{t+i} - c_{t+i}^{*1} - (1+n)^{-1}c_{t+i-1}^{*2} = 0, \quad (33)$$

$$(1+r_{t+i}^*)h_{t+i} - (1+n)h_{t+i+1} - x_{t+i} = 0, \quad (34)$$

$$u^*(c_{t+i}^{*1}) - \beta^*(1+r_{t+i+1}^*)u^*(c_{t+i}^{*2}) = 0, \quad (35)$$

$$f^*(k_{t+i}^*) - k_{t+i}^* f^*(k_{t+i}^*) - c_{t+i}^{*1} - (1+r_{t+i+1}^*)^{-1}c_{t+i}^{*2} = 0, \quad (36)$$

$$r_{t+i}^* - f^*(k_{t+i}^*) = 0. \quad (37)$$

Eqs. (32) and (33) are the resource constraints of the home country and the foreign country, respectively. Eq. (34) is the net external asset-accumulation equation for the home country. Eqs. (35) and (36) characterize competitive household equilibrium in the foreign country. The world rate of interest r^* equals the foreign marginal product of capital. Since the foreign government is passive, we lose no generality by omitting all foreign taxes. The home government has three instruments each period, τ_t^1 , τ_{t-1}^2 , and the lending or borrowing tax. These are sufficient to allow it to choose as competitive equilibrium values of c_t^1 , c_{t-1}^2 , and x_t in each period any values of these variables that satisfy the home-country resource constraint given k_t . The following conditions are satisfied in equilibrium:

$$f'(k_t) = f^*(k_t^*) + h_t f^{*'}(k_t^*),$$

$$u'(c_t^1) = \beta(1+f'(k_t))u'(c_t^2),$$

$$u'(c_t^1) = (1+\rho)^{-1}(1+f'(k_t))u'(c_{t+1}^1). \quad (38)$$

The optimal fiscal policy for the home government combines a foreign lending or borrowing tax with an efficient unfunded social-security scheme. The domestic rate of interest equals the marginal productivity of home capital.

Even if multilateral agreements restrict the use of standard protective measures to gain national advantage in international exchange, scope for policy intervention to raise national social welfare at the expense of foreign welfare remains in the overlapping-generations model. Suppose discriminatory taxes on capital income by source, investment subsidies, taxes on international lending or borrowing, and similar tax incentives are eliminated by international agreements. Because of the absence of Ricardian neutrality, lump-sum transfer fiscal policies can alter the expenditure plan for the home private sector. Such intertemporal expenditure switching can be used strategically by the government to raise its national social-welfare level at the expense of the foreign government's welfare objectives. Of course, if only lump-sum transfer policies across households within each country are allowed, then the resulting competitive equilibrium for the world economy yields a Pareto-optimal allocation unless it is dynamically inefficient. Further, if unrestricted age-dependent lump-sum transfers are feasible, balanced-budget policies achieve the same set of outcomes as do policies which involve deficit-financing (subject to the modified public-sector solvency constraint). However, with restrictions on the form of social-security retirement schemes a strategic role for the deficit policy of a government with nationalistic social-welfare objectives exists.

We now assume that the foreign planner maximizes S_t^* with respect to his national unfunded social-security policies at all dates, taking the unfunded social-security plan of the home government as fixed and that the home-country government maximizes S_t in the same manner. An open-loop Nash equilibrium in fiscal policies using only national balanced-budget lump-sum transfer policies yields a Pareto-optimal allocation with respect to household preferences and a suboptimal one with respect to national social planners' preferences and with respect to the global social-welfare function. Starting from a global social-welfare optimum or from a national social-welfare Pareto optimum, if both governments aim to maximize their own national social welfare through noncooperative strategies, they will in general select national lump-sum intergenerational-redistribution policies which cause deviations from the necessary conditions for a national social-welfare Pareto optimum or a global optimum.

Since the open-loop Nash policies we consider do not in general support national command optima, the time consistency of these policies is not guaranteed. We ensure credibility '*pro forma*' by endowing our governments with compulsive honesty ('I cannot tell a lie'). Whether these policies can be

supported with more general 'punishments' or other trigger strategies involving memory is an open question and beyond the scope of the present paper.

Without fully characterizing the Nash equilibrium we can establish its key properties by considering the optimization problem for the home government which maximizes S_t with respect to the sequence of domestic lump-sum taxes and transfers $\{(\tau_{t+i}^1, \tau_{t+i-1}^2)\}_{t=0}^{\infty}$ (and taking as given the sequence of foreign lump-sum taxes and transfers $\{(\tau_{t+i}^{*1}, \tau_{t+i-1}^{*2})\}_{t=0}^{\infty}$) subject to the following constraints:

$$u'(c_{t+i}^1) - \beta(1 + r_{t+i+1})u'(c_{t+i}^2) = 0, \quad (39)$$

$$f(k_{t+i}) - k_{t+i}f'(k_{t+i}) - \tau_{t+i}^1 - \frac{\tau_{t+i}^2}{1 + r_{t+i+1}} = c_{t+i}^1 + \frac{c_{t+i}^2}{1 + r_{t+i+1}}, \quad (40)$$

$$u^*(c_{t+i}^{*1}) - \beta^*(1 + r_{t+i+1})u^*(c_{t+i}^{*2}) = 0, \quad (41)$$

$$f^*(k_{t+i}^*) - k_{t+i}^*f^*(k_{t+i}^*) - \tau_{t+i}^{*1} - \frac{\tau_{t+i}^{*2}}{1 + r_{t+i+1}} = c_{t+i}^{*1} + \frac{c_{t+i}^{*2}}{1 + r_{t+i+1}}, \quad (42)$$

$$(1 + r_{t+i+1})(1 + \rho^*)^{-1}u^*(c_{t+i+1}^{*1}) - u^*(c_{t+i}^{*1}) = 0, \quad (43)$$

$$f^*(k_{t+i}^*) + k_{t+i}^* - (1 + n)k_{t+i+1}^* - x_{t+i} = c_{t+i}^{*1} + \frac{c_{t+i}^{*2}}{1 + n}, \quad (44)$$

$$f(k_{t+i}) + k_{t+i} - (1 + n)k_{t+i+1} + x_{t+i} = c_{t+i}^1 + \frac{c_{t+i}^2}{1 + n}, \quad (45)$$

$$(1 + r_{t+i})h_{t+i} - (1 + n)h_{t+i+1} - x_{t+i} = 0, \quad (46)$$

$$f'(k_{t+i+1}) = r_{t+i+1}, \quad (47a)$$

$$r_{t+i+1} = f^*(k_{t+i+1}^*), \quad (47b)$$

and balanced-budget constraints

$$\tau_{t+i}^1 + \frac{\tau_{t+i-1}^2}{1+n} = 0 \quad \text{and} \quad \tau_{t+i}^* + \frac{\tau_{t+i-1}^*}{1+n} = 0.$$

Eqs. (39)–(42) are necessary conditions for privately optimal household consumption and saving decisions in both countries, while (43) is the necessary condition for the foreign government's choice of fiscal policy to achieve an efficient (in terms of the foreign national social-welfare function) foreign intergenerational-distribution plan. By writing (43), we are not directly characterizing the Nash equilibrium in fiscal policies. We instead use it to show that the necessary condition for a national social-welfare Pareto optimum will not be satisfied by the home government's fiscal policy when the respective first-order condition is fulfilled by its foreign counterpart.

After some algebra, the necessary conditions for a constrained national optimum include:

$$\left(\frac{1+n}{1+\rho}\right)^{i-1} \left[\frac{u'(c_{t+i}^1)}{1+\rho} - \frac{u'(c_{t+i-1}^1)}{1+r_{t+i}} \right] = -\gamma_{t+i} \frac{u''(c_{t+i}^1)}{1+n} - \gamma_{t+i-1} \beta (1+r_{t+i}) u''(c_{t+i-1}^2), \quad (48)$$

$$(\gamma_{t+i}^* - \eta_{t+i-1}) u^{**}(c_{t+i}^*) + [\gamma_{t+i-1}^*(1+r_{t+i}) - \eta_{t+i-1}(1+\rho^*)] (1+n) \beta^* u^{**}(c_{t+i-1}^*) = 0, \quad (49)$$

$$\begin{aligned} & \gamma_{t+i} \beta u(c_{t+i}^2) + \gamma_{t+i}^* \beta^* u^*(c_{t+i}^{*2}) + \gamma_{t+i}(1+n) [u''(c_{t+i}^1) \\ & + \beta(1+r_{t+i-1})^2 u''(c_{t+i-1}^2)] \frac{f''(k_{t+i+1}) + f^{**}(k_{t+i+1}^*)}{f''(k_{t+i+1}) f^{**}(k_{t+i+1}^*)} \\ & = (\pi_{t+i+1} - \pi_{t+i+1}^* + \nu_{t+i+1}) h_{t+i+1} \\ & = \left[\left(\frac{1+n}{1+\rho} \right)^{i+1} u'(c_{t+i+1}^1) + \gamma_{t+i+1} u''(c_{t+i+1}^1) \right. \\ & \quad \left. - (\gamma_{t+i+1}^* - \eta_{t+i}) u^{**}(c_{t+i+1}^*) \right] h_{t+i+1}, \quad (50) \end{aligned}$$

where γ_{t+i} , γ_{t+i}^* , η_{t+i} , η_{t+i}^* , π_{t+i} , π_{t+i}^* , and ν_{t+i} are the Lagrange multipliers for constraints (39), (41), (43), (40), (42), and (46), respectively. $\nu_t + \pi_t - \pi_t^*$ measures the change in the optimized value of the home-country national social-welfare function brought about by a small increase in the resources available to the home country in period t [which contributes ν_t through the external asset-accumulation eq. (46)], effected by increasing the resources available to generation t in the home country and reducing the resources available to generation t in the foreign country by that small amount [which contributes $\pi_t - \pi_t^*$ through (40) and (42), the lifetime-budget constraints of home and foreign generations t]. Since the home country has unrestricted domestic intergenerational-redistribution instruments, $\nu_t + \pi_t - \pi_t^*$ will be nonnegative.

The solution implies that

$$u'(c_{t+i+1}^1) - (1+\rho)(1+r_{t+i+1})^{-1} u'(c_{t+i}^1) > 0,$$

when $h_{t+i+1} > 0$, and

$$u'(c_{t+i+1}^1) - (1+\rho)(1+r_{t+i+1})^{-1} u'(c_{t+i}^1) < 0,$$

when $h_{t+i+1} < 0$. That is, if $h_{t+i+1} > 0$, then the noncooperative national optimum lump-sum fiscal policy for the home country reduces national saving (by redistributing from the young to the old), and if $h_{t+i+1} < 0$, the noncooperative national optimum policy raises national saving beyond the level that would be prescribed in a national social-welfare Pareto optimum.

For example suppose that the initial capital stock is the same in the two countries, that $u = u^*$ and $f = f^*$, but that the private discount rates differ. Let the national social 'generational' rates of discount coincide with the respective private time-preference rates. In a Nash equilibrium (either closed-loop or open-loop), the more patient country's fiscal authority raises social-security retirement payments (hence, taxes on the young), while the less patient country's government reduces social security, relative to their respective cooperative equilibrium policies. The government of the (patient) creditor country attempts to raise the world rate of interest by reducing its national saving relative to the cooperative level, while the government of the (impatient) debtor country tries to lower the world rate of interest by increasing its national saving. In the case described, the net result would be no net change in the world rate of interest in the Nash equilibrium relative to the cooperative equilibrium. The frustrated attempts to achieve international redistribution through changes in the world rate of interest, reflected in values of τ_{t+i}^1 that are higher and values of τ_{t+i}^* that are lower than the

cooperative values, result in inferior domestic intergenerational distributions in the two countries.

We summarize these results in Proposition 6:

Proposition 6. Nondistortionary (lump-sum tax) fiscal policy can be designed to gain national advantage in international trade with respect to a utilitarian national social-welfare objective. Nash equilibria in unfunded social-security retirement schemes are not Pareto-efficient for national planner objectives, but do attain equilibrium growth paths which are Pareto-optimal with respect to household preferences.

Noncooperative selection of fiscal policies when distortionary tax instruments are unavailable creates no loss in total world surplus for households: we stay on the world contract curve (defined with respect to household preferences). However, noncooperative fiscal management leads to movements along this world contract curve. Starting from a national social-welfare Pareto optimum, the home country will choose to deviate from the unfunded social-security scheme necessary to support this plan in an attempt to raise national welfare unilaterally. This increase in utilities for home-resident households is at the expense of foreign residents. No overall distortion (in the individual Pareto sense) is created; the effect of noncooperative policy selection with binding constraints on the use of all distortionary taxes and subsidies is to redistribute welfare internationally.

Because any unfunded social-security scheme can be duplicated using age-independent lump-sum transfers observing the modified public-sector solvency constraint, public-sector debt management can be used to pursue national gain in international exchange if arbitrary age-dependent lump-sum transfers are restricted. Social-security transfer programs and deficit-financing of lump-sum fiscal policies can be used strategically to promote national welfare objectives if Ricardian equivalence fails and first-best (for the individual country) distortionary policy instruments are restricted.

5. Coordination of public-spending programs

We have shown that coordination of fiscal policies in the two-country overlapping-generations models is unnecessary for achieving a Pareto-optimal capital-accumulation and consumption plan in the absence of distortionary taxes and subsidies, technological externalities, and noncompetitive behavior. Free international capital mobility allowing equalization of rates of return to capital across borders is adequate to assure efficiency if lump-sum tax policies are available to utilitarian planners in each country. The latter assures that a dynamically inefficient path is not followed.

In the absence of international technological externalities and internationally consumed public goods, noncooperative lump-sum tax policies chosen by utilitarian planners do not yield losses of world total surplus (in terms of household preferences) in conventional competitive economies. The adverse impact of the home country's policy on foreign welfare conveyed through interest-rate changes is not a technological externality but rather a distributional consequence of economic interdependence through the competitive price system that is a pure pecuniary externality.

In this section we add an internationally consumed public good to the model. Both governments contribute to the world public-good supply which is nonexcludable and noncongestible. There is a case for international coordination of exhaustive public spending on the national provision of international public goods due to the presence of a technological externality, but again financing policies do not necessarily require coordination to ensure Pareto optimality with respect to private preferences.

The consumption externality is introduced into the household utility functions in an additive separable manner. The utility functions for the home and foreign households are now

$$U_t = u(c_t^1) + v(G_t) + \beta(u(c_t^2) + v(G_{t+1}))$$

and

$$U_t^* = u^*(c_t^{*1}) + v^*(G_t) + \beta^*(u^*(c_t^{*2}) + v^*(G_{t+1})),$$

respectively. v and v^* are increasing, strictly concave, twice continuously differentiable and satisfy the Inada conditions. The utilitarian national social-welfare functions are unchanged. For the home country, for example, we have

$$S_t = \sum_{i=0}^{\infty} \left(\frac{1+n}{1+\rho} \right)^i U_{t+i} + \left(\frac{1+\rho}{1+n} \right) \beta(u(c_{t-1}^2) + v(G_t)).$$

As before we can restrict our attention to balanced-budget financing of public expenditures with unrestricted age-dependent lump-sum taxes and transfers, because adding the possibility of deficit finance subject to our modified public-sector solvency constraint does not increase the set of instruments available to the governments. The budget constraint for the home government is

$$-\tau_t^1 - \tau_{t-1}^2 / (1+n) + g_t = 0$$

and for the foreign government

$$-\tau_t^{*1} - \tau_{t-1}^{*2} / (1+n) + g_t^* = 0,$$

where g_t and g_t^* are the public expenditures by each country at time t . Total supply and consumption of the public good are given by

$$G_t = g_t + g_t^*.$$

In the definitions of utility for households we assumed that per capita supply of the public good in terms of the number of current young in a single country enters utility. While the denominator is somewhat odd, this measure of public-good consumption is convenient because of the constant population-growth rate. It also captures the notion of nonrivalness of global public-consumption goods *via-à-vis* home-country and foreign-country residents.

Consider again the case where the home-country planner, in the pursuit of national welfare, sets its lump-sum taxes and exhaustive public spending in open-loop Nash fashion. The foreign planner keeps the paths of its lump-sum tax instruments and of its exhaustive public spending fixed.³ Home-country national chauvinistic-planner optimal public spending and unfunded social-security policies, disallowing distortionary tax incentives, satisfy the necessary conditions:

$$u'(c_t^1) - \beta(1 + r_{t+1})u'(c_t^2) = 0, \quad (51)$$

$$\left(1 + \beta \left(\frac{1 + \rho}{1 + n}\right)\right) v'(G_t) = u'(c_t^1) + \left(\frac{1 + \rho}{1 + n}\right) \gamma_t u''(c_t^1), \quad (52)$$

$$\left(\frac{1}{1 + \rho}\right) u'(c_{t+1}^1) - \beta u'(c_t^2) = -\gamma_t \beta u''(c_t^2)(1 + r_{t+1}) - \gamma_{t+1} \frac{u''(c_{t+1}^1)}{1 + n}, \quad (53)$$

where γ_t is the shadow value of the constraint given in (51): competitive home-country private optimization over consumption plans under free capital mobility.

The sign of γ_t for each t , is obtained from eqs. (48)–(50), which are unaffected because of the separability of public goods in the utility functions: if equilibrium external lending is positive, then γ_t is negative, and conversely. A creditor-country government with utilitarian objectives will wish to restrain saving and thus lending to the rest of the world. Since the social-security scheme that reduces saving raises the ratio of consumption while young to consumption while old, public-good provision is adjusted by the last term in eq. (52) to correct the marginal utility of private-good consumption while

³While it doesn't matter for the results that follow we can view the fixed paths of foreign lump-sum taxes to be in accordance with the necessary conditions for an efficient intergenerational-distribution plan across foreign residents. Foreign exhaustive public spending similarly can be taken to be fixed at what would be the national Pareto-optimal level for some particular relative weight (λ , say) of foreign national social welfare in the cooperative game.

young for this distortion from the small country necessary condition for optimal intergenerational transfers.

In the national chauvinistic uncoordinated world economy, public goods are underprovided (or bads overprovided). The necessary condition for a Pareto-optimal allocation of the public good is

$$\left[1 + \beta \left(\frac{1 + n}{1 + \rho}\right)\right] v'(G_t) + \lambda_t \left[1 + \beta^* \left(\frac{1 + n}{1 + \rho^*}\right)\right] v^{*'}(G_t) \\ = u'(c_t^1) = \lambda_t u^{*'}(c_t^{*1}), \quad (54)$$

where λ_t gives the distribution of welfare across national populations in the particular Pareto optimum. Coordination of spending policies is required to ensure that (54) holds. However, uncoordinated unfunded social-security schemes or equivalent public-expenditure financing policies do not interfere with the attainment of a Pareto optimum with respect to household preferences. As before, the use of social-security schemes or deficit finance (in the absence of unrestricted age-dependent lump-sum taxes and transfers) to gain advantage in international intertemporal trade leads to an inefficient outcome with respect to national social-welfare functions but only has a distributional effect on aggregate household welfare. The use of lump-sum taxes to alter world interest rates and pursue national intergenerational-distribution objectives changes the distribution of private (marginal utilities of) consumption across generations. While the Pareto optimal levels of provision of public goods are affected by this, it does not cause a departure from Pareto optimality.

6. Conclusion

In the absence of Ricardian debt neutrality, lump-sum transfers between households within a country can be used by governments to attain advantage in international lending and borrowing. The optimum policy for a utilitarian planner with nationalistic objectives facing a passive rest of the world is a combination of a tax on foreign borrowing or lending and a system of national intergenerational lump-sum transfers. The former is the intertemporal analogue of an optimum tariff and targets the world interest rate, lowering it for a debtor and raising it for a creditor. The lump-sum fiscal policy targets the desired distribution of welfare over residents. Thus with arbitrary domestic unfunded social security available, optimum national policy towards international transactions is the same as in the infinitely-lived representative agent. When in addition to domestic lump-sum unfunded social security distortionary instruments are available to national policy makers, a noncooperative equilibrium in the world economy leads to a Pareto-inefficient consumption and production plan just as in the static trade model.

In an integrated world economy, when governments do not have access to distortionary tax instruments, lump-sum tax-based fiscal policy can be used strategically to improve a country's intertemporal terms of trade. In this case, one instrument is used to optimize with respect to two goals, and a trade-off exists between domestic intergenerational distribution and international redistribution through interest rate manipulation. Such policies are nondistortionary in the world economy and cause no overall welfare loss, but they do affect the distribution of welfare across countries.

The incorporation of exhaustive public spending through the provision of global public goods introduces an allocational-efficiency argument for the coordination of fiscal policies. However, it is the coordination of public spending across borders and not of the financing mixes to achieve this spending that is required to achieve Pareto efficiency. Interdependence of fiscal policies involves purely distributional conflicts when only lump-sum taxes and transfers and deficits are involved.

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