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## Income Inequality, Voting Over the Size of Public Consumption, and Growth

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# Working Papers

## INCOME INEQUALITY, VOTING OVER THE SIZE OF PUBLIC CONSUMPTION, AND GROWTH

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# INCOME INEQUALITY, VOTING OVER THE SIZE OF PUBLIC CONSUMPTION, AND GROWTH

## Abstract

According to a standard argument, higher income inequality fosters redistributive activities of the government in favor of the median income earner. This paper shows that if redistribution is achieved by a public provision of goods and services rather than by transfers, higher income inequality may imply a *smaller* size of the government in majority voting equilibrium. In addition to a static voting model, an endogenous growth model is analyzed to examine the role of saving decisions of heterogeneous individuals for both the distributional incidence of proportional factor income taxes and the voting outcome.

JEL Classification: D33, H40, O41.

Keywords: income distribution, public consumption, majority voting, investment-driven growth.

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# 1. Introduction

Standard models linking the income distribution and the size of the government are based on majority voting. The median voter is, by hypothesis, the individual with the median income. Moreover, the income distribution is viewed as more unequal, the lower the median income is relative to the mean income. In these models, the more unequal income is distributed, the higher is the demand of the median voter for redistributive activities of the government (e.g. Meltzer and Richard, 1981).<sup>1</sup> This argument has also been exploited to explain the often observed negative relationship between income inequality and economic growth.<sup>2</sup> Since redistribution were financed by taxes which distort the saving decisions, higher inequality would slow down investment-driven growth through the politico-economic channel (e.g. Bertola, 1993; Persson and Tabellini, 1994; Alesina and Rodrik, 1994). However, the empirical evidence for these suggestions is, at best, mixed.<sup>3</sup>

This paper examines the link between income inequality and the size of government in a majority voting equilibrium by considering tax-financed redistribution through publicly provided goods and services rather than transfer policies.<sup>4</sup> Examples include recreational facilities, parks, roads, health and cultural services. It should be noted that, like tax-transfer schemes, this kind of public expenditure usually has a redistributive impact on the median income earner. This is because tax payments (which are used to finance publicly provided goods) rise with income, but the median income earner does

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<sup>1</sup> Meltzer and Richard (1981) derive this result in a static majority voting model with a (distortive) linear tax-transfer scheme. That is, the poorer the median income earner (i.e. the median voter) is relatively to the mean income earner, the higher is his/her net transfer. However, Roemer (1998) has shown that when voting problems are multi-dimensional, i.e. there is voting not only over redistribution but also over a non-economic issue (like religion), it may well be that poor individuals vote for conservative tax policies.

<sup>2</sup> Using a new data set about inequality measures, Deininger and Squire (1996) cast doubts on the existence of such a relationship. See, for instance, Grossmann (2001) for a review of the theoretical and empirical literature on the relationship between inequality and growth.

<sup>3</sup> Whereas Meltzer and Richards (1983) provide some time-series evidence for the U.S. in favor of their theory, Lybeck (1986) rejects the hypothesis for Sweden. In cross-country studies, Mueller and Murrell (1986) find some weak support, but Kristov, Lindert and McClelland (1992) even find that a lower median to mean income ratio *decreases* redistribution. According to Rodriguez (1998), not a single redistribution measure is positively affected by inequality of gross income. Also Perotti (1996) does not find any link between inequality and tax rates or transfers, respectively. Moreover, his estimates suggest that redistributive measures positively affect growth (see also Basett, Burkett and Putterman, 1999). However, in a recent cross-country study of 24 democracies, Milanovic (2000) finds evidence for the hypothesis that higher income inequality leads to more redistribution.

<sup>4</sup> Opposed to the long debate about whether or not higher *per capita income* yields a larger public consumption share, a hypothesis known as Wagner's law, here it is considered how the *income dispersion* affects the size of the public sector.

not necessarily consume less of publicly provided goods and services than richer individuals. As Boadway and Wildasin (1986, p. 506) state:

*“Almost any taxing or expenditure decision of local governments will have distributive implications; it cannot be avoided.”*

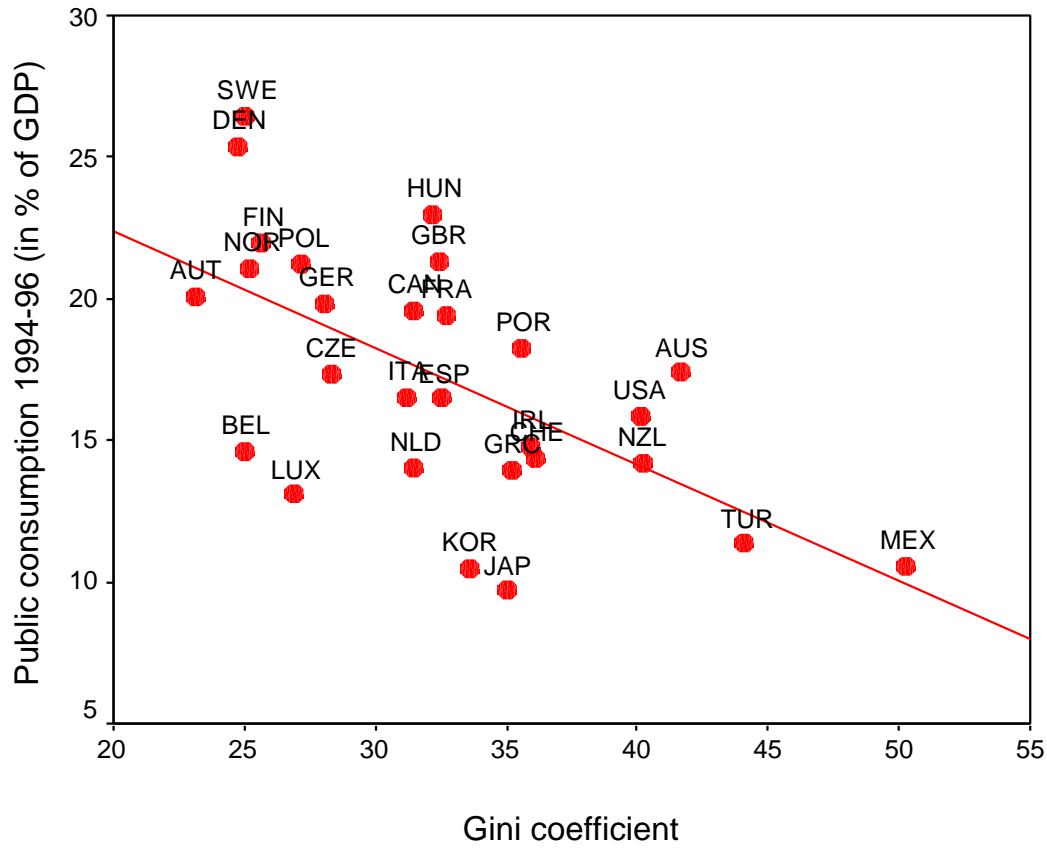
More specifically, it is analyzed if public consumption spending as share of national income rises or falls with income inequality. This is done in both a simple static model and a dynamic general equilibrium model with investment-driven growth. The intertemporal model allows to analyze the role of the tax effects on savings for the voting outcome, when individuals differ in capital endowments. In fact, this is the main focus of this paper.

As it turns out, one cannot generally expect a positive relationship between income inequality and the public consumption share in a majority voting equilibrium. For instance, assuming exogenous labor supply and specifying the tax scheme as synthetic income tax (various tax schemes are considered), higher inequality of capital endowments unambiguously leads to lower taxation and public expenditure, respectively. The reason for this is the following. As usual in models with infinite planning horizons and perfect credit markets, higher *capital* income taxation induces owners of capital to reduce savings, leaving the impact on their consumption *levels* ambiguous. In turn, lower savings slow down investment-driven growth, negatively affecting *growth* rates of both income and consumption of all individuals similarly (as usual in steady state equilibrium). In contrast, higher *labor* income taxation unambiguously reduces consumption *levels* of owners of labor but does not affect savings and *growth*. Thus, an increase in the public consumption share hurts capital-poor individuals more than capital-rich ones under a synthetic income tax.

Finally, it is shown that allowing for endogenous labor supply may lead to an additional shift of the relative tax burden towards capital-poor individuals. Analogously to the just described “savings effect”, this is the case when capital-rich individuals can also better cope with labor income taxation by adjusting leisure upward.

Fig. 1 shows that in a cross-section of OECD countries, the Gini coefficient of gross income (as measure of inequality) and public consumption expenditure as share of GDP are indeed negatively, rather than positively related. Also Clarke (1995) finds, if anything, a negative (although not very robust) relationship between inequality and the public consumption share, using a broader set of countries. Moreover, many studies

suggest a weak empirical link between income inequality indicators and various tax rates (e.g. Perotti, 1996; Figini, 1999).



**Figure 1:** Inequality and the share of public consumption in the OECD.

*Data sources:* Gini coefficients from Deininger and Squire (1996) and World Bank (1998); public consumption shares from OECD (1999).

*Notes:* The latest available Gini coefficient from the above sources is included. Moreover, the average public consumption share from 1994-96 is used.

In an alternative class of models, Bénabou (1996, 2000) and Saint-Paul (2001) show that capital market imperfections (e.g. borrowing constraints to finance higher education) lead to majority voting equilibria where redistribution and inequality may indeed be negatively related. It should be noted that the majority voting approach in this paper is not chosen because it is the best way to represent actual political processes, but in order to show that standard results about the relationship between inequality and the size of the government can be overturned. Analyzing a representative democracy model rather than a median voter model, Peltzman (1980) already derives the result that

redistribution can rise when income is distributed more equally. Moreover, whether or not one believes that actual political outcomes can be understood by median voter models, it is interesting to examine the determinants of individually preferred policies (without necessarily drawing conclusions for voting equilibria).

The results of this paper may also be compared with the literature on the relationship between inequality and the *private* provision of public goods. As pointed out by Sandler (1997), it crucially depends on the “technology of public good aggregation” whether this relationship is positive or negative.<sup>5</sup> Related work also includes the median-voter growth model of Fiaschi (1999), in which government spending is productive (Alesina and Rodrik, 1994). That is, in his model public investments enter the production function of a representative firm, whereas in my model the level of public consumption enters the utility functions of agents. Moreover, Fiaschi (1999) argues that the level of taxation need not be negatively related to growth, whereas I show that inequality need not be positively related to government spending.

Section 2 sets up a simple static median voter model and examines the link between the income distribution and the public consumption share. Section 3 proposes a growth model which is in some sense comparable with the static model of section 2. The equilibrium growth rate is derived in section 4. Section 5 identifies the additional effects on the individual demand for public consumption compared with the static case. Section 6 derives the voting equilibrium. In section 7, both the assumptions and the contribution of the model are discussed; moreover, the analysis is extended by allowing for endogenous labor supply. The last section concludes.

## 2. Voting over public expenditure: A simple model

In this section, a static model with majority voting over the level of public consumption expenditure is presented.

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<sup>5</sup> For instance, if the total provision of public goods hinges on the (richest) individual which contributes most (“best-shot technology”), higher inequality raises public good provision. However, the opposite holds if the total provision depends on the least endowed contributor (“weakest-link technology”). If the total provision depends on the sum of contributions and all individuals contribute positive amounts, then the income distribution does not affect total public good provision at all. However, this “neutrality result” does not hold in the presence of non-contributors. (For implications, see e.g. Itaya, De Meza and Myles, 1997; Cornes and Sandler, 2000.)

There are  $i \in [0,1]$  individuals with an exogenous income  $y^i > 0$ . Thus, total income  $Y = \int_0^1 y^i di$  equals per capita income. Following the politico-economic literature about income inequality and redistribution (e.g. Meltzer and Richard, 1981), an income distribution is called more equal, the higher the median income is relative to the mean.<sup>6</sup> Denote  $c^i$  the individual consumption level of a private numeraire bundle and  $G$  the level of a publicly provided good.<sup>7</sup> (In the following, these are referred to a private and a public consumption good, respectively.)<sup>8</sup> Individuals have identical preferences represented by a twice differentiable utility function  $u(c^i, G)$  which is strictly increasing in its arguments and strictly quasi-concave. Assume that one unit of the private consumption good can be transformed in one unit of the public consumption good. The public consumption good is financed by income taxes. Let  $s^i = s(y^i)$  denote the tax share (or contribution share, respectively) of individual  $i$  to total public consumption expenditure.  $s(\cdot)$  is a non-decreasing function, which is taken as given by individuals. Furthermore, denote the *average* tax rate as a function  $t(\cdot)$  of income, i.e.  $t(y^i) \in [0,1]$  is the average income tax rate of individual  $i$ . Thus, a balanced budget requires  $G = \int_0^1 t(y^i) y^i di$ , and, according to the definition of the tax share, we have

$$(1) \quad s^i = s(y^i) = \frac{t(y^i) y^i}{G}.$$

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<sup>6</sup> It is frequently found that personal income in an economy is approximately log-normally distributed. With a log-normal income distribution, one can show that the Gini coefficient increases if and only if the median to mean income ratio decreases (Aitchison and Brown, 1966). This result thus gives some justification to consider the income distribution as less equal, the lower the median income is relative to the mean income.

<sup>7</sup> The publicly provided good can either be viewed as pure public good or as private good which is consumed in equal amounts by the individuals. The reason for this is the following. If the publicly provided good is private and  $G^i = G$  for all  $i$ , where  $G^i$  denotes the individual consumption level of that good, then  $G = \int_0^1 G^i di$  with a unit mass of individuals.

<sup>8</sup> See Epplé and Romano (1996) for a different median voter model with a private numeraire bundle and a publicly provided private good. Whereas their paper analyzes the role of private supplements of the publicly provided good, my focus is the link between the income distribution and the public sector.

(Note that  $\int_0^1 s^i di = 1$ .) That is, for a given income  $y^i$ , the average tax rate of individual  $i$  endogenously adjusts to the level of public consumption  $G$ , which is the single variable individuals vote on. That is,  $t(y^i) = s(y^i)G / y^i$ , according to (1).

Each individual  $i$  solves the following problem:

$$(2) \quad \max_{c^i, G} u(c^i, G) \quad \text{s.t.} \quad c^i + s^i G \leq y^i.$$

Assuming an interior solution, the individual demand for  $G$ , denoted  $G^i$ , is given by

$$(3) \quad \frac{u_2(y^i - s(y^i)G^i, G^i)}{u_1(y^i - s(y^i)G^i, G^i)} = s(y^i).$$

(3) simply states that the marginal rate of substitution between the two goods equals the individual tax share (i.e. the individual price of the public consumption good in units of the private consumption good).<sup>9</sup> This condition implicitly defines the individual demand  $G^i$  for public consumption as function of individual income  $y^i$ .

Now consider homothetic preferences, i.e. without loss of generality, assume that the utility function  $u$  is linear homogenous.<sup>10</sup> Under this specification, (3) can be written as

$$(4) \quad \left[ MRS \left( \frac{c^i}{G^i} \right) \right] = MRS \left( \frac{y^i - s(y^i)G^i}{G^i} \right) = s(y^i),$$

<sup>9</sup> See e.g. Borchering and Deacon (1972) and Bergstrom and Goodman (1973).

<sup>10</sup> In our context, homothetic preferences can be justified as follows. Assuming both a constant price and income elasticity, denoted  $d$  and  $k$ , respectively, we have  $G^i = h(s^i)^d (y^i)^k$ ,  $h > 0$  (e.g. Bergstrom and Goodman, 1973). Under the assumption that the decisive voter is the one with median income, i.e. the public consumption good is non-inferior, this expression yields a typical estimated equation in the public choice literature on public consumption, given by  $\ln G = \ln h + d \ln s^m + k \ln y^m + h$ , where  $s^m$  and  $y^m$  is the median tax share and median income of the economy, respectively ( $h$  is an error term). Typically,  $k$ , the elasticity of public consumption with respect to the median income holding the tax share constant, is estimated around unity. (For survey articles about the empirical estimates, see Mueller, 1989, ch. 17; Holsey and Borchering, 1997). This empirical result is consistent with homothetic preferences.

where  $MRS(\cdot) \equiv u_2(\cdot, 1) / u_1(\cdot, 1)$  denotes the marginal rate of substitution. The following lemma shows how  $G^i$  depend on the individual income  $y^i$ .

*Lemma 1:* With homothetic preferences, the total elasticity of public consumption demand with respect to individual income is given by

$$(5) \quad \frac{dG^i}{dy^i} \frac{y^i}{G^i} = 1 - \mathbf{c}^i \mathbf{e}^i,$$

where  $\mathbf{e}^i \equiv \frac{d(c^i / G^i)}{d MRS(c^i / G^i)} \frac{MRS(c^i / G^i)}{(c^i / G^i)}$  is the elasticity of substitution evaluated at

$G^i$  and  $\mathbf{c}^i \equiv s'(y^i)y^i / s^i$  is the income elasticity of the individual tax share.

*Proof:* See appendix A.

The first term of the right-hand-side of (5) is the income elasticity of individual public consumption demand if the individual price of public consumption  $s^i$  is held constant.<sup>11</sup> (As it is well known, this elasticity equals unity with homothetic preferences.) According to the second term of (5), if the individual tax share function is increasing in income (i.e. if  $\mathbf{c}^i > 0$ ), the sign of the *total* income elasticity of public consumption demand is ambiguous. This is because richer individuals have to pay a higher ‘price’ for the publicly provided good. Nevertheless, rich individuals may prefer a large public sector.

Let individuals vote over the level of publicly consumption  $G$ . Since policy preferences over the level of public consumption are single-peaked (due to the strict quasi-concavity of the utility function), the median voter theorem can be applied. The voting outcome is assumed to be a one-man, one-vote decision. If there would be a monotonic relationship

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<sup>11</sup> If, e.g., the public consumption good would be financed by a uniform poll tax, this would be the only effect. Thus, in this case demand for public consumption would be a positive function of individual income (Atkinson and Stiglitz, 1980, ch. 10).

between  $G^i$  and  $y^i$ , the decisive median voter would be the median income earner.<sup>12</sup> Thus, one can conclude the following.

*Proposition 1 (Static model):* If the median income earner is the decisive voter, then higher income inequality (i.e. a lower median income for a given mean income) does not necessarily lead to a larger size of public consumption in majority voting equilibrium.

*Proof:* Directly follows from lemma 1.

Since public expenditure has a redistributive impact if the tax share is an increasing function of income, proposition 1 questions the standard argument that tax rates (and redistribution) are higher in more unequal economies.

*Example (Proportional income tax):* In the remainder of the paper, proportional income taxes are considered. In the static model above, this means that the tax share function  $s(\cdot)$  is such that  $t^i = t$  holds for all  $i$ . Thus,  $s^i = y^i / Y$  according to (1), i.e. the individual tax share equals relative income. This implies  $c^i = 1$ , i.e. the income elasticity of the individual tax share equals unity. Moreover, we have  $G = tY$ , i.e.  $t$  equals the public consumption share of total income. Hence, voting over the level of public consumption is equivalent to voting over the public consumption share. Using  $s(y^i) = y^i / Y$  and  $G = tY$ , (4) becomes

$$(6) \quad MRS\left(\frac{(1-t^i)q^i}{t^i}\right) = q^i,$$

where  $q^i = y^i / Y$  denotes relative income and  $t^i = G^i / Y$  denotes the preferred public consumption share of individual  $i$ .<sup>13</sup>

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<sup>12</sup> Note that lemma 1 implies that even with homothetic preferences the relationship between public consumption demand and individual income is not necessarily monotone such that the median income earner is generally not identical with the median voter. In this case, the voting equilibrium depends on the entire income distribution (e.g. Bergstrom and Goodman, 1973).

<sup>13</sup> Thus, for a given relative income of the median voter, the public consumption share in the politico-economic equilibrium does not depend on per capita income (i.e. Wagner's law does not hold).

*Proposition 2 (Static model with a proportional income tax):* Suppose homothetic preferences and a proportional income tax. If the median income earner  $m$  is the decisive voter and  $e^m < (=, >) 1$ , then the elasticity of the public consumption share  $t^m$  in majority voting equilibrium with respect to relative median income  $q^m$  is positive (zero, negative).

*Proof:* Using  $q^i = y^i / Y$  and  $t^i = G^i / Y$ , we have  $\frac{dt^i q^i}{dq^i t^i} = \frac{dG^i y^i}{dy^i G^i}$ . Thus,  $c^m = 1$

implies  $\frac{dt^m q^m}{dq^m t^m} = 1 - e^m$  according to (5).

The total effect of a higher (relative) income on the desired level of public consumption can be divided into two effects: first, a *substitution effect* arising from an increase in the relative ‘price’ of the public consumption good faced by an individual (since the individual tax share rises with income), and second, a *wealth effect* (or income effect, respectively) due to the rising consumption possibilities (for a given tax share). Since the publicly provided good is normal, both effect go in opposite directions. If the individually preferred ratio of private and public consumption is sufficiently elastic (inelastic) to the individual tax share, i.e. if  $e^i > 1$  ( $e^i < 1$ ), the substitution effect dominates (is weaker than) the wealth effect. With Cobb-Douglas preferences (i.e.  $e^i = 1$ ) both effects exactly cancel.

In the next section, the additional role of saving decisions of heterogeneous agents in a dynamic general equilibrium growth model in which public consumption is financed by proportional taxes on both accumulated and nonaccumulated factor income is examined.

### 3. Public expenditure in a growth model

#### 3.1 The aggregate economy

There is a private consumption good  $Y$  produced by identical firms and a publicly provided good  $G$  which is financed by proportional *factor income taxes*. Output  $Y$  is

produced with an accumulated factor  $K$  and a non-accumulated factor  $L$ .  $K$  can be viewed as a composite of human and physical capital (e.g. Rebelo, 1991), called “capital” hereafter, whereas  $L$  can be viewed as land or unskilled labor, called “labor” hereafter. The economy’s total labor supply is normalized to unity (i.e.  $L = 1$ ). The firms’ technology at time  $t$  is represented by the following production function:

$$(7) \quad Y(t) = aA(t)K(t)^{1-a}L^a, \quad a > 0, \quad 0 < a < 1,$$

where  $a$  is a productivity parameter. There is an external productivity of  $A(t) = K_A(t)^a$ , commonly interpreted to be generated by learning-by-doing or human capital spill-over effects. The aggregate capital stock  $K_A$  is taken as given by the firms.<sup>14</sup> Let the identical firms be of mass unity such that  $K_A = K$  holds in equilibrium. The resulting social production function is thus given by  $Y(t) = aK(t)$ .

In order to finance the public consumption good the government imposes taxes on capital and labor income with tax rates  $t_K \leq t_K^{\max}$  and  $t_L \leq 1$ , respectively. (See below for the definition of  $t_K^{\max}$ .) Then at time  $t$  after-tax returns  $r(t)$  and  $w(t)$  on  $K$  and  $L$ , respectively, are given by

$$(8) \quad r(t) = (1 - t_K) \frac{\partial Y}{\partial K} \Big|_{K=K_A, L=1} = (1 - t_K)(1 - a)a \equiv r,$$

$$(9) \quad w(t) = (1 - t_L) \frac{\partial Y}{\partial L} \Big|_{K=K_A, L=1} = (1 - t_L)aK(t),$$

according to (7). The government budget is assumed to be balanced in any point of time. As in the static model of section 2, let the marginal rate of transformation between the

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<sup>14</sup> Despite increasing social returns to scale, this specification allows one to maintain the assumption of perfect competition in the goods market since the technology exhibits constant returns to scale for a given level of  $A$ . Non-decreasing (social) marginal productivity of capital as source of endogenous growth has been proposed by Romer (1986). The particular specification here is chosen for its familiarity and simplicity.

private and public consumption be constant and normalized to unity. Thus, the quantity of the publicly provided good equals the tax revenue. Using (8) and (9), we have

$$(10) \quad G(t) = g a K(t), \text{ where}$$

$$(11) \quad g = \frac{G}{Y} = t_K (1 - a) + t_L a.$$

Thus, public consumption expenditure as share of total output,  $g$ , is a weighted average of the tax rates. Specify the tax scheme as

$$(12) \quad t_K = u t_L,$$

which is discussed in the following.<sup>15</sup> First, (12) ensures that the voting problem, which is considered below, is one-dimensional. Second, if  $0 < u < \infty$ , both owners of capital and owners of labor contribute to finance public consumption. Interpreting the accumulated factor as ‘human capital’ and the non-accumulated factor as ‘raw labor’ (see Romer, 1990, p. S79, for a discussion of this interpretation), the government may be incapable to distinguish (and tax differently) the components of individual earnings that correspond to the return to either factor. Thus,  $u = 1$ , i.e. a synthetic income tax, is an important special case in the analysis below. Third, if  $u = 0$  or  $u \rightarrow \infty$ , public consumption is financed solely by labor taxation (i.e.  $t_K = 0$ ) or capital taxation (i.e.  $t_L = 0$ ), respectively. Fourth, consider the case  $u < 0$ . In fact,  $u = -a/(1-a)$  amounts to the special case of Bertola (1993), who deals with factor income *redistribution* rather than with tax-financed *public consumption*. To see that  $g = 0$  holds in this case, use (11) and (12) to find the following proportional relationship between the public consumption share  $g$  and the tax rate on labor income  $t_L$ :

$$(13) \quad g = \Phi t_L, \text{ where } \Phi \equiv (1 - a)u + a.$$

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<sup>15</sup> Most of the following discussion I owe an anonymous referee.

Thus, for  $g > 0$  and  $t_L > 0$  to be possible, one needs to impose the restriction  $\Phi > 0$ , i.e.  $u > -a/(1-a)$ . Analogously, if  $t_K > 0$  and  $u < 0$  is considered,  $g > 0$  requires  $\Phi < 0$ , i.e.  $u < -a/(1-a)$ . However, note that in these cases (i.e.  $u < 0$ ) any increase in  $g$  *simultaneously* implies a redistribution of factor incomes. As this may be viewed as undesirable, I will mostly focus on  $u \geq 0$ .<sup>16</sup> (See also the discussion of an alternative tax scheme in section 7.)

Without depreciation, capital grows over time according to

$$(14) \quad \dot{K}(t) = aK(t) - C(t) - G(t),$$

where  $C(t)$  denotes the aggregate level of private consumption at time  $t$ . Thus, if there is a balanced growth rate  $J$  (which will be derived below), we obtain

$$(15) \quad J = \hat{K}(t) = \hat{Y}(t) = \hat{C}(t) = \hat{w}(t) = \hat{G}(t),$$

where the hat over a variable denotes its growth rate. Moreover, according to (10), (14) and (15), the initial level of aggregate private consumption is given by

$$(16) \quad C(0) = (a(1-g) - J)K_0,$$

where  $K(0) = K_0 > 0$  denotes the aggregate initial capital stock of the economy.

### 3.2 Individual budget constraints and preferences

There is a unit-mass continuum of infinitely living consumers indexed  $i \in [0,1]$ , who privately own the production factors. Hence, aggregates are equal to per capita values. Individuals differ in capital endowments  $k^i(0) \equiv k_0^i > 0$  (i.e. the individual skill or wealth levels) and labor endowments  $l^i > 0$ . Denoting the individual consumption of

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<sup>16</sup> According to (12), if  $u < 0$ , then one factor is actually subsidized, as in Bertola (1993). However, this is not crucial. For instance, assuming  $t_K = c + ut_L$  instead of (12) would not change any of the results but allows both tax rates to be positive (if  $c > 0$ ) although the relationship between  $t_K$  and  $t_L$  may be negative (i.e.  $u < 0$ ).

the private consumption level at time  $t$  by  $c^i(t)$ , the individual budget constraints are given by

$$(17) \quad \dot{k}^i(t) \leq rk^i(t) + w(t)l^i - c^i(t) \quad \text{and} \quad \lim_{t \rightarrow \infty} e^{-rt} k^i(t) \geq 0,$$

where the latter is the usual ‘No Ponzi Game’ condition. Each individual has the following time-separable utility function

$$(18) \quad U^i = \int_0^{\infty} e^{-rt} u(c^i(t), G(t)) dt,$$

where  $\mathbf{r}$  denotes the subjective time preference parameter. For technical reasons, assume  $0 < \mathbf{r} < (1 - \mathbf{a})a$ . Specify instantaneous utility as

$$(19) \quad u(c^i, G) = \frac{(c^i G^{\mathbf{g}})^{1-\mathbf{s}} - 1}{1-\mathbf{s}}.$$

Note that (19) is a monotonic and positive transformation of a Cobb-Douglas (and thus of a homogenous) utility function. (Hence, as common in the endogenous growth literature, preferences are homothetic.) The parameter  $\mathbf{g} > 0$  indicates the individual preference for public consumption, and  $\mathbf{s} > 0$  is the elasticity of marginal instantaneous utility with respect to private consumption. As it will turn out, the assumption  $\Omega \equiv \mathbf{s}(\mathbf{g} + 1) - \mathbf{g} > 0$  ensures that the balanced growth rate is non-negative if  $r \geq \mathbf{r}$ , i.e.

$\mathbf{t}_K \leq 1 - \frac{\mathbf{r}}{(1 - \mathbf{a})a} \equiv \mathbf{t}_K^{\max}$ , according to (8). (Ensuring non-negative growth rates is

necessary if investments are assumed to be irreversible.) Note that  $\mathbf{t}_K^{\max} \in (0, 1)$ , since  $0 < \mathbf{r} < (1 - \mathbf{a})a$  has been assumed. Two properties of (19) are notable. First, the marginal instantaneous utility with respect to private consumption increases (does not change, decreases) with the level of public consumption  $G$ , if  $\mathbf{s} < 1$  ( $\mathbf{s} = 1$ ,  $\mathbf{s} > 1$ ). And second, (19) implies that the elasticity of substitution between the two goods is equal to

one, i.e.  $e^i = 1$  for all  $i$ . Remember that in the static model of section 2 (in the case of homothetic preferences and proportional income taxation), the public consumption share in voting equilibrium does not depend on the income distribution if  $e^i = 1$  for all  $i$ , according to proposition 2.

#### 4. Equilibrium growth and public consumption

In this section the equilibrium growth rate  $J$  for given tax rates is derived. Each individual maximizes utility (18) and (19) subject to the budget constraints (17), perfectly foreseeing and taking as given the path of public consumption, determined by (10) and (11).

*Lemma 2:* Each individual  $i$  chooses the private consumption level to grow according to

$$(20) \quad \hat{c}^i(t) = \hat{C}(t) = \frac{(1 - t_K)(1 - a)a - r + g(1 - s)\hat{G}(t)}{s}.$$

*Proof:* See appendix A.

Thus, using (8), (12) and (15), the balanced growth rate is given by

$$(21) \quad J = \frac{r - r}{\Omega} = \frac{(1 - ut_L)(1 - a)a - r}{\Omega}$$

(remember  $\Omega = s(g + 1) - g > 0$ ). First, note that due to the simple technology in (7), there are no transitional dynamics to the steady state growth path. Second, (21) shows that capital taxation discourages growth since it reduces the private return on investment and thus lowers the amount of savings in this infinite-horizon framework (e.g. Rebelo, 1991). Moreover, the growth rate  $J$  does not depend on the taxation of the non-accumulated factor. The reason for this is the following. According to (20), all agents desire the same private consumption growth rate which is equal to the growth rate of

labor income  $J$  in steady state, according to (9), (15) and (21). Since agents are infinitely living, this also implies that each individual accumulates capital at the same rate  $J$ , according to (17). Thus, at each instant, the aggregate amount of savings does not depend on labor income.<sup>17</sup> Third, one finds that a higher public consumption preference parameter  $g$  raises (does not affect, lowers)  $J$  if  $s < 1$  ( $s = 1$ ,  $s > 1$ ). This result can be understood as follows. For instance, if  $s < 1$ , the marginal instantaneous utility of private consumption, which equals the current-value shadow-price of individual labor income in any point of time (see the proof of lemma 2 in appendix), increases with current public consumption. According to (20), if  $s < 1$ , it is thus optimal for an individual to choose a higher growth rate of private consumption, the stronger the preference for public consumption. (The intuition for the cases  $s = 1$  and  $s > 1$  is completely analogous.)

## 5. Individual demand for public consumption and growth

In this section, it is considered how the individual demand for the public consumption share  $g$  depends on factor incomes (or endowments, respectively). Using (8), (9), (17) and presuming  $r > J$  to obtain bounded life time consumption (see e.g. Bertola, 1993), initial consumption of individual  $i$  is given by<sup>18</sup>

$$c^i(0) = ((1 - t_K)(1 - a)a - J)k_0^i + (1 - t_L)a a K_0 l^i. \text{ Substituting (21) we have}$$

<sup>17</sup> In contrast, relaxing the infinite horizon assumption, the analysis of overlapping generations models by Uhlig and Yanagawa (1996) as well as Bertola (1996) shows that, holding the tax revenue share of national income constant, lower taxation of the non-accumulated factor at cost of higher capital income taxation may even yield faster investment-driven growth. This is because the tax burden of young agents (i.e. individuals with little capital accumulated yet) is relieved, leaving them with more income out of which to save. For instance, in an OLG model with two-period lifetimes and no bequests, only the young but not the old agents save. However, with infinite lifetimes, agents are always ‘young’ and thus keep saving forever.

<sup>18</sup> Note that  $r - J > 0$  implies  $\lim_{t \rightarrow \infty} e^{-rt} k^i(t) = 0$  (transversality condition). Since the first budget constraint in (17) holds with equality, it can be written as  $\int_0^\infty c^i(t) e^{-rt} dt + \int_0^\infty \dot{k}^i(t) e^{-rt} dt = r \int_0^\infty k^i(t) e^{-rt} dt + \int_0^\infty w(t) l^i e^{-rt} dt$ . Using the transversality condition, it is easy to show that  $\int_0^\infty \dot{k}^i(t) e^{-rt} dt = r \int_0^\infty k^i(t) e^{-rt} dt - k_0^i$ . Finally, substitute the latter expression, (8), (9) and the balanced growth paths  $c^i(t) = c^i(0) e^{Jt}$  and  $K(t) = K(0) e^{Jt}$  to obtain the expression for  $c^i(0)$ .

$$(22) \quad c^i(0) = \frac{\Gamma(1-t_K) + r}{\Omega} k_0^i + (1-t_L) a a K_0 l^i,$$

where  $\Gamma \equiv (s-1)(g+1)(1-a)a$ . For  $s=1$  this reduces to

$$(23) \quad c^i(0) = r k_0^i + (1-t_L) a a K_0 l^i.$$

The first right-hand-side term of (22) and (23), respectively, is initial capital income minus savings and the second term is initial labor income (net of taxes). Thus, if  $t_L < 1$ , the optimal private consumption expenditure exceeds labor income (remember  $k_0^i > 0$ ). This can be understood by the fact that the capital growth rate is identical among individuals which implies that capital income minus savings does not depend on the labor endowment. If  $s=1$ , capital income minus savings does not depend on the private return of investment as well. Thus, in this case only the labor tax rate  $t_L$  matters for the private consumption level. It will be useful to define relative factor endowments

$$(24) \quad \mathbf{x}^i \equiv \frac{k_0^i / K_0}{l^i}.$$

(Remember that total labor supply is normalized to unity.) Using this definition, one finds that the individual savings rate

$$(25) \quad sav^i = \frac{J\mathbf{x}^i}{r\mathbf{x}^i + a a(1-t_L)}$$

is increasing in  $\mathbf{x}^i$  if  $t_L < 1$ .<sup>19</sup> Again, this is an implication of the fact that capital accumulation rates are identical for all individuals.

In order to derive the individually preferred public consumption shares, one has to observe the restrictions on  $g$  implied by the restrictions on the tax rates. According to

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<sup>19</sup> The individual savings rate is given by  $sav^i = \dot{k}^i(t) / y^i(t)$  with  $y^i(t) = r k^i(t) + w(t) l^i$ . Using (9) and the fact that  $\dot{k}^i(t) = J k^i(t)$  yields (25).

(13), if  $\Phi > 0$  (remember that  $t_L > 0$  in this case must hold for  $g > 0$  to be feasible), then  $t_L \leq 1$  implies  $g \leq \Phi$ ; moreover, if  $t_K \geq 0$  (remember that  $\Phi < 0$  must hold if  $u < 0$  and  $t_K > 0$  for  $g > 0$  to be feasible)  $t_K \leq t_K^{\max}$  implies  $g \leq \Phi t_K^{\max} / u$ .

### 5.1 The case $s = 1$

First, in order to derive the mechanisms for a simple case (but for all feasible factor tax ratios  $u$ ),  $s = 1$  is considered. Denote indirect life-time utility of agent  $i$  by  $V^i$ . If  $s = 1$ , substituting the optimal path of individual private consumption and the path of public consumption into (18) and using (19), one obtains

$$(26) \quad rV^i = \ln c^i(0) + g \ln G(0) + \frac{(1+g)J}{r}.$$

(Note that instantaneous utility (19) becomes  $u(c^i, G) = \ln c^i + g \ln G$  as  $s$  approaches unity.) Substituting (10), (21) and (23) into this expression and using (12), (13) and (24) yields

$$(27) \quad rV^i = \ln(r\mathbf{x}^i + (1 - g/\Phi)\mathbf{a}\mathbf{a}) + g \ln g + \frac{(1+g)((1 - u g / \Phi)(1 - \mathbf{a})\mathbf{a} - r)}{r} + \Lambda,$$

where  $\Lambda \equiv \ln(a K_0^2 l^i)$  is an unessential constant. Denote the preferred public consumption share of individual  $i$  by  $g^i$ , where  $g^i = \arg \max_g V^i$  s.t.  $g \geq 0$ ,  $g \leq \Phi t_K^{\max} / u$ , and, if  $\Phi > 0$ ,  $g \leq \Phi$ . It can be shown that  $V^i$  is a strictly concave function of  $g$ . (This ensures that the median voter theorem can be applied.) Furthermore, define  $\tilde{g}^i \equiv \arg \max_g V^i$ . (Note that  $g^i = \tilde{g}^i$  if the restrictions on  $g$  are not binding.)

*Lemma 3:* For  $\mathbf{s} = 1$  and  $g^i = \tilde{g}^i$ . The individually preferred public consumption share  $g^i$  is an increasing function of the relative factor endowment  $\mathbf{x}^i$  if  $-\mathbf{a}/(1-\mathbf{a}) < \mathbf{u} < \infty$  and  $\mathbf{t}_L \geq 0$ ;  $g^i$  is a decreasing function of  $\mathbf{x}^i$  if  $\mathbf{u} < -\mathbf{a}/(1-\mathbf{a})$  and  $\mathbf{t}_K \geq 0$ ;  $g^i$  does not depend on  $\mathbf{x}^i$  if  $\mathbf{u} \rightarrow \infty$  (i.e.  $\mathbf{t}_L = 0$ ).

*Proof:* See appendix A.

Lemma 3 can be understood by inspection of the first three terms of (27). The first and the second term reflect the impact of  $g$  on utility from the initial private and public consumption *level*, respectively, whereas the third term reflects the impact of *growth* on utility. Neither the second nor the third term of (27) depends on individual endowments. This is because all individuals choose the same growth rate of private consumption (see (20)). In other words, since individual income from capital and labor are growing at the same rate, the impact of capital income taxation on *growth* affects all individuals equally. In contrast, the optimal choice of the initial private consumption *level*  $c^i(0)$  depends on the individual factor endowments  $k_0^i$  and  $l^i$ , respectively. Thus, according to (27), it suffices to examine how the impact of a (marginal) increase in the public consumption share  $g$  on  $\ln c^i(0)$  varies with factor endowments  $k_0^i$  and  $l^i$ , respectively. In other words, the question is how the elasticity of  $c^i(0)$  with respect to  $g$ , given the tax scheme, depends on the relative factor endowments  $\mathbf{x}^i$ . This elasticity determines the distributional incidence of taxation.

Note that  $c^i(0) = y^i(0) - \dot{k}^i(0)$ , where  $y^i(0) = rk_0^i + w(0)l^i$  is disposable income and  $\dot{k}^i(0) = Jk_0^i$  are initial savings. Also note that  $r$  and  $J$  are decreasing in  $\mathbf{t}_K$ , according to (8) and (21), respectively, and  $w(0)$  is decreasing in  $\mathbf{t}_L$ , according to (9). Keeping these facts in mind, in the following, the intuition of lemma 3 is discussed for various factor tax ratios  $\mathbf{u}$  (and for feasible signs of  $\mathbf{t}_K$  and  $\mathbf{t}_L$  implied, respectively).

- $0 < \mathbf{u} < \infty$ : In this case,  $g > 0$  implies both  $\mathbf{t}_L > 0$  and  $\mathbf{t}_K > 0$ . With respect to the individually preferred public consumption share, three effects of individual endowments can be distinguished. On the one hand, as in the static model of section

2, there is a *substitution effect* and a *wealth effect* of  $k_0^i$  and  $l^i$  on the individually preferred  $g$ , working through the impacts of  $k_0^i$  and  $l^i$  on disposable income  $y^i(0)$ . Whereas the wealth effect is standard (see section 2), the substitution effect reflects the fact that, if  $g$  increases, losses of disposable factor incomes are more pronounced if factor endowments are higher (i.e., all other things equal, the relative ‘price’ of public consumption, faced by an individual, is higher; again, see section 2). On the other hand, compared with the static model, there now is an additional *savings effect* of a higher individual capital endowment  $k_0^i$ . If  $u > 0$ , this effect works in the same direction as the wealth effect. To see this, note that if  $t_K > 0$ , the savings reduction of an individual after an increase in  $g$  (i.e. an increase in  $t_K$ ) is higher, the higher the capital endowment  $k_0^i$ . (To see this formally, note that  $\partial^2 k^i(0)/\partial t_K \partial k_0^i < 0$ .) In other words, due to the impact of an increase in  $g$  on initial individual savings  $\dot{k}^i(0)$ , the impact of an increase in  $g$  on the (initial) private consumption level  $c^i(0)$  is *less* pronounced for a capital-rich individual compared to a capital-poor one, for any  $u \in (0, \infty)$ .

- $u = 0$ : As  $t_K = 0$  in this case (i.e. labor bears the entire tax burden), the preferred public consumption share is higher, the more an individual can rely on capital income.
- $u \rightarrow \infty$ : As  $t_L = 0$  in this case, with  $s = 1$ , the private consumption level is not affected by an increase in  $g$ , according to (23). As a result, all individuals vote for the same public consumption share. (It is easy to show that  $\tilde{g}^i = r(a(1+g))^{-1}$  if  $t_L = 0$ .) Thus, for  $s = 1$  and  $t_L = 0$ , one obtains a similar result as in proposition 2. (Remember that  $e^i = 1$  for all  $i$ , according to (19).)
- $u < 0$ : Note that in this case,  $\Phi > 0$  if  $t_L > 0$  and  $\Phi < 0$  if  $t_K > 0$  has to be imposed for  $g > 0$  to be feasible (see above). If  $t_L > 0$  and capital is subsidized, a similar result as in the case  $u = t_K = 0$  holds, since  $c^i(0)$  is not affected by  $t_K$  (if  $s = 1$ ). If  $t_K > 0$  and labor is subsidized, then the more an individual relies on

labor income, the higher is his/her preferred public consumption share. Thus, only in the latter case capital-poorer agents vote for higher public spending.

## 5.2 The case $\mathbf{s} \neq 1$ and $0 \leq \mathbf{u} < \infty$

In order to focus the analysis, from now on  $0 \leq \mathbf{u} < \infty$  is presumed. That is, an increase in the public consumption share  $g$  does not simultaneously redistribute factor income (i.e.  $\mathbf{u} < 0$  is excluded) and  $\mathbf{t}_L > 0$  whenever  $g > 0$  (i.e.  $\mathbf{u} \rightarrow \infty$  is excluded). According to (22), if  $\mathbf{s} \neq 1$ , the initial private consumption level is also affected by capital income taxation which potentially alters the result. According to (18) and (19), life-time utility  $V^i$  is now given by<sup>20</sup>

$$(28) \quad (1 - \mathbf{s})V^i + \frac{1}{\mathbf{r}} = \frac{\left(c^i(0)^g G(0)\right)^{1-\mathbf{s}}}{\mathbf{r} - (1 - \mathbf{s})(g + 1)\mathbf{J}}.$$

It is easy to check that maximization of  $V^i$  with respect to  $g$  is equivalent to maximization of

$$(29) \quad \frac{\ln\left((1 - \mathbf{s})V^i + 1/\mathbf{r}\right)}{1 - \mathbf{s}} = \ln c^i(0) + g \ln G(0) - \frac{\ln(\mathbf{r} - (1 - \mathbf{s})(g + 1)\mathbf{J})}{1 - \mathbf{s}}.$$

Like in the case  $\mathbf{s} = 1$ , it suffices to examine how the partial derivative  $\partial \ln c^i(0) / \partial g$  depends on  $\mathbf{x}^i$ , which determines the distributional incidence of taxation (given the tax scheme). This is because, similar to the case  $\mathbf{s} = 1$ , the relationship between public consumption and growth (which is a trade-off if  $\mathbf{t}_K > 0$ ) is not individual-specific.

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<sup>20</sup> Note that according to (21),  $\mathbf{r} > \mathbf{J}$  (assumed above) is equivalent to  $\mathbf{r} > (1 - \mathbf{s})(g + 1)\mathbf{r}$ , thus implying that  $\mathbf{r} - (1 - \mathbf{s})(g + 1)\mathbf{J} > 0$ .

*Lemma 4* : For  $g^i = \tilde{g}^i$  and  $0 \leq u < \infty$ . (i) The preferred public consumption share  $g^i$  increases with (does not depend on, decreases with) the relative factor endowment  $\mathbf{x}^i$  if  $s > 1$  and  $u < (=, >) 1 + r / \Gamma$ . (ii)  $g^i$  unambiguously increases with  $\mathbf{x}^i$  if  $s < 1$ .

*Proof*: See appendix A.

First, consider the case  $s > 1$ , i.e. the intertemporal elasticity of substitution with respect to private consumption is lower than unity. In other words, individuals are fairly impatient and therefore choose low savings. This also implies that the savings effect, described above, is smaller than in the case of  $s = 1$  (all other things equal). Thus, the impact of an increase in the capital income tax rate  $t_K$  on the private consumption level  $c^i(0)$  is negative (see (22)). As a result, if the factor tax ratio  $u = t_K / t_L$  is sufficiently high, owners of capital prefer a rather low public consumption share. Note, however, that in the case of a synthetic income tax (i.e.  $u = 1$ ) the preferred public consumption share  $g^i$  of individual  $i$  still increases with his/her relative factor endowment  $\mathbf{x}^i$ .

Second, if  $s < 1$ , the private consumption level *increases* with the capital income tax rate. This is because  $s < 1$  means that individuals are fairly patient and thus the savings effect is large. As a result, the positive impact of a higher (relative) capital endowment on the preferred public consumption share is even strengthened compared to the case  $s = 1$ .<sup>21</sup>

## 6. Voting equilibrium in the growth model

In majority voting equilibrium the preferred spending fraction  $g^m$  of the individual with the median relative factor endowment  $\mathbf{x}^m$  is realized. This directly follows from the fact

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<sup>21</sup> Note that in case of  $s < 1$  and  $u > 0$ , there may not even be a trade-off between private and public consumption (i.e. if  $u$  or  $\mathbf{x}^i$  are sufficiently large). In this case, individuals face a trade-off between the consumption levels of both goods on the one hand and subsequent growth on the other hand. In contrast, for  $s \geq 1$  and  $u > 0$ , there is always a trade-off between the public consumption level on the one hand and the private consumption level and growth on the other hand.

that the individually preferred public consumption share  $g^i$  is monotonic in the relative factor endowment  $\mathbf{x}^i$ . Whereas  $\mathbf{x}^i = \mathbf{x}^m = 1$  for all  $i$  in a perfectly egalitarian economy, the real-world distribution of relative factor endowments is skewed such that  $\mathbf{x}^m < 1$ , i.e. the median voter is capital-poor (relative to his/her labor endowment).<sup>22</sup> Thus, one may refer to the capital income distribution as more equal, the higher the median relative factor endowment  $\mathbf{x}^m$ .<sup>23</sup>

*Proposition 3 (Growth model):* For  $g^m = \tilde{g}^m$  and  $0 \leq \mathbf{u} < \infty$ . A more equal capital income distribution, i.e. a higher median relative factor endowment  $\mathbf{x}^m$ , implies a higher public consumption share  $g^m$  in majority voting equilibrium if  $\mathbf{s} \leq 1$  or  $\mathbf{u} < 1 + \mathbf{r} / \Gamma$ . In case of a synthetic income tax (i.e.  $\mathbf{u} = 1$ ), a more equal capital income distribution unambiguously yields a higher  $g^m$ .

*Proof:* Directly follows from lemmas 3 and 4.

## 7. Discussion and extensions

### 7.1 An alternative tax scheme

How do the results change if, alternatively, one assumes that one factor tax rate is held constant, and the other factor tax rate varies with the public consumption share  $g$ ,

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<sup>22</sup> According to (24), the distribution of relative factor endowments not only depends on the distribution of capital but also on the distribution of the non-accumulated factor endowment. As Bertola (1993) suggests, in unequal societies land ownership is highly concentrated on the politically decisive class. In this sense, an unequal distribution of the non-accumulated factor endowment also corresponds to an unequal distribution of the relative factor endowment. However, this would mean that an individual with a higher non-accumulated factor endowment than the median is decisive (for a discussion of such a political bias, see also Bénabou, 1996). As it is not the goal of this paper to discuss this case, it is useful to think about the case of an egalitarian non-accumulated factor income distribution, i.e.  $l^i = L = 1$  for all  $i$ .

<sup>23</sup> For instance, assume that  $\mathbf{x}^i$  is log-normally distributed and let the mean of  $\mathbf{x}^i$  be equal to unity. (If  $l^i = L = 1$  for all  $i$ , this would represent a plausible real-world-distribution of relative capital). In this case, the difference between the median and the mean of  $\mathbf{x}^i$  increases if and only if the Gini coefficient of its distribution increases.

according to (11)? First, consider the case where  $\mathbf{t}_K = \text{const}$ . In this case, clearly, an increase in  $g$  (or  $\mathbf{t}_L$ , respectively) hurts owners of capital less than owners of labor. Thus, more equality unambiguously leads to a higher public consumption share in voting equilibrium.<sup>24</sup> Second, assume that  $\mathbf{t}_L = \text{const}$ . If  $\mathbf{s} = 1$ , the initial private consumption level  $c^i(0)$  is not affected by an increase in  $g$  (or  $\mathbf{t}_K$ , respectively), according to (23). Thus, all individuals face the same trade-off between public consumption and growth, implying that the voting equilibrium is not affected by inequality, i.e.  $g^m$  is independent of  $\mathbf{x}^m$ . (Compare the discussion of  $\mathbf{u} \rightarrow \infty$ , i.e.  $\mathbf{t}_L = 0$ , in section 5.1.) If  $\mathbf{s} < 1$  ( $\mathbf{s} > 1$ ), an increase in  $g$ , holding  $\mathbf{t}_L$  constant, raises (lowers) the private consumption level  $c^i(0)$ , according to (11) and (22). Thus, if  $\mathbf{s} < 1$  ( $\mathbf{s} > 1$ ), more equality leads to a higher (lower) public consumption share in voting equilibrium.<sup>25</sup>

## 7.2 Inequality and growth effects of taxation

In sum, the analysis has shown that higher inequality of capital income may lead to a smaller public sector and even a higher growth rate. This is in stark contrast to the usual argumentation of the inequality and growth relationship through the politico-economic channel. In this line of literature, capital-poor individuals demand higher capital taxes which are used to finance income (or in-kind) transfers, thus depressing growth (e.g. Bertola, 1993; Alesina and Rodrik, 1994). However, this is not necessarily true if the tax revenue is used to finance public consumption. (Recall that  $\mathbf{u} = -\mathbf{a}/(1-\mathbf{a})$ , i.e.  $g = 0$ , is the special case considered in Bertola, 1993.) In my model, publicly provided goods and services also have a strong redistributive element since individuals consume similar amounts, although being differently taxed. Nevertheless, the voting outcome may be considerably different to the one with direct transfers.

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<sup>24</sup> Formally, note that  $\partial c^i(0)/\partial \mathbf{t}_L < 0$  and  $\partial^2 \ln c^i(0)/\partial \mathbf{t}_L \partial \mathbf{x}^i > 0$ , according to (22). Thus, if  $g^m = \tilde{g}^m$ , we have  $\partial g^m / \partial \mathbf{x}^m > 0$  (applying the formal argumentation of section 5).

<sup>25</sup> Formally, note that  $\partial c^i(0)/\partial \mathbf{t}_K >, =, < 0$  and  $\partial^2 \ln c^i(0)/\partial \mathbf{t}_K \partial \mathbf{x}^i >, =, < 0$ , if  $\mathbf{s} <, =, > 1$ , according to (22). Thus, if  $g^m = \tilde{g}^m$ , we have  $\partial g^m / \partial \mathbf{x}^m >, =, < 0$  if  $\mathbf{s} <, =, > 1$ .

### 7.3 Specification of preferences and the role of savings

It may be argued that the preferences assumed in the growth model are somewhat special (i.e. preferences are homothetic with  $e^i = 1$ ). One reason for considering these preferences is, of course, analytical tractability (i.e. in order to obtain steady state growth). But there are other important reasons. First, as pointed out before, the results can be compared to literature about growth effects of public expenditure and redistribution. Second, it allows to identify the additional savings effect, compared with the static model of section 2. As pointed out before, in both models, higher individual endowments affect the individually preferred public consumption share (and thus the voting equilibrium) in two opposing ways, through a wealth effect and a substitution effect. Distinguishing between accumulated and non-accumulated factor income in an intertemporal context reveals an important additional mechanism. If labor income is taxed more heavily, current private consumption unambiguously decreases. In contrast, if the capital income tax rate rises, it may be optimal for owners of capital to adjust savings downward in order to keep up with current private consumption levels. The resulting growth reduction hurts owners of capital and owners of labor similarly, since the growth rate of labor income decreases in line with capital income growth. These properties of the model are equivalent to the fact that the savings rate is higher for capital-rich individuals than for capital-poor ones, according to (25). In fact, it is a well-known empirical regularity that the savings rate of households increases with individual income (e.g. Browning and Lusardi, 1996). Hence, the above specification of preferences allows to work out a mechanism that may be quite relevant empirically.

### 7.4 Endogenous labor supply

How are the results affected if one allows for endogenous labor supply? Note that the only heterogeneity among individuals remaining in this case are capital endowments. Define the relative capital endowment of individual  $i$  by  $z^i \equiv k_0^i / K_0$ . To focus on a simple case (analogously to subsection 5.1), let instantaneous utility now be given by

$$(30) \quad u(c^i, l^i, G) = \ln c^i + b \ln(1 - l^i) + g \ln G, \quad b, g > 0,$$

where individual time endowments are identical and normalized to unity such that leisure of individual  $i$  is given by  $(1 - l^i)$ . Analogously to (26), life-time utility  $V^i$  can be obtained by

$$(31) \quad rV^i = \ln c^i(0) + b \ln(1 - l^i) + g \ln G(0) + \frac{(1 + g)J}{r}.$$

For simplicity, the discussion focuses on an equilibrium in which all individuals choose positive labor supply (i.e.  $l^i > 0$  for all  $i \in [0, 1]$ ).<sup>26</sup> As shown in appendix B, the (initial) private consumption level then reads<sup>27</sup>

$$(32) \quad c^i(0) = \frac{rK_0}{1 + b} \left( z^i + \frac{b}{1 - (1 + b)\tilde{L}(t_L)} \right),$$

where aggregate labor supply  $L = \tilde{L}(t_L)$  is a strictly decreasing function of the labor income tax rate  $t_L$  and  $L < (1 + b)^{-1}$ . Note that due to the savings effect discussed above, the capital income tax rate  $t_K$  does not affect  $c^i(0)$  under specification (30). Moreover,  $\partial \ln c^i(0) / \partial t_L < 0$  and  $\partial^2 \ln c^i(0) / \partial t_L \partial z^i > 0$ . Thus, the negative impact of an increase in the public consumption share  $g$  on  $c^i(0)$  is again less pronounced for capital-rich individuals than for capital-poor ones if  $t_L > 0$  (i.e. if  $-a/(1 - a) < u < \infty$ ). How does individual labor supply adjust to taxation, conditional on the relative capital endowment  $z^i$ ? As also shown in appendix B, individual labor supply  $l^i$  can now be written as a function  $\tilde{l}^i(t_L, z^i)$  with  $\partial \tilde{l}^i / \partial t_L < 0$ ,  $\partial \tilde{l}^i / \partial z^i < 0$  and  $\partial^2 \tilde{l}^i / \partial t_L \partial z^i < 0$ . Thus, the negative impact of labor income taxation on individual

<sup>26</sup> A more detailed analysis is provided in appendix B, where it is shown that capital-rich individuals may not work in equilibrium. It can be shown that typically also in this case the individually preferred public consumption share  $g^i$  is monotonic (i.e. non-decreasing) in  $z^i$  if an equilibrium exists. However, an equilibrium may fail to exist for some parameter constellations.

<sup>27</sup> Initial public consumption and the equilibrium growth rate  $J = r - r$  are given by  $G(0) = gaK_0 \tilde{L}(t_L)^a$  and  $J = (1 - t_K)(1 - a)a\tilde{L}(t_L)^a - r$ , respectively.

labor supply becomes stronger, the higher the relative capital endowment  $\mathbf{z}^i$ . (Note that this is analogous to the savings effect, i.e. remember  $\partial^2 \dot{k}^i(0)/\partial \mathbf{t}_K \partial k_0^i < 0$ .) Due to this *labor supply effect*, the elasticity of leisure  $(1 - \tilde{l}^i)$  with respect to  $\mathbf{t}_L$  (or  $g$ , respectively, if  $\mathbf{t}_L > 0$ ) turns out to higher for capital-rich agents (i.e. as shown in appendix B,  $\partial^2 \ln(1 - \tilde{l}^i)/\partial \mathbf{t}_L \partial \mathbf{z}^i > 0$ ).

Again, analogous to the discussion in the preceding subsection, it should be noted that this result is an implication of the specification of preferences. However, it may not be implausible to view capital-rich individuals to be better able to adjust labor supply downward if labor income taxation increases.

## 8. Conclusion

According to a standard argument, higher income inequality fosters redistributive activities of the government in favor of the median income earner. This paper has examined the relationship between income inequality and the public consumption share in both a static and a dynamic median voter model, where public consumption is financed by income taxes. In the static case, a higher relative income of the median voter has been assumed to imply a higher individual tax share for financing public consumption. Nevertheless, the substitution effect of this higher relative price for publicly provided goods and services on the individual demand for public consumption may be dominated by a wealth effect. Thus, although public expenditure plays a redistributive role in the model, higher income inequality may nevertheless imply a smaller size of the government in majority voting equilibrium.

More interestingly, it was shown in a general equilibrium growth model, that this result may even be strengthened due to the role of taxation for savings and growth. A dynamic model allows to distinguish taxation effects of accumulated and non-accumulated factors of production. For instance, it has been shown that in the case where public consumption expenditure is financed by a synthetic proportional income tax and labor supply is exogenous, a capital-rich median voter unambiguously prefers a bigger government as provider of goods and services than a capital-poor median voter. The

reason for this is the following. Higher capital income taxation reduces savings, leaving its impact on (current) private consumption levels of owners of capital ambiguous. In contrast, owners of labor unambiguously reduce their private consumption levels in response to labor income taxation. However, the reduced savings of owners of capital slow down investment-driven growth of both capital and labor income. Thus, under a synthetic proportional income tax, savings adjustments leave capital-poor individuals to bear more of the tax burden if the public consumption share is raised. Allowing for endogenous labor supply additionally shifts the relative tax burden towards capital-poor agents, if capital-rich agents are also more able to cope with labor income taxation by reducing labor supply.

In fact, empirically, more equal economies do not seem to have smaller governments and thus do not seem to be less engaged in redistribution towards the median voter through the tax-system.

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## **Appendix**

### **A. Proof of lemmas 1-4**

*Proof of lemma 1:* Applying the implicit function theorem to (4) and manipulating the resulting expression yields

$$(A.1) \quad \frac{dG^i y^i}{dy^i G^i} = 1 - \frac{s'(\cdot)G^i(1 + MRS'(\cdot))}{MRS'(\cdot)},$$

where  $s'(\cdot)$  and  $MRS'(\cdot)$  denote first derivatives. Note that the inverse of the elasticity of substitution between the two goods can be written as

$$(\mathbf{e}^i)^{-1} = MRS'(c^i / G^i) \frac{(y^i - s^i G^i) / G^i}{s^i} \quad \text{with } s^i = MRS(c^i / G^i), \text{ according to (4).}$$

(Also note that  $c^i = y^i - s^i G^i$ ). Thus, we have  $G^i(1 + MRS'(\cdot)) = (y^i / s^i) \mathbf{e}^i MRS'(\cdot)$ .

Substituting the latter expression into (A.1) yields

$$(A.2) \quad \frac{dG^i y^i}{dy^i G^i} = 1 - \frac{s'(\cdot)y^i}{s^i} \mathbf{e}^i,$$

thus confirming lemma 1.

*Proof of lemma 2:* The current-value Hamiltonian function  $\mathfrak{S}$  for the utility maximization problem of individual  $i$ , given his/her initial capital endowment  $k_0^i > 0$ , is given by

$$(A.3) \quad \mathfrak{S}(c^i, k^i, \mathbf{I}^i) = \frac{(c^i G^g)^{1-s} - 1}{1-s} + \mathbf{I}^i (wl^i + rk^i - c^i),$$

where  $\mathbf{I}^i$  is the current-value shadow price of individual labor income. The first order conditions

$$(A.4) \quad \frac{\mathcal{I}\mathfrak{S}}{\mathcal{I}c^i} = 0 \Leftrightarrow \mathbf{I}^i = (c^i)^{-s} G^{g(1-s)},$$

$$(A.5) \quad -\frac{\mathcal{I}\mathfrak{S}}{\mathcal{I}k^i} = \dot{\mathbf{I}}^i - r\mathbf{I}^i \Leftrightarrow -\hat{\mathbf{I}}^i = r - \mathbf{r}$$

and the transversality condition  $\lim_{t \rightarrow \infty} e^{-rt} k^i(t) = 0$  (where the latter holds if  $r > J$ ) are necessary and sufficient for a maximum because of the concavity of  $\mathfrak{S}$  and positive discounting (i.e.  $r > 0$ ). Differentiating (A.4) with respect to time yields

$$(A.6) \quad -\hat{I}^i = \mathbf{s} \hat{c}^i - (1 - \mathbf{s}) \mathbf{g} \hat{G}.$$

Combining (A.5) and (A.6) and using the expression for  $r$  given in (8) yields equation (20).

*Proof of lemma 3:* Neglecting the restrictions on  $g$ , the preferred spending fraction  $\tilde{g}^i$  is given by  $\mathfrak{V} V^i / \mathfrak{V} g = 0$ . Thus, confirming  $\mathfrak{V}^2 V^i / \mathfrak{V} g^2 < 0$  and applying the implicit function theorem,  $\text{sign}(\mathfrak{V} \tilde{g}^i / \mathfrak{V} \mathbf{x}^i) = \text{sign}\left(\left(\mathfrak{V}^2 V^i / \partial g \mathfrak{V} \mathbf{x}^i\right)\Big|_{g=\tilde{g}^i}\right)$ , where

$$(A.7) \quad \left[ \frac{\partial^2 V^i}{\partial g \partial \mathbf{x}^i} \right]_{g=\tilde{g}^i} = \frac{\mathbf{a} \mathbf{a} / \Phi}{\left( \mathbf{r} \mathbf{x}^i + (1 - \tilde{g}^i / \Phi) \mathbf{a} \mathbf{a} \right)^2},$$

according to (27). Thus,  $\tilde{g}^i$  is increasing in  $\mathbf{x}^i$  if  $\mathbf{t}_L \geq 0$  and  $0 < \Phi < \infty$ , i.e. if  $-\mathbf{a} / (1 - \mathbf{a}) < \mathbf{u} < \infty$ . Moreover,  $\tilde{g}^i$  is decreasing in  $\mathbf{x}^i$  if  $\mathbf{t}_K \geq 0$  and  $\Phi < 0$ , i.e. if  $\mathbf{u} < -\mathbf{a} / (1 - \mathbf{a})$ . Finally, note that according to (27),  $\mathfrak{V} V^i / \mathfrak{V} g = 0$  does not depend on  $\mathbf{x}^i$  if  $\mathbf{t}_L = 0$ , i.e. if  $\mathbf{u} \rightarrow \infty$  and thus  $\Phi \rightarrow \infty$ . This concludes the proof.

*Proof of lemma 4:* Note that  $\tilde{g}^i$  increases (remains constant, decreases) with  $\mathbf{x}^i$  if  $\mathfrak{V}^2 \text{Inc}^i(0) / \mathfrak{V} g \mathfrak{V} \mathbf{x}^i > (=, <) 0$ . Substituting (12) and (13) into (22) yields

$$(A.8) \quad c^i(0) = \frac{\Gamma(1 - \mathbf{u} g / \Phi) + \mathbf{r}}{\Omega} k_0^i + (1 - g / \Phi) \mathbf{a} \mathbf{a} K_0 l^i,$$

and thus,

$$(A.9) \quad \frac{\mathbb{I} \ln c^i(0)}{\mathbb{I} g} = - \frac{\Gamma \mathbf{u} \mathbf{x}^i + \mathbf{a} \mathbf{a} \Omega}{(\Gamma(\Phi - \mathbf{u} g) + \mathbf{r} \Phi) \mathbf{x}^i + (\Phi - g) \mathbf{a} \mathbf{a} \Omega}.$$

Use (A.9) to confirm

$$(A.10) \quad \frac{\mathbb{I}^2 \ln c^i(0)}{\mathbb{I} g \mathbb{I} \mathbf{x}^i} = \frac{\mathbf{a} \mathbf{a} \Omega \Phi (\mathbf{r} + \Gamma(1 - \mathbf{u}))}{\left( (\Gamma(\Phi - \mathbf{u} g) + \mathbf{r} \Phi) \mathbf{x}^i + (\Phi - g) \mathbf{a} \mathbf{a} \Omega \right)^2}.$$

(i) First, consider  $\mathbf{s} > 1$  which implies  $\Gamma > 0$ . (Remember  $\Gamma = (\mathbf{s} - 1)(\mathbf{g} + 1)(1 - \mathbf{a})\mathbf{a}$ .)

Thus, the right hand side of (A.10) is positive (zero, negative) if  $\mathbf{u} < (=, >) 1 + \mathbf{r} / \Gamma$ .

(ii) Second, note that  $\mathbf{r} = (1 - \mathbf{a})\mathbf{a}(1 - \mathbf{t}_K) > \mathbf{J}$  implies  $\mathbf{r} > -\Gamma(1 - \mathbf{t}_K)$ , according to (21). (Remember  $\Omega = \mathbf{s}(\mathbf{g} + 1) - \mathbf{g}$ .) Also note that  $0 < \mathbf{t}_L \leq 1$  implies  $\mathbf{u} = \mathbf{t}_K / \mathbf{t}_L \geq \mathbf{t}_K$ . Since  $\mathbf{s} < 1$  implies  $\Gamma < 0$ ,  $\mathbf{r} > -\Gamma(1 - \mathbf{t}_K)$  implies  $\mathbf{r} > -\Gamma(1 - \mathbf{u})$ . This concludes the proof.

## B. Endogenous labor supply

The analysis of the corresponding optimal control problem is analogous to the proof of lemma 2. Using specification (30) and neglecting the restriction  $l^i \in [0, 1]$  for a moment, the first-order conditions with respect to the control variables  $c^i$  and  $l^i$  imply  $l^i = 1 - \mathbf{b} c^i / w$ . (This simply reflects the standard condition that the marginal rate of substitution between private consumption and leisure equals the wage rate.) In balanced growth equilibrium,  $\dot{c}^i(t) = \dot{w}(t)$  must hold for all  $i$ , which implies

$$(B.1) \quad l^i = 1 - \frac{\mathbf{b} c^i(0)}{w(0)}.$$

Thus,  $\dot{l}^i(t) = \dot{L}(t) = 0$  for all  $i$  and  $t$ . (Note that (A.5) remains valid.) With endogenous labor supply, (8) and (9) have to be replaced by

$$(B.2) \quad r = (1 - \mathbf{t}_K)(1 - \mathbf{a})\mathbf{a}L^{\mathbf{a}}$$

and

$$(B.3) \quad w(t) = (1 - \mathbf{t}_L)\mathbf{a}\mathbf{a}K(t)L^{\mathbf{a}-1},$$

respectively. Analogously to (23), one finds

$$(B.4) \quad c^i(0) = \mathbf{r}k_0^i + w(0)l^i.$$

Substituting (B.4) into (B.1), and using (B.3) yields

$$(B.5) \quad l^i = \frac{1}{1 + \mathbf{b}} \left( 1 - \frac{\mathbf{b}\mathbf{r}k_0^i}{(1 - \mathbf{t}_L)\mathbf{a}\mathbf{a}K_0L^{\mathbf{a}-1}} \right).$$

As (B.5) reveals, capital-rich individuals may choose  $l^i = 0$ . Moreover, an equilibrium may fail to exist for some parameter constellations, which is ruled out here by assumption.

To save space, like in the main text the exclusive focus is on the case  $l^i > 0$  for all  $i$ . Applying the equilibrium condition  $\int_0^1 l^i di = L$  and remembering  $\int_0^1 k_0^i di = K_0$ , (B.5) implies that aggregate equilibrium labor supply  $L$  is implicitly given by

$$(B.6) \quad \frac{\mathbf{b}\mathbf{r}}{(1 - \mathbf{t}_L)\mathbf{a}\mathbf{a}L^{\mathbf{a}-1}} = 1 - (1 + \mathbf{b})L,$$

i.e.  $L < (1 + \mathbf{b})^{-1}$ . Suppressing all unessential parameters, write  $L = \tilde{L}(\mathbf{t}_L)$  and note that (B.6) implies  $d\tilde{L}/d\mathbf{t}_L < 0$  by the implicit function theorem. Individual labor supply is then given by

$$(B.7) \quad l^i = \frac{1}{1+b} \left( 1 - \left[ 1 - (1+b)\tilde{L}(t_L) \right] z^i \right) \equiv \tilde{l}^i(t_L, z^i),$$

according to (B.5) and (B.6). Hence,  $\partial \tilde{l}^i / \partial t_L < 0$ ,  $\partial \tilde{l}^i / \partial z^i < 0$  and  $\partial^2 \tilde{l}^i / \partial t_L \partial z^i < 0$ . To derive  $c^i(0)$ , use (B.3), (B.4), (B.6) and (B.7), which gives (32). Finally, use (B.7) to confirm that

$$(B.8) \quad \frac{\partial^2 \ln(1 - \tilde{l}^i)}{\partial t_L \partial z^i} = - \frac{b}{(1+b)(1 - \tilde{l}^i)^2} \frac{d\tilde{L}}{dt_L} > 0.$$

This confirms all claims made in subsection 7.4.

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