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TAXCOM - A model of International Tax Competition and Tax Coordination

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1. Basic features of the TAXCOM model

The purpose of this technical working paper is to document an applied general equilibrium model of international tax competition and tax coordination named TAXCOM. The model seeks to illustrate the distortions arising from tax competition in a world with highly mobile capital. It may also be used to estimate the potential welfare gains from various forms of international tax coordination. Drawing on recent contributions to the theory of international taxation, the TAXCOM model incorporates the following features:

- Internationally mobile capital combining with immobile labour and a local fixed factor to produce an internationally traded good

- Endogenous labour supply and an endogenous global supply of capital

- International cross-ownership of firms and the existence of pure profits accruing partly to foreigners

- Productive government spending on infrastructure as well as spending on public consumption goods

- An unequal distribution of human and non-human wealth providing a motive for redistributive taxes and transfers

- Asymmetries in country sizes and in country preferences for redistribution and for public consumption

- An egalitarian social welfare function comprising classical utilitarianism as a special case

The model is static, describing a stationary long-run equilibrium. Tastes and technology are described by simple functional forms allowing calibration of strategic elasticities by appropriate choice of a few structural parameters which are easy to interpret.

The literature which has inspired the development of the TAXCOM model is reviewed in two companion papers[1] in which I also explain the properties of the model in more detail and discuss the simulation results which it produces. Hence the present paper serves only as a technical documentation of the model.

Sections 1 through 12 describe the household, business and government sectors in the representative country and the general equilibrium of the world economy in a situation with tax competition. The subsequent sections describe how the model can be modified to allow for various forms of international tax coordination. In sections 1 through 18 I assume that capital is perfectly mobile throughout the world economy and that private sector tastes and technologies as well as initial per-capita endowments are identical across countries. From section 19 and onwards I introduce imperfect capital mobility between the coordinating tax union and the rest of the world and allow private tastes, technologies and initial endowments to differ across countries. A complete list of all variables and parameters is given in the appendix.

The representative country to be described below is denoted by subscript j whenever needed. However, to avoid heavy notation this subscript will be dropped when no misunderstandings are likely to arise.

2. The household sector

Consumers in the representative country are endowed with predetermined initial levels of human and non-human wealth. By appropriate choice of units we can equate the exogenous aggregate stocks of human and non-human wealth to the exogenous total size

[1] See Peter Birch Sørensen: "The Case for International Tax Coordination Reconsidered", Economic Policy no. 31, October 2000, and Peter Birch Sørensen: "International Tax Coordination: Regionalism Versus Globalism", forthcoming IMF Working Paper, International Monetary Fund, Washington D.C.

of the country's population, denoted by N. These convenient normalizations imply that the average levels of the two types of wealth are equal to unity. We assume that consumer i owns a fraction θ_i of the aggregate stock of human wealth and a similar fraction θ_i of the total stock of non-human wealth. Hence we have

$$\text{Initial stock of human wealth held by individual } i\text{:} \quad \theta_i N$$

$$\text{Initial stock of non-human wealth held by individual } i\text{:} \quad V_i = \theta_i N$$

$$0 < \theta_i < 1, \qquad \sum_{i=1}^{N} \theta_i = 1$$

The level of utility of consumer i is given by the additive utility function

$$U_i = \overbrace{C_i}^{\substack{\text{utility from private} \\ \text{consumption}}} - \overbrace{\theta_i N \cdot \frac{h_i^{1+\varepsilon}}{1+\varepsilon}}^{\substack{\text{disutility from} \\ \text{work}}} + \overbrace{\frac{\gamma_2}{\gamma_1} G^{\gamma_1}}^{\substack{\text{utility from public} \\ \text{consumption}}} \tag{1}$$

$$\varepsilon > 0, \qquad 0 < \gamma_1 < 1, \qquad \gamma_2 > 0$$

where C is private consumption, h is the number of hours worked, and G is public consumption per capita (publicly provided private goods). Note that the disutility of work varies in proportion to the consumer's stock of human capital $\theta_i N$. In other words, a person's opportunity cost of time supplied to the labour market varies positively with his productivity.

The consumer earns income from labour and capital and receives pure profits from domestic and foreign firms. We assume that a fraction δ of domestic firms is owned by foreign residents and that consumer i holds a share θ_i in those domestic firms which are owned domestically. If domestic profits per capita are π, and if these profits are taxed at the rate τ, consumer i thus receives a net profit of $(1-\delta)\,\theta_i N \pi\,(1-\tau)$ from domestic sources.

In addition, consumer i (in country j) earns profits stemming from his shares in foreign firms. The magnitude of these foreign-source profits is determined as follows: a fraction δ of profits generated in foreign country z accrues to non-residents. The number of these non-residents is equal to $N^w - N_z$, where N^w is the total world population and

N_z is the population of country z. We assume that the citizens in country j receive a fraction $N_j/(N^w - N_z)$ of the profits flowing out of country z, corresponding to country j's share of the total number of non-residents receiving profits from country z. Let s_k denote country k's share of the total world population N^w. We then have

$$N_j \equiv s_j N^w, \qquad N_z \equiv s_z N^w, \qquad \frac{N_j}{N^w - N_z} = \frac{s_j}{1 - s_z} \tag{2}$$

Furthermore, the fraction of profits from country z accruing to consumer i in country j is θ_{ij}, implying that

$$\begin{aligned} & \text{After-tax profit from country } z \text{ received by consumer } i \text{ in country } j \\ = \; & \theta_{ij}\delta\left(\frac{s_j}{1-s_z}\right) s_z N^w \pi_z \left(1 - \tau_z\right) = \theta_{ij}\delta s_j N^w \left(\frac{s_z}{1-s_z}\right)\pi_z\left(1-\tau_z\right) \end{aligned}$$

$$\begin{aligned} & \text{Total after-tax foreign-source profits received by consumer } i \text{ in country } j \\ = \; & \theta_{ij}\delta s_j N^w \sum_{z \neq j}\left(\frac{s_z}{1-s_z}\right)\pi_z\left(1-\tau_z\right) \end{aligned}$$

Assuming for the moment that the residence country j does not levy any tax on foreign-source profits, remembering that $s_j N^w = N_j$, and dropping the country subscript j for convenience, we may now write the budget constraint for consumer i in country j as

$$\begin{aligned} C_i = & \overbrace{w_i\left(1-t\right)h_i}^{\substack{\text{after-tax} \\ \text{labour income}}} + \overbrace{\rho k_i^s}^{\substack{\text{after-tax} \\ \text{capital income}}} + \overbrace{V_i - c_i}^{\substack{\text{initial endowment net of} \\ \text{installation costs}}} \\ & + \underbrace{\theta_i N\left(1-\delta\right)\left(1-\tau\right)\pi}_{\substack{\text{after-tax} \\ \text{domestic-source profits}}} + \underbrace{\theta_i N\delta\sum_{z\neq j}\left(\frac{s_z}{1-s_z}\right)\left(1-\tau_z\right)\pi_z}_{\text{after-tax foreign-source profits}} + \underbrace{T}_{\substack{\text{government} \\ \text{transfer}}} \end{aligned} \tag{3}$$

where w_i is the real wage rate earned by a person with a stock of human capital $\theta_i N$, t is the tax rate on labour income, ρ is the after-tax real interest rate, k_i^s is the consumer's supply of real capital, c_i are the transactions costs of transforming the initial endowment V_i into real capital, and T is a government lump-sum transfer paid out to all residents.

Instead of consuming all of his initial endowment of non-human wealth V_i, the consumer thus has the option to transform (part of) this endowment into real capital earning an after-tax return ρ. However, by using this roundabout method of transforming his wealth into consumption, the consumer will incur transactions costs which may be thought of as the costs of financial intermediation. We assume that these transaction costs vary positively with the rate of investment k^s/V and proportionately with the level of wealth:

$$c_i = \frac{1}{\varphi+1}\left(\frac{k_i^s}{V_i}\right)^{\varphi+1} \cdot V_i, \qquad \varphi > 0 \tag{4}$$

The consumer's problem is to maximize the utility function (1) with respect to h_i and k_i^s, subject to the constraints (3) and (4). The first-order conditions for the solution to this problem imply that

$$h_i = \left[\frac{w_i(1-t)}{\theta_i N}\right]^{1/\varepsilon} \tag{5}$$

$$k_i^s = \rho^{1/\varphi} \cdot V_i \tag{6}$$

The implications of (5) and (6) for aggregate factor supplies will be spelled out in section 4.

3. The business sector

The business sector in country j is described by a representative competitive firm producing output Y by means of a Cobb-Douglas production function. The variables in the production function are the aggregate capital stock K, aggregate effective labour input $\sum_i \theta_i N h_i$, and a fixed factor which may be thought of as land. I assume an identical population density across countries so that each country's supply of land is proportional to its population size. This ensures that countries with small populations have no inherent productivity advantage over large countries, or vice versa. With a fixed proportionality factor b, the individual country's supply of land is thus given by bN. Assuming constant returns to scale in the three factors, and denoting total factor productivity by A, we then have

$$Y = AK^{\beta}\left(\sum_{i=1}^{N}\theta_i N h_i\right)^{\alpha}(bN)^{1-\alpha-\beta}, \qquad 0<\beta<1, \quad 0<\alpha<1, \quad 0<\alpha+\beta<1 \tag{7}$$

Noting that the average effective labour input per worker is $(1/N)\sum\theta_i N h_i = \sum\theta_i h_i$, and defining capital intensity as $k \equiv K/N$, we may rewrite (7) as

$$Y = \widetilde{A}Nk^{\beta}\left(\sum_{i=1}^{N}\theta_i h_i\right)^{\alpha}, \qquad \widetilde{A} \equiv Ab^{1-\alpha-\beta} \tag{8}$$

Due to administrative problems of distinguishing pure rents from the normal return to capital, we assume that interest income is taxed at the same rate τ as pure profits. Since ρ is the after-tax interest rate, the pre-tax interest rate is equal to $\rho/(1-\tau)$. Normalizing the output price at unity, denoting aggregate real pre-tax profits by Π, and using (8), we find that the after-tax profits accruing to the owners of firms may be written as

$$(1-\tau)\Pi = (1-\tau)\left[Y - \overbrace{\left(\frac{\rho}{1-\tau}\right)K}^{\text{total cost of capital}} - \overbrace{\sum_i w_i h_i}^{\text{wage bill}}\right]$$

$$= (1-\tau)\left[\widetilde{A}Nk^{\beta}\left(\sum_i\theta_i h_i\right)^{\alpha} - \left(\frac{\rho}{1-\tau}\right)Nk - \sum_i w_i h_i\right] \tag{9}$$

The firm maximizes these profits w.r.t. k and h_i, yielding the first-order conditions

$$\beta\widetilde{A}k^{\beta-1}\left(\sum_i\theta_i h_i\right)^{\alpha} = \frac{\rho}{1-\tau} \tag{10}$$

$$\alpha\theta_i N\widetilde{A}k^{\beta}\left(\sum_i\theta_i h_i\right)^{\alpha-1} = w_i, \qquad i = 1,2,......N \tag{11}$$

From (11) we get

$$\sum_i w_i h_i = \alpha\widetilde{A}Nk^{\beta}\left(\sum_i\theta_i h_i\right)^{\alpha} \tag{12}$$

We may now define the *average* return to human capital w as the total wage bill divided by total effective labour input:

$$w \equiv \frac{\sum w_i h_i}{\sum \theta_i N h_i} = \alpha \widetilde{A} k^{\beta} \left(\sum_i \theta_i h_i \right)^{\alpha - 1} \tag{13}$$

Equations (11) and (13) then imply that the wage rate for consumer i is equal to

$$w_i = w \theta_i N \tag{14}$$

4. Labour supply and demand

Having described the household and business sectors, we are now able to derive the equilibrium level of employment in country j as a function of the fiscal policy parameters chosen by the government. Inserting (14) into (5), we start by noting that all individuals in any given country will supply the same number of working hours:

$$h_i = h = [w(1-t)]^{1/\varepsilon} \qquad \forall \quad i \tag{15}$$

According to (15) the net wage elasticity of labour supply is given by the inverse of the elasticity of the marginal disutility of work, $1/\varepsilon$:

$$\frac{\partial h}{\partial (w(1-t))} \frac{w(1-t)}{h} = \frac{1}{\varepsilon} \tag{16}$$

Since $\sum \theta_i = 1$ it also follows from (15) that total effective labour supply per worker is equal to

$$\sum_i \theta_i h_i = h \sum_i \theta_i = h \tag{17}$$

which may be inserted into (13) to give

$$\widetilde{A} k^{\beta} = \frac{w}{\alpha} h^{1-\alpha} \tag{18}$$

Substitution of (17) and (18) into (10) yields

$$k = \left(\frac{1-\tau}{\rho}\right)\left(\frac{\beta}{\alpha}\right) wh \tag{19}$$

and (15) implies

$$w = \frac{h^{\varepsilon}}{1-t} \tag{20}$$

From (19) and (20) we get

$$k = \left(\frac{\beta}{\alpha\rho}\right)\left(\frac{1-\tau}{1-t}\right) h^{1+\varepsilon} \tag{21}$$

Our next step is to substitute (17), (20) and (21) into (13) to find

$$\alpha\widetilde{A}\left(\frac{\beta}{\alpha\rho}\right)^{\beta}\left(\frac{1-\tau}{1-t}\right)^{\beta} h^{\beta(1+\varepsilon)} h^{\alpha-1} = \left(\frac{1}{1-t}\right) h^{\varepsilon} \tag{22}$$

We now assume that adjusted total factor productivity $\widetilde{A}$ is an increasing function of the amount of productive government spending per capita, denoted by Q:

$$\widetilde{A} = Q^{\mu_1}, \qquad\qquad 0 < \mu_1 < 1 \tag{23}$$

Inserting this into (22) and rearranging, we obtain the solution for the equilibrium level of working hours in country j:

$$h(\rho, \tau, t, Q) = \left\{ Q^{\mu_1}\left(\frac{\beta(1-\tau)}{\rho}\right)^{\beta}\left[\alpha(1-t)\right]^{1-\beta} \right\}^{\eta} \tag{24}$$

$$\eta \equiv 1/\left[1-\alpha-\beta+\varepsilon(1-\beta)\right] > 0$$

For purposes of later analysis, we note that the derivatives of this employment function are

$$h_{\rho} \equiv \frac{\partial h}{\partial \rho} = -\beta\eta\left(\frac{h}{\rho}\right) < 0 \tag{25}$$

$$h_\tau \equiv \frac{\partial h}{\partial \tau} = -\beta\eta\left(\frac{h}{1-\tau}\right) < 0 \tag{26}$$

$$h_t \equiv \frac{\partial h}{\partial t} = -\left(1-\beta\right)\eta\left(\frac{h}{1-t}\right) < 0 \tag{27}$$

$$h_Q \equiv \frac{\partial h}{\partial Q} = \mu_1\eta\left(\frac{h}{Q}\right) > 0 \tag{28}$$

5. Capital supply and demand

According to (21) country j's demand for capital per worker (capital intensity) is

$$k \equiv \frac{K}{N} = \left(\frac{\beta}{\alpha\rho}\right)\left(\frac{1-\tau}{1-t}\right)h^{1+\varepsilon} \tag{29}$$

Inserting (24) into (29) and collecting terms, we get

$$k\left(\rho,\tau,t,Q\right) = \left\{Q^{\mu_1(1+\varepsilon)}\left(\frac{\beta\left(1-\tau\right)}{\rho}\right)^{1-\alpha+\varepsilon}\left[\alpha\left(1-t\right)\right]^{\alpha}\right\}^{\eta} \tag{30}$$

implying

$$k_\rho \equiv \frac{\partial k}{\partial \rho} = -\eta\left(1-\alpha+\varepsilon\right)\left(\frac{k}{\rho}\right) < 0 \tag{31}$$

$$k_\tau \equiv \frac{\partial k}{\partial \tau} = -\eta\left(1-\alpha+\varepsilon\right)\left(\frac{k}{1-\tau}\right) < 0 \tag{32}$$

$$k_t \equiv \frac{\partial k}{\partial t} = -\eta\alpha\left(\frac{k}{1-t}\right) < 0 \tag{33}$$

$$k_Q \equiv \frac{\partial k}{\partial Q} = \mu_1\eta\left(1+\varepsilon\right)\left(\frac{k}{Q}\right) > 0 \tag{34}$$

From (30) and the definition of η given in (24) it follows that the elasticity of capital demand with respect to the pre-tax real interest rate $\rho/\left(1-\tau\right)$ is given by

$$\frac{\partial k}{\partial r}\frac{r}{k} = -\eta\left(1-\alpha+\varepsilon\right) = -\left(\frac{1-\alpha+\varepsilon}{1-\alpha+\varepsilon-\beta\left(1+\varepsilon\right)}\right) < 0 \tag{35}$$

To find individual i's supply of capital we insert our assumption $V_i = \theta_i N$ into (6) to get

$$k_i^s = \rho^{1/\varphi} \cdot \theta_i N \tag{36}$$

Since $\sum \theta_i = 1$, we thus find country j's total supply of capital to be

$$K^s \equiv \sum_{i=1}^{N} k_i^s = \rho^{1/\varphi} \cdot N \tag{37}$$

According to (37) the elasticity of capital supply with respect to the after-tax real interest rate is

$$\frac{\partial K^s}{\partial \rho}\frac{\rho}{K^s} = \frac{1}{\varphi} > 0 \tag{38}$$

6. Profits

Using (9), (10), (12) and (17), we may write profits per capita in country j as

$$\pi \equiv \frac{1}{N}\Pi = \frac{1}{N}\left(1-\alpha-\beta\right)\tilde{A}k^{\beta}h^{\alpha} \tag{39}$$

Substituting (23), (24) and (30) into (39) and collecting terms, we obtain

$$\pi\left(\rho,\tau,t,Q\right) = \left(1-\alpha-\beta\right)\left\{Q^{\mu_1(1+\varepsilon)}\left(\frac{\beta\left(1-\tau\right)}{\rho}\right)^{\beta(1+\varepsilon)}\left[\alpha\left(1-t\right)\right]^{\alpha}\right\}^{\eta} \tag{40}$$

The derivatives of this profit function are

$$\pi_\rho \equiv \frac{\partial \pi}{\partial \rho} = -\eta\beta\left(1+\varepsilon\right)\left(\frac{\pi}{\rho}\right) < 0 \tag{41}$$

$$\pi_\tau \equiv \frac{\partial \pi}{\partial \tau} = -\eta\beta\left(1+\varepsilon\right)\left(\frac{\pi}{1-\tau}\right) < 0 \tag{42}$$

$$\pi_t \equiv \frac{\partial \pi}{\partial t} = -\eta\alpha\left(\frac{\pi}{1-t}\right) < 0 \tag{43}$$

$$\pi_Q \equiv \frac{\partial \pi}{\partial Q} = \eta\mu_1\left(1+\varepsilon\right)\left(\frac{\pi}{Q}\right) > 0 \tag{44}$$

7. The government budget constraint

Apart from earning factor income, each consumer also receives a government lump-sum transfer T (which is identical for all consumers). This transfer is given by the following government budget constraint where all magnitudes are measured on a per-capita basis:

$$T = \overbrace{twh}^{\substack{\text{labour tax}\\ \text{revenue}}} + \overbrace{\tau\left(\frac{\rho}{1-\tau}\right)k}^{\substack{\text{capital income}\\ \text{tax revenue}}} + \overbrace{\tau\pi}^{\substack{\text{profits}\\ \text{tax revenue}}} - \overbrace{Q}^{\substack{\text{spending on}\\ \text{infrastructure}}} - \overbrace{G}^{\substack{\text{spending on}\\ \text{public goods}}} \tag{45}$$

From (20) we have

$$wh = \frac{1}{1-t}h^{1+\varepsilon}$$

so the government budget constraint (45) may be written as

$$T = \left(\frac{t}{1-t}\right)\left[h\left(\rho,\tau,t,Q\right)\right]^{1+\varepsilon} + \left(\frac{\tau}{1-\tau}\right)\rho k\left(\rho,\tau,t,Q\right) + \tau\pi\left(\rho,\tau,t,Q\right) - Q - G \tag{46}$$

8. International capital market equilibrium

As noted earlier, capital is perfectly mobile across borders. An international capital market equilibrium is achieved when aggregate world demand for capital equals the aggregate supply of capital from all countries. If there are n countries in the world, we thus have the capital market equilibrium condition

$$\overbrace{\sum_{j=1}^{n} s_j N^w k_j}^{\substack{\text{world demand}\\ \text{for capital}}} = \overbrace{\sum_{j=1}^{n} K_j^s}^{\substack{\text{world supply}\\ \text{of capital}}} \tag{47}$$

In the absence of international cooperation and exchange of information, we assume that administrative problems prevent national governments from taxing foreign source income. Capital income taxation is therefore based on the *source principle*, implying that each national government only taxes capital income generated within its own jurisdiction. With perfect capital mobility equilibrium requires that the suppliers of capital obtain the same *after-tax* rate of return ρ in all countries. On the other hand, the size of the population N and the values of the government policy instruments τ, t and Q may vary across countries. Using (37) and the facts that $N_j \equiv s_j N^w$ and $\sum s_j = 1$, we may then write (47) as

$$\overbrace{\sum_{j=1}^{n} s_j k_j \left(\rho, \tau_j, t_j, Q_j\right)}^{\text{global capital demand per capita}} - \overbrace{\rho^{1/\varphi}}^{\text{global capital supply per capita}} = 0 \tag{48}$$

For given values of the policy instruments τ_j, t_j and Q_j in all countries, this equation determines the common global after-tax rate of return ρ which will ensure equilibrium in the world capital market.

To investigate how the global after-tax rate of return is affected by changes in fiscal policy in a single country j, we may differentiate (48) to get

$$\rho_{\tau j} \equiv \frac{\partial \rho}{\partial \tau_j} = \frac{s_j \cdot k_{\tau j}}{\varphi^{-1} \rho^{\frac{1-\varphi}{\varphi}} - \sum s_j k_{\rho j}} < 0 \tag{49}$$

$$\rho_{tj} \equiv \frac{\partial \rho}{\partial t_j} = \frac{s_j \cdot k_{tj}}{\varphi^{-1} \rho^{\frac{1-\varphi}{\varphi}} - \sum s_j k_{\rho j}} < 0 \tag{50}$$

$$\rho_{Qj} \equiv \frac{\partial \rho}{\partial Q_j} = \frac{s_j \cdot k_{Qj}}{\varphi^{-1} \rho^{\frac{1-\varphi}{\varphi}} - \sum s_j k_{\rho j}} > 0 \tag{51}$$

Note that these national policy effects on the international rate of return tend to vanish in a small country whose share s_j of the world population tends to zero.

9. The indirect utility function

To evaluate the welfare effects of government policies, we need to derive the consumer's indirect utility function. We start by noting from (14), (15) and (20) that consumer i's after-tax labour income net of his disutility of work (the consumer surplus from work) may be written as

$$w_i (1-t) h_i - \theta_i N \frac{h_i^{1+\varepsilon}}{1+\varepsilon} = \theta_i N \left(\frac{\varepsilon}{1+\varepsilon}\right) h^{1+\varepsilon} \tag{52}$$

Next we note from (4), (6) and the normalization $V_i = \theta_i N$ that the consumer's initial endowment of non-human wealth ultimately provides him with the following resources available for consumption at the end of the period:

$$V_i + \rho k_i^s - c_i = \left[1 + \left(\frac{\varphi}{\varphi+1}\right) \rho^{\frac{\varphi+1}{\varphi}}\right] \theta_i N \tag{53}$$

Substituting (52), (53) and (3) into the direct utility function (1), we get the indirect utility of consumer i in country j (again, we are suppressing the subscript j),

$$U_i = \theta_i N \left(\frac{\varepsilon}{1+\varepsilon}\right) h^{1+\varepsilon} + T + \frac{\gamma_2}{\gamma_1} G^{\gamma_1}$$

$$+\theta_i N \left\{1 + \frac{\varphi \rho^{\frac{\varphi+1}{\varphi}}}{\varphi+1} + (1-\delta)(1-\tau)\pi + \delta \sum_{z \neq j} \left(\frac{s_z}{1-s_z}\right)(1-\tau_z)\pi_z\right\} \tag{54}$$

where we remember that h and π are functions of ρ, τ_j, t_j and Q_j, and that π_z is a function of ρ, τ_z, t_z and Q_z. As we have seen in the previous section, ρ is itself a function of the fiscal policy parameters chosen by the governments of all the m countries. Equation (54) thus enables us to calculate individual welfare as a function of the fiscal policies adopted throughout the world economy.

10. Social welfare

The preceding sections have described the behaviour of the private sector conditional upon a given set of government policies. We will now specify our assumptions regarding the formation of these policies. We assume that the government in the representative country j is concerned about the *average* level of individual welfare $\overline{U}$ and about the *dispersion* of individual utilities around this mean, as reflected in the following social welfare function,

$$SW = \overline{U} - a\sqrt{\frac{1}{N}\left[\sum_i \left(U_i - \overline{U}\right)^2\right]}, \qquad a \geq 0 \tag{55}$$

where the square root measures the degree of inequality by the standard deviation of individual utilities, and where the parameter a indicates the degree of government aversion to inequality. The special case of $a = 0$ corresponds to classical utilitarianism where the policy maker simply strives to maximize the sum of individual utilities (which is equivalent to maximizing average utility when population size is exogenously given).

According to (54) the average level of utility is

$$\overline{U} \equiv \frac{1}{N}\sum_{i=1}^{N} U_i = \left(\frac{\varepsilon}{1+\varepsilon}\right) h^{1+\varepsilon} + T + \frac{\gamma_2}{\gamma_1} G^{\gamma_1}$$

$$+1 + \frac{\varphi\rho^{\frac{\varphi+1}{\varphi}}}{\varphi+1} + (1-\delta)(1-\tau)\pi + \delta \sum_{z \neq j}\left(\frac{s_z}{1-s_z}\right)(1-\tau_z)\pi_z \tag{56}$$

where we have utilized the fact that $\sum \theta_i = 1$. Inserting (54) and (56) into (55), we may write social welfare as

$$SW = T + \frac{\gamma_2}{\gamma_1} G^{\gamma_1}$$

$$+ (1-a\lambda)\left[\left(\frac{\varepsilon}{1+\varepsilon}\right) h^{1+\varepsilon} + 1 + \frac{\varphi\rho^{\frac{\varphi+1}{\varphi}}}{\varphi+1} + (1-\delta)(1-\tau)\pi + \delta \sum_{z \neq j}\left(\frac{s_z}{1-s_z}\right)(1-\tau_z)\pi_z\right] \tag{57}$$

$$\lambda \equiv \sqrt{\frac{1}{N}\sum_i (\theta_i N - 1)^2}$$

where λ is the standard deviation of individual wealth levels around the mean value of unity, reflecting the degree of inequality of the initial distribution of wealth. We will assume below that

$$a\lambda < 1 \tag{58}$$

This condition ensures that, for a given level of public consumption and transfers, an increase in private disposable incomes always increases social welfare.

Comparing (57) to (54), we see that social welfare coincides with the individual welfare of the consumer with an initial wealth endowment $\theta_i N = 1 - a\lambda$. Maximizing (57) w.r.t. to the fiscal policy instruments for different values of $a\lambda$ thus corresponds to allowing consumers with different endowments θ_i to choose their preferred policies. If consumer preferences are single-peaked in fiscal policy packages (which can be shown to be the case by simulating the model) and fiscal policies are decided by simple majority voting, the relevant government objective function is simply the median voter's indirect utility function which is obtained by setting $1 - a\lambda$ equal to the median value of $\theta_i N$ in (57). When the wealth distribution is unequal, the median level of wealth $\theta_i^m N$ will be less than the mean wealth level of unity. This is consistent with the requirement in (58) that $0 < 1 - a\lambda < 1$.

11. Fiscal policies under tax competition

In the absence of international fiscal coordination, each national government chooses its fiscal policy instruments so as to maximize national social welfare, taking the policies of other countries as given, and accounting for the government budget constraint (46). Using (46) to eliminate T from (57), and defining

$$\widehat{a}_j \equiv a_j \lambda_j \tag{59}$$

we find that social welfare in country j is given by

$$SW_j = \left[(1 - \widehat{a}_j) \left(\frac{\varepsilon}{1+\varepsilon} \right) + \left(\frac{t_j}{1 - t_j} \right) \right] \left[h \left(\rho, \tau_j, t_j, Q_j \right) \right]^{1+\varepsilon} + \frac{\gamma_{2j}}{\gamma_{1j}} G_j^{\gamma_{1j}} - G_j - Q_j$$

$$+ \left(\frac{\tau_j}{1 - \tau_j} \right) \rho k \left(\rho, \tau_j, t_j, Q_j \right) + (1 - \widehat{a}_j) \left[1 + \frac{\varphi \rho^{\frac{\varphi+1}{\varphi}}}{\varphi + 1} \right]$$

$$+ \left[(1 - \widehat{a}_j)(1 - \delta)(1 - \tau_j) + \tau_j \right] \pi \left(\rho, \tau_j, t_j, Q_j \right)$$

$$+ (1 - \widehat{a}_j) \delta \sum_{z \neq j} \left(\frac{s_z}{1 - s_z} \right) (1 - \tau_z) \pi \left(\rho, \tau_z, t_z, Q_z \right) \tag{60}$$

Country j's preferred policy is found by maximizing (60) w.r.t. τ_j, t_j, Q_j and G_j, accounting for the effects of τ_j, t_j and Q_j on the equilibrium rate of return ρ which were derived in (49) through (51). The first-order conditions for the solution to this fiscal policy problem are

$$\frac{\partial SW_j}{\partial G_j} = 0 \iff \gamma_{2j} G_j^{\gamma_{1j}-1} = 1 \iff G_j = \gamma_{2j}^{\frac{1}{1-\gamma_{1j}}} \tag{61}$$

$$\frac{\partial SW_j}{\partial Q_j} = 0 \iff$$

$$h_{Qj} \cdot \left[(1-\widehat{a}_j)\,\varepsilon + (1+\varepsilon)\left(\frac{t_j}{1-t_j}\right)\right] h_j^{\varepsilon} - 1 + \left(\frac{\tau_j}{1-\tau_j}\right)\rho \cdot k_{Qj} + \left[(1-\widehat{a}_j)(1-\delta)(1-\tau_j)+\tau_j\right]\pi_{Qj}$$

$$+\rho_{Qj} \cdot \frac{\partial SW_j}{\partial \rho} = 0 \tag{62}$$

$$\frac{\partial SW_j}{\partial t_j} = 0 \iff$$

$$\frac{h_j^{1+\varepsilon}}{(1-t_j)^2} + h_{tj} \cdot \left[(1-\widehat{a}_j)\,\varepsilon + (1+\varepsilon)\left(\frac{t_j}{1-t_j}\right)\right] h_j^{\varepsilon} + \left(\frac{\tau_j}{1-\tau_j}\right)\rho \cdot k_{tj} + \left[(1-\widehat{a}_j)(1-\delta)(1-\tau_j)+\tau_j\right]\pi_{tj}$$

$$+\rho_{tj} \cdot \frac{\partial SW_j}{\partial \rho} = 0 \tag{63}$$

$$\frac{\partial SW_j}{\partial \tau_j} = 0 \iff$$

$$h_{\tau j} \cdot \left[(1-\widehat{a}_j)\,\varepsilon + (1+\varepsilon)\left(\frac{t_j}{1-t_j}\right)\right] h_j^{\varepsilon} + \frac{\rho k_j}{(1-\tau_j)^2} + \left(\frac{\tau_j}{1-\tau_j}\right)\rho \cdot k_{\tau j}$$

$$+\left[1-(1-\widehat{a}_j)(1-\delta)\right]\pi_j + \left[(1-\widehat{a}_j)(1-\delta)(1-\tau_j)+\tau_j\right]\pi_{\tau j}$$

$$+\rho_{\tau j} \cdot \frac{\partial SW_j}{\partial \rho} = 0 \tag{64}$$

where

$$\frac{\partial SW_j}{\partial \rho} = h_{\rho j} \cdot \left[(1 - \widehat{a}_j) \varepsilon + (1 + \varepsilon) \left(\frac{t_j}{1 - t_j} \right) \right] h_j^{\varepsilon} + \left(\frac{\tau_j}{1 - \tau_j} \right) [k_j + \rho \cdot k_{\rho j}] + (1 - \widehat{a}_j) \rho^{1/\varphi}$$

$$+ [(1 - \widehat{a}_j)(1 - \delta)(1 - \tau_j) + \tau_j] \pi_{\rho j} + (1 - \widehat{a}_j) \delta \sum_{z \neq j} \left(\frac{s_z}{1 - s_z} \right) (1 - \tau_z) \pi_{\rho z} \tag{65}$$

The derivatives of ρ w.r.t. Q, t and τ appear in the policy rules (62), (63) and (64), respectively, because the government of country j must account for the fact that its actions influence the world rate of return. However, it is clear from (49) through (51) that these effects on ρ will be close to zero in a small country whose share s_j of the world population is negligible. In this case it may be reasonable for the government to take ρ as exogenously given, at least as a first approximation. Below we shall model this small-country case by multiplying the derivatives ρ_{Qj}, ρ_{tj} and $\rho_{\tau j}$ by a dummy variable D which is set equal to zero when individual countries are very small, and which is equal to one when countries are so large that they find it necessary to account for their impact on the world interest rate.

12. Summarizing the model with tax competition

Inserting the derivatives (25) through (28), (31) through (34) and (41) through (44) into equations (61) through (65) whereever appropriate, and using the fact that $\sum s_j k_j = \rho^{1/\varphi}$ according to (48), we may now summarize the model with tax competition in the following way (recall that D is a dummy variable, with $D = 0$ representing a small country, and $D = 1$ indicating a large country):

Definitions:

$$\eta \equiv \frac{1}{1 - \alpha - \beta + \varepsilon (1 - \beta)} \tag{66}$$

$$\Delta_j \equiv \left[\frac{D \cdot \varphi \eta^2 \beta s_j k_j}{\rho^{1/\varphi} [1 + \varphi \eta (1 - \alpha + \varepsilon)]} \right] \times$$

$$\{ \left(\frac{1-\widehat{a}_j}{\eta\beta}\right)\rho^{\frac{\varphi+1}{\varphi}} - \left(\frac{\tau_j}{1-\tau_j}\right)(1+\varepsilon)\,\rho k_j - \left[\varepsilon\,(1-\widehat{a}_j) + (1+\varepsilon)\left(\frac{t_j}{1-t_j}\right)\right] h_j^{1+\varepsilon}$$

$$-\,(1+\varepsilon)\left[(1-\widehat{a}_j)\,(1-\delta)\,(1-\tau_j)+\tau_j\right]\pi_j$$

$$-\,(1+\varepsilon)\,\delta\,(1-\widehat{a}_j)\sum_{z\neq j}\left(\frac{s_z}{1-s_z}\right)(1-\tau_z)\,\pi_z\ \}, \qquad j=1,2,...,n \tag{67}$$

Employment (previously (24)):

$$h_j = \left\{ Q_j^{\mu_1}\left(\frac{\beta\,(1-\tau_j)}{\rho}\right)^{\beta}\left[\alpha\,(1-t_j)\right]^{1-\beta}\right\}^{\eta}, \qquad j=1,2,.....,n \tag{68}$$

Capital intensity (previously (30)):

$$k_j = \left\{ Q_j^{\mu_1(1+\varepsilon)}\left[\frac{\beta\,(1-\tau_j)}{\rho}\right]^{1-\alpha+\varepsilon}\left[\alpha\,(1-t_j)\right]^{\alpha}\right\}^{\eta}, \quad j=1,2,..,n \tag{69}$$

Profits (previously (40)):

$$\pi_j = (1-\alpha-\beta)\times$$

$$\left\{ Q_j^{\mu_1(1+\varepsilon)}\left[\frac{\beta\,(1-\tau_j)}{\rho}\right]^{\beta(1+\varepsilon)}\left[\alpha\,(1-t_j)\right]^{\alpha}\right\}^{\eta}, \quad j=1,2,....,n \tag{70}$$

Policy rule for G_j (previously (61)):

$$G_j = {\gamma_{2j}}^{\frac{1}{1-\gamma_{1j}}}, \qquad j=1,2,......,n \tag{71}$$

Policy rule for Q_j (derived from (62)):

$$Q_j = \mu_1\eta\left[\varepsilon\,(1-\widehat{a}_j)+(1+\varepsilon)\left(\frac{t_j}{1-t_j}\right)\right]h_j^{1+\varepsilon} + \mu_1\eta\,(1+\varepsilon)\left(\frac{\tau_j}{1-\tau_j}\right)\rho k_j + \mu_1\,(1+\varepsilon)\,\Delta_j$$

$$+\mu_1\eta\,(1+\varepsilon)\left[(1-\widehat{a}_j)\,(1-\delta)\,(1-\tau_j)+\tau_j\right]\pi_j,\qquad j=1,2,...,n \tag{72}$$

Policy rule for t_j (derived from (63)):

$$\left(\frac{1}{1-t_j}\right)h_j^{1+\varepsilon}-\eta\,(1-\beta)\left[\varepsilon\,(1-\widehat{a}_j)+(1+\varepsilon)\left(\frac{t_j}{1-t_j}\right)\right]h_j^{1+\varepsilon}-\left(\frac{\tau_j}{1-\tau_j}\right)\eta\alpha\rho k_j$$

$$-\eta\alpha\left[(1-\widehat{a}_j)\,(1-\delta)\,(1-\tau_j)+\tau_j\right]\pi_j-\alpha\Delta_j=0,\qquad j=1,2,...,n \tag{73}$$

Policy rule for τ_j (derived from (64)):

$$\left(\frac{\rho}{1-\tau_j}\right)\left[1-\eta\,(1-\alpha+\varepsilon)\,\tau_j\right]k_j-\eta\beta\left[\varepsilon\,(1-\widehat{a}_j)+(1+\varepsilon)\left(\frac{t_j}{1-t_j}\right)\right]h_j^{1+\varepsilon}-(1-\alpha+\varepsilon)\,\Delta_j$$

$$+\left[1-(1-\widehat{a}_j)\,(1-\delta)\right](1-\tau_j)\,\pi_j-\eta\beta\,(1+\varepsilon)\left[(1-\widehat{a}_j)\,(1-\delta)\,(1-\tau_j)+\tau_j\right]\pi_j=0 \tag{74}$$

$$j=1,2,....,n$$

Capital market equilibrium (previously (48)):

$$\sum_{j=1}^{n}s_jk_j-\rho^{1/\varphi}=0 \tag{75}$$

Output per capita:

$$y_j=Q_j^{\mu_1}k_j^{\beta}h_j^{\alpha},\qquad j=1,2,.....,n \tag{76}$$

Ratio of transfers to GDP:

$$R_j=\left(\frac{1}{y_j}\right)\left[\left(\frac{t_j}{1-t_j}\right)h_j^{1+\varepsilon}+\left(\frac{\tau_j}{1-\tau_j}\right)\rho k_j+\tau_j\pi_j-Q_j-G_j\right],\qquad j=1,2,...,n \tag{77}$$

Ratio of public consumption to GDP:

$$g_j = \frac{G_j}{y_j}, \qquad j = 1, 2, ..., n \tag{78}$$

Ratio of infrastructure spending to GDP:

$$q_j = \frac{Q_j}{y_j}, \qquad j = 1, 2, ..., n \tag{79}$$

Endogenous variables

h_j (n variables)

k_j (n variables)

π_j (n variables)

G_j (n variables)

Q_j (n variables)

t_j (n variables)

τ_j (n variables)

y_j (n variables)

R_j (n variables)

g_j (n variables)

q_j (n variables)

Δ_j (n variables)

ρ

η

Exogenous variables and parameters

γ_{1j} (n parameters)

γ_{2j} (n parameters)

$\widehat{a}_j$ (n parameters)

s_j (n parameters)

α

β

ε

δ

φ

μ_1

μ_2

m

D

The model (66) through (79) constitutes $n \times 12 + 2$ equations determining the $n \times 12 + 2$ endogenous variables, where n is the number of countries in the world. For simplicity, we assume that the parameters of the production function as well as the parameters ε and δ are identical across countries, although the values of these parameters could easily be made country-specific.

In the special case where all countries are identical in all respects, we may drop the j-subscripts from all of the equations and parameters above and set $s_j = 1/n$. The model then reduces to 14 equations in 14 unknowns, and the capital market equilibrium condition (75) simplifies to

Capital market equilibrium with symmetric countries:

$$k = \rho^{1/\varphi} \tag{80}$$

13. Full tax coordination among symmetric countries (the closed economy)

If all countries were identical and coordinated all of their fiscal policies, they would act like a single world government maximizing social welfare for the world economy as a whole. This case can be analyzed by considering the closed-economy version of the model (66) through (79) which is obtained by setting

$$n = 1 \tag{81}$$

$$s_j = 1/n = 1 \tag{82}$$

$$\delta = 0 \tag{83}$$

14. Residence-based taxation in all countries

The tax competition model summarized in section 12 assumes that capital income taxation is based on the source principle, because national governments cannot effectively monitor and tax foreign source capital income and profit income. One type of international tax coordination could take the form of an international exchange of information enabling governments to impose domestic tax on foreign source income. This section describes the necessary changes to the TAXCOM model if all countries in the world are able to tax the worldwide income of their residents, and if source countries impose no tax on domestic-source income accruing to foreign residents.

With such a consistent application of the residence principle, perfect capital mobility will ensure a cross-country equalization of *pre-tax* interest rates at the common global level r, since each individual investor will be taxed at the same rate on his foreign-source and on his domestic-source interest income. It will then be convenient to include the pre-tax interest rate $r = \rho/(1-\tau)$ explicitly in the model rather than working with the after-tax interest rate ρ. According to (24) employment in country j may thus be written as

$$h_j(r, t_j, Q_j) = \left\{ Q_j^{\mu_1} \left(\frac{\beta}{r}\right)^{\beta} \left[\alpha(1-t_j)\right]^{1-\beta} \right\}^{\eta} \tag{84}$$

implying

$$h_{rj} \equiv \frac{\partial h_j}{\partial r} = -\beta\eta\left(\frac{h}{r}\right) \tag{85}$$

$$h_{tj} \equiv \frac{\partial h_j}{\partial t_j} = -\eta(1-\beta)\left(\frac{h_j}{1-t_j}\right) \tag{86}$$

$$h_{Qj} \equiv \frac{\partial h_j}{\partial Q_j} = \mu_1 \eta \left(\frac{h_j}{Q_j} \right) \tag{87}$$

By analogy, inserting $r = \rho / (1 - \tau)$ into (40), we may write country j's profits per capita as

$$\pi_j (r, t_j, Q_j) = (1 - \alpha - \beta) \left\{ Q_j^{\mu_1 (1+\varepsilon)} \left(\frac{\beta}{r} \right)^{\beta(1+\varepsilon)} [\alpha (1 - t_j)]^{\alpha} \right\}^{\eta} \tag{88}$$

with the derivatives

$$\pi_{rj} \equiv \frac{\partial \pi_j}{\partial r} = -\eta \beta (1 + \varepsilon) \left(\frac{\pi_j}{r} \right) \tag{89}$$

$$\pi_{tj} \equiv \frac{\partial \pi_j}{\partial t_j} = -\eta \alpha \left(\frac{\pi_j}{1 - t_j} \right) \tag{90}$$

$$\pi_{Qj} \equiv \frac{\partial \pi_j}{\partial Q_j} = \eta \mu_1 (1 + \varepsilon) \left(\frac{\pi_j}{Q_j} \right) \tag{91}$$

Similarly, we may rewrite the per-capita demand for capital stated in (30) as

$$k_j (r, t_j, Q_j) = \left\{ Q_j^{\mu_1 (1+\varepsilon)} \left(\frac{\beta}{r} \right)^{1-\alpha+\varepsilon} [\alpha (1 - t_j)]^{\alpha} \right\}^{\eta} \tag{92}$$

yielding

$$k_{rj} \equiv \frac{\partial k_j}{\partial r} = -\eta (1 - \alpha + \varepsilon) \left(\frac{k_j}{r} \right) \tag{93}$$

$$k_{tj} \equiv \frac{\partial k_j}{\partial t_j} = -\eta \alpha \left(\frac{k_j}{1 - t_j} \right) \tag{94}$$

$$k_{Qj} \equiv \frac{\partial k_j}{\partial Q_j} = \eta \mu_1 (1 + \varepsilon) \left(\frac{k_j}{Q_j} \right) \tag{95}$$

Remembering that $\rho_j \equiv r (1 - \tau_j)$, it follows from (36) that country j's capital supply per capita $\left(k_j^s \right)$ is

$$k_j^s \equiv \frac{1}{N_j} \sum_i k_i^s = [r (1 - \tau_j)]^{1/\varphi} \tag{96}$$

from which one finds that

$$k_{rj}^{s} \equiv \frac{\partial k_{j}^{s}}{\partial r} = \frac{r^{\frac{1-\varphi}{\varphi}}}{\varphi} \cdot (1-\tau_{j})^{1/\varphi} \tag{97}$$

$$k_{\tau j}^{s} \equiv \frac{\partial k_{j}^{s}}{\partial \tau_{j}} = -\frac{r^{\frac{1}{\varphi}}}{\varphi} \cdot (1-\tau_{j})^{\frac{1-\varphi}{\varphi}} \tag{98}$$

The condition for international capital market equilibrium is

$$\sum_{j=1}^{n} s_{j}\left(k_{j}-k_{j}^{s}\right)=0 \tag{99}$$

By implicit differentiation of (99) and utilization of (93) through (95) plus (97) and (98), we may derive the effects of the various policy instruments on the pre-tax world interest rate:

$$r_{\tau j} \equiv \frac{\partial r}{\partial \tau_{j}} = \frac{s_{j} k_{\tau j}^{s}}{\sum s_{j}\left(k_{rj}-k_{rj}^{s}\right)} = \frac{s_{j} r^{\frac{\varphi+1}{\varphi}}\left(1-\tau_{j}\right)^{\frac{1-\varphi}{\varphi}}}{\sum s_{j}\left[\varphi\eta\left(1-\alpha+\varepsilon\right)k_{j}+r^{1/\varphi}\left(1-\tau_{j}\right)^{1/\varphi}\right]} \tag{100}$$

$$r_{tj} \equiv \frac{\partial r}{\partial t_{j}} = \frac{-s_{j} k_{tj}}{\sum s_{j}\left(k_{rj}-k_{rj}^{s}\right)} = \frac{-s_{j}\varphi\eta\alpha r k_{j}\left(1-t_{j}\right)^{-1}}{\sum s_{j}\left[\varphi\eta\left(1-\alpha+\varepsilon\right)k_{j}+r^{1/\varphi}\left(1-\tau_{j}\right)^{1/\varphi}\right]} \tag{101}$$

$$r_{Qj} \equiv \frac{\partial r}{\partial Q_{j}} = \frac{-s_{j} k_{Qj}}{\sum s_{j}\left(k_{rj}-k_{rj}^{s}\right)} = \frac{s_{j}\varphi\eta r\mu_{1}\left(1+\varepsilon\right)k_{j}Q_{j}^{-1}}{\sum s_{j}\left[\varphi\eta\left(1-\alpha+\varepsilon\right)k_{j}+r^{1/\varphi}\left(1-\tau_{j}\right)^{1/\varphi}\right]} \tag{102}$$

Under a pure residence principle of taxation, the government budget constraint becomes

$$T_{j} = \overbrace{t_{j}\left(wh\right)_{j}}^{\text{labour tax revenue}} + \overbrace{\tau_{j}\left[rk_{j}^{s}+\left(1-\delta\right)\pi_{j}+\delta\sum_{z\neq j}\left(\frac{s_{z}}{1-s_{z}}\right)\pi_{z}\right]}^{\text{revenue from taxation of interest and profits}} - Q_{j} - G_{j} \tag{103}$$

The social welfare function is given by a modified version of equation (57), accounting for the fact that foreign-source profits are no longer subject to foreign tax, and for the fact that $\rho = r\left(1-\tau\right)$:

$$SW_j = T_j + \frac{\gamma_{2j}}{\gamma_{1j}} G_j^{\gamma_{1j}}$$

$$+ (1 - \widehat{a}_j) \left\{ \left(\frac{\varepsilon}{1+\varepsilon} \right) h_j^{1+\varepsilon} + 1 + \frac{\varphi \left[r \left(1 - \tau_j\right)\right]^{\frac{\varphi+1}{\varphi}}}{\varphi + 1} + (1-\delta)(1-\tau_j)\pi_j + \delta(1-\tau_j) \sum_{z \neq j} \left(\frac{s_z}{1 - s_z} \right) \pi_z \right\} \tag{104}$$

Inserting (96) and (103) into (104) and remembering from (20) that $wh = \left(\frac{1}{1-t}\right) h^{1+\varepsilon}$, we get the social welfare function under the pure residence principle:

$$SW_j = \left[(1 - \widehat{a}_j) \left(\frac{\varepsilon}{1+\varepsilon} \right) + \left(\frac{t_j}{1 - t_j} \right) \right] h_j^{1+\varepsilon} + \frac{\gamma_{2j}}{\gamma_{1j}} G_j^{\gamma_{1j}} - G_j - Q_j + \tau_j r^{\frac{\varphi+1}{\varphi}} (1-\tau_j)^{\frac{1}{\varphi}}$$

$$+ (1 - \widehat{a}_j) \left\{ 1 + \frac{\varphi \left[r \left(1 - \tau_j\right)\right]^{\frac{\varphi+1}{\varphi}}}{\varphi + 1} \right\} + (1-\delta) \left[(1 - \widehat{a}_j)(1-\tau_j) + \tau_j \right] \pi_j$$

$$+ \delta \left[\tau_j + (1 - \widehat{a}_j)(1-\tau_j) \right] \sum_{z \neq j} \left(\frac{s_z}{1 - s_z} \right) \pi_z \tag{105}$$

The government maximizes the social welfare function (105) with respect to the four policy instruments G_j, Q_j, t_j and τ_j. The first-order conditions for the solution to this problem are

$$\frac{\partial SW_j}{\partial G_j} = 0 \Longleftrightarrow \gamma_{2j} G_j^{\gamma_{1j}-1} = 1 \tag{106}$$

$$\frac{\partial SW_j}{\partial Q_j} = 0 \Longleftrightarrow$$

$$h_{Qj} \cdot \left[\varepsilon (1 - \widehat{a}_j) + \left(\frac{t_j}{1 - t_j} \right) (1+\varepsilon) \right] h_j^{\varepsilon} - 1$$

$$+ (1-\delta) \left[(1 - \widehat{a}_j)(1-\tau_j) + \tau_j \right] \pi_{Qj} + r_{Qj} \cdot \frac{\partial SW_j}{\partial r} = 0 \tag{107}$$

$$\frac{\partial SW_j}{\partial t_j} = 0 \Longleftrightarrow$$

$$\frac{h_j^{1+\varepsilon}}{(1-t_j)^2} + h_{tj} \cdot \left[\varepsilon\left(1-\widehat{a}_t\right) + (1+\varepsilon)\left(\frac{t_j}{1-t_j}\right)\right] h_j^{\varepsilon}$$

$$+ (1-\delta)\left[\left(1-\widehat{a}_j\right)\left(1-\tau_j\right)+\tau_j\right]\pi_{tj} + r_{tj} \cdot \frac{\partial SW_j}{\partial r} = 0 \tag{108}$$

$$\frac{\partial SW_j}{\partial \tau_j} = 0 \Longleftrightarrow$$

$$r^{\frac{\varphi+1}{\varphi}}\left(1-\tau_j\right)^{\frac{1}{\varphi}}\left[\widehat{a}_j - \frac{1}{\varphi}\left(\frac{\tau_j}{1-\tau_j}\right)\right] + \widehat{a}_j\left(1-\delta\right)\pi_j$$

$$+\delta \widehat{a}_j \sum_{z\neq j}\left(\frac{s_z}{1-s_z}\right)\pi_z + r_{\tau j} \cdot \frac{\partial SW_j}{\partial r} = 0 \tag{109}$$

where

$$\frac{\partial SW_j}{\partial r} = h_{rj} \cdot \left[\varepsilon\left(1-\widehat{a}_j\right) + \left(\frac{t_j}{1-t_j}\right)(1+\varepsilon)\right] h_j^{\varepsilon} + \left[r\left(1-\tau_j\right)\right]^{\frac{1}{\varphi}}\left[1+\frac{\tau_j}{\varphi} - \widehat{a}_j\left(1-\tau_j\right)\right]$$

$$+ (1-\delta)\left[1-\widehat{a}_j\left(1-\tau_j\right)\right]\pi_{rj} + \delta\left[1-\widehat{a}_j\left(1-\tau_j\right)\right]\sum_{z\neq j}\left(\frac{s_z}{1-s_z}\right)\pi_{rz} \tag{110}$$

By analogy to the model with source-based taxation summarized in section 12, we may multiply the derivatives r_{Qj}, r_{tj} and $r_{\tau j}$ by a dummy variable D which is set equal to zero in the case of a small country perceiving the world interest rate to be exogenously given. This dummy will be included below.

15. Summarizing the model with residence-based taxation in all countries

The model with pure residence-based taxation in all countries may now be restated as follows:

Definition (previously (66)):

$$\eta = \frac{1}{1-\alpha-\beta+\varepsilon\left(1-\beta\right)} \tag{111}$$

Definition (obtained by inserting (85), (89) and (93) into (110) and noting from (107) through (109) plus (100) through (102) that $\partial SW_j/\partial r$ always gets multiplied by the factor $s_j/\left\{\sum s_j\left[\varphi\eta\left(1-\alpha+\varepsilon\right)k_j+r^{1/\varphi}\left(1-\tau_j\right)^{1/\varphi}\right]\right\}$):

$$\Delta_j^r = \left\{\frac{D\cdot s_j}{\sum_{j=1}^{m} s_j\left[\varphi\eta\left(1-\alpha+\varepsilon\right)k_j+r^{\frac{1}{\varphi}}\left(1-\tau_j\right)^{1/\varphi}\right]}\right\}\times$$

$$\{\, r^{\frac{\varphi+1}{\varphi}}\left(1-\tau_j\right)^{\frac{1}{\varphi}}\left[1+\frac{\tau_j}{\varphi}-\widehat{a}_j\left(1-\tau_j\right)\right]$$

$$-\eta\beta\left[\varepsilon\left(1-\widehat{a}_j\right)+\left(1+\varepsilon\right)\left(\frac{t_j}{1-t_j}\right)\right]h_j^{1+\varepsilon}-\eta\beta\left(1+\varepsilon\right)\left(1-\delta\right)\left[1-\widehat{a}_j\left(1-\tau_j\right)\right]\pi_j$$

$$-\eta\beta\left(1+\varepsilon\right)\delta\left[1-\widehat{a}_j\left(1-\tau_j\right)\right]\sum_{z\neq j}\left(\frac{s_z}{1-s_z}\right)\pi_z\,\}, \qquad j=1,2,.....,n \tag{112}$$

Employment (previously (84)):

$$h_j = \left\{Q_j^{\mu_1}\left(\frac{\beta}{r}\right)^{\beta}\left[\alpha\left(1-t_j\right)\right]^{1-\beta}\right\}^{\eta}, \qquad j=1,2,......,n \tag{113}$$

Capital intensity (previously (92)):

$$k_j = \left\{Q_j^{\mu_1(1+\varepsilon)}\left(\frac{\beta}{r}\right)^{1-\alpha+\varepsilon}\left[\alpha\left(1-t_j\right)\right]^{\alpha}\right\}^{\eta}, \qquad j=1,2,......,n \tag{114}$$

Profits (previously (88)):

$$\pi_j = (1-\alpha-\beta)\times$$

$$\left\{ Q_j^{\mu_1(1+\varepsilon)} \left(\frac{\beta}{r}\right)^{\beta(1+\varepsilon)} \left[\alpha\left(1-t_j\right)\right]^{\alpha} \right\}^{\eta}, \qquad j=1,2,......,n \tag{115}$$

Policy rule for G_j (previously (106)):

$$G_j = \gamma_{2j}^{\frac{1}{1-\gamma_{1j}}}, \qquad j=1,2,.......,n \tag{116}$$

Policy rule for Q_j (derived from (87), (91), (102), and (107)):

$$Q_j = \mu_1\eta\left[\varepsilon\left(1-\widehat{a}_j\right)+\left(\frac{t_j}{1-t_j}\right)(1+\varepsilon)\right]h_j^{1+\varepsilon}$$

$$+\mu_1\eta(1+\varepsilon)\left\{(1-\delta)\left[1-\widehat{a}_j\left(1-\tau_j\right)\right]\pi_j+\varphi\Delta_j^r k_j\right\}, \qquad j=1,2,.......,n \tag{117}$$

Policy rule for t_j (derived from (86), (90), (101), (94) and (108)):

$$\frac{h_j^{1+\varepsilon}}{1-t_j}-\eta(1-\beta)\left[\varepsilon\left(1-\widehat{a}_j\right)+(1+\varepsilon)\left(\frac{t_j}{1-t_j}\right)\right]h_j^{1+\varepsilon}$$

$$-\eta\alpha\left\{(1-\delta)\left[1-\widehat{a}\left(1-\tau_j\right)\right]\pi_j+\varphi\Delta_j^r k_j\right\}=0, \qquad j=1,2,......,n \tag{118}$$

Policy rule for τ_j (derived from (100) and (109)):

$$\widehat{a}_j(1-\delta)\pi_j + r^{\frac{\varphi+1}{\varphi}}\left(1-\tau_j\right)^{\frac{1}{\varphi}}\left[\widehat{a}_j-\frac{1}{\varphi}\left(\frac{\tau_j}{1-\tau_j}\right)\right]+r^{\frac{1}{\varphi}}\left(1-\tau_j\right)^{\frac{1-\varphi}{\varphi}}\cdot\Delta_j^r$$

$$+\delta\widehat{a}_j\sum_{z\neq j}\left(\frac{s_z}{1-s_z}\right)\pi_z=0, \qquad j=1,2,.......,n \tag{119}$$

Capital market equilibrium (derived from (96) and (99)):

$$\sum_{j=1}^{n} s_j \left\{ k_j - [r(1-\tau_j)]^{1/\varphi} \right\} = 0 \tag{120}$$

In addition to these equations, the model also includes the definitions stated in (76) through (79).

16. Regional tax coordination: a minimum capital income tax rate in a subset of countries

We now consider the case where international tax coordination involves only a subset u of all the n countries in the world. We will refer to these u coordinating countries as the "union", and we will assume that tax coordination among the u union countries takes the form of a binding minimum capital income and profits tax rate τ_u, levied according to the source principle. This harmonized union-wide capital income tax rate is set by a supra-national union authority with the purpose of maximizing union-wide social welfare, taking the fiscal instruments chosen by governments outside the union as given, but accounting for the fact that union member states will react to the harmonization of τ_u by subsequently adjusting their policy instruments t and Q to the levels which maximize their national welfare. In relation to union governments the supra-national union authority thus acts as a Stackelberg leader in the fiscal policy game, with union member states playing the role of followers. At the same time the union authority plays a Nash game with the rest of the world.

The union-wide social welfare SW_u is a weighted average of the social welfare of each member state, where the weight $\widehat{s}_j$ of union country j equals its share of total union population:

$$\widehat{s}_j \equiv \frac{s_j}{\sum_{z=1}^{u} s_z} \tag{121}$$

The social welfare of union member state j is given by (60), but we now allow for the fact that all of the u union countries have the same capital income tax rate τ_u. At the same time we allow for the possibility that foreign ownership shares may differ across countries, with δ_j denoting the foreign ownership share in country j. Hence the social welfare of the union may be written as

$$SW_u = \sum_{j=1}^{u} \widehat{s}_j SW_j = \sum_{j=1}^{u} \widehat{s}_j \left\{ \frac{\gamma_{2j}}{\gamma_{1j}} G_j^{\gamma_{1j}} - G_j - Q_j + \frac{\tau_u \rho k_j}{1-\tau_u} + (1-\widehat{a}_j) \left[1 + \frac{\varphi \rho^{\frac{\varphi+1}{\varphi}}}{\varphi+1} \right] \right.$$

$$+ \left[(1-\widehat{a}_j) \left(\frac{\varepsilon}{1+\varepsilon} \right) + \left(\frac{t_j}{1-t_j} \right) \right] h_j^{1+\varepsilon} + \left[(1-\widehat{a}_j)(1-\delta_j)(1-\tau_u) + \tau_u \right] \pi_j$$

$$\left. + (1-\widehat{a}_j) \left[(1-\tau_u) \sum_{z=1,\, z\neq j}^{u} \frac{s_z \delta_z \pi_z}{1-s_z} + \sum_{v=u+1}^{n} \frac{s_v \delta_v \pi_v (1-\tau_v)}{1-s_v} \right] \right\} \qquad (122)$$

When the union authority sets τ_u, it allows for its impact on the net world interest rate ρ, for even if each union member state may be small, the union as a whole may have a non-negligible weight in the world economy. The union authority also accounts for the fact that member states will optimally adjust their fiscal instruments Q_j and t_j in response to a change in τ_u. However, at the optimum each member state fulfills the national optimum conditions $\partial SW_j / \partial Q_j = \partial SW_j / \partial t_j = 0$, so these adjustments of Q_j and t_j will have no impact on union social welfare $SW_u = \sum \widehat{s}_j SW_j$ (this is just an application of the envelope theorem). Hence the first-order condition for the union authority's optimal choice of τ_u is simply that

$$\frac{\partial SW_u}{\partial \tau_u} = \sum_{j=1}^{u} \widehat{s}_j \cdot \frac{\partial SW_j}{\partial \tau_u} = 0$$

From (122) we find this first-order condition to be

$$\sum_{j=1}^{u} \widehat{s}_j \left\{ \frac{\rho k_j}{(1-\tau_u)^2} + \frac{\rho \tau_u k_{\tau j}}{1-\tau_u} + \rho_{\tau u} \left(\frac{\tau_u}{1-\tau_u} \right) [k_j + \rho k_{\rho j}] + \rho_{\tau u} (1-\widehat{a}_j) \rho^{\frac{1}{\varphi}} \right.$$

$$+ [h_{\tau j} + \rho_{\tau u} \cdot h_{\rho j}] (1+\varepsilon) \left[(1-\widehat{a}_j) \left(\frac{\varepsilon}{1+\varepsilon} \right) + \left(\frac{t_j}{1-t_j} \right) \right] h_j^{\varepsilon} + [1 - (1-\widehat{a}_j)(1-\delta_j)] \pi_j$$

$$+\left[\pi_{\tau j}+\rho_{\tau u}\cdot\pi_{\rho j}\right]\left[\left(1-\widehat{a}_j\right)\left(1-\delta_j\right)\left(1-\tau_u\right)+\tau_u\right]-\left(1-\widehat{a}_j\right)\sum_{z=1,\ z\neq j}^{u}\frac{s_z\delta_z\pi_z}{1-s_z}$$

$$+\left(1-\widehat{a}_j\right)\left[\left(1-\tau_u\right)\sum_{z=1,\ z\neq j}^{u}\frac{s_z\delta_z}{1-s_z}\left(\pi_{\tau z}+\rho_{\tau u}\pi_{\rho z}\right)+\sum_{v=u+1}^{n}\frac{s_v\delta_v}{1-s_v}\left(1-\tau_v\right)\rho_{\tau u}\pi_{\rho v}\right]\Bigg\}=0 \tag{123}$$

Collecting all the terms involving the derivative $\rho_{\tau u}$, we may rewrite (123) as

$$\sum_{j=1}^{u}\widehat{s}_j\left\{\frac{\rho k_j}{\left(1-\tau_u\right)^2}+\frac{\rho\tau_u k_{\tau j}}{1-\tau_u}+h_{\tau j}\left[\varepsilon\left(1-\widehat{a}_j\right)+\left(1+\varepsilon\right)\left(\frac{t_j}{1-t_j}\right)\right]h_j^{\varepsilon}+\left[1-\left(1-\widehat{a}_j\right)\left(1-\delta_j\right)\right]\pi_j\right.$$

$$+\left[\left(1-\widehat{a}_j\right)\left(1-\delta_j\right)\left(1-\tau_u\right)+\tau_u\right]\pi_{\tau j}+\left(1-\widehat{a}_j\right)\sum_{z=1,\ z\neq j}^{u}\left(\frac{s_z\delta_z}{1-s_z}\right)\left[\left(1-\tau_u\right)\pi_{\tau z}-\pi_z\right]$$

$$\left.+\rho_{\tau u}\cdot\Delta_j^u\right\}=0 \tag{124}$$

where

$$\Delta_j^u\equiv\frac{\partial SW_j}{\partial\rho}=\left(\frac{\tau_u}{1-\tau_u}\right)\left(k_j+\rho k_{\rho j}\right)+\left(1-\widehat{a}_j\right)\rho^{\frac{1}{\varphi}}$$

$$+h_{\rho j}\left[\varepsilon\left(1-\widehat{a}_j\right)+\left(1+\varepsilon\right)\left(\frac{t_j}{1-t_j}\right)\right]h_j^{\varepsilon}+\left[\left(1-\widehat{a}_j\right)\left(1-\delta_j\right)\left(1-\tau_u\right)+\tau_u\right]\pi_{\rho j}$$

$$+\left(1-\widehat{a}_j\right)\left[\left(1-\tau_u\right)\sum_{z=1,\ z\neq j}^{u}\frac{s_z\delta_z\pi_{\rho z}}{1-s_z}+\sum_{v=u+1}^{n}\frac{s_v\delta_v\left(1-\tau_v\right)\pi_{\rho v}}{1-s_v}\right] \tag{125}$$

The capital market equilibrium condition is given by (48) which implies that

$$\rho_{\tau u}\equiv\frac{\partial\rho}{\partial\tau_u}=\frac{\sum_{j=1}^{u}s_jk_{\tau j}}{\left(1/\varphi\right)\rho^{\frac{1-\varphi}{\varphi}}-\sum_{j=1}^{m}s_jk_{\rho j}} \tag{126}$$

17. Summary of model with a minimum capital income tax rate within a subgroup of countries

The derivatives of h, k and π appearing in (124) through (126) are given in equations (26) through (28), (32) through (34) and (42) through (44). Inserting these expressions whereever appropriate, we may now summarize the model with a regional minimum capital income tax rate as follows:

Equations common to all countries

Definition (previously (66)):

$$\eta \equiv \frac{1}{1-\alpha-\beta+\varepsilon(1-\beta)} \tag{127}$$

Employment (previously (68)):

$$h_j = \left\{ Q_j^{\mu_1} \left(\frac{\beta(1-\tau_j)}{\rho} \right)^{\beta} [\alpha(1-t_j)]^{1-\beta} \right\}^{\eta}, \qquad j = 1, 2, ..., n \tag{128}$$

Capital intensity (previously (69)):

$$k_j = \left\{ Q_j^{\mu_1(1+\varepsilon)} \left[\frac{\beta(1-\tau_j)}{\rho} \right]^{1-\alpha+\varepsilon} [\alpha(1-t_j)]^{\alpha} \right\}^{\eta}, \qquad j = 1, 2, ..., n \tag{129}$$

Profits (previously (70)):

$$\pi_j = (1-\alpha-\beta) \times$$

$$\left\{ Q^{\mu_1(1+\varepsilon)} \left[\frac{\beta(1-\tau_j)}{\rho} \right]^{\beta(1+\varepsilon)} [\alpha(1-t_j)]^{\alpha} \right\}^{\eta}, \qquad j = 1, 2, ..., n \tag{130}$$

Policy rule for G_j (previously (71)):

$$G_j = \gamma_{2j}^{\overline{\frac{1}{1-\gamma_{1j}}}}, \qquad j = 1, 2, ..., n \tag{131}$$

Capital market equilibrium (previously (75)):

$$\sum_{j=1}^{m} s_j k_j - \rho^{1/\varphi} = 0 \tag{132}$$

Output per capita (previously (76)):

$$y_j = Q_j^{\mu_1} k_j^{\beta} h_j^{\alpha}, \qquad j = 1, 2, ..., n \tag{133}$$

Ratio of transfers to GDP (previously (77)):

$$R_j = \left(\frac{1}{y_j}\right)\left[\left(\frac{t_j}{1-t_j}\right) h_j^{1+\varepsilon} + \left(\frac{\tau_j}{1-\tau_j}\right)\rho k_j + \tau_j \pi_j - Q_j - G_j\right], \qquad j = 1, 2, ..., n \tag{134}$$

Ratio of public consumption to GDP (previously (78)):

$$g_j = \frac{G_j}{y_j}, \qquad j = 1, 2, ..., n \tag{135}$$

Ratio of infrastructure spending to GDP (previously (79)):

$$q_j = \frac{Q_j}{y_j}, \qquad j = 1, 2, ..., n \tag{136}$$

Equations specific to union countries

Definition (analogous to (67)):

$$\Delta_j^u \equiv \left[\frac{D \cdot \varphi \eta^2 \beta s_j k_j}{\rho^{1/\varphi}\left[1+\varphi\eta\left(1-\alpha+\varepsilon\right)\right]}\right] \times$$

$$\{ \left(\frac{1-\widehat{a}_j}{\eta\beta}\right)\rho^{\frac{\varphi+1}{\varphi}} - \left(\frac{\tau_j}{1-\tau_j}\right)\left(1+\varepsilon\right)\rho k_j - \left[\varepsilon\left(1-\widehat{a}_j\right)+\left(1+\varepsilon\right)\left(\frac{t_j}{1-t_j}\right)\right] h_j^{1+\varepsilon}$$

$$-\left(1+\varepsilon\right)\left[\left(1-\widehat{a}_j\right)\left(1-\delta_j\right)\left(1-\tau_u\right)+\tau_u\right]\pi_j$$

$$-\left(1+\varepsilon\right)\left(1-\widehat{a}_j\right)\left[\left(1-\tau_u\right)\sum_{z=1,\ z\neq j}^{u}\frac{s_z\delta_z\pi_z}{1-s_z}+\sum_{v=u+1}^{n}\frac{s_v\delta_v\left(1-\tau_v\right)\pi_v}{1-s_v}\right]\}, \qquad j=1,2,...,u \tag{137}$$

Policy rule for Q_j (analogous to (72)):

$$Q_j = \mu_1\eta\left[\varepsilon\left(1-\widehat{a}_j\right)+\left(1+\varepsilon\right)\left(\frac{t_j}{1-t_j}\right)\right]h_j^{1+\varepsilon} + \mu_1\eta\left(1+\varepsilon\right)\left(\frac{\tau_u}{1-\tau_u}\right)\rho k_j + \mu_1\left(1+\varepsilon\right)\Delta_j^u$$

$$+\mu_1\eta\left(1+\varepsilon\right)\left[\left(1-\widehat{a}_j\right)\left(1-\delta_j\right)\left(1-\tau_u\right)+\tau_u\right]\pi_j, \qquad j=1,2,...,u \tag{138}$$

Policy rule for t_j (analogous to (73)):

$$\left(\frac{1}{1-t_j}\right)h_j^{1+\varepsilon} - \eta\left(1-\beta\right)\left[\varepsilon\left(1-\widehat{a}_j\right)+\left(1+\varepsilon\right)\left(\frac{t_j}{1-t_j}\right)\right]h_j^{1+\varepsilon} - \left(\frac{\tau_u}{1-\tau_u}\right)\eta\alpha\rho k_j$$

$$-\eta\alpha\left[\left(1-\widehat{a}_j\right)\left(1-\delta_j\right)\left(1-\tau_u\right)+\tau_u\right]\pi_j - \alpha\Delta_j^u = 0, \qquad j=1,2,...,u \tag{139}$$

Definition:

$$\widehat{s}_j \equiv \frac{s_j}{\sum_{z=1}^{u} s_z}, \qquad j = 1, 2, ..., u \tag{140}$$

Definition (derived from (125)):

$$\widehat{\Delta}_j^u \equiv (1-\widehat{a}_j)\,\rho^{\frac{\varphi+1}{\varphi}} - \eta\beta\,(1+\varepsilon)\left(\frac{\tau_u}{1-\tau_u}\right)\rho k_j - \eta\beta\left[\varepsilon\,(1-\widehat{a}_j) + (1+\varepsilon)\left(\frac{t_j}{1-t_j}\right)\right] h_j^{1+\varepsilon}$$

$$-\eta\beta\,(1+\varepsilon)\left[(1-\widehat{a}_j)\,(1-\delta_j)\,(1-\tau_u) + \tau_u\right]\pi_j$$

$$-\eta\beta\,(1+\varepsilon)\,(1-\widehat{a}_j)\left[(1-\tau_u)\sum_{z=1,\ z\neq j}^{u}\frac{s_z\delta_z\pi_z}{1-s_z} + \sum_{v=u+1}^{n}\frac{s_v\delta_v\,(1-\tau_n)\,\pi_v}{1-s_v}\right], \quad j = 1, 2, ..., u \tag{141}$$

Definition (derived from (126)):

$$\widehat{\rho}_{\tau u} \equiv -\frac{\varphi\eta\,(1-\alpha+\varepsilon)\sum_{j=1}^{u} s_j k_j}{\rho^{\frac{1}{\varphi}}\left[1+\varphi\eta\,(1-\alpha+\varepsilon)\right]} \tag{142}$$

Policy rule for τ_u (derived from (124)):

$$\sum_{j=1}^{u}\widehat{s}_j\left\{\left(\frac{\rho}{1-\tau_u}\right)\left[1-\tau_u\eta\,(1-\alpha+\varepsilon)\right]k_j - \eta\beta\left[\varepsilon\,(1-\widehat{a}_j) + (1+\varepsilon)\left(\frac{t_j}{1-t_j}\right)\right] h_j^{1+\varepsilon}\right.$$

$$+\left[1-(1-\widehat{a}_j)\,(1-\delta_j)\right](1-\tau_u)\,\pi_j - \eta\beta\,(1+\varepsilon)\left[(1-\widehat{a}_j)\,(1-\delta_j)\,(1-\tau_u)+\tau_u\right]\pi_j + \widehat{\rho}_{\tau u}\cdot\widehat{\Delta}_j^u$$

$$\left. -\eta\,(1-\tau_u)\,(1-\widehat{a}_j)\,(1-\alpha+\varepsilon)\sum_{z=1,\ z\neq j}^{u}\frac{s_z\delta_z\pi_z}{1-s_z}\right\} = 0 \tag{143}$$

Social welfare of individual union country (analogous to (60)):

$$SW_j = \frac{\gamma_{2j}}{\gamma_{1j}}G_j^{\gamma_{1j}} - G_j - Q_j + \frac{\tau_u\rho k_j}{1-\tau_u} + (1-\widehat{a}_j)\left(1+\frac{\varphi\rho^{\frac{\varphi+1}{\varphi}}}{\varphi+1}\right)$$

$$+\left[(1-\widehat{a}_j)\left(\frac{\varepsilon}{1+\varepsilon}\right)+\left(\frac{t_j}{1-t_j}\right)\right]h_j^{1+\varepsilon}+\left[(1-\widehat{a}_j)(1-\delta_j)(1-\tau_u)+\tau_u\right]\pi_j$$

$$+(1-\widehat{a}_j)\left[(1-\tau_u)\sum_{z=1,\ z\neq j}^{u}\frac{s_z\delta_z\pi_z}{1-s_z}+\sum_{v=u+1}^{n}\frac{s_v\delta_v(1-\tau_v)\pi_v}{1-s_v}\right], \qquad j=1,2,....,u \quad (144)$$

Social welfare of the union:

$$SW_u=\sum_{j=1}^{u}\widehat{s}_j\cdot SW_j \quad (145)$$

Equations specific to non-union countries

Definition (analogous to (67)):

$$\Delta_v^n\equiv\left[\frac{D\cdot\varphi\eta^2\beta s_v k_v}{\rho^{1/\varphi}\left[1+\varphi\eta(1-\alpha+\varepsilon)\right]}\right]\times$$

$$\{\left(\frac{1-\widehat{a}_v}{\eta\beta}\right)\rho^{\frac{\varphi+1}{\varphi}}-\left(\frac{\tau_v}{1-\tau_v}\right)(1+\varepsilon)\rho k_v-\left[\varepsilon(1-\widehat{a}_v)+(1+\varepsilon)\left(\frac{t_v}{1-t_v}\right)\right]h_v^{1+\varepsilon}$$

$$-(1+\varepsilon)\left[(1-\widehat{a}_v)(1-\delta_v)(1-\tau_v)+\tau_v\right]\pi_v$$

$$-(1+\varepsilon)(1-\widehat{a}_v)\sum_{z=1,\ z\neq v}^{n}\frac{s_z\delta_z(1-\tau_z)\pi_z}{1-s_z}\}, \qquad v=u+1,....,n \quad (146)$$

Policy rule for Q_v (analogous to (72)):

$$Q_v=\mu_1\eta\left[\varepsilon(1-\widehat{a}_v)+(1+\varepsilon)\left(\frac{t_v}{1-t_v}\right)\right]h_v^{1+\varepsilon}+\mu_1\eta(1+\varepsilon)\left(\frac{\tau_v}{1-\tau_v}\right)\rho k_v+\mu_1(1+\varepsilon)\Delta_v^n$$

$$+\mu_1\eta(1+\varepsilon)\left[(1-\widehat{a}_v)(1-\delta_v)(1-\tau_v)+\tau_v\right]\pi_v, \qquad v=u+1,.....,n \quad (147)$$

Policy rule for t_v (analogous to (73)):

$$\left(\frac{1}{1-t_v}\right) h_v^{1+\varepsilon} - \eta\left(1-\beta\right)\left[\varepsilon\left(1-\widehat{a}_v\right) + \left(1+\varepsilon\right)\left(\frac{t_v}{1-t_v}\right)\right] h_v^{1+\varepsilon} - \left(\frac{\tau_v}{1-\tau_v}\right)\eta\alpha\rho k_v$$

$$-\eta\alpha\left[\left(1-\widehat{a}_v\right)\left(1-\delta_v\right)\left(1-\tau_v\right)+\tau_v\right]\pi_v - \alpha\Delta_v^n = 0, \qquad v = u+1, ..., n \tag{148}$$

Policy rule for τ_v (analogous to (74)):

$$\left(\frac{\rho}{1-\tau_v}\right)\left[1-\eta\left(1-\alpha+\varepsilon\right)\tau_v\right]k_v - \eta\beta\left[\varepsilon\left(1-\widehat{a}_v\right)+\left(1+\varepsilon\right)\left(\frac{t_v}{1-t_v}\right)\right]h_v^{1+\varepsilon} - \left(1-\alpha+\varepsilon\right)\Delta_v^n$$

$$+\left[1-\left(1-\widehat{a}_v\right)\left(1-\delta_v\right)\right]\left(1-\tau_v\right)\pi_v - \eta\beta\left(1+\varepsilon\right)\left[\left(1-\widehat{a}_v\right)\left(1-\delta_v\right)\left(1-\tau_v\right)+\tau_v\right]\pi_v = 0 \tag{149}$$

$$v = u+1, ..., n$$

Social welfare for individual non-union country (analogous to (60)):

$$SW_v = \left[\left(1-\widehat{a}_v\right)\left(\frac{\varepsilon}{1+\varepsilon}\right) + \left(\frac{t_v}{1-t_v}\right)\right] h_v^{1+\varepsilon} + \frac{\gamma_{2v}}{\gamma_{1v}} G_v^{\gamma_{1v}} - G_v - Q_v$$

$$+\frac{\tau_v \rho k_v}{1-\tau_v} + \left(1-\widehat{a}_v\right)\left(1+\frac{\varphi\rho^{\frac{\varphi+1}{\varphi}}}{\varphi+1}\right) + \left[\left(1-\widehat{a}_v\right)\left(1-\delta_v\right)\left(1-\tau_v\right)+\tau_v\right]\pi_v$$

$$+\left(1-\widehat{a}_v\right)\sum_{z=1,\ z\neq v}^{n}\frac{s_z\delta_z\left(1-\tau_z\right)\pi_z}{1-s_z}, \qquad v = u+1, ..., n \tag{150}$$

By including equations (147) through (149) in the model, we are assuming that the rest of the world reacts to the coordinated union policy by adjusting its fiscal policy instruments optimally. As an alternative benchmark case one may assume that fiscal policies in the rest of the world are unaffected by the union's coordination efforts. This may be modelled by treating Q_v, t_v and τ_v as exogenous, thus leaving out equations (147) through (149).

18. A global minimum capital income tax rate

The model of the previous section may easily be used to analyse the case of *global* coordination taking the form of a binding minimum source-based capital income tax rate for all countries in the world. This is simply the special case of the model in the previous section where $u = n$ so that $\widehat{s}_j = s_j$.

19. A model with imperfect capital mobility and asymmetric tastes, technologies and endowments

We have so far assumed perfect capital mobility between all countries in the world, and we have assumed identical private tastes, technologies and per-capita endowments across countries. From now on we will allow for cross-country asymmetries in tastes, technologies and endowments (by introducing country subscripts in the relevant parameters), and we will allow for imperfect capital mobility between the coordinating tax union and the rest of the world. The idea is that a group of countries engaging in tax coordination are likely to have closer economic links with each other than with the rest of the world. For example, in the context of economic and monetary union in Europe, it seems reasonable to assume that the degree of capital mobility within the EU is higher than the degree of capital mobility between the EU and the rest of the world. To capture this distinction in a stylized way, we divide the world's n countries into a group of $u = n - 1$ potential union countries, and the final country n representing the rest of the world (ROW). Within the group of potential union countries there is still perfect capital mobility, so source-based taxation establishes a common after-tax rate interest rate ρ_u within the union. However, capital is only imperfectly mobile between the union and ROW, so the after-tax interest rate ρ_n in the latter region may deviate from ρ_u.

We previously normalized each country's initial per-capita endowment of human as well as non-human wealth to be equal to unity. Now we will allow these per-capita endowments to deviate from one and to differ across countries. If e_j is the per-capita endowment of human capital in country j, the total initial stock of human capital H_{ij} held by consumer i in country j will be given by

$$H_{ij} = \theta_{ij} H_j = \theta_{ij} e_j N_j, \qquad i = 1, 2, ..., N_j \tag{151}$$

where $H_j \equiv e_j N_j$ is country j's aggregate stock of human wealth. Similarly, if v_j is the initial per-capita endowment of non-human wealth in country j, the initial wealth held by consumer i in that country will be

$$V_{ij} = \theta_{ij} v_j N_j, \qquad i = 1, 2, ..., N_j \tag{152}$$

By analogy to (1), the direct utility of consumer i may then be written as

$$U_{ij} = C_{ij} - \theta_{ij} e_j N_j \cdot \frac{h_{ij}^{1+\varepsilon_j}}{1+\varepsilon_j} + \frac{\gamma_{2j}}{\gamma_{1j}} G^{\gamma_{1j}} \tag{153}$$

The consumer allocates his savings across union and non-union assets, obtaining an average after-tax return q. As we shall see below, all consumers residing in a (potential) union country will obtain the same average after-tax return $q = \rho$, whereas consumers outside the union will earn a different after-tax return $q = r$. Hence we may write the consumer budget constraint as

$$C_{ij} = w_i h_i \left(1 - t_j\right) + q k_{ij}^s + V_{ij} - \overbrace{\frac{1}{\varphi_j + 1} \left(\frac{k_{ij}^s}{V_{ij}} \right)^{\varphi_j + 1}}^{\text{transaction costs}} + T_j$$

$$+ \theta_{ij} N_j \left[\left(1 - \delta_j\right) \left(1 - \tau_j\right) \pi_j + \sum_{z=1,\, z \neq j}^{n} \left(\frac{s_z \delta_z}{1 - s_z} \right) \left(1 - \tau_z\right) \pi_z \right], \qquad q = \rho, r \tag{154}$$

Maximization of utility subject to the budget constraint can be shown to yield the following labour supply and savings schedules:

$$h_{ij} = h_j = \left[\frac{w_{ij} \left(1 - t_j\right)}{\theta_{ij} e_j N_j} \right]^{1/\varepsilon_j} = \left[w_j \left(1 - t_j\right) \right]^{1/\varepsilon_j} \qquad \forall \quad i \tag{155}$$

$$w_j \equiv \frac{\sum_i w_{ij} h_{ij}}{L_j} = \frac{\sum_i w_{ij} h_{ij}}{\sum_i \theta_{ij} e_j N_j h_{ij}} \tag{156}$$

$$w_{ij} = \theta_{ij} e_j N_j w_j \tag{157}$$

$$k_{ij}^{s} = q^{1/\varphi_j} \cdot \theta_{ij} v_j N_j, \qquad q = \rho, r \tag{158}$$

Inserting (154), (155) and (158) into (153), we find the indirect utility function

$$U_{ij} = \theta_{ij} N_j \left(\frac{\varepsilon_j}{1+\varepsilon_j}\right) e_j h_j^{1+\varepsilon_j} + \left[1 + \left(\frac{\varphi_j}{1+\varphi_j}\right) q^{\frac{\varphi_j+1}{\varphi_j}}\right] \theta_{ij} v_j N_j + T_j + \frac{\gamma_{2j}}{\gamma_{1j}} G_j^{\gamma_{1j}}$$

$$+\theta_{ij} N_j \left[(1-\delta_j)(1-\tau_j)\pi_j + \sum_{z=1,\ z\neq j}^{n} \left(\frac{s_z \delta_z}{1-s_z}\right)(1-\tau_z)\pi_z\right], \tag{159}$$

$$q = \rho \quad \text{for} \quad j = 1, \ldots.., u; \qquad q = r \quad \text{for} \quad j = n$$

To account for inherent cross-country differences in total factor productivities, we will respecify equation (23) as

$$\widetilde{A}_j = \mu_{2j} Q_j^{\mu_{1j}}, \qquad j = 1, 2, \ldots\ldots.., n \tag{160}$$

where μ_2 is a scale parameter which may vary across countries. Using (160), following a procedure similar to the one described in sections 3 through 7, and dropping the country subscript j for convenience, it is easy to show that equations (21), (22), (39) and (45) modify to

$$k = \left(\frac{\beta}{\alpha\rho_v}\right)\left(\frac{1-\tau}{1-t}\right) e h^{1+\varepsilon}, \qquad v = u, n \tag{21.a}$$

$$\alpha\mu_2 Q^{\mu_1} \left(\frac{\beta}{\alpha\rho_v}\right)^{\beta} \left(\frac{1-\tau}{1-t}\right)^{\beta} e^{\alpha+\beta-1} h^{\beta(1+\varepsilon)+\alpha-1} = \frac{h^{\varepsilon}}{1-t}, \qquad v = u, n \tag{22.a}$$

$$\pi = (1-\alpha-\beta)\,\mu_2 Q^{\mu_1} k^{\beta} (eh)^{\alpha} \tag{39.a}$$

$$T = tweh + \left(\frac{\tau}{1-\tau}\right)\rho_v k + \tau\pi - Q - G, \qquad v = u, n \tag{45.a}$$

In these specifications a distinction is made between the after-tax rate of return on capital invested within the coordinating tax union (ρ_u), and the after-tax return on capital invested outside the union (ρ_n), since these two magnitudes will differ as a result of imperfect capital mobility between the two regions.

Imperfect capital mobility results from imperfect substitutability between capital supplied to the union region (k^{su}) and capital supplied to the rest of the world (k^{sn}). Thus we assume that consumer i in country j can allocate his total supply of capital k^s_{ij} between the two regions according to the CES transformation curve

$$k^s_{ij} = \left[\Psi_j^{-\frac{1}{\sigma}} \left(k^{su}_{ij} \right)^{\frac{\sigma+1}{\sigma}} + (1-\Psi_j)^{-\frac{1}{\sigma}} \left(k^{sn}_{ij} \right)^{\frac{\sigma+1}{\sigma}} \right]^{\frac{\sigma}{\sigma+1}}, \qquad \sigma > 0, \quad 0 < \Psi_j < 1 \tag{161}$$

where σ is the elasticity of substitution between capital invested in the two regions. For a consumer residing in a union country, the total after-tax income from capital is

$$\rho k^s_{ij} = \rho_u k^{su}_{ij} + \rho_n k^{sn}_{ij}$$

The consumer wishes to allocate his total capital stock so as to maximize his total net income from capital, subject to the transformation technology (161). We assume that the 'home bias' parameter Ψ_j takes the same value Ψ for all union countries. The solution to the portfolio allocation problem of union residents then yields

$$k^{su}_{ij} = \left(\frac{\rho_u}{\rho} \right)^{\sigma} \Psi k^s_{ij} \qquad\qquad k^{sn}_{ij} = \left(\frac{\rho_n}{\rho} \right)^{\sigma} (1-\Psi)\, k^s_{ij} \tag{162}$$

$$\rho = \left[\Psi \rho_u^{\sigma+1} + (1-\Psi)\, \rho_n^{\sigma+1} \right]^{\frac{1}{\sigma+1}} \tag{163}$$

$$\text{for} \quad j = 1, ...u$$

For a consumer living in the non-union country n, the total after-tax income from capital

$$r k^s_{in} = \rho_u k^{su}_{in} + \rho_n k^{sn}_{in}$$

is maximized when

$$k^{su}_{in} = \left(\frac{\rho_u}{r} \right)^{\sigma} \Psi_n k^s_{in} \qquad\qquad k^{sn}_{in} = \left(\frac{\rho_n}{r} \right)^{\sigma} (1-\Psi_n)\, k^s_{in} \tag{164}$$

$$r = \left[\Psi_n \rho_n^{\sigma+1} + (1-\Psi_n)\,\rho_n^{\sigma+1}\right]^{\frac{1}{\sigma+1}} \tag{165}$$

where we have allowed for the possibility that $\Psi_n \neq \Psi$. Thus consumers optimize their total capital supply in accordance with (158), given the average rates of return specified in (163) and (165), and they then allocate their total capital stock across union and non-union assets in accordance with the portfolio balance rules (162) and (164). Equilibrium in the union capital market is attained when total capital demand in the union equals the total capital stock supplied to the union by union and non-union residents, i.e., when

$$\sum_{j=1}^{u} s_j k_j = \sum_{j=1}^{u} s_j \sum_{i=1}^{N_j} k_{ij}^{su} + s_n \sum_{i=1}^{N_n} k_{in}^{su} \tag{166}$$

In a similar way, the capital market in the non-union country clears when

$$s_n k_n = \sum_{j=1}^{u} s_j \sum_{i=1}^{N_j} k_{ij}^{sn} + s_n \sum_{i=1}^{N_n} k_{in}^{sn} \tag{167}$$

With these preliminaries, we are ready to summarize the model of tax competition under imperfect capital mobility.

20. Summary of model with imperfect capital mobility and tax competition

Equations common to all countries

GDP per capita:

$$y_j = \mu_{2j} Q_j^{\mu_{1j}} k_j^{\beta_j} (e_j h_j)^{\alpha_j}, \qquad j = 1, ..., n \tag{168}$$

Policy rule for G (restatement of (71)):

$$G_j = \gamma_{2j}^{\frac{1}{1-\gamma_{1j}}}, \qquad j = 1, ..., n \tag{71}$$

Average return to saving for union residents (previously (163)):

$$\rho = \left[\Psi \rho_u^{\sigma+1} + (1-\Psi)\,\rho_n^{\sigma+1}\right]^{\frac{1}{\sigma+1}} \tag{169}$$

Average return to saving for non-union residents (previously (165)):

$$r = \left[\Psi_n \rho_u^{\sigma+1} + (1-\Psi_n)\,\rho_n^{\sigma+1}\right]^{\frac{1}{\sigma+1}} \tag{170}$$

Capital market equilibrium in union (derived from (158), (162), (164) and (166)):

$$\sum_{j=1}^{u} s_j k_j = \rho_u^{\sigma}\left[\Psi \sum_{j=1}^{u} s_j v_j \rho^{\frac{1-\sigma\varphi_j}{\varphi_j}} + s_n v_n \Psi_n r^{\frac{1-\sigma\varphi_n}{\varphi_n}}\right] \tag{171}$$

Capital market equilibrium in ROW (derived from (158), (162), (164) and (167)):

$$s_n k_n = \rho_n^{\sigma}\left[s_n v_n (1-\Psi_n)\, r^{\frac{1-\sigma\varphi_n}{\varphi_n}} + (1-\Psi)\sum_{j=1}^{u} s_j v_j \rho^{\frac{1-\sigma\varphi_j}{\varphi_j}}\right] \tag{172}$$

Auxiliary variables:

$$\eta_j \equiv \frac{1}{1-\alpha_j-\beta_j+\varepsilon_j\left(1-\beta_j\right)}, \qquad j = 1, 2, ..., n \tag{173}$$

$$\widehat{\varphi}_j \equiv \left(\frac{1-\varphi_j}{\varphi_j}\right) - 2\sigma, \qquad j = 1, 2, ..., n \tag{174}$$

Effect of a rise in ρ_u on excess supply of capital to the union (derived from (169), (170), (171) and (180)):

$$a_u^u \equiv \left(\frac{1}{\rho_u}\right)\sum_{j=1}^{u} s_j\left[\sigma + \eta_j(1-\alpha_j+\varepsilon_j)\right]k_j$$

$$+\rho_u^{2\sigma}\left[\Psi^2 \sum_{j=1}^{u} s_j v_j\left(\frac{1-\sigma\varphi_j}{\varphi_j}\right)\rho^{\widehat{\varphi}_j} + s_n v_n \Psi_n^2\left(\frac{1-\sigma\varphi_n}{\varphi_n}\right) r^{\widehat{\varphi}_n}\right] \tag{175}$$

Effect of a rise in ρ_n on excess supply of capital to the union (derived from (169), (170) and (171)):

$$a_n^u \equiv \rho_u^\sigma \rho_n^\sigma \left[\Psi \left(1-\Psi\right) \sum_{j=1}^{u} s_j v_j \left(\frac{1-\sigma\varphi_j}{\varphi_j} \right) \rho^{\widehat{\varphi}_j} + s_n v_n \Psi_n \left(1-\Psi_n\right) \left(\frac{1-\sigma\varphi_n}{\varphi_n} \right) r^{\widehat{\varphi}_n} \right] \quad (176)$$

Effect of a rise in ρ_n on excess supply of capital to ROW (derived from (169), (170), (172) and (195)):

$$a_n^n \equiv \left(\frac{s_n}{\rho_n} \right) \left[\sigma + \eta_n \left(1-\alpha_n+\varepsilon_n\right) \right] k_n$$

$$+\rho_n^{2\sigma} \left[\left(1-\Psi\right)^2 \sum_{j=1}^{u} s_j v_j \left(\frac{1-\sigma\varphi_j}{\varphi_j} \right) \rho^{\widehat{\varphi}_j} + s_n v_n \left(1-\Psi_n\right)^2 \left(\frac{1-\sigma\varphi_n}{\varphi_n} \right) r^{\widehat{\varphi}_n} \right] \quad (177)$$

Auxiliary variable (Jacobian of (171) and (172)):

$$\widehat{\Delta}^i \equiv a_u^u \cdot a_n^n - \left(a_n^u\right)^2 \quad (178)$$

Equations specific to union countries

Working hours in union (derived from (22.a)):

$$h_j = \left\{ \mu_{2j} e_j^{\alpha_j+\beta_j-1} Q_j^{\mu_{1j}} \left(\frac{\beta_j \left(1-\tau_j\right)}{\rho_u} \right)^{\beta_j} \left[\alpha_j \left(1-t_j\right)\right]^{1-\beta_j} \right\}^{\eta_j}, \qquad j=1,2,.....,u \quad (179)$$

Capital intensity in union (derived from (21.a) and (179)):

$$k_j = \left\{ \mu_{2j}^{1+\varepsilon_j} e_j^{\varepsilon_j \alpha_j} Q_j^{\mu_{1j}(1+\varepsilon_j)} \left[\frac{\beta_j \left(1-\tau_j\right)}{\rho_u} \right]^{1-\alpha_j+\varepsilon_j} \left[\alpha_j \left(1-t_j\right)\right]^{\alpha_j} \right\}^{\eta_j}, \quad j=1,..,u \quad (180)$$

Profits per worker in union (derived from (39.a), (179) and (180)):

$$\pi_j = \left(1 - \alpha_j - \beta_j\right) \times$$

$$\left\{\mu_{2j}^{1+\varepsilon_j} e_j^{\varepsilon_j \alpha_j} Q_j^{\mu_{1j}(1+\varepsilon_j)} \left[\frac{\beta_j (1-\tau_j)}{\rho_u}\right]^{\beta_j(1+\varepsilon_j)} \left[\alpha_j (1-t_j)\right]^{\alpha_j}\right\}^{\eta_j}, \quad j = 1, ..., u \tag{181}$$

Social welfare in union (derived from (55), (159) and (45.a)):

$$SW_j^u = \frac{\gamma_{2j}}{\gamma_{1j}} G_j^{\gamma_{1j}} - G_j - Q_j + \left(\frac{\tau_j}{1-\tau_j}\right) \rho_u k_j + v_j (1-\widehat{a}_j) \left[1 + \left(\frac{\varphi_j}{1+\varphi_j}\right) \rho^{\frac{\varphi_j}{1+\varphi_j}}\right]$$

$$\left[(1-\widehat{a}_j)\left(\frac{\varepsilon_j}{1+\varepsilon_j}\right) + \frac{t_j}{1-t_j}\right] e_j h_j^{1+\varepsilon_j} + \left[(1-\widehat{a}_j)(1-\delta_j)(1-\tau_j) + \tau_j\right] \pi_j$$

$$+ (1-\widehat{a}_j) \sum_{z=1,\ z\neq j}^{n} \left(\frac{s_z \delta_z}{1-s_z}\right)(1-\tau_z)\,\pi_z, \qquad j = 1, ..., u \tag{182}$$

Effect of ρ_u on social welfare in union ($\partial SW_j^u / \partial \rho_u$):

$$\Delta_j^{uu} = \left(\frac{1}{\rho_u}\right) \left\{ v_j (1-\widehat{a}_j) \Psi \rho_u^{\sigma+1} \rho^{\frac{1-\sigma\varphi_j}{\varphi_j}} - \eta_j \beta_j (1+\varepsilon_j) \left(\frac{\tau_j}{1-\tau_j}\right) \rho_u k_j \right.$$

$$-\eta_j \beta_j \left[\varepsilon_j (1-\widehat{a}_j) + (1+\varepsilon_j)\left(\frac{t_j}{1-t_j}\right)\right] e_j h_j^{1+\varepsilon_j}$$

$$-\eta_j \beta_j (1+\varepsilon_j) \left[(1-\widehat{a}_j)(1-\delta_j)(1-\tau_j) + \tau_j\right] \pi_j$$

$$\left. - (1-\widehat{a}_j) \sum_{z=1,\ z\neq j}^{u} \left(\frac{s_z \delta_z}{1-s_z}\right) \eta_z \beta_z (1+\varepsilon_z)(1-\tau_z)\,\pi_z \right\}, \qquad j = 1, ..., u \tag{183}$$

Effect of ρ_n on social welfare in union ($\partial SW_j^u/\partial\rho_n$):

$$\widehat{\Delta}_j^{un} = \left(\frac{1-\widehat{a}_j}{\rho_n}\right)\left\{v_j\left(1-\Psi\right)\rho_n^{\sigma+1}\rho^{\frac{1-\sigma\varphi_j}{\varphi_j}}\right.$$

$$\left.-\left(\frac{s_n\delta_n}{1-s_n}\right)\eta_n\beta_n\left(1+\varepsilon_n\right)\left(1-\tau_n\right)\pi_n\right\}, \qquad j=1,.....,u \tag{184}$$

Effect of τ_j on ρ_u ($\partial\rho_u/\partial\tau_j$):

$$V_{\tau j}^{uu} = -\frac{a_n^n s_j\eta_j\left(1-\alpha_j+\varepsilon_j\right)k_j}{\left(1-\tau_j\right)\widehat{\Delta}^i}, \qquad j=1,.....,u \tag{185}$$

Effect of τ_j on ρ_n ($\partial\rho_n/\partial\tau_j$):

$$V_{\tau j}^{un} = \frac{a_n^u s_j\eta_j\left(1-\alpha_j+\varepsilon_j\right)k_j}{\left(1-\tau_j\right)\widehat{\Delta}^i}, \qquad j=1,.....,u \tag{186}$$

Effect of t_j on ρ_u ($\partial\rho_u/\partial t_j$):

$$V_{tj}^{uu} = -\frac{a_n^n s_j\eta_j\alpha_j k_j}{\left(1-t_j\right)\widehat{\Delta}^i}, \qquad j=1,.....,u \tag{187}$$

Effect of t_j on ρ_n ($\partial\rho_n/\partial t_j$):

$$V_{tj}^{un} = \frac{a_n^u s_j\eta_j\alpha_j k_j}{\left(1-t_j\right)\widehat{\Delta}^i}, \qquad j=1,.....,u \tag{188}$$

Effect of Q_j on ρ_u ($\partial\rho_u/\partial Q_j$):

$$V_{Qj}^{uu} = \frac{a_n^n s_j\mu_{1j}\eta_j\left(1+\varepsilon_j\right)k_j}{Q_j\widehat{\Delta}^i}, \qquad j=1,.....,u \tag{189}$$

Effect of Q_j on ρ_n ($\partial\rho_n/\partial Q_j$):

$$V_{Qj}^{un} = -\frac{a_n^u s_j\mu_{1j}\eta_j\left(1+\varepsilon_j\right)k_j}{Q_j\widehat{\Delta}^i}, \qquad j=1,.....,u \tag{190}$$

Policy rule for τ_j $(\partial SW_j^u/\partial \tau_j = 0)$*:*

$$\left(\frac{\rho_u}{1-\tau_j}\right)\left[1-\tau_j\eta_j\left(1-\alpha_j+\varepsilon_j\right)\right]k_j-\eta_j\beta_j\left[\varepsilon_j\left(1-\widehat{a}_j\right)+\left(1+\varepsilon_j\right)\left(\frac{t_j}{1-t_j}\right)\right]e_jh_j^{1+\varepsilon_j}$$

$$+\left[1-\left(1-\widehat{a}_j\right)\left(1-\delta_j\right)\right]\left(1-\tau_j\right)\pi_j-\eta_j\beta_j\left(1+\varepsilon_j\right)\left[\left(1-\widehat{a}_j\right)\left(1-\delta_j\right)\left(1-\tau_j\right)+\tau_j\right]\pi_j$$

$$+\left(1-\tau_j\right)\left(V_{\tau j}^{uu}\Delta_j^{uu}+V_{\tau j}^{un}\widehat{\Delta}_j^{un}\right)=0, \qquad j=1,.....,u \tag{191}$$

Policy rule for t_j $(\partial SW_j^u/\partial t_j = 0)$*:*

$$\frac{e_jh_j^{1+\varepsilon_j}}{1-t_j}-\eta_j\left(1-\beta_j\right)\left[\varepsilon_j\left(1-\widehat{a}_j\right)+\left(1+\varepsilon_j\right)\left(\frac{t_j}{1-t_j}\right)\right]e_jh_j^{1+\varepsilon_j}$$

$$-\left(\frac{\tau_j}{1-\tau_j}\right)\eta_j\alpha_j\rho_uk_j-\eta_j\alpha_j\left[\left(1-\widehat{a}_j\right)\left(1-\delta_j\right)\left(1-\tau_j\right)+\tau_j\right]\pi_j$$

$$+\left(1-t_j\right)\left(V_{tj}^{uu}\Delta_j^{uu}+V_{tj}^{un}\widehat{\Delta}_j^{un}\right)=0, \qquad j=1,.....,u \tag{192}$$

Policy rule for Q_j $(\partial SW_j^u/\partial Q_j = 0)$*:*

$$Q_j=\mu_{1j}\eta_j\left[\varepsilon_j\left(1-\widehat{a}_j\right)+\left(1+\varepsilon_j\right)\left(\frac{t_j}{1-t_j}\right)\right]e_jh_j^{1+\varepsilon_j}+\mu_{1j}\eta_j\left(1+\varepsilon_j\right)\left(\frac{\tau_j\rho_uk_j}{1-\tau_j}\right)$$

$$+\mu_{1j}\eta_j\left(1+\varepsilon_j\right)\left[\left(1-\widehat{a}_j\right)\left(1-\delta_j\right)\left(1-\tau_j\right)+\tau_j\right]\pi_j$$

$$+Q_j\left(V_{Qj}^{uu}\Delta_j^{uu}+V_{Qj}^{un}\widehat{\Delta}_j^{un}\right), \qquad j=1,.....,u \tag{193}$$

Equations specific to non-union country

Working hours in ROW (derived from (22.a)):

$$h_n = \left\{ \mu_{2n} e_n^{\alpha_n + \beta_n - 1} Q_n^{\mu_{1n}} \left(\frac{\beta_n (1 - \tau_n)}{\rho_n} \right)^{\beta_n} [\alpha_n (1 - t_n)]^{1 - \beta_n} \right\}^{\eta_n} \tag{194}$$

Capital intensity in ROW (derived from (21.a) and (194)):

$$k_n = \left\{ \mu_{2n}^{1+\varepsilon_n} e_n^{\varepsilon_n \alpha_n} Q_n^{\mu_{1n}(1+\varepsilon_n)} \left[\frac{\beta_n (1 - \tau_n)}{\rho_n} \right]^{1 - \alpha_n + \varepsilon_n} [\alpha_n (1 - t_n)]^{\alpha_n} \right\}^{\eta_n} \tag{195}$$

Profits per worker in ROW (derived from (39.a), (194) and (195)):

$$\pi_n = (1 - \alpha_n - \beta_n) \times$$

$$\left\{ \mu_{2n}^{1+\varepsilon_n} e_n^{\varepsilon_n \alpha_n} Q_n^{\mu_{1n}(1+\varepsilon_n)} \left[\frac{\beta_n (1 - \tau_n)}{\rho_n} \right]^{\beta_n (1 + \varepsilon_n)} [\alpha_n (1 - t_n)]^{\alpha_n} \right\}^{\eta_n} \tag{196}$$

Social welfare in ROW (derived from (55), (159) and (45.a)):

$$SW_n = \frac{\gamma_{2n}}{\gamma_{1n}} G_n^{\gamma_{1n}} - G_n - Q_n + \frac{\tau_n \rho_n k_n}{1 - \tau_n} + \upsilon_n (1 - \widehat{a}_n) \left[1 + \frac{\varphi_n r^{\frac{\varphi_n}{1+\varphi_n}}}{1 + \varphi_n} \right]$$

$$\left[(1 - \widehat{a}_n) \left(\frac{\varepsilon_n}{1 + \varepsilon_n} \right) + \frac{t_n}{1 - t_n} \right] e_n h_n^{1+\varepsilon_n} + [(1 - \widehat{a}_n)(1 - \delta_n)(1 - \tau_n) + \tau_n] \pi_n$$

$$+ (1 - \widehat{a}_n) \sum_{j=1}^{u} \left(\frac{s_j \delta_j}{1 - s_j} \right) (1 - \tau_j) \pi_j \tag{197}$$

Effect of ρ_u on social welfare in ROW ($\partial SW_n / \partial \rho_u$):

$$\Delta^{nu} = \left(\frac{1 - \widehat{a}_n}{\rho_u} \right) \left\{ \upsilon_n \Psi_n \rho_u^{\sigma+1} r^{\frac{1 - \sigma \varphi_n}{\varphi_n}} \right.$$

$$\left. - \sum_{j=1}^{u} \left(\frac{s_j \delta_j}{1 - s_j} \right) \eta_j \beta_j (1 + \varepsilon_j)(1 - \tau_j) \pi_j \right\} \tag{198}$$

Effect of ρ_n on social welfare in ROW ($\partial SW_n/\partial \rho_n$):

$$\widehat{\Delta}^{nn} = \left(\frac{1}{\rho_n}\right)\left\{v_n\left(1-\widehat{a}_n\right)\left(1-\Psi_n\right)\rho_n^{\sigma+1}r^{\frac{1-\sigma\varphi_n}{\varphi_n}} - \eta_n\beta_n\left(1+\varepsilon_n\right)\left(\frac{\tau_n\rho_n k_n}{1-\tau_n}\right)\right.$$

$$-\eta_n\beta_n\left[\varepsilon_n\left(1-\widehat{a}_n\right)+\left(1+\varepsilon_n\right)\left(\frac{t_n}{1-t_n}\right)\right]e_n h_n^{1+\varepsilon_n}$$

$$\left.-\eta_n\beta_n\left(1+\varepsilon_n\right)\left[\left(1-\widehat{a}_n\right)\left(1-\delta_n\right)\left(1-\tau_n\right)+\tau_n\right]\pi_n\right\} \tag{199}$$

Effect of τ_n on ρ_u ($\partial\rho_u/\partial\tau_n$):

$$V_{\tau}^{nu} = \frac{a_n^u s_n\eta_n\left(1-\alpha_n+\varepsilon_n\right)k_n}{\left(1-\tau_n\right)\widehat{\Delta}^i} \tag{200}$$

Effect of τ_n on ρ_n ($\partial\rho_n/\partial\tau_n$):

$$V_{\tau}^{nn} = -\frac{a_u^u s_n\eta_n\left(1-\alpha_n+\varepsilon_n\right)k_n}{\left(1-\tau_n\right)\widehat{\Delta}^i} \tag{201}$$

Effect of t_n on ρ_u ($\partial\rho_u/\partial t_n$):

$$V_{t}^{nu} = \frac{a_n^u s_n\eta_n\alpha_n k_n}{\left(1-t_n\right)\widehat{\Delta}^i} \tag{202}$$

Effect of t_n on ρ_n ($\partial\rho_n/\partial t_n$):

$$V_{t}^{nn} = -\frac{a_u^u s_n\eta_n\alpha_n k_n}{\left(1-t_n\right)\widehat{\Delta}^i} \tag{203}$$

Effect of Q_n on ρ_u ($\partial\rho_u/\partial Q_n$):

$$V_{Q}^{nu} = -\frac{a_n^u s_n\mu_{1n}\eta_n\left(1+\varepsilon_n\right)k_n}{Q_n\widehat{\Delta}^i} \tag{204}$$

Effect of Q_n on ρ_n ($\partial\rho_n/\partial Q_n$):

$$V_{Q}^{nn} = \frac{a_u^u s_n\mu_{1n}\eta_n\left(1+\varepsilon_n\right)k_n}{Q_n\widehat{\Delta}^i} \tag{205}$$

Policy rule for τ_n ($\partial SW_n/\partial\tau_n = 0$):

$$\left(\frac{\rho_n k_n}{1-\tau_n}\right)\left[1-\tau_n\eta_n\left(1-\alpha_n+\varepsilon_n\right)\right]-\eta_n\beta_n\left[\varepsilon_n\left(1-\widehat{a}_n\right)+\left(1+\varepsilon_n\right)\left(\frac{t_n}{1-t_n}\right)\right]e_n h_n^{1+\varepsilon_n}$$

$$+\left[1-\left(1-\widehat{a}_n\right)\left(1-\delta_n\right)\right]\left(1-\tau_n\right)\pi_n-\eta_n\beta_n\left(1+\varepsilon_n\right)\left[\left(1-\widehat{a}_n\right)\left(1-\delta_n\right)\left(1-\tau_n\right)+\tau_n\right]\pi_n$$

$$+\left(1-\tau_n\right)\left(V_\tau^{nu}\Delta^{nu}+V_\tau^{nn}\widehat{\Delta}^{nn}\right)=0 \tag{206}$$

Policy rule for t_n ($\partial SW_n/\partial t_n = 0$):

$$\frac{e_n h_n^{1+\varepsilon_n}}{1-t_n}-\eta_n\left(1-\beta_n\right)\left[\varepsilon_n\left(1-\widehat{a}_n\right)+\left(1+\varepsilon_n\right)\left(\frac{t_n}{1-t_n}\right)\right]e_n h_n^{1+\varepsilon_n}$$

$$-\left(\frac{\tau_n}{1-\tau_n}\right)\eta_n\alpha_n\rho_n k_n-\eta_n\alpha_n\left[\left(1-\widehat{a}_n\right)\left(1-\delta_n\right)\left(1-\tau_n\right)+\tau_n\right]\pi_n$$

$$+\left(1-t_n\right)\left(V_t^{nu}\Delta^{nu}+V_t^{nn}\widehat{\Delta}^{nn}\right)=0 \tag{207}$$

Policy rule for Q_n ($\partial SW_n/\partial Q_n = 0$):

$$Q_n=\mu_{1n}\eta_n\left[\varepsilon_n\left(1-\widehat{a}_n\right)+\left(1+\varepsilon_n\right)\left(\frac{t_n}{1-t_n}\right)\right]e_n h_n^{1+\varepsilon_n}+\mu_{1n}\eta_n\left(1+\varepsilon_n\right)\left(\frac{\tau_n}{1-\tau_n}\right)\rho_n k_n$$

$$+\mu_{1n}\eta_n\left(1+\varepsilon_n\right)\left[\left(1-\widehat{a}_n\right)\left(1-\delta_n\right)\left(1-\tau_n\right)+\tau_n\right]\pi_n$$

$$+Q_n\left(V_Q^{nu}\Delta^{nu}+V_Q^{nn}\widehat{\Delta}^{nn}\right) \tag{208}$$

21. A global minimum capital income tax rate: the case of imperfect capital mobility

In this section we describe how the model with imperfect capital mobility summarized in the previous section would need to be modified if all countries in the world agreed to adhere to a binding minimum source-based capital income tax. In that case all countries would obviously have the same capital income tax rate, so $\tau_j = \tau$ for $j = 1, ..., n$. Like before, we assume that the common capital income tax rate τ would be chosen so as to maximize the population-weighted welfare of individual countries. The first-order condition for the maximization of global welfare with respect to the common capital income tax would then be

$$\sum_{j=1}^{u} s_j \left(\frac{\partial SW_j^u}{\partial \tau} \right) + s_n \left(\frac{\partial SW_n}{\partial \tau} \right) = 0 \tag{209}$$

The social welfare levels SW_j^u and SW_n are still given by (182) and (197), with τ_j and τ_n replaced by τ. From these expressions one finds that

$$\frac{\partial SW_j^u}{\partial \tau} = \left(\frac{\rho_u k_j}{1-\tau} \right) \left[1 - \tau \eta_j \left(1 - \alpha_j + \varepsilon_j \right) \right]$$

$$-\eta_j \beta_j \left[\varepsilon_j \left(1 - \widehat{a}_j \right) + \left(1 + \varepsilon_j \right) \left(\frac{t_j}{1-t_j} \right) \right] e_j h_j^{1+\varepsilon_j} + \left[1 - \left(1 - \widehat{a}_j \right) \left(1 - \delta_j \right) \right] \left(1 - \tau \right) \pi_j$$

$$-\eta_j \beta_j \left(1 + \varepsilon_j \right) \left[\left(1 - \widehat{a}_j \right) \left(1 - \delta_j \right) \left(1 - \tau \right) + \tau \right] \pi_j$$

$$- \left(1 - \widehat{a}_j \right) \left(1 - \tau \right) \sum_{z=1;\ z \neq j}^{n} \left(\frac{s_z \delta_z}{1 - s_z} \right) \eta_z \left(1 - \alpha_z + \varepsilon_z \right) \pi_z$$

$$+ \left(1 - \tau \right) \left(V_\tau^u \Delta_j^{uu} + V_\tau^n \widehat{\Delta}_j^{un} \right), \qquad j = 1, ..., u \tag{210}$$

$$\frac{\partial SW_n}{\partial \tau} = \left(\frac{\rho_n k_n}{1-\tau} \right) \left[1 - \tau \eta_n \left(1 - \alpha_n + \varepsilon_n \right) \right]$$

$$-\eta_n \beta_n \left[\varepsilon_n \left(1 - \widehat{a}_n \right) + \left(1 + \varepsilon_n \right) \left(\frac{t_n}{1-t_n} \right) \right] e_n h_n^{1+\varepsilon_n}$$

$$+\left[1-\left(1-\widehat{a}_n\right)\left(1-\delta_n\right)\right]\left(1-\tau\right)\pi_n-\eta_n\beta_n\left(1+\varepsilon_n\right)\left[\left(1-\widehat{a}_n\right)\left(1-\delta_n\right)\left(1-\tau\right)+\tau\right]\pi_n$$

$$-\left(1-\widehat{a}_n\right)\left(1-\tau\right)\sum_{j=1}^{u}\left(\frac{s_j\delta_j}{1-s_j}\right)\eta_j\left(1-\alpha_j+\varepsilon_j\right)\pi_j+\left(1-\tau\right)\left(V_\tau^u\Delta^{nu}+V_\tau^n\widehat{\Delta}^{nn}\right) \quad (211)$$

where the marginal effects of τ on ρ_u and ρ_n are given by the following expressions:

Effect of τ on ρ_u $(\partial\rho_u/\partial\tau)$:

$$V_\tau^u=\sum_{j=1}^{u}V_{\tau j}^{uu}+V_\tau^{nu} \quad (212)$$

Effect of τ on ρ_n $(\partial\rho_n/\partial\tau)$:

$$V_\tau^n=\sum_{j=1}^{u}V_{\tau j}^{un}+V_\tau^{nn} \quad (213)$$

The complete model with a global minimum capital income tax rate may now be obtained from the model in the previous section by setting $\tau_j=\tau_n=\tau$, and by replacing equations (191) and (206) by equations (209) through (213).

22. A regional minimum capital income tax rate in a world with imperfect capital mobility

Suppose next that tax coordination only involves the u "union" countries whereas tax competition still prevails between the union and the rest of the world (country n). The union countries choose a common binding minimum source-based capital income tax

$$\tau_j=\tau_u, \qquad j=1,......,u$$

with the purpose of maximizing the population-weighted average social welfare for the union as a whole, implying the first-order condition

$$\sum_{j=1}^{u} s_j \left(\frac{\partial SW_j^u}{\partial \tau_u} \right) = 0$$

Using (182), we find this first-order condition to be equivalent to

$$\sum_{j=1}^{u} s_j \left\{ \left(\frac{\rho_u k_j}{1-\tau_u} \right) \left[1 - \tau_u \eta_j \left(1 - \alpha_j + \varepsilon_j \right) \right] \right.$$

$$-\eta_j \beta_j \left[\varepsilon_j \left(1 - \widehat{a}_j \right) + \left(1 + \varepsilon_j \right) \left(\frac{t_j}{1-t_j} \right) \right] e_j h_j^{1+\varepsilon_j} + \left[1 - \left(1 - \widehat{a}_j \right) \left(1 - \delta_j \right) \right] \left(1 - \tau_u \right) \pi_j$$

$$-\eta_j \beta_j \left(1 + \varepsilon_j \right) \left[\left(1 - \widehat{a}_j \right) \left(1 - \delta_j \right) \left(1 - \tau_u \right) + \tau_u \right] \pi_j$$

$$- \left(1 - \widehat{a}_j \right) \left(1 - \tau_u \right) \sum_{z=1;\ z \neq j}^{u} \left(\frac{s_z \delta_z}{1 - s_z} \right) \eta_z \left(1 - \alpha_z + \varepsilon_z \right) \pi_z$$

$$\left. + \left(1 - \tau_u \right) \left(V_{\tau u}^{uu} \Delta_j^{uu} + V_{\tau u}^{un} \widehat{\Delta}_j^{un} \right) \right\} = 0 \tag{214}$$

where the marginal effects of τ_u on ρ_u and ρ_n are given by (215) and (216), respectively:

$$V_{\tau u}^{uu} = -\frac{a_n^n \sum_{j=1}^{u} s_j \eta_j \left(1 - \alpha_j + \varepsilon_j \right) k_j}{\left(1 - \tau_u \right) \widehat{\Delta}^i} \tag{215}$$

$$V_{\tau u}^{un} = \frac{a_n^u \sum_{j=1}^{u} s_j \eta_j \left(1 - \alpha_j + \varepsilon_j \right) k_j}{\left(1 - \tau_u \right) \widehat{\Delta}^i} \tag{216}$$

The complete model with a regional minimum capital income tax is obtained from the model of section 20 by setting $\tau_j = \tau_u$ for $j = 1, ..., u$, by substituting equations (215) and (216) for (185) and (186), respectively, and by replacing (191) by (214).