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**Redistribution, Wealth Tax Competition
and Capital Flight in Growing Economies**

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Redistribution, Wealth Tax Competition and Capital Flight in Growing Economies *

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Abstract

This paper considers the trade-off between growth and redistribution policies in a two-country world with endogenous growth, tax competition, perfect capital mobility and extreme investment behaviour, two classes in each country and governments having opposing political preferences. It is shown that higher or lower growth when governments redistribute depends on their opponents when setting taxes. We find that the growth redistribution trade-off problem hinges on technological efficiency. If countries are equally efficient, no redistribution takes place, not even by two left-wing governments, for fear of capital flight. We show that redistribution is possible with a high growth rate as long as an efficiency gap can be maintained. This leads to capital flight for the inefficient country.

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1   Introduction

This paper considers the trade-off between growth and redistribution policies in a two-country world with tax competition and perfect capital mobility. It extends the results of Rehme (1994b) by introducing the possibility of countries experiencing capital flight.

In many policy discussions that address the issue of growth vs. redistribution, setting higher taxes for redistributive purposes is deemed to slow growth. Yet most developed and some developing countries redistribute a significant share of their GNP. Does this always lead to lower growth? In the model developed in this paper it is argued that the experience of lower or higher growth when governments opt for redistribution depends on who their opponents are when setting taxes. In particular, it is shown that the growth redistribution trade-off problem depends on technological parameters, especially technological efficiency. Thus, the paper presents a model that reflects some aspects of current policy debates, which identify on the one hand redistribution and high growth with securing high technological efficiency or international competitiveness and the possibility of experiencing drastic capital outflows as has been the case in some LDC countries in the 80's on the other.

The model framework follows Barro and Sala–i–Martin (1990) who study the impact of government spending on the private return on capital in growing economies using an endogenous growth set-up. Their results suggest that the government has room to stabilize the private return on capital and through this the growth rate. Recently, there have been some contributions that investigate the *trade-off between growth and redistribution* using endogenous growth models.

Alesina and Rodrik (1991) have analyzed how a benevolent government in a Closed Economy with *wealth taxes* might solve this problem. They show that a government that cares about the non-accumulated factor of production (e.g. labour) experiences slower growth if it redistributes. capital (wealth) or capital income taxation leads to slower growth if a government redistributes to the non-accumulated factor, e.g. labour. This vein of research would suggest that the room for redistri-

bution in terms of growth is very limited for governments that wish to or are compelled to pursue redistributive policies.

The present paper extends the growth redistribution trade-off problem as formulated in Alesina and Rodrik (1991), (1994) to a two-country world. Capital is assumed perfectly mobile across countries. Governments in each country are assumed to be of two types. They can be either 'right-wing' and only care about the owners of the accumulated factor of production, i.e. capital, or they can be 'left-wing' caring about the welfare of the owners of the non-accumulated factor of production, i.e. labour. Thus, each country is assumed to consist of two classes, namely 'Capitalists' and 'Workers'. To formulate the model in these terms serves to keep matters simple and allows one to concentrate on the problem of growth and redistribution. The Capitalists make the decision where to invest. It is shown that this decision optimally depends on the after-tax returns in the various countries in an extreme way. The investors immediately shift their entire capital to the country where the return to their investment is higher. This simple framework allows one to analyze the effect of capital flight on growth and redistribution.

In order to fix ideas and in line with most of the literature on capital taxation we will abstract from taxation of the non-accumulated factor of production (labour). This facilitates the analysis and permits focusing on the problems associated with taxing capital.

The governments in each country (domestic and foreign) have to solve the trade-off problem by determining taxes and redistribution non-cooperatively.[1]

For open economies the following tax principle for e.g. capital income taxation as tax rules are common:[2]

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[1] For a model that studies the related problem of solving the trade-off between the provision of government consumption goods and growth in a Barro (1990) world see Devereux and Mansoorian (1992).

[2] Razin and Yuen (1992) use an endogenous growth set-up in order to show that the *residence principle* is Ramsey efficient. This result seems to suffer from a time inconsistency problem since distortionary capital or wage taxation may produce time inconsistent solutions. [Cf. Fischer (1980), Chamley (1985).] Capital taxation in

Under the *'Residence Principle'* residents are taxed uniformly on their worldwide income regardless of the source of income (domestic or foreign), while non-residents are not taxed on income originating in the country.

Under the *'Source Principle'* all types of income originating in a country are taxed uniformly, regardless of the place of residence of the income recipients.

It is shown that capital is good for left and right-wing countries. Thus, if a country loses capital it will suffer in terms of utility or some other objective criterion.

If a country is exposed to the danger of capital flight, the *source principle* appears more suited as a tax principle, since the governments in a non-cooperative environment cannot perfectly monitor their residents' income or wealth. Therefore, in this paper a variant of the *source principle* is adopted, since we will allow for non-uniform tax rates.

First, it is assumed that taxes are levied on *wealth*, that is, *capital instead of capital income*[3]. Governments of otherwise identical economies compete for capital by setting tax rates and a redistribution parameter.[4] Given the capital the governments would like to pursue their preferred growth and distribution policies.

For countries that are technologically similar, i.e. are equally efficient it is shown that in the *Nash Equilibrium* of the *tax competition*

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economies with high capital mobility has received quite some attention recently in e.g. Chamley (1992), Canzonieri (1989), Roubini and Sala–i–Martin (1992), Gosh (1991) and Devereux and Shi (1991).

[3]The choice of tax base is not at all innocuous. As has been pointed out by Bertola (1991), (1993) and Alesina and Rodrik (1994) indirect taxation may lead to very different results as regards the growth redistribution trade-off. Capital income taxation cum equal investment tax subsidy e.g. is equivalent to a tax on consumption. This tax policy may then guarantee higher growth for left-wing governments than right-wing ones as is shown in Rehme (1994a).

[4]Competition for capital has recently been studied by e.g. Sinn (1993).

game there is optimally no room for redistribution, *even for two egalitarian governments.* Thus, the model would predict that even left-wing governments who face an equally efficient opponent will not redistribute.

The intuition behind this result is the following: Suppose given the same capital stock or the same investment quota in a right and a left-wing country the left-wing country derives higher utility from being able to redistribute. For redistribution the left-wing government has to set higher taxes in this model. Higher taxes in turn imply lower investment given the same gross return to capital. This induces capital flight. The resulting decrease in utility is so high that a left-wing government is better off if it does not redistribute. Compensation is given by stopping the capital outflow and securing higher wages, which in an endogenous growth model increase with growing capital. Since the probability of finding two identically equally efficient countries is very small this result provides a benchmark for the following case.

If countries differ in terms of technological *efficiency* it is shown that in the *Nash Equilibrium* the efficient country is always able to guarantee a higher after-tax return on capital. Thus, an efficient country will always find more capital invested in its economy than an inefficient one. This result seems to correspond to empirical observation. The question is whether the efficient country chooses a wealth tax profile that allows for some redistribution. The answer is yes. An efficient left-wing government is able to undertake some redistribution. The amount of redistribution is limited by the tax choices of its opponent and its efficiency advantage. With the extreme behaviour of the worldwide investors the inefficient country will then experience capital flight.

From this one may conclude that redistribution may go together with a higher growth rate than that of one's opponent as long as the efficiency gap can be maintained. Interestingly and in contrast to Rehme (1994b) it is argued that a redistributing government of an efficient economy is better off when capital is perfectly mobile.

The paper is organized as follows: Section 2 presents the model set-up, derives the equilibrium in a Closed Economy and briefly presents

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the optimal policy choices as have been put forth in Alesina and Rodrik (1991). Section 3 formulates a dynamic game where the governments with opposing political objectives compete for capital by setting wealth tax rates. In two propositions the main results of this paper are stated. Section 4 concludes. Proofs of the propositions made in Section 3 can be found in the Appendix.

2   The Model

Consider a Two-Country World with a "domestic" and a "foreign" country. Let us denote variables in the foreign country by a (*). There are two kinds of many identical individuals in each country, those who own capital and no labour and those who own labour, but no capital. Let us call the latter Workers and the former Capitalists. Workers and Capitalists are assumed to have the following simple logarithmic utility functions[5]:

$$U(C_t^i) = \ln C_t^i, \quad i = W, k \quad .\tag{1}$$

Hence, both agents derive utility from the consumption of a homogeneous, malleable good that is produced in the two countries. This assumes that foreign and domestic output, Y_t and Y_t^* are perfect substitutes in consumption.

Those who own capital, own shares of two representative firms. A firm is assumed a production unit only. It takes the following important form:

$$Y_t = A K_t^\alpha G_t^{1-\alpha} L_t^{1-\alpha}, \quad \text{where} \quad 0 < \alpha < 1 \quad \text{and}\tag{2}$$

$$K_t = \omega_t k_t + (1 - \omega_t^*)k_t^*\tag{3}$$

where Y_t is output produced in the home country, K_t the overall domestically installed real capital stock, k_t (k_t^*) is the real capital stock owned by

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[5]This specification is adopted for analytical convenience. The model can be extended to more general classes of utility functions without altering the results.

domestic (foreign) Capitalists, G_t are public inputs to production and A is an efficiency parameter, which is assumed constant over time. We will set $L_t = 1$, so that labour is supplied inelastically over time. Throughout the analysis we will abstract from problems arising from depreciation.

Unless stated otherwise it is assumed that $A = A^*$ so that both countries are equally efficient. I will call these economies *similar*. If this does not hold, I will refer to the countries as being *different*. The variable $\omega_t \in [0,1]$ where $\omega \in \mathbb{R}^1$ denotes the fraction of real capital at date t owned by domestic Capitalists invested in the home country. The fraction $1 - \omega_t$ is invested abroad by the domestic Capitalists. Similar reasoning applies to the foreign Capitalists.[6]

Note that we assume that foreign and domestic capital are substitutes. This abstracts from the possibility that e.g. foreign capital may be a necessary input for domestic production. As it is the aim of this paper to model competition for capital, assuming complementarity would only exacerbate the competition, but would not change the results of this paper in any fundamental way.

From now on the subscript t will be dropped whenever it is clear that the variables in question and the ones derived from them depend on time.

This form of a production function has been introduced by Barro (1990). We may note that in the absence of a government a Closed Economy breaks down and the Workers and the Capitalists starve.

2.1 The Public Sector

The governments in both countries choose to tax wealth. Let t_1 be the tax rate on real capital (wealth) which is held domestically by domestic investors. Thus, t_1 is levied on ωk. The government also taxes real

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[6]Note that this formulation allows for the case that all of the domestically owned capital is invested abroad. This serves to bring out the effect of capital flight more clearly. Alternatively we could have assumed that $\omega \in [q,1]$ where q is a - possibly - small number. The results of the paper would not change in any significant way.

foreign capital invested in the home country, i.e. $(1 - \omega^*)k^*$. Denote the tax rate on this by t_2. Analogous definitions hold for the foreign country. This way of taxing wealth means that the countries adopt a variant of the *Source Principle* as a tax rule.

The *Source Principle* implies that all types of wealth present in a country are taxed *uniformly*, regardless of the place of residence of the owners of wealth.

If capital is internationally mobile it makes sense to adopt this principle since governments in a non-cooperative environment cannot perfectly monitor their residents' wealth. At this stage we still allow for non-uniform tax rates which the principle rules out in order to concentrate on the instruments that are at the governments' disposal.

Let us define τ as the average tax rate levied on the overall installed capital stock in the economy. Given the Barro-type production function we can then define the following government budget constraint, which is assumed to be balanced at each point in time:

$$\tau K = \dot{G} + \lambda \tau K \ . \tag{4}$$

The LHS depicts the tax revenues and the RHS public expenditures. The Workers receive $\lambda \tau k$ as transfers and G is spent on public inputs to production.[7]

Rearranging and taking into account that the domestic government may have two sources of tax revenues we contemplate the following budget constraint:

$$G = (1 - \lambda)[t_1 \omega k + t_2(1 - \omega^*)k^*] \equiv (1 - \lambda)\tau K \ . \tag{5}$$

Underlying this is our earlier definition of the average tax rate τ. Using (5) and (3) the average tax rate then amounts to the following

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[7]Note that $\tau(1 - \lambda) = G/K$ so that $\tau = \tau(K(k, k^*))$. Also, Y is homogeneous of degree 1 in k and k^* so that τ is homogeneous of degree 0 in k and k^*. Thus if K increases by some factor ϕ, τ will remain constant so that r will remain constant as well.

expression:

$$\tau = \frac{t_1 \omega k + t_2(1 - \omega^*)k^*}{\omega k + (1 - \omega^*)k^*} \ . \tag{6}$$

Thus, the average tax rate depends on six variables, namely t_1, t_2, ω, ω^*, k and k^*. The only variables under the direct discretion of the government in the determination of τ are t_1 and t_2. We may note that τ is set by the government independently of other factors in the economy if it chooses $t_1 = t_2 = \tau$ which corresponds to the uniform taxation of wealth as required by the *Source Principle*.

2.2   Property Structure and Firms

There are many identical firms in each country which operate in a perfectly competitive environment. A representative firm is assumed to be a profit maximizer. The firms are owned by domestic and foreign capital owners. Foreign and domestic Capitalists rent capital to and demand shares of the representative domestic firm. The same holds for the foreign firm. The domestic Capitalists' assets are their shares of the two representative firms. The shares of the two firms are collateralized one-to-one by physical capital. The markets for assets and physical capital are assumed to clear at each point in time so that the representative domestic firm faces a path of a uniform, market clearing rental rate, $\{r_t\}$, of domestically installable capital, K.

Given perfect competition the firms in the domestic economy rent capital and hire labour in spot market in each period in their country. We assume that foreign and domestic output are perfect substitutes and set the price of Y and Y^* equal to 1. Given constant returns to capital and labour, factor payments exhaust output. Profit maximization then entails that firms pay each factor of production its marginal product

$$r = \partial Y / \partial K = \alpha A[(1 - \lambda)\tau]^{1-\alpha}, \tag{7}$$

$$w = \partial Y / \partial K \equiv \eta(\tau, \lambda)K = (1 - \alpha)A[(1 - \lambda)\tau]^{1-\alpha}K, \quad L = 1 \ . \tag{8}$$

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Note that (7) implies that there is an intra-country arbitrage at work which makes the return on foreign and domestic capital installed in each firm equal in the domestic country. The same, of course, applies to the foreign country.

We see that the average tax rate has a bearing on the marginal product of capital which is set equal to the rental rate of capital, i.e. the rate of return for the Capitalists, by the firms if the capital market is in equilibrium.

We may now consider how the rate of return and wages are affected by changes in government parameters and capital composition.

Let us use the definitions given in (3), (5), and (6), and assume $0 < \omega \leq 1$, $0 \leq \omega^* < 1$ and *fixed* for the home country. Then

$$\frac{\partial r}{\partial t_1} = \alpha(1-\alpha)A[(1-\lambda)\tau]^{-\alpha}(1-\lambda)\frac{\omega k}{K} > 0 , \qquad (9a)$$

$$\frac{\partial r}{\partial t_2} = \alpha(1-\alpha)A[(1-\lambda)\tau]^{-\alpha}(1-\lambda)\frac{(1-\omega^*)k^*}{K} > 0 , \qquad (9b)$$

$$\frac{\partial r}{\partial \lambda} = \alpha(1-\alpha)A[(1-\lambda)\tau]^{-\alpha}(-\tau) < 0 . \qquad (9c)$$

So redistribution has a negative effect on the interest rate and increases in the tax rates raise the rate of return.

Defining $\Delta \equiv \alpha(1-\alpha)A[\cdot]^{-\alpha}(1-\lambda)$ we get a rather more ambiguous picture for capital flows

$$\frac{\partial r}{\partial k} = \Delta \left[\frac{(t_1 - t_2)\omega(1-\omega^*)k^*}{K^2} \right] \gtreqless 0 \quad \text{if} \quad t_1 \gtreqless t_2. \qquad (10)$$

Thus the effect of more domestic capital on the interest rate depends on government parameters. Equivalently, for k^* we get

$$\frac{\partial r}{\partial k^*} = \Delta \left[\frac{(t_2 - t_1)\omega(1-\omega^*)k}{K^2} \right] \gtreqless 0 \quad \text{if} \quad t_2 \gtreqless t_1. \qquad (11)$$

The equations (10) and (11) capture the fact that the capital that flows into the country should be taxed more heavily ceteris paribus since it provides the basis for more public inputs to production.

For the wages we obtain the following relationships that are easy to verify

$$\eta_{t_1} > 0, \quad \eta_{t_2} > 0, \quad \eta_\lambda < 0 . \tag{12}$$

Thus for *fixed* ω, ω^* increases in t_1 or t_2 lead to positive changes in the rate of return and in wages. Redistribution lowers each of them.[8]

2.3 Capitalists

There are many identical Capitalists in each country, who cannot move, and choose how much of their income they consume or invest. Each individual Capitalist has to take prices such as r as given.

Since they have the opportunity to invest in either country they have to determine where their investment is to take place, ω. We will assume that it is *costless* to send and install capital abroad so that perfect capital mobility between the countries prevails. This assumption may be justified by the fact that we have assumed that physical capital is entirely collateralized by stocks that are traded. Then perfect capital mobility amounts to a situation where the world capital market is taken to be fully integrated, which for some countries and assets seems to be a reasonable approximation of reality.[9]

A representative Capitalist is assumed to have perfect foresight as the the price and tax rate paths and maximizes his/her intertemporal utility according to the following programme taking prices and tax rates

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[8]As argued in e.g. Razin and Sadka (1994) or Bovenberg (1994) the *Source Principle* entails a *uniform* taxation of residents' and foreigners' capital income. In this paper this condition is not imposed and the derivatives above prove crucial in the tax competition game we will concern ourselves with below.

[9]The alternative case of costly capital transfers is dealt with in Rehme (1994b). The assumption of perfect capital mobility allows one to concentrate on the issue of capital flight, which we will do in this paper.

as given.

$$\max_{C^k,\omega} \int_0^\infty U(C^k)\, e^{-\rho t} dt \qquad (13)$$

$$s.t. \quad \dot{k} = (r - t_1)\omega k + (r^* - t_2^*)(1 - \omega)k - C^k \,, \qquad (14)$$

$$0 \leq \omega \leq 1 \,, \qquad (15)$$

$$k(0) = \bar{k}, \quad k(\infty) = \text{free}. \qquad (16)$$

In (14) we reflect the fact that the representative Capitalist has to take r and r^* as given since we assumed earlier on that the asset and capital markets clear at all times. Equation (14) is the dynamic budget constraint of the representative Capitalist. Note that the Capitalists are assumed to earn income at home, $r\omega k$, and abroad, $r^*(1 - \omega)k$.

The necessary first order conditions for this problem are given by (14), (15), (16) and the following equations:

$$U' - \mu = 0 \qquad (17a)$$

$$\mu(r - t_1)k - \mu(r^* - t_2^*)k = 0 \qquad (17b)$$

$$\dot{\mu} = \mu\rho - \mu\left[(r - t_1)\omega + (r^* - t_2^*)(1 - \omega)\right] \qquad (17c)$$

$$\lim_{t \to \infty} k\mu e^{-\rho t} = 0. \qquad (17d)$$

where μ is a positive co-state variable which can be interpreted as the instantaneous shadow price of one more unit of investment at date t. Equation (17a) equates the marginal utility of consumption to the shadow price of more investment, (17c) is the standard *Euler* equation which relates the costs of foregone investment (LHS) to the discounted gain in marginal utility (RHS), noting $U' = \mu$, and (17d) is the transversality condition for the capital stock which ensures that the capital stock does not grow without bound asymptotically.

Equation (17b) describes the Capitalists' investment decision. This

takes a "*bang-bang*" form and so investment is given by:[10].

$$\omega = \begin{cases} 1 & : & (r - t_1) - (r^* - t_2^*) > 0 \\ \in [0,1] & : & (r - t_1) = (r^* - t_2^*) \\ 0 & : & (r - t_1) - (r^* - t_2^*) < 0 \,. \end{cases} \qquad (18)$$

Thus, the Capitalists investment behaviour is *extreme* in that they immediately shift their capital to the country where the after-tax return on capital is higher. This replicates the simplifying assumption that capital can costlessly be transferred to other countries. The simple formulation allows one to concentrate on the observation that international after-tax return differentials induce capital flows in the direction indicated above.[11]

Then, depending on the after-tax returns in the two countries, we get a *steady state* growth rate of consumption which follows in a standard way from (17c) and (18):

Case 1: $\omega = 0$: $\gamma_1 = (r^* - t_2^*) - \rho$

Case 2: $\omega \in [0,1]$: $\gamma_2 = (r - t_1)\omega + (r^* - t_2^*)(1 - \omega) - \rho$ (19)

Case 3: $\omega = 1$: $\gamma_3 = (r - t_1) - \rho \,.$

It follows that consumption of the Capitalists grows at a rate which depends on the after-tax returns in the two countries. Note that for Case 1 the growth rate is completely determined by the after-tax return in the foreign country and all the domestic capital "bangs" into the foreign country. If $\omega > 0$, however, part of the domestic capital remains in the home country, but this implies that the after-tax returns in the two countries must be equal. Case 2 is of particular interest below. Note that we have allowed ω to go where it would like if the after-tax returns are equal. Thus if the latter are equal we may well observe that all the capital of e.g. the home country bangs into the foreign country (Case 1) or entirely remains at home (Case 3). In Case 3 all the growth takes place in the home country, if the after-tax return is higher there. This completely describes the behaviour of the Capitalists.

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[10] For a more detailed treatment of this form in intertemporal problems cf. e.g. Chiang (1992), Kamien and Schwartz (1991).

[11] For an example that physical capital may actually be transferred because of return differentials see Ruffin (1984).

2.4 Workers

The Workers are assumed to derive a utility stream from consuming their wages. They do not invest and they are not taxed by assumption.[12] Thus, their intertemporal utility is given by

$$\int_0^\infty U(C^W)\, e^{-\delta t} dt \quad \text{where} \quad C^W = \eta(\tau, \lambda) K + \lambda \tau K. \qquad (20)$$

This assumption is reminiscent of growth models such as Kaldor (1956), where different proportions of profits and wages are saved. In the extreme case Capitalists save and Workers do not, which is the "*Classical Savings Rule*". In Kaldorian models the Capitalists' investment decision is determined by the exogenously given growth rate. Recently, Bertola (1993) has derived the "*Classical Savings Rule*" result from utility maximization, which endogenizes the investment decisions and therefore the growth rate. In that sense our set-up reflects this result. However, Bertola does not use a two class model and there are important differences to post-Keynesian models of growth, the most important of which is probably that the causality in both approaches is running in opposite directions. Whereas in Kaldorian models the growth rate determines the factor share incomes, in endogenous growth models the direction is rather from factor shares to the growth rate.

2.5 Equilibrium

2.5.1 Closed Economy

In the Closed Economy $\omega = 1, t_1 = t_2 = \tau, K = k$. The agents take the parameters and the prices as given.

The overall resource constraint in our economy is:

$$I = \dot{k} = (r - \tau)k + (\eta + \lambda \tau)k - C^k - C^W. \qquad (21)$$

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[12]Negative values for λ would be tantamount to wage taxes or taxes on human capital. In order to focus on the effects of capital taxation we will abstract from any effects of wage taxes on our economies.

Since the Workers' consumption is $C^W = (\eta + \lambda\tau)k, \forall t$ this constraint is binding. This simplifies (21) to

$$\dot{k} = (r - \tau)k - C^k . \tag{22}$$

The Capitalists' consumption grows at

$$\gamma_{C^k} = \frac{\dot{C^k}}{C^k} = (r - \tau) - \rho . \tag{23}$$

The rental rate, r, is given by (7) and is constant by (6), hence γ_{C^k} is constant. In *steady state* all variables are supposed to grow at the same constant rate. To verify that this is the case consider (2). Use the definition of G, that is, $G = (1 - \lambda)\tau k$, and substitute in (2). Recalling that $L_t = 1$ and taking logarithms and time derivatives yields $\gamma_Y = \gamma_k$.

Now divide (22) by k. In *steady state* all variables must grow at a constant rate. Rearrange (22) to obtain

$$\gamma_k - (r - \tau) = constant = -C^k/k . \tag{24}$$

Taking logarithms and time derivatives yields $\gamma_{C^k} = \gamma_k$.

Hence, in *steady state* we have balanced growth with

$$\gamma_Y = \gamma_k = \gamma_{C^k} = \gamma_{C^W} .$$

This describes the dynamic equilibrium of the Closed Economy.

2.5.2 Two-Country World

In this section we will only make a few observations on the nature of the equilibrium in the presence of arbitrarily given tax rates. We can have the following situations for the domestic country: $t_1 > t_2$, $t_1 < t_2$ or $t_1 = t_2$. Thus, we would have to go through six domestic vs. foreign tax rate configurations, noting that the levels of the tax rates have been unspecified and we have used symmetry. If we partition $\omega \in [0, 1]$ into $\omega_1 = 0$, $\omega_2 \in (0, 1)$, and $\omega_3 = 1$ and similarly ω^*, and invoke symmetry we have six possible ω, ω^* configurations.

The determination of ω, ω^* is crucial for the description of the equilibrium of the two-country world. Given the above possibilities one would have to go through 36 possible cases. Since ω depends on $\max(r - t_1, r^* - t_2^*)$ in the way given by (18) and the level of the tax rates has been left unspecified it stands to reason that any ω, ω^* can be sustained as a possible equilibrium. This is especially true if there are great differences in the levels. For instance if $\hat{\tau} > t_1 - t_2 > t_1^* - t_2^*$ and since r, r^* are increasing in tax rates then $(\omega = 1, \omega^* = 0)$ so that capital flight occurs.

I have tried to argue that almost all ω, ω^* configurations can be sustained given arbitrary levels and combinations of the tax rates and conclude from the above that each ω, ω^* combination can be sustained by multiple tax rate combinations and that these combinations constitute an extremely large, possibly infinite space of possible equilibria.

Economically, this suggests that we cannot say very interesting things about the economies unless we put more restrictions on the way taxes are set, which is the objective of the tax competition game we will contemplate below.

2.6 The Government in a Closed Economy

We will now look at a government that cares about the two groups in a closed economy. In this case our model reduces to one, where $\omega = 1$ and $t_1 = t_2 = \tau$. We will consider the domestic economy. Respecting the right of private property, it has to choose the paths of τ and λ in order to solve the following intertemporal problem, which is taken from the model of Alesina and Rodrik (1991):

$$\max_{\tau,\lambda} (1 - \beta) \int_0^\infty \ln C^k \, e^{-\rho t} dt + \beta \int_0^\infty \ln C^W \, e^{-\delta t} dt \qquad (25)$$

$$s.t. \qquad C^k = \rho k \,, \qquad (26)$$

$$C^W = \eta(\cdot)k + \lambda \tau k \,, \qquad (27)$$

$$\dot{k} = \gamma(\tau, \lambda)k \,, \qquad (28)$$

$$\lambda \geq 0 \,. \qquad (29)$$

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For this we note that $C^k = (r - \tau)k - \dot{k}$ and $\gamma = (r - \tau) - \rho$ so that $C^k = \rho k$.

The parameter $\beta \in [0,1]$ represents the welfare weight attached to the two groups in the economy. If $\beta = 1, (0)$, the government cares about the Workers (Capitalists) only. I will refer to the government's choice of β as being a

$\beta = 1, (0)$ - left-wing (right-wing) government.

Note that the condition $\lambda \geq 0$ restricts the governments in such a way that even a right-wing government does not tax workers. In that sense even a right-wing government is "nice" to the workers. A negative λ would effectively amount to a tax on wages.

Let us consider the case of equal discount rates, $\delta = \rho$. The solution to the government's problem is presented in Alesina and Rodrik (1991) and is given by:

If $\quad \beta \geq \dfrac{[(1 - \alpha)A]^{1/\alpha}}{\delta} \quad$ then:

$$\check{\tau} = \beta\delta, \qquad\qquad \check{\lambda} = 1 - \frac{[(1 - \alpha)A]^{1/\alpha}}{\beta\delta} . \qquad (30)$$

If $\quad \beta < \dfrac{[(1 - \alpha)A]^{1/\alpha}}{\delta} \quad$ then:

$$\check{\tau}[1 - \alpha(1 - \alpha)A\check{\tau}^{-\alpha}] = \beta\delta(1 - \alpha), \qquad \check{\lambda} = 0 . \qquad (31)$$

A right-wing government, $\beta = 0$, is only concerned about growth. The growth maximizing tax rate $(\lambda = 0)$ is

$$\hat{\tau} = [\alpha(1 - \alpha)A]^{1/\alpha} . \qquad (32)$$

A left-wing government, $\beta = 1$, cares about the Workers only:

$$\check{\tau} = \delta, \quad \check{\lambda} = 1 - \frac{[(1 - \alpha)A]^{1/\alpha}}{\delta} . \qquad (33)$$

From (32) and (33), we see that $\check{\tau} > \hat{\tau}$ when $\lambda \geq 0$ so that growth is not maximized. This becomes clearer from the following graph.

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Figure 1: The relationship between γ and τ in a Closed Economy
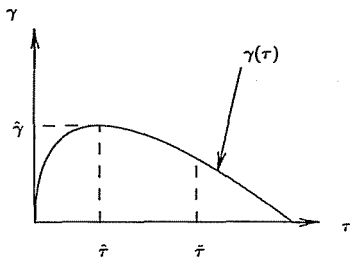
Parameter values: $\alpha = 1/2$, $\rho = 0$, $A = 2$.

At $\hat{\tau}$ the growth rate is maximal. If higher taxes are levied for redistribution then the growth rate decreases, i.e. growth is traded off against redistribution at a point such as $\tilde{\tau}$.

To keep matters simple we will only look at the border cases of $\beta = 1$, and $\beta = 0$ in what is to follow. It can be seen from above that β is inversely related to the growth rate. Alesina and Rodrik (1991) derive some interesting results from the above. They analyze the effects of changes in A and, more interestingly for this paper, find that in the "high β" region the tax rate will approach the growth maximizing one with $\lambda = 0$. They justify this by setting $\rho < \delta$ and argue that if the Capitalists are more patient the Social Planner arbitrages between the two groups' time preference with the effect that the growth rate starts out low but picks up over time.

We will see that this result is not uninteresting for our analysis. In their footnote (3), though, they rule this out for the extreme cases $\beta = 0$, $\beta = 1$, which are of interest in this paper.

An interesting implication of the above is that there is a wide range of values where no redistribution takes place. Note that given non-perverse coefficients of technology and if $\rho = \delta$ is a lot lower than β, i.e. Capitalists and Workers are patient, then even a left-wing government might not redistribute.

However, if the Capitalists and the Workers are not sufficiently pa-

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tient, then a left-wing government seems to force a non-maximal growth rate on its economy. From this we get a rather gloomy picture for governments in terms of the growth rate that take the objective of redistribution "at heart".

Finally, we may note that the optimal tax rates are non-zero. This is due to the assumption that λ is non-negative and labour supply inelastic. As has been shown by Jones, Manuelli and Rossi (1993a) and Jones, Manuelli and Rossi (1993b) and in contrast to e.g. Chamley (1986) this leads to non-zero tax rates on e.g. capital income.

3 Tax Competition in a Two-Country World with Perfect Capital Mobility

The question we shall pose ourselves in this section is:

What happens to the optimal choices of tax rates and redistribution parameters if these choices have to be made in a two-country world with capital mobility and costly capital transfers and countries cannot coordinate their policies?

This is a relevant question for countries where full tax harmonization may not be possible. There is a possibility then that countries engage in tax competition.[13]

We will look for a Nash Equilibrium of the game described below. The strategies of the two governments are the choices of t_1, t_2, λ and t_1^*, t_2^*, λ^*. Only pure strategies choices are considered.[14]

For the formulation of the game we have in mind we will employ the following

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[13]For a similar point cf. e.g. Bovenberg (1994).
[14]Cf. e.g. Fudenberg and Tirole (1991).

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Assumptions:

1. There is no uncertainty. Perfect knowledge about all the parameters, objective functions, the strategies and the sequence of moves prevails.

2. All agents act non-cooperatively.

3. The governments move simultaneously.

4. The private sector, that is, the Workers and the Capitalists move simultaneously.

5. The governments move before the private sector.

6. At each point in time the agents are confronted with the same problem.

7. Agents remember at t only what they have done at date 0.

8. $k_0 = k_0^*$, i.e. both countries have the same initial capital stock. (Unless stated otherwise.)

9. $A = A^*$, i.e. the countries are equally efficient or *similar*. (Unless stated otherwise.)

10. $\rho = \rho^*$, i.e. the countries' rate of time preference is equal across countries.

Assumption (5.) defines a game whose solution is called a *Ramsey Equilibrium*. This is similar to a *Stackelberg Leadership Solution*, where the governments are the Stackelberg leaders. Assumption (6.) defines a *repeated game* and (7.) means that the information structure is *open-loop*.[15] Also, if the Capitalists can invest in a global environment it makes sense to assume that they have the same rate of time preference.

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[15]The justification for assuming this information structure may lie in the fact that democratic governments of either political leaning may constantly be reminded of their pre-election promises so that the outcome of the game in the first stage provides a benchmark for their decisions at time t. If the governments could remember the whole

3.1 The Government's Objective

Denote the domestic and foreign government by Π^i and Π^{i*} where $i =$ left (l), right (r), respectively. We will consider government objectives where each government would like to have as much capital in its country as possible *and* maximize its domestic objective function. It is shown that this is consistent with the objectives as put forth in the set-up of Alesina and Rodrik (1991).

To see this note the following: The governments have to take the $\omega's$ as *given* from the second stage of the game. For the argument to follow the only thing we need is that the investors take the price paths of r_t, w_t and the taxes as *given* and then choose their optimal $\omega's$. Then the government goes through a comparative static thought exercise and indirectly chooses optimal $\omega's$ through its choice of tax parameters.

For what is to follow and to keep matters simple we will define *capital flight* as a situation where one country gets all the capital. For the domestic country this would amount to $\omega = 1$ and $\omega^* = 0$ for instance.

A change in the composition of the overall installed capital stock is given by $dK = \omega\, dk + (1 - \omega^*)\, dk^*$. Noting that $k_0 = k_0^*$ a small change in k or k^* has a positive effect on K and this change depends on ω, ω^*. Hence, for governments that prefer more capital to less policies affecting k or k^* play an important role. Note that we have assumed that domestic and foreign capital are substitutes in production. For this we will contemplate governments that do not prefer domestic over foreign capital.

From our earlier discussion we know that the Capitalists take r, r^* as given and that firms pay each factor its marginal product, also taking prices as given. Thus, in a competitive situation the agents and the

history of the game, time inconsistency issues would emerge. Modelling problems of time inconsistency and assuming appropriate trigger strategies for a *closed loop* information structure is beyond the scope of this paper. Thus it is implicitly assumed that governments commit themselves to their decisions. How this commitment is enforced is outside of this model. References for dynamic games are e.g. Petit (1990) and Basar and Olsder (1982).

firms do not take account of their effect on G. From the fact that the production function is constant returns to scale with respect K and L it follows that *gross* capital income is given by $rK = \alpha Y$ and *gross* wage income by $wL = (1 - \alpha)Y$. The effect of more capital, i.e. an increase in k or in k^* on domestic output from the government's viewpoint is given by

$$dY = Y_k \, dk + Y_{k^*} \, dk^* \, . \tag{34}$$

where Y_k and Y_{k^*} are the partial derivatives with respect to k and k^* respectively, evaluated at the second stage equilibrium values of the $\omega' s$.

These derivatives are given by

$$Y_k = [\alpha A K^{\alpha-1} G^{1-\alpha} + (1 - \alpha) A K^\alpha G^{-\alpha} t_1] \, \omega \geq 0, \tag{35a}$$
$$Y_{k^*} = [\alpha A K^{\alpha-1} G^{1-\alpha} + (1 - \alpha) A K^\alpha G^{-\alpha} t_2] \, (1 - \omega^*) \geq 0 \, . \tag{35b}$$

and are evaluated at $L = 1$ and the optimal $\omega' s$ from the second stage of the game. It follows that $dY \geq 0$. Thus, an increase in k and in k^* raises domestic output. But it also raises the *gross* income of both types of agents, since

$$d(rK) = \alpha \, dY \geq 0 \quad \text{and} \quad d(wL) = (1 - \alpha) \, dY \geq 0 \, . \tag{36}$$

So more capital in the domestic country leads to higher income. This in turn loosens the budget constraints of both Capitalists and Workers as can be seen from (14) and (20).

This means that an increase in k and k^* is in the interest of right-wing and left-wing governments. For consistency with the objective functions as put forth in section 2.6 all we require then are objective functions that are (a) continuous in tax parameters and increasing in (k, k^*) *given* ω and $(1 - \omega^*)$.

We know from the theory of optimal taxation that the government's problem can be stated in terms of the indirect utility function.[16]

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[16]Note that the welfare function is a function of the government's instruments and that this function need not necessarily coincide with the individual agents' utilities as noted in e.g. Atkinson and Stiglitz (1989), chpt.12 and Diamond and Mirrlees (1971).

Out of this class of objective functions we will consider the following welfare function for the domestic right-wing (r) and left-wing (l) government, Π:

$$V^i = V(C^k(\cdot), C^W(\cdot)) = V(\beta\lambda, t_1, t_2, k, k^*)_{|D=\text{given}} \qquad i = l, r \quad (37)$$

where $D \equiv \omega + (1 - \omega^*)$ and ω, ω^* are taken as *given* by the government. V^i has the following properties $\exists V^i_{t_j}$ for $t_j, j = 1, 2$ and

$$\frac{\partial V^i}{\partial k}, \frac{\partial V^i}{\partial k^*} > 0, \quad \frac{\partial V^l}{\partial \lambda} \geq 0, \quad \frac{\partial V^i}{\partial \tau}_{|\tau \lessgtr \hat{\tau}} \gtrless 0 \quad \text{and} \quad V^i_{D=0} \leq 0. \quad (38)$$

In Appendix A.1 it is shown that (37) satisfies (a) and represents in a concise form the properties of the indirect utility functions of both the agents and the governments.[17] $V^l_\lambda \geq 0$ reflects the fact that only left-wing governments ($\beta = 1$) derive utility from redistribution. The condition on V^i_τ is assumed for consistency with the closed economy solution where we argued that there is an optimal tax rate $\hat{\tau}$ that insures maximum growth. For this notice that $\tau = \tau(t_1, t_2)$.

We may note that (37) incorporates an important feature of competition for capital. Having argued that capital is good for right-wing and left-wing governments, the objectives of each government are to get as much capital as possible, i.e. $V^i_{|D_1} > V^i_{|D_2}$ if $D_1 > D_2$. Then the ideal situation for e.g. the domestic country would be one where all the capital would be invested at home, $\omega = 1$ and $\omega^* = 0$.

The objective function also makes it possible for each government to pursue its domestically preferred policy, $\tau \in [\tau_r, \tau_l]$. This is captured by the fact that a right-wing government, $\beta = 0$, is only concerned about the Capitalists' welfare. This is tantamount to choosing taxes in a way so as to guarantee high k and k^*.

For the rest of the paper this objective function will be assumed to represent the governments' objectives.

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[17]Note that only the domestic Capitalists' consumption enters this function. This is so because a national government usually only represents the interests of its own citizens.

3.2 Competition for Capital

In this section we will look for a Nash equilibrium in tax rates and the redistribution parameters λ, λ^*. From the assumptions about the game the following should be noted: Given the timing of moves and the assumption on the information structure the game is reduced to a repeated two-stage game. First the public sector moves and then the private sector. For our game this means that *given* the investment decision of the Capitalists, i.e. ω and $(1-\omega^*)$, the governments decide on the tax rates and redistribution. *Given* the tax rates and λ, λ^* the private sector decides on where to invest.

Given investment let us note that the growth rate of domestically installed capital is given by $\Gamma = \nu\gamma_k + \nu^*\gamma_{k^*}$ where $\nu \equiv \frac{\omega k}{K}$ and $\nu^* \equiv \frac{(1-\omega^*)k^*}{K}$ are the shares of domestic and foreign capital in domestically installed capital.

Solving backwards requires a government to solve (37) taking its opponent's choices of $(t_1^*, t_2^*, \lambda^*)$ as given. The solution to this problem is presented in Appendix A.2 and leads to the following proposition:

Proposition 1: For two *similar* countries there exist nine classes of pure strategy Nash Equilibria. The average after-tax returns in both countries are equal, i.e. $\hat{r} - \hat{\tau} = \hat{r^*} - \hat{\tau^*}$ with $\hat{\tau} = \hat{\tau^*}$ and $\hat{r} = \hat{r^*}$. The investors are indifferent where to go, i.e. $\omega \in [0, 1]$ and $\omega^* \in [0, 1]$ and never pay more than the average tax rates. No redistribution takes place, i.e. $\lambda, \lambda^* = 0$ regardless of political preferences. Capital flight may occur if $t_1^*, t_2^* \geq \hat{\tau^*}$ or $t_1, t_2 \geq \hat{\tau}$ which happens in two classes of pure strategy equilibria. Both countries grow at the same rate, $\Gamma = \gamma_k = \gamma_{k^*} = \Gamma^*$ if no capital flight occurs.

If Proposition 1 is assumed to hold one can see that the dynamic equilibrium is similar to the Closed Economy case.

Two important features of the Proposition merit attention. First, we get equal average tax rates in both countries, but individual tax rates such as t_1, t_2 may be different around $\hat{\tau}$. Thus, the strict form of the

source principle does not necessarily hold in equilibrium. This is, of course, due to the indeterminacy of the $\omega's$. Note also that the taxes are non-zero despite the presence of perfect capital mobility. Second, left-wing governments will not redistribute in equilibrium. The reason for this is that the concern for inequality is competed away by fear of capital flight. Capital is good to left-wing governments for redistributive reasons and for wages. Facing tax competition the left-wing government is better off if it puts more emphasis on securing high wages instead of redistribution. This is so even if, as has been assumed in (37), *given* the capital a left-wing government derives more utility than a right-wing one with the same capital. Intuitively, it does not pay a left-wing government to redistribute in this situation since redistributed capital is not productive. To have higher wages intertemporally yields higher utility then. Third, perfect capital mobility may accidentally lead to capital flight in which case one country does not grow at all. This consequence cannot be ruled out because of the extreme behaviour we have assumed.

Therefore, in a situation where both countries are equally efficient both governments optimally act as a right-wing government would by setting the growth maximizing tax rates. Note also that Proposition 1 predicts that we will see a very unequal distribution of capital over time. Tax competition provides a force that perpetuates this inequality.

Proposition 2: If two *different* countries' governments compete for capital the more efficient country, $A > A^*$, always gets all the capital, $\omega = 1, \omega^* = 0$. The inefficient country, $A^* < A$, chooses $t_1^* = t_2^* = \hat{\tau}^*$ regardless of political preferences, i.e. $\beta^* = 1, (0)$. The efficient country $(A > A^*)$ chooses either

(1) $t_1 = t_2 = \hat{\tau}$ and $\lambda = 0$ if $\beta = 0$, or

(2) $t_1 = t_2 = \tau \in [\hat{\tau}, \check{\tau}]$, where $\check{\tau} < (\check{r} - \hat{r^*}) + \hat{\tau}^*$ and $\lambda \geq 0$ if $\beta = 1$.

An efficient right-wing country gets the same amount of capital as a redistributing efficient left-wing country, i.e. $\omega_{\Pi l}^* = \omega_{\Pi r}^* = 0$ and $\omega = 1$.

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This proposition, which is proved in Appendix A.3, derives an extreme result that follows from the extreme investment behaviour of the Capitalists coupled with perfect capital mobility. The model would predict that redistribution is possible if a country is more efficient than the other one. Redistribution then depends on the opponent's technology. Also note that an efficient left-wing government will get more capital *and* guarantee a higher after-tax return. Its growth rate will therefore also be higher as shown below. If there is an efficiency difference there is hence a possibility for a left-wing government to pursue a policy which will have higher growth than its opponent and redistribution. The redistributive freedom is limited by the efficiency difference. For an inefficient left-wing government redistribution is always suboptimal.

We will now look at the dynamic equilibrium of the domestic economy under Proposition 2. From (14) and (19) we get $\gamma_C = \gamma_k$. The same holds for the foreign Capitalists. In the two-country world the resource constraint for the domestic country is given by

$$I = \dot{K} = (r - \tau)[\omega k + (1 - \omega^*)k^*] - C^K . \tag{39}$$

where it is important to note that $C^K \neq C^k$, C^K is the aggregate consumption of the domestic and foreign Capitalists consuming the domestic output and we have used the binding constraint, $C^W = [\eta + \lambda \tau]K$. Given the constancy of the after-tax return, dividing (39) by K, taking logarithms and time derivatives yields $\dot{K}/K = \dot{C}/C$. From the production function we get $\dot{K}/K = \dot{Y}/Y$ by a similar procedure. One may then verify that the aggregate growth rate on a balanced growth path is given by

$$\Gamma \equiv \dot{Y}/Y = \dot{C}/C = \dot{K}/K = \nu \gamma_k + \nu^* \gamma_{k^*} . \tag{40}$$

This completely characterizes the dynamic equilibrium for the efficient economy. The inefficient economy gets no capital, $\omega^* = 0, \omega = 1$, and so does not grow at all. Hence for $A > A^*$ we have $\Gamma > \Gamma^* = 0$.

Recall that for two equally efficient countries, the left-wing country will grow less than the right-wing one, cf. Proposition 1. It is interesting

to note, however, that an efficient left-wing country is better off in a world with perfect capital mobility than in a world where investors face transaction or installation costs. With imperfect capital mobility it is shown in Rehme (1994b) that an efficient left-wing country gets more but not all capital.

From this it is clear that an efficient redistributing government pays redistribution by an efficiency difference vis-à-vis its opponent. If this difference is small, redistribution will be small as well. Should one observe redistribution, though, the inequality in the capital distribution will decrease over time. Thus, inequality reducing policies are ultimately made possible by aggregate efficiency differences.

Finally, let us note that the equilibria of Propositions 1 and 2 are all Pareto-efficient.[18] To see this note that if we took only a tiny amount of capital away from the capital possessing country it would be worse off which violates the Pareto Principle.

4 Conclusion

Employing the framework of a simple endogenous growth model with distributional conflicts seems to imply that if one taxes *wealth*, the growth rate is reduced by redistribution. This is the argument presented e.g. in Alesina and Rodrik (1994) and Bertola (1993) and would suggest that redistribution always implies lower growth.

If one extends the growth redistribution trade-off problem to a a two-country world with perfect capital mobility, extreme investment behaviour and introduces non-cooperative behaviour, by which governments compete in *wealth tax* rates using the *source principle*, the possibility of capital flight features saliently in the optimal decisions of a government that wishes to redistribute.

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[18]This provides an example for a recent result stated in Janeba and Peters (1994) who have shown that in a game where the payoff functions have discontinuities and Nash Equilibria exist, they will be Pareto-efficient.

It has been shown that in a situation where the opponent is equally efficient, i.e. the countries are technologically similar, no redistribution will take place in the optimum. This holds even when the two opponents both care about redistribution. The intuitive reason for this is that given the technology capital is good for right-wing and left-wing governments. It has been argued that capital flight reduces wages and the utility loss of a government incurred by a drop in wages absolutely outweighs the utility gain derived from redistribution, which is not productive. In terms of the distribution of capital we will observe an unequal distribution over time. But the workers are compensated for this by higher wages. This result provides a benchmark for the case where countries are technologically different.

If the countries are technologically different, i.e. one country is more efficient than another one, then more capital will locate in the efficient country. If the efficient country wishes to redistribute, it can 'afford' to do so without loosing any capital. This is in contrast to Rehme (1994b) where investors operate in a world of imperfect capital mobility. The amount of redistribution depends on who the opponent is and in particular on the efficiency gap that distinguishes it from its opponents.

From this it follows that policies that are geared to make an economy more efficient are in the interest of both workers and capital owners. *Redistribution does not necessarily cause slower growth in comparison to other countries if the countries are competing for capital and the country in question is technologically more efficient.* But then it appears that the true trade-off is between policies that guarantee a high capital stock and an efficient technology. With a large enough efficiency gap redistribution is then a matter of political leanings.

Several caveats apply. We have only considered wealth taxes as a tax base. Other tax base choices may change the results in a two-country world considerably. [Cf. Rehme (1994a)] We have abstracted from questions of time inconsistency. If countries could remember the whole history of the game the outcome might well be different. We have not analyzed the role of tariffs and capital flight. It is quite likely that a country that experiences capital outflows or capital flight will set up

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tariffs. It would also be desirable to use a less aggregated set-up when investigating the trade-off problem. In reality workers own capital and some well capital endowed persons enter employment.

These and other problems provide room for further extensions of this model and for more research on the so-called trade-off between growth and redistribution.

A   Appendix

A.1   The indirect utility function

From the optimal decision of the Capitalists and in particular from (14), (19) we get that in steady state $C^k = \rho k$. This is clearly increasing in k. If one maximizes this subject to e.g. $\dot{k} = \gamma_2 k$ we know that γ is concave in τ and the derivatives of τ w.r.t. t_1, t_2 exist. Hence, the restriction on V^r. So any function that is increasing in C^k such as $V^r(C^k)$ represents Capitalists' welfare.

The Workers just consume their wage income plus transfers. This is given by (20). Rearranging (5) yields $\tau = \frac{G}{K(1-\lambda)}$. We can then express the Workers' consumption as

$$C^W = (1 - \alpha)A\left(\frac{G}{K}\right)^{1-\alpha} K + G\frac{\lambda}{1 - \lambda}. \qquad (41)$$

The first expression on the RHS corresponds to the wages and they are given by $\eta K = (1 - \alpha)AG^{1-\alpha}K^\alpha$. This expression is increasing in k, k^*. As to the second expression. G is clearly increasing in k, k^* as well.

A left-wing government wishes to redistribute. Only the second expression involves λ. Changes of C^W w.r.t. positive changes in λ are given $\frac{G}{(1-\lambda)^2}$, which is positive.

Hence, any utility function V^l that is increasing in C^W satisfies (a).

The condition of changes in τ on the properties of V^i follow from the fact that maximization should be carried out subject to the growth

rate. This provides the justification for the restrictions on V_r^i as given in (38). Hence, $V^i(\cdot)$ may capture the properties of the respective indirect utility functions.

A.2 Proof of Proposition 1

Let $\natural$ indicate a contradiction. We will prove the proposition in three steps. The first step only considers right-wing governments ($\lambda = \lambda^* = 0$) and shows that in a *proposed* Nash Equilibrium one government can improve upon the proposed equilibrium by a small change in one of the tax rates so that the proposed Nash Equilibrium could not have been a Nash Equilibrium. This eliminates impossible classes of Nash Equilibria. In a second step it will be proven that the remaining possible classes of Nash Equilibria are indeed Nash Equilibria. In the third step it is shown that left-wing governments will optimally not redistribute.

Recall the governments' objective functions are continuous in the tax rates and increasing in (k, k^*), *given ω and ω^**.

Note that in the case of equal after-tax returns on capital ω is a correspondence. For $r - t_1 = r^* - t_2^*$ we see that $\omega \in [0,1]$. Thus, ω can take any value in the closed interval $[0,1]$. For unequal after-tax returns this indeterminacy is resolved. For what is to follow we take the values of ω, ω^* as given from the second stage of the game and do a comparative static exercise.

Step 1

Claim 1:

The following characterizes one possible class of *Nash Equilibria*.

1. $\omega \in (0,1) \wedge \omega^* \in (0,1)$ and $t_2^* = t_1^* = \hat{\tau}^* = \hat{\tau} = t_1 = t_2$

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Proof:

In this (ω, ω^*) combination it cannot be that e.g. $t_1 > t_2$. Suppose the inequality holds. Then we must have that $t_2^* > t_1^*$. Note it is true at $\omega \in (0,1) \wedge \omega^* \in (0,1)$ that

$$(A): \quad r - t_1 = r^* - t_2^* \quad \wedge \quad (B): \quad r - t_2 = r^* - t_1^* \qquad (42)$$

If $t_1 \neq t_2$ then the following cases are possible.

a.	$t_1 > \hat{\tau} > t_2$	**b.**	$t_2 > \hat{\tau} > t_1$	**c.**	$t_1 > t_2 > \hat{\tau}$
d.	$t_2 > t_1 > \hat{\tau}$	**e.**	$t_1 < t_2 < \hat{\tau}$	**f.**	$t_2 < t_1 < \hat{\tau}$

Let us note that

$$(C): \quad \alpha A t_1^{1-\alpha} - t_1 \geq \alpha A t_2^{*1-\alpha} - t_2^*$$
$$or \qquad\qquad (43)$$
$$(D): \quad \alpha A t_1^{1-\alpha} - t_1 < \alpha A t_2^{*1-\alpha} - t_2^*$$

This is always true. We may note that if $1 - \omega^* = 0$ and $\omega > 0$ then $r = \alpha A t_1^{1-\alpha}$. Assume that (C) holds then the domestic government can improve on its outcome in the proposed Nash Equilibrium and if (D) holds the foreign government can improve by a similar argument.

I will now show that given e.g. $t_1 > t_2$ the home country can get more capital by tiny changes in the tax rates t_1 or t_2. Thus, we concentrate on cases **a.**, **c.** and **f.**. For the moment assume that **a.** so that $t_1 > \hat{\tau} > t_2$. We know that $t_1 > t_2$ entails $t_2^* > t_1^*$ at (A) and (B). The domestic country can do two things. It can either cut t_1 by a tiny amount ϵ, then the new tax rate is $t_1' = t_1 - \epsilon$, or it can raise t_2 by a tiny amount and we get $t_2' = t_2 + \epsilon$. From now on all changes induced by tiny changes in the tax rates will be denoted by a ('). Thus, we have that e.g. $t_1' \leq t_1$, but it is still assumed true that $t_1' > t_2 \wedge t_2^* > t_1^*$.

Consider the case of a tax cut in t_1. Then it is always true that

$$(r' - t_1') - (r - t_1) - [(r' - t_2) - (r - t_2)] = t_1' - t_1 = \epsilon > 0 \quad (44)$$
$$(r^{*'} - t_2^*) - (r^* - t_2^*) - [(r^{*'} - t_1^*) - (r^* - t_1^*)] = 0 . \quad (45)$$

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Using (A) and (B) these two expressions imply

$$(r' - t_1') - (r^{*'} - t_2^*) > (r' - t_2) - (r^{*'} - t_1^*) \qquad (46)$$

This is equivalent to

$$(r' - t_1') > (r^{*'} - t_2^*) \Leftrightarrow \omega = 1$$
$$or$$
$$(r' - t_2) < (r^{*'} - t_1^*) \Leftrightarrow \omega^* = 1$$

Thus either $\omega' = 1$ or $\omega^{*'} = 1$. Assume $\omega^{*'} = 1$. Recall that we did not change t_1, t_1^*, t_2^* and that for the case $t_1' > t_2$ and $t_2^* > t_1^*$ the following derivatives apply for changes in the capital stock as can be verified from (10) and (11) in the text

$$r_k' > 0, \qquad r_{k^*}' < 0, \qquad r_{k^*}^{*'} < 0, \qquad r_k^{*'} > 0 \qquad (47)$$

If $\omega^{*'} = 1$ then $1 - \omega^{*'} = 0$. If ϵ is sufficiently small, i.e. $\epsilon \to 0$, then

$$r' - t_1' = \alpha A(t_1')^{1-\alpha} - t_1' \approx \alpha A(t_1)^{1-\alpha} - t_1 \geq \alpha A(t_2^*)^{1-\alpha} - t_2^* \qquad (48)$$

So for $\omega^{*'} = 1 > 0$ and $t_2^* > t_1^*$, no matter how small ϵ is, we must have that $r^{*'} < \alpha A(t_2^*)^{1-\alpha}$. This follows from (47). So

$$r^{*'} - t_2^* < \alpha A(t_2^*)^{1-\alpha} - t_2^* \leq \alpha A(t_1')^{1-\alpha} - t_1' \approx \alpha A(t_1)^{1-\alpha} - t_1 \qquad (49)$$

So $\omega^{*'} = 1 \Rightarrow \omega' = 1$. Thus, it must be that $\omega' = 1$. If $\omega^{*'} \geq \omega^*$ then $r' > r$ and $r^{*'} < r^*$. But then $r' - t_2 > r^{*'} - t_1^*$ so ♮. So we have $\omega^{*'} < \omega^*$. Then $\omega' = 1 > \omega$ and $\omega^{*'} < \omega^*$ means that the domestic government is definitely better off since it gets more capital.

It is easy to verify that the same result can be obtained by an ϵ-increase in t_2. Note that if (C) does not hold, then (D) holds and the foreign government can also get more capital by either a tiny cut in t_2^* or an increase in t_1^*. For instance, it can be shown that, if $\alpha A(t_1)^{1-\alpha} - t_1 < \alpha A(t_2^*)^{1-\alpha} - t_2^*$, the foreign country can do better by cutting t_2^* by a small amount.

This means that the *proposed* class of Nash Equilibria is not a class of Nash Equilibria with $t_1 > \hat{\tau} > t_2$ so we must have $t_1 \leq \hat{\tau} \leq t_2$ and $\alpha A(t_1)^{1-\alpha} - t_1 \leq \alpha A(t_2^*)^{1-\alpha} - t_2^*$.

Now assume **b.**, i.e. $t_2 > \hat{\tau} > t_1$ and correspondingly $t_1^* > t_2^*$ and again assume $\alpha A(t_1)^{1-\alpha} - t_1 \leq \alpha A(t_2^*)^{1-\alpha} - t_2^*$.

Then a tiny tax cut in t_2 or a small increase in t_1 leads to either $\omega = 0$ or $\omega^* = 0$. Going through similar arguments as before shows that the domestic country can get more capital than before by one of the changes mentioned. Analogous arguments hold for the foreign government. Thus, **b.** does not characterize a possible class of Nash Equilibria.

Hence, we must have $t_1 = t_2 = t_1^* = t_2^*$. Also $t_1 = t_2 = \hat{\tau} = \hat{\tau}^* = t_1^* = t_2^*$ must hold.

Suppose not and that $t_1 = t_2 \neq \hat{\tau}$. As the technologies of the two countries are the same we have $\hat{\tau} = \hat{\tau}^*$. If $t_1 = t_2 > \hat{\tau}$ then the foreign government can move $t_1^* = t_2^*$ closer to $\hat{\tau}$ and get all the capital. This rules out all the other cases, i.e. **c. - f.**

Therefore, $t_1 = t_2 = t_1^* = t_2^* = \hat{\tau} = \hat{\tau}^*$ and $\omega \in (0,1)$ and $\omega^* \in (0,1)$ characterizes a possible class of Nash Equilibria.

Claim 2:

All the following are also possible classes of *Nash Equilibria*

2. $\omega = 1 \wedge \omega^* \in (0,1)$, and $t_2^* \geq t_1^* = t_1 = t_2 = \hat{\tau}^* = \hat{\tau}$
3. $\omega = 0 \wedge \omega^* \in (0,1)$, and $t_1 \geq t_2 = t_1^* = t_2^* = \hat{\tau}^* = \hat{\tau}$
4. $\omega \in (0,1) \wedge \omega^* = 1$, and $t_2 \geq t_1 = t_1^* = t_2^* = \hat{\tau}^* = \hat{\tau}$
5. $\omega \in (0,1) \wedge \omega^* = 0$, and $t_1^* \geq t_2^* = t_1 = t_2 = \hat{\tau}^* = \hat{\tau}$
6. $\omega = 1 \wedge \omega^* = 1$ and $t_2^* \geq t_1^* = \hat{\tau}^* = \hat{\tau} = t_1 \leq t_2$
7. $\omega = 0 \wedge \omega^* = 0$ and $t_1^* \geq t_2^* = \hat{\tau}^* = \hat{\tau} = t_2 \leq t_1$
8. $\omega = 1 \wedge \omega^* = 0$ and $t_2 = t_1 = \hat{\tau}^* = \hat{\tau} \leq t_1^*, t_2^*$
9. $\omega = 0 \wedge \omega^* = 1$ and $t_1^* = t_2^* = \hat{\tau}^* = \hat{\tau} \leq t_1, t_2$

Proof:

Suppose e.g. **2..** so that $\omega = 1$ and $\omega^* \in (0,1)$. Also assume that **a.** so that $t_1 > \hat{\tau} > t_2$. Then all the arguments of **Claim 1** hold. Thus, we must at least have $t_1 = t_2 = \hat{\tau} = t_1^* \leq t_2^*$. But due to the the Reaction Functions of the Private Sector we cannot exclude the possibility of $\omega = 1$ at $t_1 = t_2 = \hat{\tau} = t_1^* \leq t_2^*$. Thus, for the *proposed* equilibrium to be Nash Equilibrium we must have $t_2^* \geq \hat{\tau}^*$.

Hence, for the proposed Nash Equilibrium to be a Nash Equilibrium we have that $t_1 = t_2 = t_1^* = \hat{\tau}$ and $t_2^* \geq \hat{\tau}^*$ for $\omega = 1$ and $\omega^* \in (0,1)$.

It can be verified that analogous reasoning holds in all the other cases.

Step 2

We now turn to the question of *existence*. It is easy to verify that all the possible classes of Nash Equilibria can be summarized by a situation where all the tax rates are equal to $\hat{\tau}$. To this end we consider a situation where

$$t_1 = t_2 = \hat{\tau} = \hat{\tau}^* = t_1^* = t_2^* \quad and \quad \omega \in [0,1] \wedge \omega^* \in [0,1]$$

Now, suppose without loss of generality that we cut t_1 by a small amount at $t_1 = t_2 = t_1^* = t_2^* = \hat{\tau} = \hat{\tau}^*$ and $\omega \in (0,1)$ and $\omega^* \in (0,1)$, then

$$r' < \hat{\tau} = \hat{\tau}^* = \alpha A \hat{\tau}^{1-\alpha} \quad \text{given that} \quad t_2 = t_1^* = t_2^* = \hat{\tau}$$

So $\omega^{*'} \to 1$. Then $r' - t_1' < \hat{r}^* - \hat{\tau}^*$ because $t_1' < \hat{\tau} = t_2$ and then $\omega^{*'} = 1$. But then $\omega \to 0$ and the domestic country gets worse off.

Suppose we raise t_1 by a small amount. Then for any $\omega^{*'}$

$$r' - t_1' < \alpha A \hat{\tau}^{1-\alpha} - \hat{\tau} = r^* - t_2^* = r^{*'} - t_2^*$$

So the domestic capital definitely leaves, $\omega = 0$. Then

$$r' - t_2 = \alpha A t_2^{1-\alpha} - t_2 = r - t_2 = r^* - t_1^* = r^{*'} - t_1^*$$

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Now the foreign capital is indifferent where to go. We can reasonably assume then $\omega^{*'} \geq \omega^*$. So again the domestic country is worse off.

Suppose $t_1' > t_1$ and $t_2' > t_2$. Now if $t_1' \geq t_2'$ then $r' - t_1' < \alpha A \hat{r}^{1-\alpha} - \hat{r} = r^{*'} - t_2^*$. So $\omega = 0$. Then $r' - t_2' < \alpha A \hat{r}^{1-\alpha} - \hat{r} = r^{*'} - t_1^*$ and $\omega^{*'} = 1$. So this is bad for the domestic government. Similarly, $t_1' \leq t_2'$ induces loss of capital.

Now suppose $t_1 < \hat{r}$ and $t_2 > \hat{r}$. Then for all ω' and $\omega^{*'}$ we have $r' = r(t_1', t_2', \omega', \omega^{*'}) \leq r(t_2', t_2', \omega', \omega^{*'})$. So $r' - t_2' < r^{*'} - t_1^*$ and $\omega^{*'} = 1$. If $\omega^{*'} = 1$ then $r' - t_1' < \alpha A \hat{r}^{1-\alpha} - \hat{r} = r^{*'} - t_2^*$. So $\omega = 0$ and therefore bad for the domestic country.

Similar arguments hold for changes of the foreign country's tax rates. Hence, each deviation from $t_1 = t_2 = t_1^* = t_2^* = \hat{r} = \hat{r}^*$ makes the country that deviates worse off. By similar arguments all the proposed classes of Nash Equilibria are Nash Equilibria.

Step 3

From Step 1 and 2 we know that that $\hat{r} = \hat{r}^*$. If $\lambda \geq 0$ then $\tilde{r} \neq \hat{r}$. First suppose the other government is right-wing. Then it can find a t_1^*, t_2^* combination so that it gets all the capital. But then from (38) we have $V_{|\lambda>0}^l = 0 < V_{|\lambda=0}^l$ so that Π^l is worse off. The opposite holds for the foreign country if it sets $\lambda^* \geq 0$.

Now suppose both countries are left-wing. As the capital may bang from one country to the other lowering λ is good for either government.

If a government sets $\tilde{r} \neq \hat{r}$ then the other country gets all the capital. Hence, each left-wing government will set $\lambda = \lambda^* = 0$, $\tilde{r} = \hat{r}$ and $\tilde{r}^* = \hat{r}^*$.

Finally, from (19) it follows that $\Gamma = \gamma_k = \gamma_{k^*} = \Gamma^*$ except for the classes **8.** and **9.**. $\square$

A.3 Proof of Proposition 2

Let the home country be more efficient, $A > A^*$. I will now show that the maximum after-tax return in the efficient country is higher than in the inefficient one. Assume that $\lambda = 0$. Recall the expressions for $\hat{r}$ and $\hat{\tau}$.

$$\hat{r} = \alpha A \hat{\tau}^{1-\alpha}, \qquad \hat{\tau} = [\alpha(1-\alpha)A]^{1/\alpha} \tag{50}$$

We want to show that $\hat{r} - \hat{\tau} > \hat{r^*} - \hat{\tau^*}$. To this end let us assume that $A = xA^*$, where $x > 1$. If we make the appropriate substitutions we obtain

$$x^{\frac{1}{\alpha}}(\hat{r^*} - \hat{\tau^*}) > (\hat{r^*} - \hat{\tau^*}) \tag{51a}$$

$$x^{\frac{1}{\alpha}} > 1 \tag{51b}$$

If $x > 1$, then $\hat{r} - \hat{\tau} > \hat{r^*} - \hat{\tau^*}$. We will express this fact in a little Lemma.

Lemma 1: If $A > A^*$, then $\hat{r} - \hat{\tau} > \hat{r^*} - \hat{\tau^*}$.

If $A = xA^*, x > 1$ it is easy to verify that $\hat{r} > \hat{r^*}$ and $\hat{\tau} > \hat{\tau^*}$. We make this

Lemma 2: If $A > A^*$ then $\hat{r} > \hat{r^*}$ and $\hat{\tau} > \hat{\tau^*}$.

Equipped with these two Lemmas the proof proceeds as in Appendix A.2 as regards the choice of t_1, t_2, t_1^*, t_2^*. Then we have to distinguish these cases

1. rr^*: Π^r will set $\tau = \hat{\tau}$ and Π^{r*} chooses $\hat{\tau^*}$. But then you immediately get $\omega = 1, \omega^* = 0$ by Lemma 1.

2. rl^*: Π^r sets $\tau = \hat{\tau}$ and then you get the same outcome as in 1.

3. lr^*: Π^l chooses $\tau \in [\hat{\tau}, \check{\tau}]$ and Π^{r*} sets $\tau^* = \hat{\tau^*}$. So by (38) Π^l will set τ such that $r - \tau > \hat{r^*} - \hat{\tau^*}$ so that it gets all the capital. Since $V_D^l >> V_{D^*}^l \leq 0$ and $V_\lambda^l \geq 0$, Π^l may set τ so that $\check{r} - \check{\tau} = r^* - \tau^* + \epsilon > \hat{r^*} - \hat{\tau^*}$ with $\lambda \geq 0$ and ϵ small.

4. ll^*: $\Pi^l : \tau \in [\hat{\tau}, \check{\tau}]$ and $\Pi^{l*} : \tau^* \in [\hat{\tau^*}, \check{\tau^*}]$. From above we know that Π^l must set $\hat{\tau^*}$, but then we get the same result as in 3.

Since $\check{r} \leq \hat{r}$ and $\check{\tau} > \hat{\tau}$ we must have $\omega^*_{\Pi^l} = \omega^*_{\Pi^r} = 0$ from the private sector's reaction and Lemmas 1 and 2, equation (18), and so $\omega = 1$ for all Π^i. $\qquad\qquad\square$

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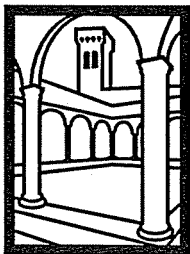
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